Retrieval-induced forgetting and memory for actions.

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Abstract

Previous research has demonstrated a retrieval-induced forgetting effect for verbal material (Anderson & Spellman, 1995), colours and shapes (Ciranni & Shimamura, 1999), eyewitness testimony (MacLeod, 2002), and images of novel actions (Koutstaal et al., 1999). However, little research has been conducted into retrieval-induced forgetting and self-performed actions. A recent study by Sharman (2011) demonstrated retrieval-induced forgetting for familiar and bizarre self-performed actions. The current thesis aims to examine retrieval-induced forgetting and actions including self-performed and observed actions, and combinations of self-performed and observed actions. The first experiment demonstrated retrieval-induced forgetting for novel motor sequences. In addition, retrieval-induced forgetting was also found for less novel actions (Experiments 3 and 4) for both typical and non-typical self-performed actions (Experiment 3) and memorable self-performed actions (Experiment 4). Experiment 2 demonstrated a retrieval-induced forgetting effect for objects associated with actions suggesting that retrieval-induced forgetting effects occur both for the action and the object. However the findings of experiment 5 suggest that retrieval-induced forgetting may not occur for goal-orientated actions. These experiments may suggest that retrieval-induced forgetting occurs for non goal-orientated actions, but may not occur for goal-orientated actions. These findings are discussed in terms of the inhibitory account.

Declaration

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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This thesis is the result of my own independent work/investigation, except where otherwise stated. Other sources are acknowledged. A bibliography is appended.

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Definitions and Abbreviations

RIF (Retrieval-Induced Forgetting) – The forgetting of items, which are related to the practiced items but were not themselves practiced.

Rp+ items – Items that were practiced during the retrieval practice phase.

Rp- items – Items that were related to the practiced items (Rp+ items) but were not themselves practiced.

Nrp items – Items that were not related to the practiced items and were not practiced.

T – Typical items.

NT – Non-Typical items.

M – Memorable items.

NM – Non-memorable items.

Chapter 1
Memory for Actions

Actions play a part in everyday life in many of the tasks individuals perform. In order to successfully complete a task several actions may be required. Additionally, these actions may consist of several motor sequences. For example, if an individual was asked to make a cup of tea, the process may follow a similar pattern to the one demonstrated below (see Figure 1).

Figure 1: Example of Process of Making a Cup of Tea

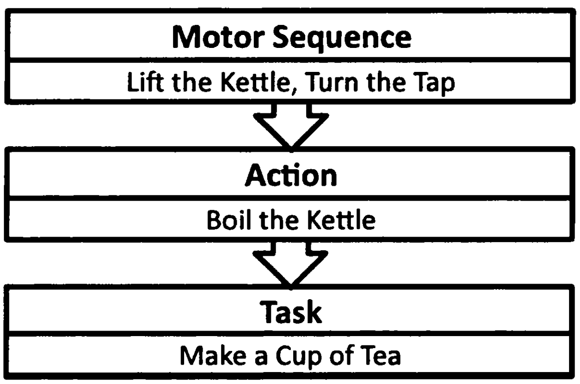


Figure 1. Example of some of the motor sequences and actions involved in the task of making a cup of tea.

For a task to be completed successfully, motor sequences and actions need to come together and be performed in the correct sequence, and in an appropriate and timely manner (Zimmer & Cohen, 2001). Failure to do this could lead to several consequences, for example, the task may not be completed at all, completed incorrectly, or late. The past few decades have seen an increase in research relating to memory for actions including how memory for actions differs to memory for verbal information or verbal materials and how individuals remember actions. Earlier research for the most part has focussed on 'mini-tasks' (or individual actions) such as 'lift the pen' or 'roll the dice', however, recent research has also taken into account the goal-orientated aspect of actions, such as packing a rucksack.

Memory for Actions: An Enactment Effect

Memories for actions play an important part in everyday life and take a variety of forms, for example, remembering where the car keys are, if the front door of the house has been locked or remembering how to perform an action. Prior to the 1980's much of the memory research completed focused on verbal material, however, the beginning of the 1980's in particular saw a move towards researching memory for actions. It is important to note that memories for actions and memories for verbal material may differ in several ways. This may also highlight the need to study memory for actions as well as memory for verbal material. Zimmer and Cohen (2001) noted several differences, which may occur between memory for actions and memory for verbal material (see also Cohen, 1981; Helstrup, 1986). Firstly, many actions are remembered unintentionally, that is individuals are often able to remember actions without having to put too much effort into remembering the actions. Secondly, a key component of many actions are that they are performed by the individual themselves. Thirdly, Zimmer and Cohen noted that actions often involve an input and an output. The above may not necessarily occur with regards to verbal material, and highlight the differences, which may occur between memory for actions and memory for verbal material.

Subject-Performed Tasks (SPT)

Research into memory for actions often involves comparing recall performance for subject-performed tasks (SPT) (i.e. actions performed by the individual themselves, self-performed actions) with the recall performance of verbally learnt information (VT). In general, the method in studies in this area involves instructing participants to perform a series of actions, for example, 'lift the pen' or 'knock the door'. During the study phase, participants in the subject-performed condition (SPT) are asked to perform the actions themselves whilst participants in the control condition study the tasks verbally (VT). All participants then complete a test phase. In order to determine if memory for subject-performed tasks differs to memory for verbally learnt tasks, the results of the control condition (VT condition) are compared to the results of the subject-performed condition. Results generally demonstrate an improvement for subject-performed tasks (SPT condition) compared to verbally learnt tasks (VT condition).

Research into memory for subject-performed tasks began to emerge in the early 1980s in several different research groups, independently of each other (Cohen, 1981; Engelkamp & Krumnacker, 1980; Saltz & Donnenwerth-Nolan, 1981). Engelkamp and Krumnacker (1980) asked participants to study a list of forty-eight actions either through self-performing actions (SPT condition) or listening to actions (VT condition). During the test phase participants were asked to recall and write down the name of the actions they were able to remember in a free recall test. Recall performance for subject-performed tasks (SPT condition) ($M = .62$) was higher than recall performance for listening to the tasks (VT condition) ($M = .45$), a difference of .17. The results demonstrated an improvement in the number of actions recalled correctly in the SPT condition compared to the number of actions recalled in the VT condition. Around the same time, Cohen (1981) conducted a study during which participants were instructed to study four lists of fifteen actions (either through self-performance or verbally). This was followed by a free recall test. The results demonstrated an improved recall performance for subject-performed tasks compared to recall performance of those that were learnt verbally. In general, it would seem that actions (e.g. lift the pen) are remembered better if the participant performs the actions themselves rather than if the information is verbally learnt (see also Backman & Nilsson, 1984; Helstrup, 1984; Kausler & Lichty, 1986; Knopf, 1981). This improvement in subject-performed tasks (i.e. self-performed actions) has been termed the *enactment effect* (see Roediger & Zaromb 2010, for review). An enactment effect has been demonstrated regardless of whether the objects were present or imagined (Engelkamp & Zimmer, 1994; Kormi-Nouri, 2000), whether recall or recognition tests were used (Cohen, 1989; Engelkamp& Zimmer, 1994), or if visual information was available or not (Hornstein & Mulligan, 2004).

In addition to an improvement in the number of actions correctly recalled when the participants perform the actions themselves compared to verbally learning the actions Koriat, Pearlman-Avnion, and Ben-Zur (1998) found that subject-performed tasks led to a reduction in the number of false alarms made for subject-performed tasks. Zimmer (1996) found a false alarm rate of only .04 for subject-performed tasks however a higher false alarm rate of .23 was found for verbally learnt information, a difference of .19 (see also Engelkamp & Zimmer, 1995; Leynes & Bink, 2002). These findings suggest that not only does self-performance of the actions lead to an increase in the number of actions correctly recalled but it can also decrease the number of false alarms made.

Recall performance for subject-performed tasks has also been compared to recall performance for imagining the tasks being performed (Engelkamp & Krumnacker, 1980; see also Denis, Engelkamp, & Mohr, 1991; Ecker & Engelkamp, 1995; Engelkamp & Perrig, 1986; Perrig & Hofer, 1989; Saltz & Donnenwerth-Nolan, 1981) and observing others performing the tasks (i.e. experimenter performed tasks (EPT)) (Hornstein & Mulligan, 2004; see also Cohen, 1981; Cohen & Bean, 1983; Dick, Kean, & Sands, 1989; Steffens, 2007).

The improvement in recall performance for subject-performed tasks compared to verbal learning has also been demonstrated with imagining actions being performed. Findings suggest that recall performance for subject-performed tasks is better than that following imagining the performance of the tasks. Engelkamp and Krumnacker (1980) asked participants to either, self-perform the tasks, imagine performing the tasks or verbally learn the tasks auditorily. The results demonstrated higher recall performance for self-performed tasks ($M = .62$) compared to imagined tasks ($M = .53$) and higher recall performance for imagined tasks compared to those that were verbally learnt ($M = .45$). Saltz and Donnenwerth-Nolan (1981) also found higher recall performance for subject-performed tasks ($M = .58$) compared to imagined tasks ($M = .50$) (see also Engelkamp & Perrig, 1986). These findings suggest that an enactment effect also occurs in relation to subject-performed tasks compared to imagined tasks.

However, the findings regarding subject-performed tasks compared to observed tasks (or experimenter performed tasks (EPT)) are less clear. Hornstein and Mulligan (2004) asked participants to either self-perform tasks (SPT) (e.g. 'lift the pen') or observe tasks (EPT) being performed by the researcher. Additionally, this was done either with the participant's eyes open, their eyes closed or whilst the participant was facing a mirror. The results demonstrated better recall performance for subject-performed tasks compared to experimenter-performed tasks (see also Engelkamp & Zimmer, 1989), suggesting that an enactment effect also occurs for subject-performed tasks compared to experimenter-performed tasks. Other findings however suggest that there is no improvement in recall performance for subject-performed tasks compared to experimenter-performed tasks. Steffens (2007) examined memory performance for both self-performed tasks (i.e. SPT) and observed tasks (i.e. EPT) in two experiments. The first experiment involved participants packing a rucksack, whilst the second experiment involved making clay. Participants in both experiments either, listened to instructions on a tape and then performed the tasks, listened to the instructions followed by observing the tasks being performed or only listening to the instructions (no self-performance or observation occurred in this condition). In both experiments, Steffens did not find a difference in the recall performance for self-performed tasks (i.e. SPT condition) compared to observed tasks (i.e. EPT condition). These findings are the opposite to the findings of Hornstein and Mulligan. A lack of an enactment effect for subject-performed tasks compared to experimenter-performed tasks has also been demonstrated in several other studies (Cohen, 1981; see also Cohen, 1983; Cohen & Bean, 1983).

One proposed reason for the differences in the findings of studies comparing subject-performed tasks and experimenter-performed tasks is experimental design and the length of the lists used (Engelkamp & Dehn, 2000; see also Engelkamp & Zimmer, 1997). Engelkamp and Dehn (2000) studied the impact of both short lists (e.g. lists comprising 8 items) and long lists (e.g. lists comprising 24 items). Lists used in the study either, consisted wholly of subject-performed tasks, wholly of experimenter-performed tasks, or the list was a combination of subject-performed and experimenter performed tasks. The findings suggested that subject-performed tasks led to better item-specific information processing compared to the experimenter performed (i.e. observation) tasks. The authors suggest that this may be because self-performance of the task (e.g. 'lift then pen') *"forces the individual to focus on action relevant information and to ignore action-relevant context information"* (Engelkamp and Dehn, 2000, p. 672; see also Cornoldi, Corti, & Helstrup, 1994; Helstrup, 1989). This may be necessary in order to allow the actions to be performed. Additionally order information was found to be better following experimenter performed tasks compared to subject-performed tasks. When the list comprised of both subject-performed and experimenter performed tasks the improvement previously seen for order information regarding experimenter performed tasks seemed to be hindered (see also Engelkamp & Zimmer, 1997). These findings were related to the short lists (e.g. lists containing 8 items); however, when the lists were long (e.g. lists containing 24 items) there were differences in the findings. The finding relating to item processing in the pure subject-performed tasks in the short lists continued to be seen in the long list. However in the long lists the demonstrated order information effect seen in the pure, short experimenter performed task lists were not seen in the long lists. In the long lists little difference was seen between subject-performed tasks and experimenter performed tasks lists in terms of order information. These findings suggest that the design and length of lists can have an impact, and may provide an explanation for the differences in findings between different studies.

Several theories have been proposed to explain the enactment effect. These include the motor code theory (Engelkamp & Krumnacker, 1980), an episodic integration account (Kormi-Nouri, 1994), and the goal-orientated aspect of actions (Ratner & Foley, 1994).

Motor Code Theory

The motor code theory proposes that the motor component of self-performed tasks (i.e. subject-performed tasks) is a key component in explaining the enactment effect. For example, perhaps during the self-performance of tasks an additional motor code is left in the participants' memory which in turn enhances memory for the tasks (see Engelkamp & Krumnacker, 1980; Engelkamp & Zimmer, 1983), allowing more self-performed tasks to be correctly recalled compared to control conditions. Therefore, an enactment effect may only be found with regards to the self-performance of tasks as this typically requires the participant to physically perform the tasks which could potentially explain why an improved recall performance is demonstrated in the subject-performed task condition compared to verbally learnt material, observed tasks (i.e. experimenter performed tasks) and imagined tasks. In this sense the motor code theory may be able to explain the enactment effect. However, although the motor code theory notes the importance of the motor component, the theory does not rule out other types of encoding (Engelkamp, 2001). As such the motor theory code can be thought of as a multimodal approach (Zimmer & Engelkamp, 1985), which may include aspects such as motor, verbal and visual components.

A dual-code theory developed by Paivio (1971) suggested that visual memories could consist of verbal (i.e. verbal label) and visual information (i.e. sensory information), which may be processed in different ways. Both of these processes produce separate but interactive verbal or analogue codes and visual memory traces, which are then used in order to organise new information and can be used during the retrieval of information. If the verbal code is unavailable then memory performance may still remain satisfactory due to the availability of the visual code, and vice versa. The dual code theory is supported by research conducted by Anderson and Bower (1973) who found that memory of information could be enhanced if the appropriate visual information was presented, or if the participant could visualise the appropriate image. Evidence from PET scans and fMRI studies has also been found to support the dual code theory, demonstrating that participants used the same brain areas when processing imagined visual information as when they saw the actual image (Drose & Allen, 1994), suggesting that perceiving external visual information and imagining internal generated information may use similar areas of the brain. As such the multimodal approach of the motor code theory may be seen an advancement or follow-on of the dual code theory specifying the key role that the motor component may play in the enactment effect.

Evidence for the motor code theory as an explanation for the enactment effect comes from several sources. Firstly, evidence comes from experiments comparing self-performed tasks (SPT) and observed tasks (EPT). Findings suggest that participants' recall performance for subject-performed tasks is higher than recall performance for experimenter performed tasks (see Engelkamp & Krumnacker, 1980; Engelkamp & Zimmer, 1989; Hornstein & Mulligan, 2004). This may suggest that a motor component plays a key role, as one condition involves physically performing the actions or tasks (i.e. the subject-performed task condition) whereas the other condition does not (i.e. observed or experimenter performed task condition). However, Cohen (1981) did not find a difference between the recall performance of subject-performed tasks compared to those which were observed (see also Cohen, 1983; Cohen & Bean, 1983; Steffens, 2007) which may be considered as evidence against the motor code theory.

Secondly, supporting evidence also comes from research that has found improved recall performance for subject-performed tasks regardless of whether or not visual information was available to the participant during self-performance of the task itself. This suggests that self-performance of tasks alone can lead to an improvement in recall performance. Engelkamp, Zimmer, and Biegelmann (1993) compared subject-performed tasks with those that were verbally learnt. The results demonstrated that an enactment effect continued to occur even if the participant was blindfolded during the study phase, which limited the amount of visual information available to the participant. This is further supported by a more recent study conducted by Hornstein and Mulligan (2004). Participants were asked to self-perform actions (i.e. SPT condition) with either their eyes closed, eyes open or facing a mirror and compared the results to an observation condition. An enactment effect was demonstrated in all subject-performed conditions regardless of the amount of visual information available to participants. This may suggest that visual information is not essential in terms of an enactment effect, but that the motor component may play a crucial role, as such this may be considered as evidence to support the motor code theory.

Thirdly, additional evidence is provided by selective interference experiments, which demonstrate that a secondary motor task can impair the enactment effect for subject-performed tasks to a greater extent than a secondary visual task. Zimmer, Engelkamp, and Sieloff (1984) demonstrated a greater impairment in the enactment effect when the secondary task was a motor task compared to a secondary visual task (see also Zimmer & Engelkamp, 1985). Saltz and Donnenwerth-Nolan (1981) studied three action conditions: a visual, a verbal and performance condition. The secondary tasks were also of the same nature (i.e. visual, verbal or performance). The results suggested that when the original task and the secondary task were in the same mode (e.g. first task: performance – second task: performance) recall performance was poorer compared to when the original and secondary tasks differed (e.g. first task: performance – second task: verbal). The performance of actions however did not seem to be affected by a secondary verbal or visual task. A secondary motor task however did have an effect.

However, this is not always the case as Backman, Nilsson, and Kormi-Nouri (1993) demonstrated. The verbal task in this particular experiment required the participants to count backwards in 6's and 3's in turn, for example, from 300. This secondary task impaired participants performance for subject-performed tasks, even though the task was not motor in nature, suggesting that the impairment can occur even if the secondary task is not motor related. These findings were also found by Kormi-Nouri, Nilsson, and Backman (1994). These findings however contradict the findings of Zimmer et al. (1984). Kormi-Nouri and Nilsson (2001) argued that as the Saltz and Donnenwerth-Nolan (1981) experiment did not include a control condition it may not be the case that the verbal and visual secondary tasks do not impact memory performance for subject-performed tasks.

Some additional evidence which may support the motor code theory comes from recognition tests which have demonstrated an improvement in recognition following self-performance of actions (i.e. SPT). For example, Knopf (1991) studied actions of different levels of familiarity in both younger and older participants. The results demonstrated an enactment effect in both free recall and recognition tests that followed the study phase (see also Mohr, Engelkamp, & Zimmer, 1989; Zimmer, 1991). Engelkamp, Zimmer, Mohr, and Sellen (1994) also studied recognition, however in addition to deciding verbally whether they recognised the actions participants were also instructed to perform the action prior to deciding if they recognised the action or not. The authors proposed that performing the actions again during the recognition test after having self-performed the actions during the study phase would lead to an improvement in recognition. This would not be the case if participants had only verbally learnt the information in the study phase and only performed the actions as part of the recognition test. The results demonstrated that this was the case, supporting the notion that the motor component of self-performed actions (i.e. subject-performed tasks) is an important feature in terms of memory for actions.

Findings relating to false alarm rates may also provide support for the motor code theory. Results suggest that when the subject-performed task and the distracter task were similar in terms of the action (i.e. the motor components were similar) the number of false alarms increased (see Zimmer, 1984). For example, if the first action was 'mix the paint', a similar distracter could be 'mix the sauce', whereas a dissimilar distracter could be 'shuffle the cards' (Zimmer, 1984). False alarm rates would therefore be higher for 'mix the paint' with the distracter 'mix the sauce', compared to 'mix the paint' with the distracter 'shuffle the cards'. Engelkamp and Zimmer (1994) found that for items which were similar in terms of their concept and motor components the false alarm rate was .67 for subject-performed tasks, however when the concepts were similar but the motor components were dissimilar the false alarm rate fell to .13. When both the motor components and the concept were dissimilar to the distracters the false alarm rate was only .01. Motor similarities between the original and secondary actions seem to impact on the number of false alarms made by participants.

Brain imagining studies may also provide some supporting evidence for the motor code theory. Nilsson et al. (2000) conducted a study using PET scans and demonstrated that the highest level of recall performance and motor cortex activity was in relation to subject-performed tasks, whereas the lowest level of recall performance and motor cortex activity was found in the verbal learning condition (see also Nyberg, Nilsson & Aberg, 2001). Heil et al. (1999) also suggested that the enactment effect may be due to self-performance of actions reactivating motor information. This may support the suggestion that a motor component plays a role in the enactment effect.

Retrieval re-enactment studies however do not seem to support the motor code theory. Based on the motor code theory it may be suggested that self-performance of actions during both the study and test phases would further improve recall performance, more so than if self-performance had only occurred during the study phase. Saltz and Dixon (1982) however demonstrated that this may not be the case. Participants were asked to either self-perform or verbally learn twelve actions during the study phase. During the test phase participants were asked to either self-perform the actions before verbally recalling the action or to only recall the action verbally. An enactment effect was found regardless of whether the action had been self-performed during the study phase only or during both the study and test phases (see also Knopf, Mack, Lenel, & Ferrante, 2005; Norris & West, 1993; Saltz, 1988). On the other hand, Engelkamp et al. (1994) found that self-performance during the study and test phases led to an improvement in recall performance compared to the improvement seen when self-performance occurred only during one phase (see also Mulligan & Hornstein, 2003) which would be more in line with the motor code theory. Although there are some findings that do support and do not support the motor code theory there are alternative accounts to the motor code theory to consider.

Episodic Integration Account

A second proposed explanation of the enactment effect is an episodic integration account (Kormi-Nouri, 1994), suggesting that self-performance of actions can lead to integration, for example, between the action (e.g. lift) and the object (e.g. pen), and the participant and the action-object (e.g. lift the pen). This may allow the participant to become more aware of actions that have been performed. However, verbally learning or observation may not lead to the same integration. This may explain the improvement found for subject-performed tasks compared to other types of tasks (e.g. observed tasks or verbally learnt tasks).

Self-performance of actions involves a greater degree of self-involvement and self-reference. This may not be something which would be necessary during verbal learning or observation of the actions being performed by another individual. Kormi-Nouri and Nilsson (2001) noted that "*enactment is the glue that cements the components of actions into a single memory unit or more closely connected memory units*" (Kormi-Nouri and Nilsson, 2001, in Zimmer et al., 2001, p. 105). For example, Kormi-Nouri and Nilsson suggest that if the action was 'lift the pen' then performing the action 'lift' leads to it being associated with the object 'pen' whilst 'pen' becomes associated with 'lift', therefore lift and pen become one piece rather than two separate pieces.

One study designed to examine semantic integration using subject-performed tasks and verbally learnt tasks was conducted by Kormi-Nouri (1995) (see also Kormi-Nouri & Nilsson, 1998; Kormi-Nouri, Nyberg, & Nilsson, 1994). During the study phase participants made use of either well-integrated tasks that made logical or functional sense (e.g. open the book) or poorly integrated tasks (e.g. point at the wallet). The results demonstrated an effect of semantic relation (between the verb and the noun) in subject-performed tasks, suggesting episodic integration. However this had not occurred with regards to the verbal tasks suggesting that perhaps episodic integration had not occurred in that condition. This lends support to the notion that self-performance of actions provides an environment where episodic integration can occur, this may not occur in other conditions.

In addition, the episodic integration account suggests that within event information (i.e. item specific processing) is enhanced. This is something other research also supports and there seems to be a general consensus in memory for action research, that self-performance of actions does lead to an improvement in item-specific processing (see also Earles & Kersten, 2002; Einstein & Hunt, 1980; Engelkamp & Zimmer, 1997; Olfosson, 1997). The episodic integration account also proposes that between-event information (i.e. relational processing) would be enhanced. Findings regarding relational processing are less clear. For example, several studies have found an improvement in relational processing following self-performance (Kormi-Nouri &

Nilsson, 1999) whereas other studies have failed to find this (Engelkamp, 1986; see also Engelkamp, Zimmer, & Mohr, 1990; Engelkamp & Zimmer, 1996; Zimmer & Engelkamp, 1989). Kormi-Nouri and Nilsson (1999) found evidence of an improvement both in terms of item-specific and relational processing which would be in line with the predictions of the episodic integration account, and provides some evidence which may support the episodic integration account.

Supporting evidence for the episodic integration account also comes from two experiments conducted by Kormi-Nouri (2000). Participants were either asked to self-perform actions or to imagine performing the actions. Additionally, participants either used real objects or imagined the objects. One condition also involved verbally learning the actions, therefore the actions were not performed and no objects would be used. The results demonstrated an enactment effect for both self-performed and imagined actions. In addition, an enactment effect was demonstrated regardless of whether an object was physically used or imagined. These findings suggest that neither the use of objects nor the motor component explain the enactment effect fully on their own, instead suggesting that both components play a role. This further supports the notion that self-performance of actions can result in episodic integration, and illustrates the role that both actions and objects may play with regards to the enactment effect.

Additional evidence to support an episodic integration account comes from studies that have failed to find retrieval re-enactment effects. When participants self-perform actions during both the study and test phases findings suggest the size of the enactment effect is not greater than the size of the enactment effect when participants self-perform the actions during one phase only. Norris and West (1993) required participants to either self-perform or verbally learn thirty-two actions during the study phase and then either to self-perform or verbally recall those actions during the test phase. The results demonstrated no additional improvement in recall performance when self-performance occurred both at the study and test phases compared to when self-performance only occurred during one phase (see also Saltz & Dixon, 1982). Engelkamp et al. (1994) however did find an increase in the size of the enactment effect when self-performance occurred during the study and test phases compared to self-performance only at the study phase. The findings of Engelkamp et al. could be viewed as support for the motor code theory; however, Kormi-Nouri and Nilsson (2001) instead propose that these results may stem from the increased efficiency of the performed cue.

Studies which have found that non-motor secondary tasks can also impact on recall performance for a primary motor task may also support the episodic integration account. Kormi-Nouri et al. (1994) asked participants to count the number of red dots that were presented on scatter plots. Participants then had to remember the number of red dots presented on a scatter plot and add that number to the number of red dots on a subsequent scatter plot. Recall performance for the primary tasks was tested using cued recall (Experiments 1 and 2). In both experiments memory for the actions was effected by this secondary task, which were not motor tasks, suggesting that secondary non-motor tasks can impact on recall performance for a primary motor task (see also Backman et al., 1993). However, other studies have not found this effect with verbal and visual tasks (Saltz & Dixon, 1982) nor kinematic tasks (Zimmer & Engelkamp, 1985). A lack of retrieval re-enactment and the effect of visual and verbal information may suggest that perhaps a motor code explanation alone may not explain why the enactment effect occurs. In addition, it may suggest that a number of aspects are involved such as visual, verbal and motor information and as such may support the episodic integration account proposed by Kormi-Nouri (1994).

Goal-Orientated Actions

The above research has often focussed on 'mini-tasks' such as 'lift the pen' or 'knock the door', however, actions individuals perform during their daily lives would more likely be goal-orientated (Steffens, 2007), for example, packing a rucksack or making breakfast, therefore, considering the goal aspect may also be an important feature to consider. Ratner and Foley (1994) proposed that the improved memory performance for subject-performed tasks may be due to the goal-directed aspect of actions. This suggests that individuals perform actions and tasks and influence the environment in order to achieve a specific goal; therefore, it could be suggested that self-performance of actions provides an interface between the participants internal and external information (Ratner & Foley, 1994). Additionally, it was proposed that actions consist of four aspects that can contribute to memory for actions (Foley & Ratner, 2001). Firstly, there are prospective features, this may be where the planning for the action takes place and the most likely outcomes of the actions are considered. Secondly, expectations for the actions may lead to an outcome; for example, this may be as a result of the participant performing the actions. Thirdly, actions consist of several sequences of smaller actions that can be combined with each other. And finally, actions provide the participant with the opportunity to reflect on previous and current actions (Foley & Ratner, 2001).

Actions are often attached to goals in everyday life, and individuals often utilise actions in order to try to achieve a specific goal or complete a task. The presence of a goal is also one of the key differences between actions performed in a laboratory setting and actions performed as part of everyday life (Steffens, 2007). Actions performed in the laboratory usually take the form of 'mini-tasks' or individual actions such as 'lift the pen' with no goal; however, everyday actions are usually attached to a goal, for example 'lift the pen' to place in a bag being packed. Goal-directed actions are also more likely to be more relevant to the individual, and the individual may be more motivated to complete the action or the goal. For example, packing a bag for a trip would be more relevant to the individual than only 'lift the pen'. Glover, Timme, Deyloff, and Rogers (1987) demonstrated that actions with a goal attached to them are more likely to be remembered that those without a goal. This was also demonstrated by Ratner, Padgett, and Bushney (1988). An earlier study by Ratner, Smith, and Dion (1986) found that the outcomes of actions were remembered well when the actions were performed by the participant themselves (see also Mandler & Johnson, 1977). Participants were asked during the experiment to make and play with clay. Interviews were then conducted immediately following this and one week later. The results suggested that participants made use of the goal in order to help recall the actions and tasks involved in making and playing with the clay.

More recently, Steffens (2007) also examined actions with a goal, with the author proposing that self-performance and observation of actions would lead to better recall performance than those that were verbally learnt. Experiment 1 involved packing a rucksack with a number of different objects. During the study phase participants self-performed the actions, observed the actions being performed by the experimenter or verbally studied the actions. During the test phase participants completed a verbal recall test and a performance test during which participants were asked to repack the rucksack. The results suggested that participants completed repacking most successfully after observation and self-performance of the actions, compared to verbal learning. These findings were also found during experiment 2 which followed a similar procedure to experiment 1 however here participants were asked to make clay rather than pack a rucksack (see also Fivush, Pipe, Murachver, & Reese, 1997; Ratner & Hill, 1991; Smyth, 1991). These finding would seem to point to the importance of a goal, which would be in line with the suggestions of Ratner and Foley (1994).

Additionally, outcomes are able to influence memory for actions (Foley & Ratner, 2001). Ratner and Foley (1996) asked children to perform two types of actions. One of the actions was to pull the strings of a puppet; this would lead to the puppet moving. The other action also involved pulling the strings of a puppet; however in this case the puppet did not move. The actions either led to an outcome (i.e. the puppet moved) or did not lead to an outcome (i.e. the puppet did not move). The results demonstrated that participants remembered the actions with an outcome better than the actions that did not have an outcome. This was also found by Ratner and Hill (1991) who demonstrated that children remembered more actions if there was a visible outcome during the study phase. These findings suggest that the outcomes of actions can also impact on memory for actions. Foley and Ratner (2001) account for this as outcomes are one of the four aspects of goal-directed actions which may contribute to memory for actions.

As this theory is based on goal-orientated actions, whereas other studies are focused on individual actions or 'mini-tasks', this theory is perhaps more similar to everyday situations as most actions people perform on a daily basis involves a goal and consist of a sequence of smaller actions. As such as well as accounting for the goal aspect of actions, the theory also accounts for other aspects such as planning (Ratner, Smith, & Bazzy, 1987), social context (Foley & Johnson, 1985), outcomes (Ratner & Foley, 1996; Ratner & Hill, 1991) and anticipation (Foley, Ratner, & Passalacqua, 1993).

Evidence to support a goal-directed approach also comes from studies which demonstrate that planning can contribute to the enactment effect. Ratner, Smith, and Bazzy (1987) asked a group of five year old children and a group of adults to make clay. For some of the actions, the participants were only asked to say what would happen if the action were to be performed (i.e. the outcome), however for other actions the participants were asked to actually perform the actions. The authors proposed that if the motor component were essential to the enactment effect then it may be expected that an improved recall performance would be seen only for the self-performed actions compared to actions which participants were only asked to say what would happen and not perform them. Additionally, actions which were planned might enhance the advantage of performing actions, and actions planned but not performed would not be recalled as well as actions planned and performed. Ratner et al. found that this was not the case, and found that what was essential seemed to be whether or not the participant was involved in the planning, with improved recall performance demonstrated for self-planned actions compared to actions planned by others, regardless of who eventually performed the action (see also Bender & Levin, 1976). Ratner, Foley, and Gimpert (2000) completed a further study during which children were asked to trace pictures or to imagine tracing the pictures. When this task occurred along with hearing a story about the pictures they traced or were imagining tracing, the children seemed confused about whether they had actually traced the pictures themselves or only imagined the pictures being traced. This would suggest that self-planning the actions is also important.

Additionally, Koriat, Ben-Zur, and Nussbaum (1990) found that memory performance was better for actions participants performed with the intention to perform the actions at test, compared to memory performance of participants who performed actions with the intention of verbally recalling the information at test (see also Engelkamp, 1997). Foley and Johnson (1985) demonstrated that children seemed to demonstrate little or no confusion about the source of the action when there is no goal involved, however, when the activity took place in an environment with others the children became confused about the source of the action (see also Ratner et al., 2000). Foley and Ratner (2001) proposed that in everyday life confusion may be due to more individuals being involved in the child's social circle, for example, family, friends, neighbours and teachers. These findings demonstrate that other components may also play a role in memory for actions.

Item-Specific and Relational Processing

Research into memory for actions has also focussed on item-specific and relational processing. Although there seems to be consensus which suggests that self-performance of actions improves item-specific processing, there is some debate as to whether or not relational processing is improved by self-performance. Engelkamp and Zimmer (1997) proposed that when participants perform the actions themselves item-specific processing is improved (see also Earles & Kersten, 2002; Einstein & Hunt, 1980; Engelkamp & Dehn, 2000; Olfosson, 1997; Steffens, 2007). Participants in the verbal learning conditions, however, seemed to benefit from knowing the categories (Engelkamp, Mohr, & Zimmer, 1991; Engelkamp & Seiler, 2003). Additional evidence for item-specific processing comes from the finding that self-performance of actions leads to improved memory on recognition tests (Engelkamp & Krumnacker, 1980; Svensson & Nilsson, 1989).

Self-performed actions in both younger and older adults have also been studied in terms of intentional forgetting utilizing a directed forgetting paradigm (Earls & Kersten, 2002). Participants were required to either self-perform or verbally learn actions. The younger participants demonstrated significantly better intentional forgetting compared to older participants. Actions which were self-performed seemed very difficult for the participants to forget, regardless of whether the participants were younger or older. The authors suggested that self-performance of actions led to stronger item-specific processing. An improvement in terms of item-specific processing may be because self-performance of actions allows the participant to focus on the action-relevant information. This may not occur in other conditions such as observation or verbal learning (Engelkamp, 1995). The consensus which exists regarding item-specific processing and self-performed actions does not seem to exist with regards to relational processing.

Several studies however have failed to find an improvement in relational processing (Golly-Haring & Engelkamp, 2003; Koriat et al., 1998); however other studies suggest that self-performance may lead to an improvement in relational processing (Kormi-Nouri & Nilsson, 1999). The adjusted ratio of clustering (ARC) scores (Roenker, Thompson, & Brown, 1971), which measures the organisation of recall, has also produced conflicting results regarding relational processing. Engelkamp, Seiler, and Zimmer (2005) noted that the higher the ARC scores, the more likely it is that the participants have processed and made use of the category information. Backman, Nilsson, and Chalom (1986) found higher ARC scores for self-performed actions compared to those which were learnt verbally (see also Engelkamp, Seiler, & Zimmer, 2004), suggesting that perhaps relational processing is improved by the self-performance of actions. In addition, more clustering was found for self-performed actions if the actions were recalled in direct succession (Backman & Nilsson, 1984; Backman & Nilsson, 1985), and if actions belonged to the same semantic category (Backman et al., 1986).

However, Engelkamp and Zimmer (1996) did not find a difference between subject-performed tasks and verbal tasks in relation to ARC scores (see also Norris & West, 1993; Zimmer & Engelkamp, 1989). Other studies have found a higher ARC score for verbal tasks compared to subject-performed tasks (Zimmer & Engelkamp, 1989; see also Engelkamp & Seiler, 2003; Olofsson, 1997). These findings would suggest that relational processing is not enhanced by self-performance of actions.

A recent study conducted by Steffens (2007) found evidence to suggest that item-specific processing was improved during self-performance of actions however relational processing was not. Two experiments found no enactment effect when comparing self-performed actions with observed actions. Additionally, organisation was found to be best after observation. Steffens suggests that the lack of a difference between the self-performed and observed actions is because relational processing is improved with observation of items, but item-specific processing is improved with self-performance of actions. Free recall organisation was seen to be best for observed actions, supporting the suggestion that observation improved relational processing. However, in cued recall this was not the case and no difference was found between organisation following self-performed actions compared to organisation following observed actions. This could provide evidence against the motor code theory because organisation does not provide motor information (Steffens, 2007). Instead, Steffens suggests that self-performing actions increases some processing (e.g. item-specific processing) and hinders others (e.g. relational processing), a sort of cost-benefit relationship (Steffens, 2007, see also Knopf et al., 2005; Van Essen, 2005).

Self-performance of actions therefore may not benefit everything. For example, self-performing actions does not seem to benefit serial recall. Olofsson (1996) found that following self-performance of actions participants were not better at recalling the actions in the right order compared to verbally learnt actions (see also Zimmer, Helstrup, & Engelkamp, 1993). Also, self-performance of actions does not lead to an improvement in pair associated learning (Engelkamp, 1986), or to an improvement in associations between the items and the context (Helstrup, 1989; see also Zimmer, 1994; Zimmer, 1996). Mulligan and Hornstein (2004) demonstrated that self-performance of actions may either make no difference to source memory, or may even impair source memory. During the study phase participants either self-performed or observed actions. When participants self-performed the actions they did so either with their eyes closed, eyes open, or whilst facing a mirror. In all three conditions (i.e. eyes closed, eyes open and facing mirror) an enactment effect was seen compared to the observation condition, however, source memory for actions the individual had performed themselves did not improve. The authors found that the more visual information or feedback that was provided to the participant the poorer the participant's source memory became. Source memory was found to be more accurate in the eyes closed condition than in the eyes open and facing the mirror condition.

The Role of Objects

Another issue of debate in memory research is the presence or absence of objects during the experiment, and what role objects may play with regards to the enactment effect. Previous memory for action research has varied in whether the objects have been physically present during the study (Backman et al., 1986; see also Kormi-Nouri & Nilsson, 1999) or imagined (Kormi-Nouri, 2000; see also Engelkamp & Zimmer, 1983). Backman and Nilsson (1984) found that the enactment effect was greater when participants performed actions with the objects present than when participants imagined the objects. This was also found by Nyberg et al. (2001) who found that actions performed with the objects present during the study phase demonstrated a greater enactment effect than those performed without the objects being present. Steffens, Buchner, and Wender (2003) found that when items with objects and without objects in the same study list are separated the results suggest that an enactment effect occurred for the actions with objects present but not for actions with objects absent. One possible explanation for this given by Steffens et al. is that the actions with objects present may suppress those with the objects absent (see also Steffens, Buchner, Decker, & Wender, 2007).

However, a study by Kormi-Nouri (2000) found that whether the objects were physically present or imagined did not impact on the results, with an enactment effect found in both cases. Research by Engelkamp and Zimmer (1983) examined whether the presence or absence of objects impacted on the size of the enactment effect. With objects present the size of enactment effect was .14, when objects were not present the size of the effect was .15, suggesting that the presence or absence of objects did not impact on the size of the enactment effect. Engelkamp and Zimmer (1997) in experiment 1 found that the size of the enactment effect was the same in both conditions (i.e. when objects were present and not present). These findings may suggest that the presence or absence of objects during the performance of actions does not play a key role in the enactment effect, or alone cannot completely explain the enactment effects.

Self-performance of actions may also impact on memory of the arrangements of actions and objects. Conway and Dewhurst (1995) studied objects and locations in three different conditions: either the participant placed the object in the location themselves; the participant imagined placing the object or the participant observed the objects being placed at the location by another individual. The results demonstrated that recognition of object arrangements was better for self-performed arrangements compared to observed arrangements, and imagined arrangements. Zimmer (1996) conducted a study looking at object positions in subject-performed tasks and observed tasks; no difference was found in the Zimmer study between subject-performed and observed conditions. Koriat, Ben-Zur, and Druch (1991) however found that observation led to an improved ability to discriminate between lists of objects. The lists used in the study involved the objects being in different locations as well as varying whether the individual involved was the participant themselves or someone else.

The saliency of cues has also been a topic of research in recent years. Steffens et al. (2003) proposed that the saliency of cues may also play a role in the enactment effect, suggesting that items are more likely to be remembered if the object is present during both the study and test phases, compared to when the objects were only present during one phase. The authors proposed that this may be due to a high level of association between the object and action when the object is presented alongside the action in the study phase, which could in turn result in the improved recall during the test phase. This high degree of association would not occur if the object was not present when the action was performed, nor if actions were only verbally learnt. This association means that if the object is also present at the test phase then it could act as a retrieval cue, leading to an improved memory performance for those actions. Three experiments demonstrated a diminished enactment effect for actions where the objects were not present. The authors proposed that if the object was present during the study phase, then its presence at the test phase would act as a retrieval cue, therefore, the size of the enactment effect may be modulated by the presence or absence of the object during the study and/or test phases.

It was hypothesised that for actions where the object was present the enactment effect would be greater for those actions than for actions where objects were not present, which the results demonstrated. In experiment 1 participant's who self-performed the actions demonstrated improved memory performances compared to those that were verbally learnt. When the objects were not present, for actions which were self-performed by the participants there was no enactment effect compared to those which were verbally learnt. For actions that involved body parts (e.g. comb-hair) greater memory performance was demonstrated for self-performed actions compared to the verbally learnt actions. The authors note however that these results could be attributed to the cue saliency hypothesis or suggest that there is something special about body parts.

In order to address this issue an additional experiment was carried out with actions that did not involve body parts. In this experiment, the findings of experiment 1 were replicated and it was also found that more self-performed actions with objects present were recalled than those without objects. Steffens et al. (2003) proposed that these findings support the cue-saliency hypothesis rather than the suggestion that the results were due to the role of body parts. A further experiment was conducted which examined the role of objects which were more context appropriate, that is, that the object would be likely be found in that context (e.g. a computer in an office). The authors also designed this experiment to see if those in the verbal learning condition could make use of the cues if they were salient. The results of the experiment also supported the cue salience hypothesis. Participants in the verbal learning condition could make use of objects as cues, and the effects demonstrated that the results in the previous experiments were not due to the type of phrases used. The results demonstrated that the size of the enactment effect was moderated by the presence or absence of an object further suggesting that cues play a role in the enactment effect (see also Steffens, Buchner, Wender, & Dekker, 2003; Steffens, Jelenec, Mecklenbracker, & Thompson, 2006). One issue Steffens et al.

(2003) note is that the experiment splits actions and objects into two groups: actions with objects and actions without objects. The authors themselves note that this is a simplification of how processes are more likely to work in everyday life. For example, the authors provide the example of a floppy disk being present could be used as a cue for a CD even though a CD may not be physically present. Additionally, body parts will more than likely always play a role even when not explicitly mentioned. The authors suggest that objects as cues form part of a process, in that it modulates the enactment effect, and this may indicate that other components or aspects may also play a role in the enactment effect (see also Steffens, Buchner, Wender, & Decker, 2007).

Chapter 2
Retrieval-Induced Forgetting

Research into forgetting and memory has a long history in psychology dating back to 1885 when Hermann Ebbinghaus became one of the first to study memory and forgetting under control conditions. Ebbinghaus (1885) suggested that items were placed in memory through the formation of associations, and demonstrated that the repetition or practice of items led to the improved recall of the practiced items and that the rate of forgetting was rapid during the first hour following the initial study phase. After the first hour the rate of forgetting was seen to have decreased dramatically.

Forgetting is something all individual's experience and it occurs in everyday life. For example, individuals may forget where they placed their car keys, or where they parked their car in the supermarket car park. In circumstances such as these forgetting can be seen as having a negative consequence, for example, if an individual loses their car keys they may in turn be late for a meeting. Additionally forgetting could be considered a nuisance, for example, if an individual cannot find their car in a supermarket car park when they have a trolley full of groceries. However, more recent research suggests that forgetting can be beneficial and perhaps necessary in order for an individual's memory to function.

Earlier theories of forgetting can be considered to be based on passive processes during which memories become weaker as a function of their age. For example, the trace decay theory proposes that when something new is learned a neurochemical trace is formed allowing the memory to be retrieved at a later time (i.e. Thorndike's law of disuse, 1911). Over time the trace disintegrates and the information becomes more difficult to retrieve, suggesting that as more time passes, the more forgetting there is (Brown, 1958). However, the only evidence to support the trace decay theory comes from animal studies (see Minami & Dallenbach, 1946) and has not been demonstrated in human participants (Jenkins & Dallenbach, 1924). For example, research has found that sometimes older memories are stronger than more recent memories, which suggests that the trace decay theory on its own cannot explain forgetting (Brown, 1958; see also Bjork & Bjork's new theory of disuse, 1992). Several other theories exist which aim to explain how forgetting occurs, for example, it has been suggested that new memories overlay the older memories leading to the older memories being less accessible (see Mueller & Pilzecher, 1900). Additionally, it has been suggested that during forgetting memories disintegrate and the separate parts, which are the result of that process, are then lost (Bower, 1967).

It has been suggested that retrieval is a process that modifies the memory system so that retrieving a memory strengthens it and increases its memorability whilst decreasing the memorability of other related but non-retrieved items (Bjork & Bjork, 1992). This notion of retrieval modifying the memory system suggests that forgetting can be an active process, rather than a passive process as previously suggested, as indicated by Rundus' (1973) retrieval competition theory, which suggests that learning involves a process of associating items in a hierarchical method, and that the strength of the associations is dependent on practice; therefore the more practiced items are stronger and easier to retrieve than the weaker, less practiced items (Cokley, 2003).

More recently, a theory has been proposed which suggests that retrieval from memory can be aided via a mechanism that reduces the competition emanating from out of date but related information which promotes the selection of the desired information. This mechanism would be hugely beneficial as it would not be possible for an individual to actively remember all the information that they know for several reasons. Firstly, this would make it difficult to complete tasks as there would be a large amount of relevant but out of date information present which would interfere with the information required for the task that the individual is trying to complete at that time. Secondly, this could cause confusion on behalf of the individual completing the task and lead to the task being completed incorrectly or slowly. Thirdly, if all the information was active then it would flood the individual's mind, and cause memory to be more error prone than it currently is (Anderson, 2003) as we may select an active but unwanted memory instead of the desired memory.

Typically, overly general cues are used in order to activate a desired memory (Anderson, 2003). When this is done other related but currently unwanted or out-of-date information is also activated in addition to the required information (Anderson, Bjork, & Bjork, 1994). For example, if someone is trying to retrieve where they parked the car in the supermarket car park, a retrieval search may also activate where the car was parked on previous occasions. This suggests that there is a need for a mechanism that allows the desired memory (i.e. where the car is currently parked) to be quickly and efficiently recalled, and allows other information (i.e. where the car was parked on previous occasions) which may have also been activated during a retrieval search to be 'forgotten'. This mechanism would stop the related but unwanted information from competing with the desired information during recall. This forgetting of related but unwanted information has been termed retrieval-induced forgetting.

Retrieval-Induced Forgetting

A retrieval practice paradigm is used in order to investigate retrieval-induced forgetting. The retrieval practice paradigm allows the related but unwanted information to be placed in competition with the target item, which is essential as research suggests that retrieval-induced forgetting occurs because of the competition between items. The paradigm typically involves three stages: study phase, retrieval practice phase, followed by a distracter, and a test phase (see Figure 2). During the study phase participants are given a list of category-exemplar pair words (e.g. FRUIT-Apple; FRUIT-Banana; BIRD-Robin; BIRD-Sparrow). After studying the items, participants progress to the retrieval practice phase where they practice half of the items from half of the categories (e.g. FRUIT-Apple). For example, retrieval practice would occur through word stem completion tasks (e.g. FRUIT- A__). However, participants are not required to do anything with the other items that were seen during the study phase (e.g. FRUIT-Banana; BIRD-Robin; BIRD-Sparrow). Participants are then given a distracter task. Following this participants are given a recall test on all of the items that were seen during the study phase.

Figure 2: Diagram of the Stages Typically Involved in a Retrieval Practice Paradigm Experiment

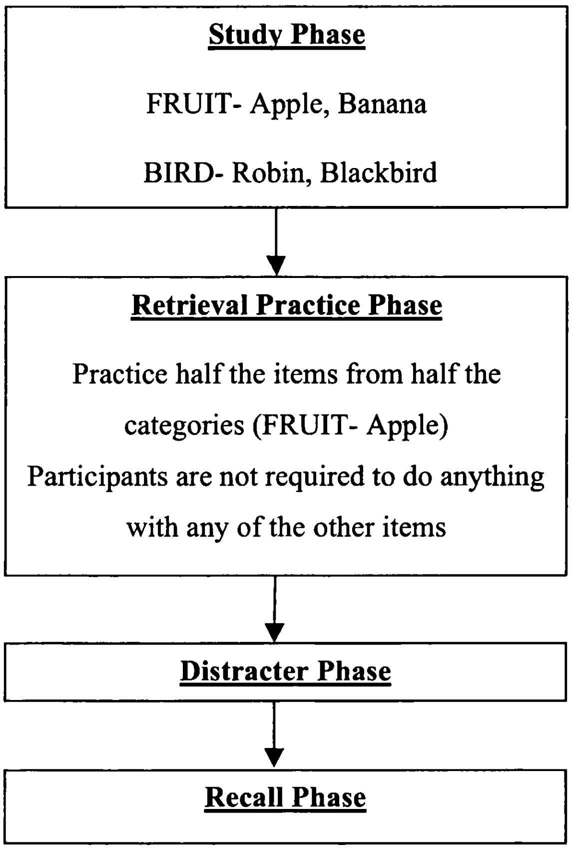


Figure 2. An example of the stages involved in a retrieval practice paradigm.

Two findings are typically found in these experiments (see Figure 3). Firstly, it is found that memory performance for practiced items from the practiced category (Rp+ items e.g. FRUIT-Apple) is better than memory performance for unpractised items from an unpractised category (Nrp items e.g. BIRD-Robin; BIRD-Sparrow). This is known as a facilitation effect, and demonstrates that practice facilitates memory. Secondly, studies typically find that memory performance for unpractised items from the practiced category (Rp- items e.g. FRUIT-Banana) is worse than memory performance for unpractised items from an unpractised category (Nrp items e.g. BIRD-Robin; BIRD-Sparrow). This is known as a retrieval-induced forgetting effect.

Figure 3: Graph of the Typical Findings of a Retrieval Practice Paradigm Experiment

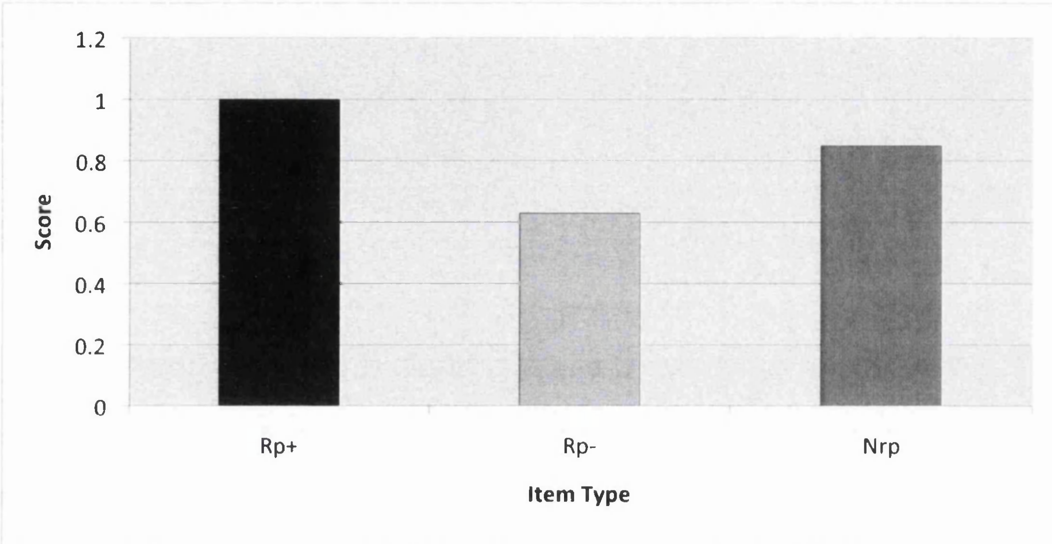


*Figure 3.*Explanation of the item types from figure 3. There are three item types. Rp+ items are items that are practiced and are from a practiced category (e.g. FRUIT-Apple), Rp- items are items that are unpracticed and are from a practiced category (e.g. FRUIT-Banana), and Nrp items are items that are unpracticed items and are from an unpracticed category (e.g. BIRD-Robin, BIRD-Sparrow). These figures are fictional, and do not represent data from an actual study.

The retrieval practice paradigm was first used by Anderson, Bjork, and Bjork (1994). During the study phase participants studied a list of category-exemplar pair words (e.g. FRUIT-Orange, FRUIT-Banana). In the following retrieval practice phase participants completed word stem completion tasks (e.g. FRUIT-Or___). Following a twenty minute interval participants were given a recall test. Anderson et al. found that memory performance for Rp+ items was 25% better than memory performance for Nrp items demonstrating a facilitation effect. This finding of better memory performance for Rp+ items compared to Nrp items has also been demonstrated in other studies (see also Anderson & Spellman, 1995; Bjork, Bjork, & Anderson, 1998; Carrier & Pashler, 1992). Anderson and colleagues also found that memory performance for Rp- items was

11% worse than performance for Nrp items, demonstrating a retrieval-induced forgetting effect. Since then retrieval-induced forgetting has been demonstrated with a range of different stimuli, for example words (Anderson et al., 1994; Anderson & Spellman, 1995), coloured objects and shapes (Ciranni & Shimamura, 1999), photographs of novel actions (Koutstaal, Schacter, Johnson, & Galluccio, 1999), false recognition (Starns & Hicks, 2004) and eyewitness memory (MacLeod, 2002; Shaw, Bjork, & Handal, 1995).

There has however been some debate as to how retrieval-induced forgetting can be explained. Currently, there are two theories which have been developed which explain the retrieval-induced forgetting effect. These are the inhibitory and non-inhibitory theories.

Inhibitory and Non-Inhibitory Theories

The inhibitory theory (Anderson & Spellman, 1995) is the more recent to be developed, and has become the dominant theory in the area. Inhibitory theories propose that it is the item itself which is inhibited in order to reduce the competition. As such the theory is able to explain a number of findings relating to retrieval-induced forgetting such as cue independence, whereas other theories may be unable to account fully for findings such as cue independence. The inhibitory theory suggests that using an alternative retrieval route (i.e. an independent cue) would not allow individuals to retrieve an item which had previously been un-retrievable as it is the item itself which is inhibited and not the retrieval route. Anderson and Spellman (1995) demonstrated that retrieval-induced forgetting could continue to be seen even under independent cue conditions.

Additionally, inhibitory theories suggest that retrieval-induced forgetting is most likely to occur in situations where the items are strong. Strong items are more likely to come to mind during retrieval practice than the weak items. For example, Anderson et al. (1994) found that retrieval-induced forgetting was greatest for strong Rp- items. An alternative account to the inhibitory theory that may also explain retrieval-induced forgetting is the non-inhibitory theory.

Non-inhibitory theories propose that Rp+ items are strengthened through practising the items; which also blocks the Rp- items, which are weak as these items have not been practiced. A possible reason for this is that the association between the Rp+ items and the cue is strengthened during practice, which leads to the associations between the Rp- items and the cue being weakened. Non-inhibitory theories therefore suggest that retrieval-induced forgetting may occur in situations where Rp- items are weak. Weak items are less likely to come to mind than strong items. This blocking effect may occur because retrieval practice is thought to strengthen the association between the retrieval practice cue and the Rp+ items; this in turn weakens the association between the shared cue and the Rp- items.

There are several examples of accounts which suggest non-inhibitory mechanisms including Melton and Irwin (1940) who proposed an associative learning account. This theory suggests that practice at the learning stage involves the weakening of the connection between Rp- items (e.g. FRUIT-Banana) and the strengthening of the connection between Rp+ items (e.g. FRUIT-Apple). Likewise the response competition theory suggested that interference effects were due to the increased competition *"arising from the association of additional traces to a retrieval cue"* (Anderson, 2003, p.416; see also McGeoch, 1942), suggesting that retrieval-induced forgetting is most likely to occur in situations where the Rp- items are weak.

Non-inhibitory theories also suggest that it is interference along the retrieval route which is the cause of retrieval-induced forgetting. This suggests that it would be possible for an item that has suffered interference to be retrieved through another route; that is, employing a cue in the test phase which was not used during practice, utilising an interference free retrieval route. A benefit of such a suggestion is that if interference occurs along the retrieval route then attempting to retrieve the item through the use of another retrieval route, through the use of an independent cue (i.e. one which differs to the cue used in the study phase), should remove the interference and allow the target item to be retrieved successfully. Perfect et al. (2004) failed to find a retrieval-induced forgetting effect under independent cue conditions, supporting the non-inhibitory theories. Additionally, Camp, Pecher, and Schmidt (2007) failed to find an independent cue effect in their experiments (see also Williams & Zacks, 2001). Although some evidence (e.g. ability to use an alternative retrieval path) suggests that there are positives to the non-inhibitory theories, there is less empirical evidence to support the theory than there is to support the inhibitory theory. There are several lines of research which have allowed the predictions of the inhibitory and non-inhibitory theories to be compared.

Item Strength

The inhibitory theory suggests that strong items are likely to be inhibited, specifically it has been suggested that this occurs in cases where Rp- items are strong (i.e. as measured by exemplar strength). As the Rp- items are strong they are more likely to interfere with retrieval. For example, stronger items are more likely to compete with the target items for retrieval (i.e. they are more likely to come to mind during retrieval practice than the weak items). This contradicts the predictions of the non-inhibitory theories which would suggest that retrieval-induced forgetting can also occur when the Rp- items are weak. Anderson et al. (1994) examined the predictions made by both the non-inhibitory and inhibitory theories. During the study, Anderson et al. manipulated the strength of the Rp- items, varying from weak Rp- items to strong Rp- items. If the inhibitory theories predictions were correct, it would be expected that retrieval-induced forgetting would be found for the strong Rp- items. However, if the non-inhibitory theories predictions are correct, then retrieval-induced forgetting should be found in cases where the Rp+ items have been practiced (i.e. strengthened) as these would cause interference with the Rp- items, leading to a retrieval-induced forgetting effect. Therefore, retrieval-induced forgetting may also be found for the weak Rp- items. The results demonstrated that retrieval-induced forgetting was greatest when the Rp- items were strong. This suggests that strong Rp- items create the greatest retrieval competition, and as such are more likely to intrude into conscious awareness. This means that strong Rp- items are more likely to be inhibited so as to allow the target item to be recalled, and to resolve the competition issue which has arisen between the Rp+ items and the strong Rp- items.

The findings of Anderson et al. therefore support the predictions of the inhibitory theory.

More recently, Major, Camp, and MacLeod (2008) also investigated item strength. During the study participants were asked to either read or generate items in the study phase. The authors proposed that items which were generated would be stronger than items which were only read; as such the results should demonstrate a greater retrieval-induced forgetting effect for the generated items than the retrieval-induced forgetting effect found for the read items. However, the retrieval-induced forgetting effect found for the generated items was not more than that of the examples which were only read. This was also the case with Jakab and Raajmakers (2009) who conducted three experiments which looked at the position of the item within the category (Experiments 1 and 2) and the number of presentations (Experiment 3). The experiments failed to find a larger retrieval-induced forgetting effect for stronger items (i.e. earlier presented items or items presented more times) than was seen for the weaker items. Also of note is that in experiments looking at item strength the measure or definition of strength alters slightly. For example, Jakab and Raajmakers used the position of items and number of presentation as measures of item strength, whereas Major et al. used reading and generation, and Anderson et al. (1994) used frequency of items to determine whether items were strong or weak. This suggests that although each experiment studies strong and weak items in terms of retrieval-induced forgetting there is some variation in how strong and weak items are measured or defined. Recently, Bauml, Pastotter, and Hanslmayr (2010) suggested that although item strength plays a part in retrieval-induced forgetting it may not necessarily play a large part.

Retrieval Processes

Inhibitory theories also propose that the forgetting of Rp- items is specific to retrieval processes, meaning that the general strengthening of the association between the cue and Rp+ items via other methods such as extra study time is inadequate to initiate retrieval competition and inhibition. This suggests that retrieval is a key aspect. However, non-inhibitory theories propose that retrieval-induced forgetting emanates from the strengthening of the Rp+ items, and retrieval may not be necessary for this to occur. For example, other techniques such as extra study time or re-presentation are suggested as methods which could strengthen the Rp+ items leading to the forgetting of the Rp- items. Anderson, Bjork, and Bjork (2000) compared retrieval practice with re-presentation with regards to their ability to initiate retrieval-induced forgetting. In order to test retrieval practice and retrieval-induced forgetting participants were required to retrieve the Rp+ item in response to a cue and word stem completion task, which is thought to activate the desired memory as well as other related but unwanted items, leading to retrieval competition. Re-presentation however is thought to present sufficient information to activate only the desired item in memory, and not activate the other related but unwanted information; therefore there should be no retrieval competition. The study found that retrieval-induced forgetting was only seen in situations where competition occurred which was in the retrieval practice condition, supporting the predictions of the inhibitory theories (see also Campbell & Phenix, 2009; Ciranni & Shimamura, 1999; Storm, Bjork, & Bjork, 2007). Anderson, Bjork, et al. concluded that the retrieval-induced forgetting effect is not due to the strengthening of the memory trace but that it is due to *"recall specific mechanisms"* (p. 522) which inhibit non-practiced related items due to the retrieval process increasing the retrieval competition between the desired memory and the related items.

These findings were also supported by Bauml (2002), who demonstrated that the semantic generation of items can also lead to retrieval-induced forgetting. In the study phase participants were asked to study a list of items, and during the subsequent retrieval practice phase participants either generated related items or were presented with intact items from the study phase. All participants were then given a recall test. The results showed that semantic generation led to retrieval-induced forgetting but re-presentation of the items did not, supporting the findings of Anderson, Bjork, et al. (2000) and the inhibitory theory.

A more recent study by Storm, Bjork, Bjork and Nestojko (2006) examined whether it is necessary for individuals to correctly recall information during the retrieval practice phase in order for retrieval-induced forgetting to occur. The authors modified the practice phase of the retrieval practice paradigm through giving participants a word stem completion task involving either a category-example pair which participants could generate a response for (i.e. an exemplar which had been associated with that category) or ones in which it would be impossible for the participant to complete. If retrieval-induced forgetting was due to non-inhibitory mechanisms retrieval-induced forgetting would only be demonstrated for the items which were possible for the participants to complete. On the other hand, if the effect is due to inhibitory mechanisms then retrieval-induced forgetting should be demonstrated with all of the items, regardless of whether it was possible to complete the items or not. Participants were tested after ten minutes and after one week. The results demonstrated a retrieval-induced forgetting effect regardless of whether or not an item was retrieved correctly during the practice phase, suggesting that what is important is that the participants attempted to retrieve the item, not necessarily that the participant was successful at doing so. These results were demonstrated in the data collected after ten minutes and after one week, although on the whole slightly less information was recalled during the one week test than at the ten minute test. These findings support the inhibitory theories, as it demonstrates that retrieval is an important component with regards to the retrieval-induced forgetting effect. However, the authors note that it could be suggested that during the retrieval practice phase participants did generate something, and even if those generations were incorrect it could have had an impact on the results, if this were the case then the non-inhibitory theory cannot be discounted as an explanation (Storm et al., 2006). To counter this, Storm et al. state that during retrieval practice participants who made few responses displayed more retrieval-induced forgetting. The inhibitory theory could explain this in that once a response is generated no more attempts are made to generate a response for that particular item, resulting in no additional retrieval-induced forgetting (Storm et al., 2006). Storm and Nestojko (2010) have also found that retrieval being successful is not necessary for retrieval-induced forgetting to occur. Four experiments demonstrated that retrieval-induced forgetting continued to be seen even if successful retrieval was impossible for the participants. This may suggest that it is an attempt at retrieval and active retrieval which is important and not whether the attempt at retrieval was successful or not.

Cue Independence

A further prediction of the inhibitory theory is that inhibition occurs at the item level rather than interference occurring along the retrieval route as the non-inhibitory theories suggest. If it is the case that inhibition occurs at the item level then using an independent cue would not allow the item to be successfully retrieved. An independent cue refers to different cues being used in the retrieval practice and the test phases. For example, participants may practice Glue-Chair in the retrieval practice phase, however in the test phase participants would be given the cue Table rather Glue (see Anderson & Spellman, 1995). This has led to different predictions by the inhibitory and non-inhibitory theories. The non-inhibitory theories suggest that retrieval-induced forgetting occurs because of interference between the cue and the competitor. If this were the case then it would be expected that the introduction of a new cue would bypass the interference and allow the item to be successfully retrieved (see Figure 4).

Figure 4: Diagram of the Non-Inhibitory Theories Predictions Relating to Cue Independence Suggesting that Interference Occurs Along the Retrieval Route

Retrieval Practice Cue Test Phase Cue

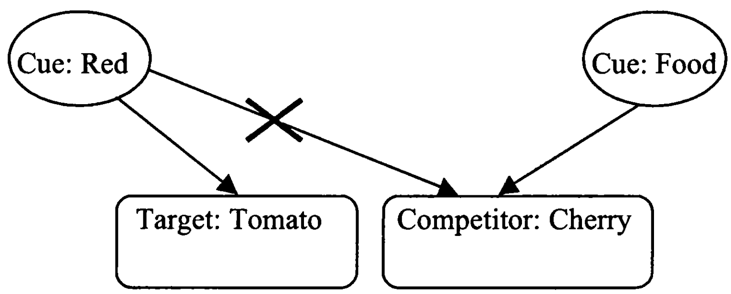


Figure 4. This figure demonstrates that in a retrieval practice paradigm, the participant would be unable to recall the competitor cherry. According to the non-inhibitory theories using a different cue (i.e. food in place of red) in the test phase would allow the participant to recall the competitor (i.e. cherry) as the use of a different cue allows a different retrieval route to be used.

The inhibitory theories however suggest that retrieval-induced forgetting occurs because the item itself is inhibited, and not because of interference occurring along the retrieval route (see Figure 5). This would suggest that using a different cue in the test phase would not allow the item to be successfully retrieved as it is the item itself which is inhibited and not interference occurring between the original cue and the item.

Figure 5: Diagram of the Inhibitory Theories Prediction Relating to Cue Independence Suggesting that the Item Itself is not inhibited

Retrieval Practice Cue Test Phase Cue

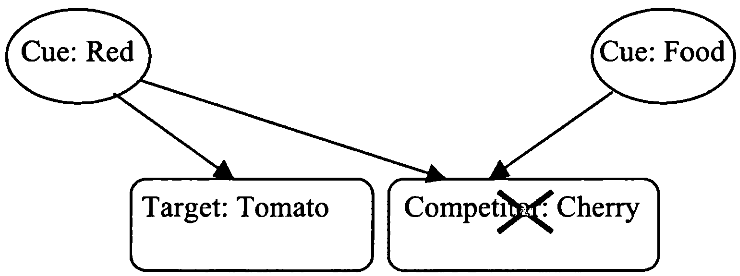


Figure 5. This figure demonstrates that in a retrieval practice paradigm, the participant would be unable to recall the competitor cherry, and according to the inhibitory theories using a different cue (i.e. food in place of red) in the test phase would not allow the participant to recall the competitor (i.e. cherry) as it is the item itself which is inhibited.

This idea is supported by Anderson and Spellman (1995) who found evidence of cue independence demonstrating that retrieving items from memory can impair the later recall of other studied items even under independent cue conditions. During the study phase participants were asked to study categories of exemplars, of these some of the items had a pre-existing association with a second category. For example, under the category Red participants studied the word tomato; however tomato also belonged to the category Food, which was also studied. Anderson and Spellman found that tomato continued to be inhibited even when tested under the Food category rather than the Red category. These findings contradict the non-inhibitory theories which would predict that if tomato was retrieved under the category Food rather than Red then the word tomato would be successfully retrieved as the use of a new cue would allow the word tomato to be retrieved through another retrieval route. Anderson and Spellman's findings are consistent with the prediction of the inhibitory theories and suggest that inhibitory processes contribute to the retrieval-induced forgetting effect. This made the competing memories less accessible, this was found to be true regardless of what cue was used in the test phase (see also Anderson & Bell, 2001).

These findings contradict the predictions of the non-inhibitory theories which would suggest that it should be possible to retrieve Rp- items with the use of a new cue as the interference has been circumvented via a new interference free retrieval route. Anderson and Spellman's (1995) findings are consistent with the inhibitory theory as it suggests that the memorial representation of the Rp- item has been inhibited. As the interference occurs at the level of the memorial representation, even moving to a novel cue (i.e. an independent cue) will continue to lead to impaired memory for Rp- items. Therefore, the findings of Anderson and Spellman are consistent with the inhibitory theory of retrieval-induced forgetting (see also Bauml, 2002; Saunders & MacLeod, 2006). Cue independent findings have been replicated in several other studies. For example, MacLeod and Saunders (2005) found cue independent forgetting with Rp- items and Nrp-similar items (see also Saunders & MacLeod, 2006). Veling and van Knippenberg (2004) also replicated the cue-independent effects of Anderson and Spellman.

Cue independence has also been demonstrated in the Think/No-Think paradigm (Anderson & Green, 2001). During the experiment participants studied pairs of related words, for example, flag-sword. Participants were trained to respond to the second item (i.e. sword) when told the first one (i.e. flag). The Think/No-Think phase followed. For certain pairs of words participants were suppose to not think about the response. The authors proposed that if participants were able to stop thinking about the item then participants should be unable to recall the item in the following recall test. The results seem to suggest that this was the case. Additionally, the greater the number of times the participants tried to stop thinking about the item, the worse recall performance was. This effect occurred even when independent cues were used. During a control experiment participants were asked to not say the word, but were not told to avoid thinking about the item. In this case no inhibition occurred for the items. These results support the notion of inhibitory processes in memory.

Although cue independence has been demonstrated in a number of studies there are also several studies which have been unable to find retrieval-induced forgetting when using an independent cue, most notably Perfect et al. (2004). Perfect et al. conducted a number of experiments, and found that retrieval-induced forgetting was only found under cue dependent conditions (see also Camp et al., 2007; Williams & Zacks, 2001). Participants in experiments 1 and 2 were shown a picture of a face with a category-exemplar pair. During the study phase, participants were instructed to relate each pair to the face. The retrieval practice phase in experiment 1 consisted of a category cue. During the test phase participants completed one of three tests. The first type was a category cue test where the category cue was presented to the participant and participants were asked to recall exemplars of the category. The second type was a face cue test where the image of the face was presented to the participant. The third type was a face plus category cue test during which participants were presented with both the image of a face and the category. In experiment 1 retrieval-induced forgetting was only found in the category cue test. Experiment 2 followed a similar procedure to that of experiment 1 with one difference in that during retrieval practice a face plus category cue was also used. In this experiment retrieval-induced forgetting was found for the category cue and face plus category cue test conditions. Experiment 3 instead of using faces the researchers used words which had no association with any of the items which were used. Participants learned the episodic-exemplar association first followed by learning the category-exemplar. Retrieval-induced forgetting was found for category cues but not for episodic cues. These findings suggest two things, firstly, that retrieval-induced forgetting is cue dependent, and secondly, the findings support the non-inhibitory theories. Perfect et al. proposed that transfer appropriate forgetting could provide an explanation for these results, this is where *"retrieval competition is closely matched to the items from the first retrieval competition"* (p.409). When retrieval competition occurred in the category cues condition, retrieval-induced forgetting was demonstrated in the category cues condition, but did not appear in any other conditions (Experiment 1). Transfer appropriate forgetting may also explain the findings of experiment 2. The authors also propose that context may play a role in the modulation of retrieval-induced forgetting. This may lead to the suggestion that retrieval *"offers a* *powerful contextual cue at practice that is reinstated at the test phase"* (Perfect et al., 2004, p. 415).

A related question is whether independent cues are actually independent. Camp, Pecher, Schmidt, and Zeelenberg (2009) examined this, specifically looking at one of the key components of independent cues that *"studied cues not presented during test (and unrelated to test cues) should not contribute to the retrieval process"* (p.934). The authors concluded that it is not always the case that independent cues are truly independent, for example, participants may make use of covert cues, even when independent cues are used. This mixture of results concerning retrieval-induced forgetting and independent cues suggests that cue independence may be a fragile effect to find, and perhaps a more sensitive measure is required in order to accurately study the role of cue independence/cue dependence and retrieval-induced forgetting.

Cross-Category Inhibition

Another proposal made by inhibitory theories is that any Nrp item which could potentially be a source of retrieval competition is inhibited, this includes items which are related to the entire category, only the Rp+ items (i.e. cross-category inhibitory, see Anderson & Spellman, 1995; Saunders & MacLeod, 2006), or only the Rp- items (i.e. second-order inhibition, see Anderson & Spellman, 1995; Saunders & MacLeod, 2006). Anderson and Spellman (1995) examined cross-category inhibition (see Figure 6). This means that items from one category may have inhibited the recall of items from other categories. For example, participants completed retrieval practice of the pair Red-Blood, this would inhibit performance on Red-Tomato (Rp- item), and additionally a related item from another category such as Food-Strawberry (known as an Nrp-similar item) may also be affected. It was predicted that participants would demonstrate impairment for Nrp-similar items. Anderson and Spellman found evidence of cross-category inhibition, demonstrating impairment in items which are similar to the items in the retrieval practice category, which was in line with the predictions of the study. The authors note however that these results may be due to the participants being unsure which category an item actually belonged to.

Figure 6: Cross-Category Inhibition Effects demonstrating that Nrp Items can be inhibited if they are Semantically Related to the Rp+ Items

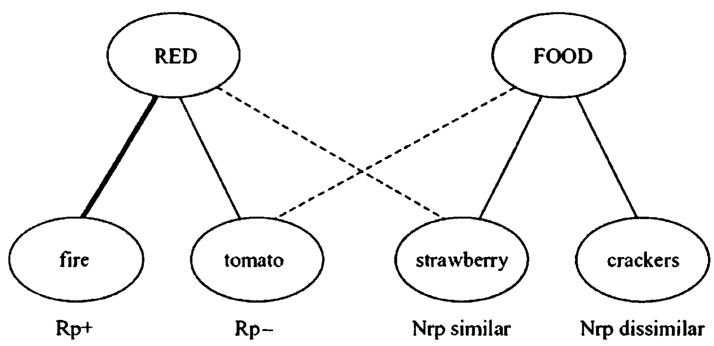


Figure 6. The above figure demonstrates that Nrp items can inhibited if they are semantically related to the Rp+ items. For example, participants would practice Red-Blood, which would lead to Red-Tomato being forgotten (Rp- item). In addition Food-Strawberry (Nrp-Similar item) may also be forgotten (Image from Saunders & MacLeod, 2006, p.309).

However, Saunders and MacLeod (2006) note that Anderson and Spellman (1995) did not have a pure measure of cross-category inhibition because Nrp items were related to the entire retrieval practice category (i.e. to both the Rp+ and Rp- items). As Nrp-similar items were related to both the Rp+ items and the Rp- items, this means that their findings could be due to second-order inhibition effects, not cross-category inhibition. In order to examine whether cross-category inhibition can occur, Saunders and MacLeod studied the relationship between Rp+ items and Nrp-similar items without the influence of Rp- items. This was achieved through dividing Nrp items into two subcategories: Nrp-similar items which were semantically similar to items from the practiced category; and Nrp-dissimilar items which were semantically dissimilar to the items from the practiced category. This division of Nrp items into two categories (Nrp-similar and Nrp-dissimilar) solves the issues raised in connection with Anderson and Spellman's study regarding not knowing whether the results are due to the Nrp items relation to Rp+ items or their relation to Rp- items. Participants in the Saunders and

MacLeod study reported fewer Nrp-similar items to Rp+ items than Nrp-dissimilar items, demonstrating cross-category inhibition as well as fewer Nrp-similar items to Rp- items, demonstrating second-order inhibition. This finding of cross-category inhibition and second-order inhibition suggests that items with pre-existing associations with Rp+ items and Rp- items are also a source of retrieval competition, and these may also be subject to retrieval-induced forgetting. Findings of cross-category inhibition would seem to support the inhibitory theories, as non-inhibitory theories are unlikely to be unable to explain these findings.

Second Order Inhibition Effects

Second-order inhibition effects (see Figure 7) refer to items from an unpracticed set which are semantically related to unpracticed items in a practiced set (i.e. Nrp-similar to Rp- items). Anderson and Spellman (1995) found evidence of second-order inhibition, where retrieval practice of Rp+ items (Red-Blood) inhibits Nrp-similar to Rp- items (Food-Crackers).

Figure 7: Second-Order Inhibition Effects demonstrating that Nrp-Similar Items may also be inhibited

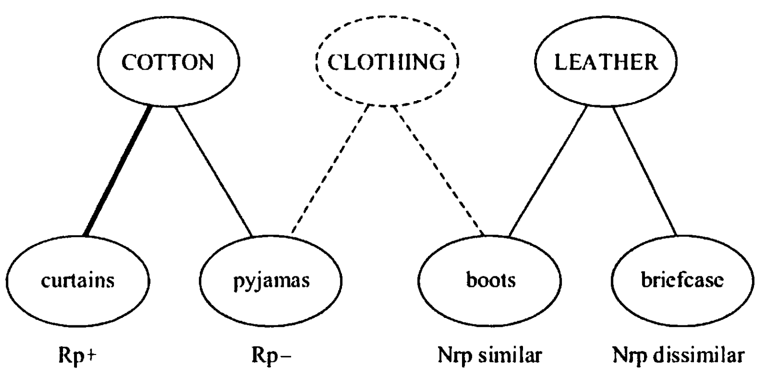


Figure 7. The above figure demonstrated that Nrp-similar items which may be related to Rp+ items through the Rp- items may also be susceptible to inhibition. Nrp-dissimilar items should remain unaffected (Image from Saunders & MacLeod, 2006, p. 310).

This finding was described as unexpected by Anderson and Spellman (1995), as it would be predicted that as there is no semantic relationship between, for example, crackers and blood, that there would be no inhibition. However, Anderson and Spellman note that although the two items are not directly semantically related, Food-Crackers were similar to its competitors of blood, for example, blood and tomato are both examples of Red, and crackers and tomato are both examples of the category Food, so therefore the items may be indirectly related semantically. Although these findings are consistent with an inhibitory theory there is more than one inhibitory account which could be responsible for retrieval-induced forgetting, namely, lateral inhibition and pattern suppression.

Lateral Inhibition

Lateral inhibition was suggested by Blaxton and Neely (1983) and is based on the mechanism of lateral inhibition in the nervous system (see also Baddeley, 1999). Lateral inhibition suggests that the bias of *"memory targets could be achieved through automatic lateral inhibition processes"* (Anderson & Spellman, 1995, p.10). Lateral inhibition proposes that activation spreads from the retrieval cue associated with a category to the exemplars of the category. A benefit of this account is that it can explain cross-category inhibition effects (see Anderson & Spellman, 1995; Saunders & MacLeod, 2006). If a participant is given the pairing Red-Blood during the retrieval practice phase then the activation may spread from Red-Blood to other items which may be related to the category Red (e.g. Food-Tomato, Food-Strawberry). Anderson and Spellman (1995) suggest that strawberry might be affected even though it was studied under a different category cue (i.e. Food) because it is also red and is therefore associated with the category Red (see Figure 8). However, although this was suggested no specific mechanisms as to how this could be achieved have been identified at present.

Figure 8: Diagram demonstrating how Lateral Inhibition may work in Relation to Memory

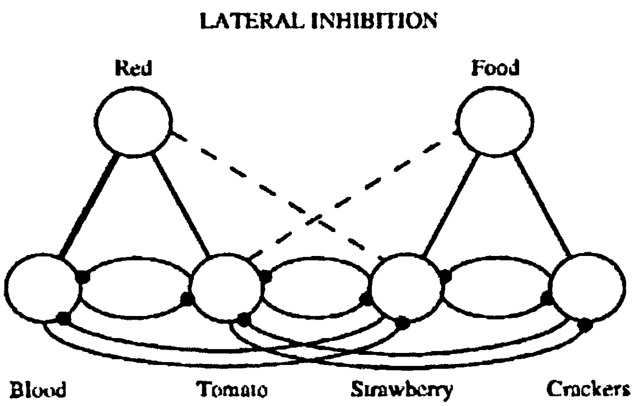


Figure 8. In the above figure the curved lines with dark circles represent lateral inhibition connections (e.g. Blood-Crackers). The straight solid lines represent studied category-exemplar pairs (e.g. RED-Tomato). The heavy lines represent subset of pairs in retrieval practice (e.g. Red-Blood). Finally, the thin dashed lines represent the category-exemplar pairs which were not studied (e.g. RED-Strawberry) (Image from Anderson & Spellman, 1995, p. 90).

A disadvantage of the lateral inhibition account is that it can account for numerous effects such as, cross-category inhibition and second-order inhibition effects (see Anderson & Spellman, 1995; Saunders & MacLeod, 2006), and third-order inhibition effects. However, research has found no deflation in the Nrp-dissimilar baseline when compared to a no retrieval practice control condition, this would suggest that either third-order effects do not occur or are very weak and as such unmeasurable (MacLeod & Saunders, 2005). Also, Anderson and Spellman (1995) failed to find Nrp-dissimilar facilitation, which lateral inhibition would predict would occur due to the inhibition of Nrp-similar items. These could be considered as further evidence against the lateral inhibition account. A further disadvantage of the lateral inhibition account is that it would predict that first-order effects would be greater than second-order effects because practising the Rp+ items should inhibit the Rp- items, reducing their ability to inhibit

Nrp-similar items (Anderson & Spellman, 1995). However, Anderson and Spellman found that there was a tendency for second-order inhibition effects to be as great as first-order effects, which contradicts the predictions of the lateral inhibition account (see also Saunders & MacLeod, 2006). Anderson and Spellman use the following example to demonstrate what they would have expected to find. The practice of Green-Emerald would impair Soups-Mushroom which had a lesser ability to exert lateral inhibition on Soups-Chicken. Although this was not found, lateral inhibition does provide a better account of some findings than the non-inhibitory theories.

Pattern Suppression

A second and more dominant approach is the pattern suppression approach, which assumes that categories and examples are complex representations; this is the opposite of other approaches which would suggest that categories and examples are simple units (Anderson & Spellman, 1995). Pattern suppression suggests that successful retrieval of an Rp- item is dependent upon its net facilitation from its associations with the Rp+ item and its net inhibition arising from unwanted competition with the Rp+ item. If more of the semantic features are facilitated than inhibited then the item will be recalled, however, if more of the semantic features are inhibited than facilitated then the item will not be recalled.

As this theory is based on features, and shared features, it raises the possibility of Nrp items being inhibited if the Nrp items shared some inhibited features with the Rp+ or Rp- items. This means that forgetting should extend to items from the unpracticed categories which are semantically related to the items from practiced categories due to competition which would occur during retrieval (Saunders & MacLeod, 2006). For example, if a participant was given the category-exemplar pair of Green-Emerald (see Figure 9), the cue Green could activate emerald and lettuce as they are both green, however, if the target memory was emerald, then the features of lettuce which would have been activated by the cue Green would need to be suppressed in order to allow emerald to be successfully retrieved. Retrieval practice of Green-Emerald would strengthen the features which make up emerald, and as such lettuce would be inhibited (i.e. in order to allow the retrieval of emerald), this should mean that the features which make up lettuce are more difficult to reinstate at a later date (Anderson & Spellman, 1995).

A strength of the pattern suppression approach is in its use of semantic features, and also in the action involved in the pattern suppression (Anderson & Spellman, 1995). The approach suggests that similar items often overlap in the units which make up the items; which impacts on retrieval (see also Anderson, Green, & McCulloch, 2000). Pattern suppression also has the advantage of being able to explain several effects such as cross-category inhibition and second-order effects. Unlike the lateral inhibition approach the pattern suppression approach does not predict third-order effects. Anderson and Spellman (1995) propose that cross-category inhibition effects arise because the items features are inhibited due to their competition with the Rp+ items, whereas second-order effects occur because the items share inhibited features with the Rp- items.

Figure 9: Representation of how Pattern Suppression and Retrieval-Induced Forgetting may Work

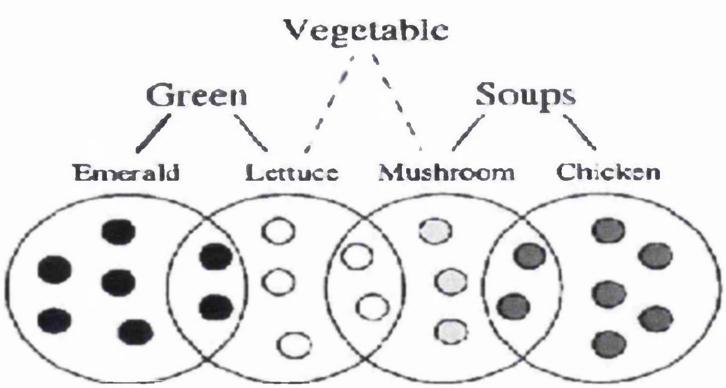


Figure 9. The larger circles represent a set of features of the item named above the circle, for example, a set of features associated with emerald. The smaller circles represent individual features (Image from Anderson & Spellman, 1995, p. 91).

Another benefit of the pattern suppression account is its ability to account for different degrees of inhibition. Anderson and Spellman (1995) discuss an example of how the pattern suppression approach may work. If the Rp+ items and the Rp- items had 35% of their features overlapped (due to similarity), then the other 65% of features which are not similar should be inhibited during the retrieval practice process. However if we consider a Nrp-similar item and Rp- item which have a 95% overlap with the Rp- items non-similar features, then it would be expected that the Nrp-similar item would be impaired, and perhaps more so than the Rp- items as there is a 30% difference between the two in how many features are required to be inhibited. One disadvantage of pattern suppression is that many of its mechanisms are still unknown, although Anderson and Spellman point out that the pattern suppression approach does have potential and seems to be supported better by empirical evidence than the lateral inhibition account.

The lateral inhibition and pattern suppression accounts differ from each other in two ways. Firstly, lateral inhibition can account for third-order effects, however, pattern suppression does not as it suggests that third-order items do not share features with Rp+ or Rp- items, and as such should not be influenced by being inhibited or facilitated. Studies would seem to support the predictions of the pattern suppression account in this case and contradict the predictions of the lateral inhibition account, for example, Anderson and Spellman (1995) did not find third-order effects. Secondly, lateral inhibition suggests that *"first-order similarities would be more inhibited than second-order similarities"* (p.69), however pattern suppression suggests that the effects should vary. Again, evidence seems to support the pattern suppression account finding that Nrp-similar items can be inhibited to the same degree as Rp- items (Anderson & Spellman, 1995; Saunders & MacLeod, 2006). This would suggest that at present the pattern suppression account could provide a better explanation for some of the effects, although the mechanisms for pattern suppression seem to need to be developed further.

Integration

Further support for the pattern suppression model may come from integration. For example, the amount of integration can impact upon the amount of retrieval-induced forgetting which occurs. Anderson and McCulloch (1999) discuss two lines of research which may also support the notion that integration can protect memories from retrieval-induced forgetting. The first of these is research into fact recognition. Radvansky and Zacks (1991) demonstrated that competition can be eliminated through integrating facts. When participants in the study phase were asked to learn facts about one location with many objects in the location there was no hindrance to the participant's performance, however, performance was hindered when participants learnt about objects which were found in many locations. Radvansky and Zacks proposed that these results occurred because when participants learnt about one location with many objects they were able to integrate items to form a complete 'picture' of the location (see also Myers, O'Brien, Balota, & Toyofuku, 1984; Smith et al., 1978). This may not have occurred in the many objects in many locations condition. Secondly, several studies have demonstrated that integration has the potential to reduce proactive and retroactive interference. For example, Russell and Storms (1955) found that if a mediating relationship could be found between two lists of pairs of words then the effect of interference would be reduced (see also Martin & Dean, 1964). These findings seem to suggest that integration has the potential to protect memories from retrieval-induced forgetting.

During a study in which participants integrated items, Anderson and McCulloch (1999) found that the retrieval-induced forgetting effect was diminished (see also Anderson & Bell, 2001; Moeser, 1976). The authors found in three experiments that if participants were instructed to integrate items during the study phase retrieval-induced forgetting was reduced. This was also the case if participants spontaneously integrated the items. Anderson and McCulloch used a retrieval practice paradigm (Anderson et al., 1994) and manipulated the instructions given to participants during the initial study phase in order to examine the effects of integration on retrieval-induced forgetting. In the standard condition participants were shown category-exemplar paired words and asked to relate the exemplar (e.g. orange) to the category (e.g. fruit). Those in an integration condition were also encouraged to form a relationship between the exemplars. In order to account for whether participants integrated items anyway without encouragement during the instructions, participants completed a post study questionnaire. Participants demonstrated a reduced retrieval-induced forgetting effect in the integration condition in both a category cued recall test (Experiments 1 and 2) and category-stem cued recall test (Experiment 3). Additionally Anderson and McCulloch demonstrated that participants often spontaneously integrated items without having to be instructed to do so.

Similarity between items may also be a moderating factor (i.e. the amount of retrieval-induced forgetting can be moderated by the semantic similarity between items). Bauml and Hartinger (1999) manipulated the amount of similarity which occurred between items in a category and whether practiced items belonged to the same subcategory. For example, lemon and orange belonged to the same subcategory (citrus), whereas lemon and cherry would not belong to the same category. Experiment 1 demonstrated a retrieval-induced forgetting effect for items when a subcategory was shared and when they did not share a subcategory. However, there was a reduction in the amount of retrieval-induced forgetting when items shared a subcategory although this was not statistically significant. In the second experiment participants were told what the subcategory was (e.g. citrus) in order to highlight the similarities. The results demonstrated that retrieval-induced forgetting was eliminated when items belonged to the same category. This was replicated by Bauml and Hartinger (2002) who used a similar method to the 1999 experiment and the results again demonstrated that as the similarity increased between Rp+ and Rp- items, the amount of retrieval-induced forgetting decreased. However, these findings were not replicated by Smith and Hunt (2000), contradicting the findings of Bauml and Hartinger. Smith and Hunt completed two experiments looking at distinctive processing (see also Hunt & McDaniel, 1993; Hunt & Smith, 1996) and the effect on retrieval-induced forgetting. Smith and Hunt propose that distinctive processing will also reduce the amount of retrieval-induced forgetting. The results of the first experiment suggested that retrieval-induced forgetting was eliminated following distinctive processing, during a study in which participants were asked to think about how the items differed from each other (see also Hunt &

Einstein, 1981; Hunt & Smith, 1996). During experiment 2 the instructions were changed slightly and also included asking the participants to think about how the items were similar. Also included were two other conditions: a standard condition of studying pairs in the study phase, and an integration condition. Participants demonstrated retrieval-induced forgetting in the similarity condition and in the standard condition, but not in the integration condition. Firstly, the finding of no retrieval-induced forgetting in the integration condition could support the findings of Anderson and McCulloch (1999) and secondly, these findings support Smith and Hunt's suggestion regarding the role of distinctive processing in reducing retrieval-induced forgetting. Smith and Hunt suggest that combining distinctiveness and organisation could explain why no retrieval-induced forgetting was found for that condition. However, the authors note that another possible suggestion is integration (see Anderson & McCulloch, 1999), and not distinctive processing. As such experiment 2 was conducted in order to address this issue through including an integration condition when addressing similarity. A retrieval-induced forgetting effect continued to be seen in the similarity condition despite the introduction of the integration instructions. These findings do not seem to support the inhibitory theory; however, the authors note that the aim of their experiments was not to study mechanisms involved in retrieval-induced forgetting.

An explanation for these seemingly contradictory findings was suggested by Anderson, Green, and McCulloch (2000). This explanation is based upon whether similarity is examined in terms of target-competitor similarity or competitor-competitor similarity, and each of these would have a different effect on retrieval-induced forgetting. The net similarity or distinctiveness may determine whether the item is facilitated or inhibited. For example, if the target-competitor similarity is high it should decrease retrieval-induced forgetting, whereas if competitor-competitor similarity is high, the retrieval-induced forgetting would be amplified (see Figure 10).

Figure 10: Diagram of Target-Competitor Pairs (A) and Competitor-Competitor Pairs (B) Demonstrating the Role of Similarity and Differences in Remembering Items

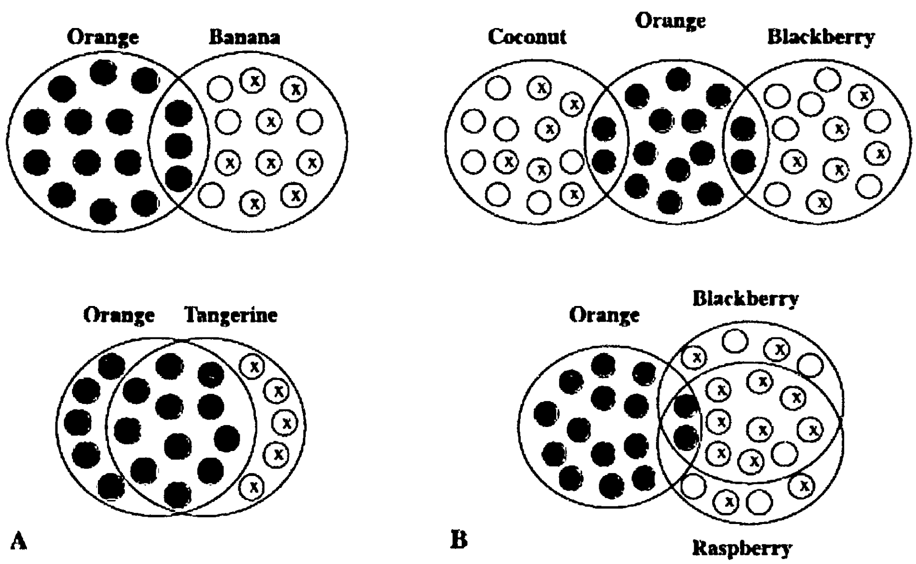


Figure 10. The bigger circles represent memory items (e.g. Coconut) whereas the smaller circles represent semantic features of the item. The overlapped larger circles represent how items may overlap. The darker smaller circles represent features which are facilitated. The Xs represent features which are inhibited. Image A shows an example of target-competitor similarity. Image B shows an example of competitor-competitor similarity (Image from Anderson, 2003, p.247).

Regarding target-competitor similarity (similarity between the retrieval practice item and an unpracticed competitor) orange and banana share fewer similarities than orange and tangerine (Anderson, 2003; see also Figure 10). Retrieval practice of orange could lead to the strengthening of tangerine through the shared features (i.e. similarities) the two items have in common, as such retrieval-induced forgetting may be reduced or eliminated. This would not be the case for banana as the items share fewer features, and share much dissimilarity; as such the item may be more likely to be inhibited. The more similar a target and competitor become the less likely it is that inhibition will occur.

This would be line with the findings of Hartinger and Bauml (1999) (see also Anderson & Spellman, 1995; Bauml & Hartinger, 2002).

Target-competitor similarity could then be an explanation for finding a reduced inhibition effect when items are similar. Competitor-competitor similarity could then explain the findings of Smith and Hunt (2000). It is suggested that competitor-competitor similarity could have the opposite effect to target-competitor similarity (Anderson, Green, et al., 2000). This would suggest that the greater the number of similar features competitors have in common, the greater the inhibitory effect. For example, the features inhibited for blackberry would also be inhibited in raspberry because of the similarities between the items leading to an increase in retrieval-induced forgetting. However, this would be less likely to occur with blackberry and coconut, as they are less similar (see Figure 10). This would be in line with findings of Smith and Hunt. The distinction between target-competitor similarity and competitor-competitor similarity could explain the different results found by Smith and Hunt and the findings of Hartinger and Bauml (1999).

In order to test this Anderson, Green, et al. (2000) asked participants to rate how good of an example of the category the item in question was. Participants were then asked to note the similarities and differences between exemplars for either a target-competitor pair or competitor-competitor pair. Participants then completed retrieval practice. The results demonstrated that when participants noted the similarities between the target and competitor a facilitation effect occurred for the competitor (Experiment 1), however, during the second experiment when participants noted what was distinctive between the target and competitor retrieval-induced forgetting was found. When participants studied the similarities between competitor and competitor those items were inhibited, although the size of the effect was reduced when in a second experiment participants looked at distinctiveness (Anderson, Green, et al., 2000). The authors concluded that *"the present findings illustrate the important role of representation in determining the behavioural impact of the inhibitory processes that support memory retrieval"* (Anderson, Green, & McCulloch, 2000, p. 1158).

Spreading Activation Account

An alternative account to the lateral inhibition and pattern suppression accounts discussed above is the spreading activation account (Quillian, 1962; Quillian, 1967), which suggests that inhibition may not occur at the level of the memorial representation. Saunders and MacLeod (2006) suggest that retrieval-induced forgetting, cross-category inhibitory effects, and second-order inhibitory effects can all be explained by inhibition occurring as a mechanism for counteracting the unwanted spreading activation from unwanted items. Quillian's theory viewed memory search as *"spreading activation from two or more concept nodes"* (Collins & Loftus, 1975, p.407). The spreading activation account suggests that activation spreads through nodes, and that as one node ends and another begins an activation tag is left in between the two nodes. When another tag is added an intersection is created, and the intersection can be analysed to see if it fits the rules. The activation tags and intersections form a path, which can be retraced (Collins & Loftus, 1975). However, it is possible for the paths and links to differ in strength, and for example, could rely upon the number of times an individual accesses the information.

Quillian's spreading activation account has been extended by Collins and Loftus (1975) in several ways. Firstly, Collins and Loftus suggest that the longer the concept is processed, for example, through practising the item, the longer the activation occurs, suggesting that activation can only take place at one node at a time. Secondly, Collins and Loftus suggest that activation can decrease over a period of time. Thirdly, Collins and Loftus suggest that the network is organised with regards to semantic relatedness. The more related two items are the more links there will be between two items, for example, different types of flowers may have many links in common. However, items which are different but happen to be, for example, red in colour (e.g. fire engine and cherries) will not have many links as although they have one property in common, there are numerous features that they do not share (see Figure 11).

Supporting evidence for the spreading activation account comes from McNamara (1992) who showed participants a word, for example, Red, and then either a word that was closely related to it, such as Roses or a word that was less closely related to it, such as Flowers (see Baddeley, Eysenck, & Anderson, 2009). A stronger facilitation effect was found for words which were strongly related to the original word (i.e. Roses) than the words which were less closely related to the word (i.e. Flowers). This was also found by Meyer and Schvaneveldt (1976) in that words which were semantically related to the original word would be easier for participants to identify than words which were not semantically related to the original word (see also Schacter et al. 1996).

Figure 11: Diagram of the Semantic Relatedness of Items in Memory

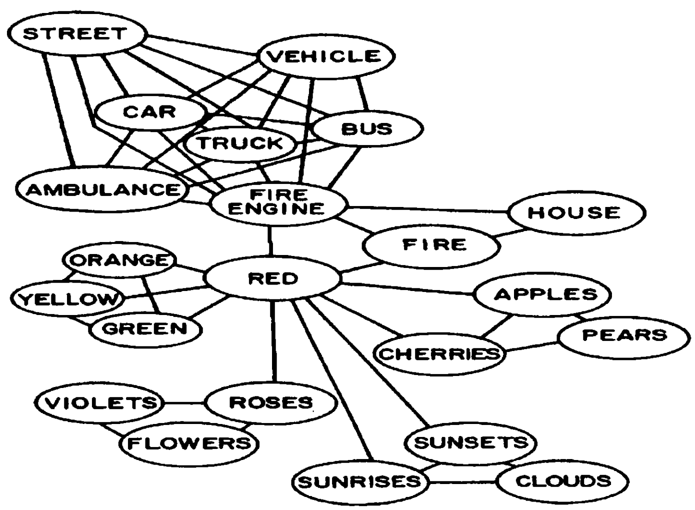


Figure 11. The shorter lines represent items which are highly related, for example, ambulance and car. The longer lines represent items which are less related, for example, ambulance and street (Image from Collins &Loftus, 1975, p.412).

More recently, Saunders and MacLeod (2006) have proposed that the spreading activation account can account for both facilitatory and inhibitory effects demonstrated in retrieval-induced forgetting studies, and suggest that if it is possible to facilitate memory then it is also possible that there is a method of stopping the spreading of activation to other items when spreading activation would be contrary to the individual's current processing goal. If the ability to counteract unwanted spreading activation did not exist, retrieval of target memories would be affected by activated memories. Although Saunders and MacLeod agree with Anderson and Spellman (1995) that there is an inhibitory mechanism which reduces the interference which comes from unwanted related items in memory, Saunders and MacLeod suggest that it is possible to reduce the interference by limiting the spread of activation. Anderson and Spellman suggested that this would be dealt with by inhibiting the items themselves, whereas Saunders and MacLeod suggest that this could be achieved through inhibition stopping the spread of activation, and that inhibition could occur at the category level. If inhibition occurs at the category level, then this means that inhibition can make sure that it is only certain connections that are strengthened, which would maximise the potential to learn (Saunders & MacLeod, 2006). By limiting the spread of activation, this means that competing items can be stopped from reaching the threshold for retrieval, meaning that these items are less likely to interfere (Saunders & MacLeod, 2006). This could however be beneficial for learning as if inhibition does occur at a category level then inhibitory control can ensure that connections are strengthened between a limited number of categories and the items attached to those categories, which can maximise an individual's potential to learn. Saunders and MacLeod conclude their paper by stating if items which are activated can be controlled then it is possible to stop unwanted competitors from reaching the threshold required for retrieval, making the item less likely to be the source of interference.

Strategy Disruption

The strategy disruption account, as suggested by Basden, Basden, and Galloway (1977) (see also Basden & Basden, 1995) propose *"that the presentation of cue items disrupts retrieval by forcing a serial recall order that is inconsistent with the subjective organisation of the list"* (Bauml & Aslan, 2004, p. 611). Specifically, if the participant is asked to use a specific recall order which is different to the original organisation of the categories and exemplars (see Basden et al., 1977; see also Basden & Basden, 1995). Saunders and MacLeod (2006) explain how strategy disruption may work in terms of retrieval induced forgetting. For example, retrieval practice of Rp+ items can interfere with the organisation of the original items within the categories. This may lead to lower accurate recall for Rp- items, as Rp- items would be more difficult to retrieve compared to Nrp items which may not have been subject to strategy disruption.

One line of evidence suggested to support strategy disruption is that retrieval-induced forgetting seems to disappear after twenty-four hours when a twenty-four hour delay is introduced between the retrieval practice and test phases (MacLeod & Macrae, 2001). Dodd, Castel, and Roberts (2006) suggest that this may be because inserting a twenty-four hour delay allows the participants to have *"been far removed from the disruptive session and that they were able to return to their original memory strategy"* (p. 104). Retrieval practice may disrupt the organisation of items; however, the delay which follows may allow the process to be reversed. Although the authors note that a lack of retrieval-induced forgetting after twenty-four hours could also represent the inhibition effect having decreased over that period of time (see MacLeod & Macrae, 2001). Another line of evidence is the failure in some studies to find a difference in the performance of strong and weak category exemplars (for example, Williams & Zacks, 2001).

Retrieval-induced forgetting and the strategy disruption account were compared in a study by Dodd et al. (2006). In three experiments Dodd et al. found evidence to support the strategy disruption theory. The experiments manipulated which items participants were asked to recall during a retrieval practice phase. Experiments 1 and 2 found that if items do not interfere with the participant's retrieval strategy then retrieval-induced forgetting can be eliminated. This was also found in a third experiment, which utilised a different set of stimuli. There were three conditions in experiment 1: a random practice condition, a serial position practice condition (e.g. recall the last five items studied), and an every-other-word-practice condition. The inhibitory theory may suggest that retrieval-induced forgetting would be found in all three conditions, however, strategy disruption would suggest that retrieval-induced forgetting would be found in only one condition, the random practice condition. The results suggest that retrieval-induced forgetting was only found in the random practice condition, which would be in line with the strategy disruption account. However, the authors note that this is based on an acceptance that the participants were both encoding and recalling the items in a serial order, which may or may not have been the case. Experiment 2 was designed to ensure that participants did encode the items in the order given to them. This was done through providing instructions to the participants instructing them to do so. The procedure followed that of experiment 1, involving the same conditions. Additionally, participants were asked to rate on a scale of 1 (no attempt) to 5 (made every attempt) whether they had attempted to encode and recall the items in the order presented to them. The results suggested that participants had listened to the instructions provided to them and encoded and recalled the items serially. The results of experiment 2 replicated those of experiment 1. Experiment 3 replicated the findings of experiments 1 and 2, however, with a different set of stimuli. These three experiments would seem to support the strategy disruption account, and suggest that the strategy disruption account may provide some explanation for retrieval-induced forgetting.

It should be noted that although these findings and other findings such as a lack of retrieval-induced forgetting after twenty-four hours (MacLeod & Macrae, 2001), may support a strategy disruption account, the account seems unable to account for other findings, for example, cue independent forgetting (Anderson & Spellman, 1995), cross-category inhibition and secondary-order effects (Saunders & MacLeod, 2006) and the finding that retrieval-induced forgetting can occur in item recognition tests (Hicks & Starns, 2004; Verde, 2004), and with more visual stimuli, such as colour and shape (Ciranni & Shimamura, 1999). In this case Dodd et al. (2006) suggest that perhaps strategy disruption may be a component involved in retrieval-induced forgetting.

Neural Network Model

Recent research has also noted the role of specific brain regions which may be involved in retrieval-induced forgetting. For example, the prefrontal regions of the brain have been proposed as an important area in terms of retrieval-induced forgetting (Johansson, Aslan, Bauml, Gabel, & Mecklinger, 2007). Kuhl, Kahn, Dudukovic, and Wagner, (2008) noted that the anterior cingulate and lateral prefrontal cortex may also be activated during retrieval-induced forgetting. In addition, a neural network model has been proposed with the aim of explaining how retrieval-induced forgetting might occur, and one of the essential features of the neural network model is the learning algorithm (Norman, Newman, & Detre, 2007; Norman, Newman, Detre, & Polyn, 2006; Norman, Newman, & Perotte, 2005). The algorithm aims to explain how target items may be strengthened and the competitors weakened. In order to aid the retrieval of the target item the learning algorithm adjusts synaptic weights, this is done through strengthening the target items and weakening the competing items. For target items the weight is increased, whereas for competitors the weights may be decreased (K-Winners-Take-All Inhibition rule (Norman, Newman, Detre, & Polyn, 2006)). Furthermore, a cortical network and a hippocampal network may also be involved. Both networks consist of two layers (an associate layer and an item layer) and both layers contain 40 units. Norman, Newman, and Detre (2007) suggest that the cortical network is associated with semantic memory whereas the hippocampal network is associated with episodic memory. In both networks the layers are connected. The connected layers in the cortical network may play a role in stopping the spread of excitatory activity. One possible way this may occur is through inhibitory interneurons (Norman, Newman, & Perotte, 2005; see also O'Reilly & Munakata, 2000).

Interneurons may be able to sample the amount of excitatory activity occurring in a region; the interneurons are then able to send back the necessary amount of inhibition (Norman, Newman, Detre, & Polyn, 2006). If more inhibition is sent then the excitatory activity reduces whereas if there is a decrease in the inhibition then the amount of excitatory activity increases. Therefore an excitatory neuron is only active if the excitation the neuron has received is high enough to counter the amount of inhibition the neuron has received.

In more detail, the learning algorithm (Norman, Newman, Detre, & Polyn, 2006; see also Norman et al., 2007; Norman, Newman, & Perotte, 2005) utilises oscillations, perhaps theta oscillations (see Norman et al., 2007). One line of evidence which may point to theta oscillations is that the oscillations play a role in learning (Seager, Johnson, Chabot, Asaka, & Berry, 2002). Additionally, Hanslmayr, Staudigl, Aslan, and Bauml

(2010) found evidence of theta oscillations with regards to retrieval-induced forgetting. Results demonstrated that interference was found in the theta oscillations, however, only during the competitive retrieval condition.

The neural network model may be able to explain how retrieval-induced forgetting occurs. For example, Norman et al. (2007) ran several simulations aimed at studying retrieval-induced forgetting in terms of the neural network model, and to examine whether the neural network model can also account for some of the previous findings found with relation to retrieval-induced forgetting. The retrieval practice paradigm here involved a category (an association layer) linked to multiple items (an item layer). Additionally, retrieval practice, reversed practice and re-presentation were used during the practice phase. The results of the simulations demonstrated that the model can account for a number of previous findings. For example, simulations demonstrated that retrieval-induced forgetting occurred only in the retrieval competition conditions (simulation 1.1 (see also simulation 8) – see also Anderson, Bjork, et al., 2000) and occurs with independent cues (simulation 1.2 – see also Anderson& Spellman, 1995). Simulation 5 however demonstrated that retrieval-induced forgetting may not occur with all independent cues (see also Perfect et al., 2004). Further simulations found an effect of strength of competitors in that retrieval-induced forgetting occurred for strong items, but did not occur with the weak items (simulation 2.1 – see also Anderson et al., 1994). Simulation 3 replicated the previous findings that retrieval-induced forgetting can occur following semantic generation (see also Bauml, 2002). These simulations suggest that the neural network model can account for retrieval-induced forgetting and several findings surrounding the inhibitory theory (e.g. strength of competitor, independent cues). This suggests that inhibition occurs with regards to retrieval-induced forgetting, and specifies a method by which that might that occur. That a method is specified would be advantage of the neural network method, in addition the model takes into account both semantic and episodic memory.

Transfer Appropriate Forgetting Account

An alternative to the inhibitory theory is the transfer appropriate forgetting account. Retrieval-induced forgetting and cue independence were demonstrated by Anderson and Spellman (1995). However, Perfect et al. (2004) proposed that the retrieval-induced forgetting found in experiments 2 and 4 (Anderson & Spellman, 1995) may have been due to a high level of recall for Nrp-Similar items. This leads to the suggestion that Nrp-Similar items benefited from the retrieval process. Perfect et al. note another issue with the findings demonstrated in Anderson and Spellman relating to cue independence. Participants may have studied Red-Brick and Red-Tomato during the study phase, which is followed by retrieval practice of Red-Brick. The cue Food may then be used in the test phase in relation to tomato. According to the inhibitory theory even under independent cue conditions participants would be not be able to successfully retrieve tomato. However, Perfect et al. note that in the Anderson and Spellman experiment out of eight studies of Red-exemplars that took place, half of those were foods, and the foods were not studied under other categories, therefore, it could be argued that foods and the category Red have become associated with each other during the course of the experiment. As such the findings may not be independent, and may not suggest that retrieval-induced forgetting occurs under cue independent conditions. An alternative account, an associative account, may be proposed as an explanation for some of the findings (see Perfect et al., 2004).

Following on from this, Perfect et al. (2004) conducted a study which used items which were episodically related to items rather than semantically related as in previous experiments utilising independent cues. During experiments 1 and 2 participants were presented with a picture of a face alongside a category-exemplar pair. The face was independent from the pair of words. Retrieval practice in experiment 1 involved participants being shown the category cue-word stem only, participants were not shown the image of the face. During the test phase three conditions were used: a category cue condition, a face only condition, and a category-plus face condition. According to the inhibitory theory, retrieval-induced forgetting would be demonstrated, regardless of whether it was the category cue, face, or category-plus face which was provided to the participant during the test phase. An associative account would suggest that using faces as cues in the test phase would not lead to retrieval-induced forgetting, whereas providing the category cue would. However, if the category and face were provided to the participant then whether retrieval-induced forgetting occurred would depend on whether the cue or the face was used by the participant as the retrieval cue. The results demonstrated a retrieval-induced forgetting effect only in the category cue condition, no retrieval-induced forgetting was found in the category-plus face nor the face only conditions, which would be more in line with the associative account rather than the inhibitory theory. Furthermore this may suggest that retrieval-induced forgetting may be a cue dependent effect. Experiment 2 followed a similar method however faces were also presented along with the category cue during retrieval practice, which was not the case during experiment 1. The results demonstrated a retrieval-induced forgetting effect in both the category cue condition as in experiment 1, and also in the face plus category cue condition.

Transfer appropriate forgetting maybe one explanation for the findings (Perfect et al., 2004) (see Figure 12). This approach suggests that retrieval-induced forgetting is most likely to occur in test conditions which match those of the retrieval practice phase. This may explain why in experiment 1 when the retrieval practice phase consisted of a category cue-word stem task retrieval-induced forgetting was only seen in the category cue condition, and not the face condition or the category cue plus face condition. The same effect may be seen in experiment 2 where retrieval practice also consisted of a category cue and the face, retrieval-induced forgetting was also found in the category cue plus face condition. Experiment 3 was conducted with the aim of examining any output interference effects which may have occurred during experiments 1 and 2. In experiment 3 unrelated words were used in place of the faces used during experiment 1 and 2. Under category cue conditions there was a retrieval-induced forgetting effect, however, the effect did not occur in the episodic cue condition. All three experiments demonstrated cue dependent forgetting. A number of other studies have also failed to find a retrieval-induced forgetting under cue independent conditions. For example, Williams and Zacks (2001) did not find a cue independent effect (see also Camp et al., 2007). Camp et al. (2009) questioned whether independent cues used are actually independent. The authors proposed that not all independent cues are independent, for example, participants may be able to make use of covert cues.

In addition in some conditions in the Perfect et al. (2004) study no facilitation effect was demonstrated either, suggesting that the category cue and the face may not access a single representation of an item (Perfect et al., 2004). Alternatively the cues may access different parts (Perfect et al., 2004; see also Tulving & Thomson, 1973). If the cues do access different parts, this may suggest that this occurs in context dependent conditions and *"the retrieval practice phase constitutes an encoding opportunity"* (Perfect et al., 2004, p. 412; see also Landauer & Bjork, 1978). In addition a second retrieval opportunity strengths and weakens the association between the cue and other items. For example, associations between the cue and the retrieved item may be strengthened but previous associations between the cue and other items may be weakened. These aspects allow for transfer appropriate forgetting to occur (Perfect et al., 2004). However, Bajo, Gomez-Ariza, Fernandez, and Marful (2006) proposed that alternatively the findings in Perfect et al.'s experiment could also be explained as representation-dependent.

Figure 12: The Associative Model of the Findings Seen in Perfect et al. (2004) Study

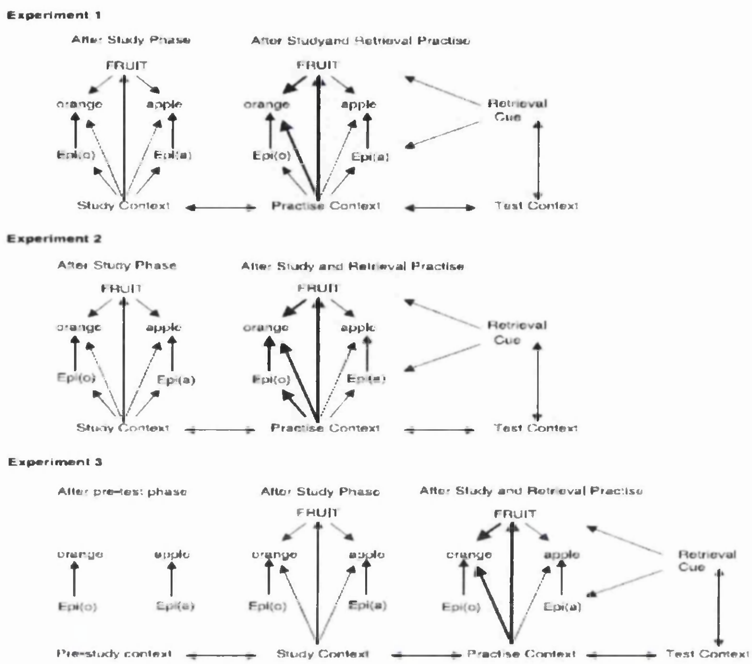


Figure 12. This figure represents an illustration of the associative model seen in the experiments conducted by Perfect et al. (2004) discussed previously. EpiO represents an episodic cue which is associated with orange. EpiA represents an episodic cue associated with apple (Image from Perfect et al., 2004, p. 414).

Retrieval-Induced Forgetting and Time

One possible boundary condition with regards to retrieval-induced forgetting is time. Bodenhausen and Macrae (1998) suggest that in order to be beneficial inhibition should be able to respond when there are changes in an individual's goals, and that these changes to goals can occur quickly (see also Macrae & Bodenhausen, 2000). MacLeod and Macrae (2001) noted that it may not be beneficial for inhibition to occur long term. MacLeod and Macrae studied the role of time and retrieval-induced forgetting. The authors proposed that if a large period of time passes, for example twenty-four hours, between the retrieval practice and test phases then no retrieval-induced forgetting should be found. If little time lapses between the two phases then it would be expected that a retrieval-induced forgetting effect would be found. Experiment 1 examined the effect of a delayed test compared with an immediate test. The delayed test occurred twenty-four hours after the other phases of the experiment. In line with the predictions of the authors no retrieval-induced forgetting occurred in the delayed condition, but it did occur in the immediate condition. MacLeod and Macrae note that a possible alternative explanation to the findings is output interference (see Roediger & Schmidt, 1980). However, further analysis of the data by the authors demonstrated that the results were not due to output interference.

In a second experiment MacLeod and Macrae (2001) introduced a twenty-four hour delay between the study and retrieval practice phases. One aim of this was to create a situation which may be more similar to what occurs in everyday life, for example, it is not always the case that study and retrieval practice would occur at the same time. The authors propose that when the information is studied in relation to when the retrieval practice phase occurs should not impact on the effect, and retrieval-induced forgetting should continue to occur. Participants either completed retrieval practice immediately following the study phase, or after a twenty-four hour delay. The results demonstrated that retrieval-induced forgetting occurred even when a delay was introduced although the size of the effect was smaller than that which had occurred in the previous experiment. Several other studies have also demonstrated results consistent with the findings of MacLeod and Macrae (Saunders & MacLeod, 2002; see also Saunders, Fernandes, & Kosnes, 2009). Migueles and Garcia-Bajos (2007) however found findings which were inconsistent with the findings of MacLeod and Macrae (see also Garcia-Bajos, Migueles, & Anderson, 2009; Storm et al., 2006). Participants were asked to watch a video of a robbery during the study phase. The participants in the retrieval practice condition then completed retrieval practice with actions from the video. A free recall test of the actions followed immediately and twenty-four hours later. No retrieval-induced forgetting was exhibited in either the immediate recall or the twenty-four hour delayed recall tests. Experiment 2 looked at the characteristics of the offenders in place of the actions, following a similar procedure to experiment 1. However in this case retrieval-induced forgetting was demonstrated in both the immediate and twenty-four hour delayed recall tests.

The Effects of Different Types of Tests

Some previous research suggests that retrieval-induced forgetting is not found with all types of tests. Butler, Williams, Zacks, and Maki (2001) note that in general, retrieval-induced forgetting has been found using category cued recall tests; however, this may not be the case for all types of tests. Butler et al. (2001) studied whether retrieval-induced forgetting occurred in other types of tests. A retrieval-induced forgetting effect was found with a category cued recall task, however, no retrieval-induced forgetting was found for a number of other types of tests such as category-plus-stem-cued recall test, category-plus-fragment-cued recall test and a fragment completion task. One proposed reason for this may be that presenting item specific cues during the test phase can eliminate retrieval-induced forgetting (Butler et al., 2001). Hicks and Starns (2004) however demonstrated a retrieval-induced forgetting effect in recognition tests in two experiments (see also Gomez, Lechuga, Pelegrina, & Bajo, 2005; Verde, 2004). Koutstaal, Schacter, Johnson, and Galluccio (1999) found retrieval-induced forgetting with Rp- items when tested using a free recall test, but did not find retrieval-induced forgetting when a recognition test was used, demonstrating that the type of test used may impact on the results.

Also, the type of test or measure used could have an impact on the findings (Racsmany & Conway, 2006). Racsmany and Conway (2006) proposed that if a test or measure at the end of the study included items from the study phase but does not require access to the memory of the study phase then performance on the final task may not be influenced by the pattern of activation and inhibition. During their study, Racsmany and Conway found that that with a lexical decision task items were unaffected with regards to reaction times, however, when analysing recall performance there was an effect on participant's performance.

Applied Aspects of Retrieval-Induced Forgetting Research

It is important to study inhibition not only to examine mechanisms involved in retrieval-induced forgetting but also because it can have an adaptive function, for example, it can play a role in forgetting in everyday memory. Anderson et al. (1994) suggested that retrieval processes play an important role in everyday forgetting, suggesting that items which could interfere with the retrieval of relevant information are inhibited allowing the relevant and required information to be brought to the surface through inhibiting the related but unwanted information (Oram & MacLeod, 2001). This would be adaptive for students studying for exams as students are required to study for several exams within a short period of time, meaning that they need to learn several pieces of information for several different exams. Being able to inhibit certain items (e.g. information revised for a previous exam) could be beneficial; allowing them to have access to the relevant information required (e.g. revising for the next exam) (see also Carroll, Campbell-Ratcliffe, Murnane, & Perfect, 2007).

While retrieval-induced forgetting may be beneficial under such exam conditions it can also be a hindrance when revising for one particular exam. Macrae and MacLeod (1999) tested participant's knowledge of two fictional islands (Tok and Bilu), and found three key results. Firstly, it was found that retrieval-induced forgetting can be seen in everyday situations, for example, taking exams. Secondly, it was found that forgetting could be elicited in cases where the person was highly motivated to remember the material, for example, an individual would be motivated to remember relevant material for their exam. Thirdly, forgetting is not moderated by the amount of retrieval-induced forgetting experienced, meaning that one session of retrieval is enough to elicit a retrieval-induced forgetting effect. To return to the example of exams, this means that even in a situation where a person is highly motivated to remember (e.g. highly motivated to do well in the exam) forgetting is still possible, and that one session of retrieval (e.g. practising for the exam) could be enough to lead to retrieval-induced forgetting. Also, this could lead to the forgetting of information which is not relevant to the exam the person is taking, and it demonstrates that retrieval practice is important as practice improves the memory for the items being practised. Tandoh and Naka (2007) looked at the durability of retrieval-induced forgetting in three conditions. The first condition consisted of no time delay between the retrieval practice and test phases, another condition with a one hour delay and a third condition with a one week delay between the phases. Retrieval-induced forgetting was evident in all three of these conditions. Additionally, the size of the effect did not change between conditions.

A recent study by McCulloch, Fujita, Aarts and Bargh (2008) has used the retrieval practice paradigm to look at goals. Goals play an important part in individual's lives on a daily basis. McCulloch et al. propose that it would beneficial if retrieval-induced forgetting also occurred with goals. The authors use the example of posting a letter for work, suggesting that it would be beneficial to be able to forget other work associated goals in order to complete the goal of posting the letter. The benefit of being able to forget the other goals to complete the goal at hand has also been noted by other researchers (see also Kuhl & Beckman, 1985; Shah, Friedman, & Kruglanski, 2002). Experiment 1 looked at whether practising one method of achieving a goal would lead to retrieval-induced forgetting for other methods of achieving the goal. Participants during the study phase were asked to imagine performing methods of achieving a goal. For example the goal would be finding a job, and participants would be asked to image methods for finding a job including preparing a CV, writing to interviewers and so on. During retrieval practice participants practiced a subset of those methods, for example, retrieving the method 'preparing a resume' through completing a stem cued recall task. A test phase would then follow. The results demonstrated a retrieval-induced forgetting effect for Rp- items. A further experiment (Experiment 2) replicated the findings of experiment 1. In addition this experiment also looked at whether retrieval-induced forgetting would occur when the methods or sub-goals were all involved with the same goal. For example, an overarching goal (see Figure 13) may be 'taking care of a patient' this goal may include two sub-goals which were related to this overarching goal: 'treating a patient' and 'preparing a patient for a visit'. In addition two unrelated sub-goals were also attached to the goal, for example, 'finding a job' and 'setting up camp' (McCulloch et al., 2008). The results demonstrated that retrieval-induced forgetting can occur for goals. This only occurred for the methods of the same goal, not when the methods did not compete. In addition to this if the goals benefited each other a facilitation effect was seen, suggesting that *"retrieval-induced forgetting is functional and sensitive to relationships between goals"* (McCulloch, Aerts, Fujita, & Bargh, 2008, p.864).

Figure 13: Figure of how an Overarching Goal may be divided into Sub-Goals. The Sub-Goals may also Consist of Several Smaller Sub-Goals.

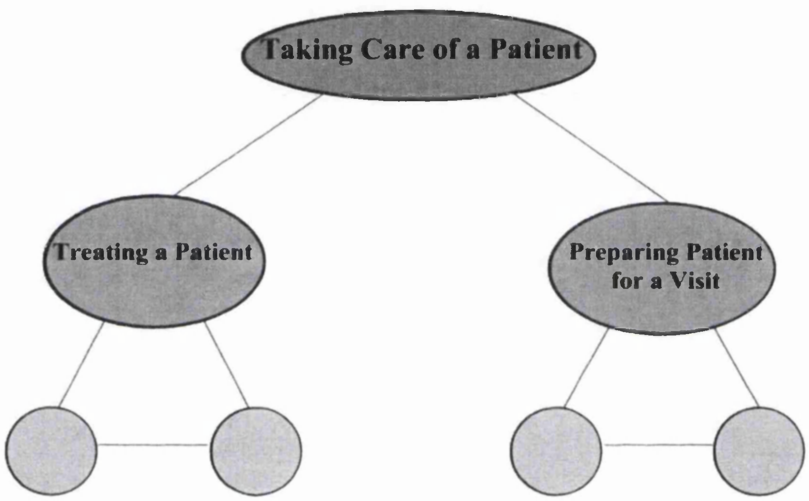


Figure 13. The figure represents an example of a higher order goal (e.g. taking care of a patient) and sub-goals which are then involved in the higher order goal. For example some sub-goals may include treating a patient and preparing a patient for a visit. These sub-goals form part of the higher order goal (Image from McCulloch, Aerts, Fujita, & Bargh, 2008, p.864).

This was further supported by Shah, Friedman, and Kruglanski (2002), who asked participants to list the activities they would be performing during the next week, for example, running. McCulloch et al. (2008) noted that if the goals (e.g. running) belong to the same super ordinate or over arching goal (e.g. exercising) competition between these items should occur. Shah et al. demonstrated that competing goals (e.g. cycling may be a competing goal with running) are also inhibited. Bauml et al. (2010) also suggest that *"inhibitory processes operate to serve the function of goal-directed remembering"* (p.1047). Fishbach, Friedman, and Kruglanski (2003) however have demonstrated that when completing a goal then other goals which would be beneficial to the completion of the target goal then these would not be inhibited.

Research has also demonstrated retrieval-induced forgetting with regards to eyewitness memory and testimony. For example, Shaw, Bjork, and Handel (1995) demonstrated retrieval-induced forgetting with eyewitness memory. Specifically, the authors studied repeated questioning, through showing participants images of a crime and then questioning them repeatedly about some of the details they would have seen in the image. The use of questions and how those questions are used is of great importance with regards to eyewitness's testimony. For example, eyewitnesses are questioned by the police when the crime first occurs, then lawyers as the case goes to court, and repeated questioning about some parts of the crime could impact on the memory for other items of the crime. The results showed that this form of questioning can lead to the information being questioned repeatedly being recalled better than other information. Repeatedly recalled information (Rp+ items) scores were on average higher when compared to information from a different category (Nrp items). This also has the effect of leading to some information being forgotten, for example, the average score for the information from the same category as the repeatedly recalled information (Rp- items) was smaller compared to Nrp items. Shaw et al. conclude that it is possible for repeated questioning to impact of the eyewitness memory, and that this can occur even when the questions contain no misinformation. One issue with this study is the possibility that the findings were due to output interference effects (Shaw et al., 1995).

Following this MacLeod (2002) aimed to examine if retrieval-induced forgetting occurs in eyewitness testimony without the possibility of the effects occurring due to output interference. MacLeod found that retrieval-induced forgetting continued to be demonstrated for eyewitness testimony. During experiment 1 participant's imagined that they were police officers who were attending a crime scene in two houses (house A and house B). Following the presentation of the scene and the items missing from the house, the participant was provided with a booklet of retrieval practice questions. A retrieval-induced forgetting effect was demonstrated, which was not the result of an output interference effect. MacLeod notes that one possible issue with experiment 1 was that participants were told to pay attention to the items and information in the experiment, and as such did not represent what may occur when individuals are eyewitnesses. Experiment 2 was designed with this in mind, and to study under which conditions retrieval-induced forgetting might occur. During this experiment participants were told about a crime involving bogus charity collections, and participants were asked to imagine that they were an eyewitness at the crime. This was followed by a presentation of slides showing the crime. Participants were then asked to complete a booklet similar to that used in experiment 1. The results also demonstrated that retrieval-induced forgetting can occur with eyewitness testimony. The results also suggest that retrieval-induced forgetting can occur without the explicit categories. Furthermore, MacLeod suggests that participants can use strategies in order to organise the stimuli in the meaningful way.

These findings demonstrate that it is possible for retrieval-induced forgetting to occur for meaningful stimuli. Also that retrieval-induced forgetting can occur even if the participant is motivated to remember the information, as one would be with information about a crime (see also Macrae & MacLeod, 1999). This could also have an impact on eyewitness testimony and questioning, for example, the impact of repeated questioning on a subset of information. MacLeod (2002) notes that, for example, with the cognitive interview, one issue may be that it involves repetitive questions and that could impact on other information on the crime. MacLeod however notes that stimuli involved in the experiment were chosen to avoid cuing, which may not occur in real life eyewitness scenarios, and cuing could play a role in those situations. However the findings of these two experiments support Shaw et al.'s (1995) findings and suggest that the retrieval-induced forgetting effect cannot be explained by output interference effects, which in turn supports the inhibitory theory.

Retrieval-induced forgetting may also play a role in social psychology, for example, retrieving personality traits of an individual can lead to an impairment of other traits (Macrae & MacLeod, 1999). For example, during experiment 1participants were asked to form impressions of two individuals, John and Bill. Participants were then shown a card with the name of the individual (e.g. Bill) and a trait (e.g. romantic). Retrieval-induced forgetting of traits was demonstrated in this situation (see also Macrae & MacLeod, 1999 experiments 2 and 3). This was also demonstrated by Dunn and Spellman (2003) who found that retrieving traits of an individual can impair stereotypic traits of that person. Participants in the study phase learnt about a person who belonged to a stereotyped group. Participants were then required to complete retrieval practice of a subset of the target's characteristics. Additionally, the stronger the participant believed in the stereotype the less inhibition of the stereotype-relevant traits was found. Furthermore, it has been suggested that self-referential information may protect individuals from retrieval-induced forgetting (Macrae & Roseveare, 2002). Possible reasons for this maybe that self-referential information may involve distinctive encoding (Bower & Gilligan, 1979; Klein & Loftus, 1988). Additionally, integration (Anderson & McCulloch, 1999) could play a role, for example, it has been demonstrated that when participants integrate items during the study phase, the retrieval-induced forgetting effect has been reduced. Macrae and Roseveare (2002) asked participants to memorize a number of gifts in one of three conditions: either imagine that the participant themselves had purchased the gifts, or imagine that the gifts had been bought by their best friend or imagine that the gifts had been bought by someone else. In the condition where participants imagined their best friend or someone else buying the present retrieval-induced forgetting was found with participants scoring higher for Nrp items compared to Rp- items. This was not the case in the self condition during which participants imagined themselves buying the gifts. The authors proposed that participants in the self condition would be more likely to imagine people the gifts could be given too, which may not have been the case in the other conditions. Retrieval-induced forgetting was also eliminated when items were distinctive. These findings highlight the adaptive function of retrieval-induced forgetting, for example, it would not be beneficial to 'temporarily forget' self-relevant information. Furthermore, these findings seem to suggest that self-relevant information may be protected from retrieval-induced forgetting. This may be because the information is distinctive (see Smith & Hunt, 2000), or because of integration allowing for multiple routes to gain access to the information (Anderson & McCulloch, 1999). Self-relevant information is likely to be subjected to a higher degree of integration than information which is relevant to the best friend or the other person (Macrae & Rosevere, 2002).

Research has demonstrated that during the early stages of Alzheimer's action memory is preserved with individuals making few omissions in their actions, however, as Alzheimer's progresses action memory begins to fragment leading to an increase in omissions of actions (Rusted & Sheppard, 2002; see also Mack, Eberle, Frolich, & Knopf, 2005). Rusted and Sheppard (2002) found that as individuals progressed from the early stages to later stages of dementia the number of omissions in actions increased, leading to routines becoming more fragmented. However, despite an increase in omissions and fragmentation of routines individuals were able to complete tasks such as pouring a cup of tea. Rusted and Sheppard suggest that this may be due to individual's familiarity with actions such as pouring a cup of tea. Individuals asked to perform unfamiliar routines did make more omission and repetition errors, suggesting that memory for actions can be inhibited (Rusted & Sheppard, 2002). As Alzheimer's disease is associated with inhibitory deficits this decline in action based memory could be due to deficits in the inhibition of memory, suggesting that less inhibition occurs allowing more memories for actions to flood the mind which would lead to poorer performance for actions. However, Moulin et al. (2002) studied retrieval-induced forgetting in Alzheimer's disease, and suggested that if a reduction in inhibitory processes played a role it would be expected that a greater amount of inhibition would be found, however, the results suggested that this was not the case.

Inhibiting items has also been suggested as being beneficial by Bjork, Bjork, and Anderson (1998) for example, with cases of abuse. Bjork et al. proposed that abuse victims, who have positive and negative memories of the abuser, may inhibit the negative memories via remembering the positive memories. Retrieval-induced forgetting and inhibition may be the mechanism which allows the victim to do this, suggesting that retrieval-induced forgetting could be associated with the suppression of traumatic memories (Anderson, 2001; Anderson & Green, 2001; Freyd, 1996). Freyd (1996) suggests that abuse by family, family friends or care-giver is more likely to be forgotten than abuse by strangers. This may be because forgetting of abuse by a family member may be adaptive in that it allows the child to survive within the abusive environment. Freyd suggests that this may be because of the effect the information could have on the family's structure. Retrieval-induced forgetting would be a way of achieving this, with the happy memories remaining, and with the abuse memories being inhibited or suppressed. Freyd, DePrince, and Zurbriggen (2001) also found that individuals who had suffered abuse by family members were more likely to report self-reported memory loss when compared to those who had been abused by strangers (see also Stoler, 2000).

Retrieval-Induced Forgetting and Actions

Little research however has been conducted with regards to actions and retrieval-induced forgetting. Previous research by Koutstaal et al. (1999) demonstrated that it is possible for retrieval-induced forgetting to occur with actions (Experiment 1); however, this particular study did not look at memory for actually performed actions during both the study and retrieval practice phases. An earlier study conducted by Koutstaal, Schacter, Johnson, Angell, and Gross (1998) required participants to view everyday events on a videotape, and then complete retrieval practice which involved either seeing a sub-section of the images as photographs (review condition) or were not shown the images again (control condition). The results demonstrated a suggestive retrieval-induced forgetting for experiment 1, however, no retrieval-induced forgetting was found in experiment 2. The authors noted several issues in the experiment that may have contributed to the lack of an effect. Firstly, in some conditions participants only viewed the images again once; a sub-section of the data specifically with younger adults seemed to show that the effect may be demonstrated when viewing the images more than once. Secondly, when participants did see the images again more than once this was done altogether with no time in between each viewing and the authors considered whether including a time delay would have an impact (see also Launder & Bjork, 1976). Thirdly, the materials used in the original study phase (i.e. the videotape) and the images used as part of the review conditions retrieval practice phases were from two difference scenarios, which included the use of different individuals and contexts.

In light of these considerations Koutstaal et al. (1999) developed a study which took into account the above points, and additionally, examined self-performed actions. During the initial study phase of experiment 1 participant's self-performed a series of actions. Two days later participants were shown images of another individual performing a sub-section of the actions that the participant had previously self-performed. Participants were then asked to recall which actions they had performed earlier in the study and information about the event (e.g. objects, actions). This was done three times, with a delay occurring between each one, unlike the method used in the previous experiment (see Koutstaal et al., 1998). A free recall test followed. In this case, a significant retrieval-induced forgetting effect was found. This effect was not replicated in experiment 2 when retrieval cues were provided.

Several studies have failed to find retrieval-induced forgetting in relation to actions. For example, Migueles and Garcia-Bajos (2007) failed to find retrieval-induced forgetting in relation to actions. During experiment 1, participants were shown a video of a crime; in this case a robbery, which consisted of twenty actions. This was followed by retrieval practice of the actions and a free recall test. The results demonstrated no retrieval-induced forgetting effect. Retrieval-induced forgetting was found in experiment 2 which looked at the characteristics of the offenders in place of the actions. These studies however do not specifically look at the self-performance of actions, including self-performance of actions during the study and retrieval practice phases. The next step then may be to examine retrieval-induced forgetting and actions. At present however there is little research into this area. It is essential to discover if retrieval-induced forgetting plays a role with actions, especially to see the role of inhibition in inhibiting contextually inappropriate actions. Inhibition in retrieval-induced forgetting usually occurs without the person knowing it, but nevertheless using an action appropriately in the correct context is important. Firstly, using an inappropriate action can lead to social conflict, others may not be happy with the action the person has performed which may cause conflict between two groups. Secondly, asides from the social aspect, using a contextually inappropriate action could lead to harm (e.g., touching a hot saucepan).

One such study which has done so was conducted by Sharman (2011). Participants were asked to either self-perform or observe bizarre (e.g. place the pencil across the cup) and familiar (e.g. sharpen the pencil) actions. Participants also completed self-performance or observation of the actions during the retrieval practice phase. Following the study and retrieval practice phases participants completed a cued recall test. Participants were provided with the name of the object used and asked to recall the actions they had previously performed with that object. Experiment 1 studied whether retrieval-induced forgetting occurred with relation to bizarre and familiar self-performed actions, and the results suggest that this was the case. Experiment 2 aimed to see if these findings could be replicated and also compared self-performed and observed actions. As in experiment 1 retrieval-induced forgetting was found for both the bizarre and familiar actions. In addition retrieval-induced forgetting was only found for self-performed actions. Sharman suggests two possible explanations for why an effect is found for self-performed actions but not the observed actions. Firstly, a larger difference between self-performed and observed actions with regards to item-specific processing was found compared to that which occurred between the familiar and bizarre actions. Secondly, observation may not involve active retrieval during retrieval practice whereas self-performance of actions would. In order to further examine this during experiment 3 participants observed the actions being performed in the study phase and then self-performed the actions during retrieval practice. Retrieval-induced forgetting continued to be seen suggesting that a lack of effect in the observation condition in experiment 2 was due to the lack of retrieval. These findings however suggest that retrieval-induced forgetting can occur for self-performed actions.

Although little research has been conducted into actions in terms of retrieval-induced forgetting, some evidence to suggest that actions can be impaired may come from interference studies. For example, Jax and Buxbaum (2010) recently demonstrated that interference can occur with regards to actions. The authors noted that several different actions can be associated with one object (see also Ansuini, Giosa, Turella, Altoe, & Castiello, 2008). For example, with a calculator one action would be to pick the item up (i.e. grasp), which is related to the structure of the object and a second action may be to use the item (i.e. poke), which is related to the function of the object. In the case of the calculator the actions grasp and poke would involve interacting with the objects in different ways, Jax and Buxbaum propose that this is a 'conflict'. Other objects however have one action which is based both on the structure and function of the object. During the experiment participants completed two tasks, a grasp task during which participants were asked to put their hand on the object as if they were going to grasp the object to hand it to another person, and a use task, during which participants placed their hand on the object as they would if they were going to use the object. When the positioning of the hand was different for the grasp and use tasks participants responded slower, than when the positioning of the hand was the same for both the grasp and use tasks. Additionally, use actions interfered with grasp actions. These findings suggest interference can occur with regards to actions.

An interference effect has also been demonstrated in tasks or actions learned closely together. Walker, Brakefield, Hobson, and Stickgold (2003) demonstrated that learning a second task interfered with the performance of a first task which participants also learned. Participants were asked to complete a finger tapping task. Participants who had slept following learning a task demonstrated an enhanced performance. However, participants in a second condition who were also trained on a second task, which occurred immediately following the first task, demonstrated an interference effect for the first task. One possible reason for this is that the second task may stop the first task being consolidated into memory (Tong, Wolpert, & Flanagan, 2002; see also Stephan, Meier, Orosz, Cattapan-Ludewig, & Kaelin-Lang, 2009).

Previous research has also considered how actions may be stopped. Anderson (2003) discusses the possibility of intentionally suppressing actions, which Anderson suggests may involve tapping into a response override system (see Figure 14). This suggests that an individual can stop an action if they choose too, for example, to stop themselves reaching for a falling item (Anderson, 2003). In a response override system an individual needs to stop the response to the stimulus (e.g. to stop themselves from reaching for the falling item).

Figure 14: A Response Override System for Responses where Strong Responses can be Over Ridden by Weaker, Contextually Appropriate Responses

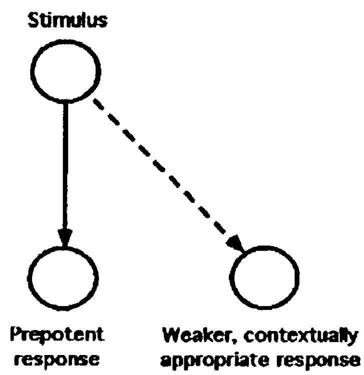


Figure 14. The circles represent representations in memory and the lines represent the associations between the stimulus and the response. The solid line demonstrates a strong association between the stimulus and the response whereas the dotted line represents a weaker association between a stimulus and a response. In this case the weaker response may be the more contextually appropriate response. This suggests that a mechanism may allow individuals to suppress the stronger response in order to select the weaker but more appropriate response (Image from Anderson, 2003, p. 417).

As figure 14 demonstrates stimuli can be associated with more than one response, one response may be strongly associated with the stimulus whilst the other response has a weak association with the stimulus. If an individual is presented with the stimulus, the stimulus activates a representation, the activation then spreads to the associated responses. If there are several possible responses then the response which crosses the threshold first would be the one used; however, that does not necessarily mean that it is the most appropriate response, one of the weaker responses may be the more appropriate response but this will not be activated if another response has already reached the threshold and utilised. Inhibition may be the method used to stop a response reaching the threshold, allowing weaker responses to be activated, a process known as inhibitory control. Anderson (2003) suggests that it would be necessary to do this in one of two conditions either the circumstance requires the response to be withheld, or the response is not appropriate for the context. If we were not able to do this, Anderson suggests that our reflexes would dominate the individual.

Previous research by Naussauer and Halperin (2003) provides some evidence to suggest that for behaviour to function correctly there is a need for the irrelevant responses, along with irrelevant stimuli to be inhibited. Naussauer and Halperin designed a 'perceptual and motor conflict task', in order to examine perception and motor inhibition. Participants were asked to respond to arrows on a screen through pressing the right or left buttons to indicate where on the computer screen the arrow was (perceptual inhibition assessment). In sub-tests they were required to press a button in the opposite to the direction of the arrow on the screen (motor inhibition assessment). The aim of this research was to examine whether perception and motor inhibition worked separately or together. Naussauer and Halperin suggest that as no interaction effect of perception and motor interaction was found that perception and motor inhibition work separately. However participants' performance on the tasks was significantly correlated, suggesting that the area is complex and it is slightly unclear as to whether the perception and motor inhibition areas work separately or together. This piece of research however did not look at whether inhibition occurred, or at retrieval-induced forgetting and motor actions, which is the aim of experiments in this thesis.

Chapter 3

Retrieval-Induced Forgetting and Motor Sequences

Experiment 1

Background

Typically, retrieval-induced forgetting studies utilise a retrieval practice procedure (see Anderson et al., 1994). This method typically involves a study phase, for example, during which participants study a list of category-exemplar pair words. This is then followed by a retrieval practice phase during which the participants are required to recall a sub-section of items usually three times. A memory test then follows, for example, a recall test. This generally gives rise to two findings. Firstly, a facilitation effect that is participant's memory performance for the practiced items is better than memory performance for a baseline measure. Secondly, a retrieval-induced forgetting effect is found, where participants demonstrate poorer memory performance for items which were not practiced, but were related to the items which were practiced. This effect has been demonstrated with a range of different stimuli including words (Anderson & Spellman, 1995); coloured objects and shapes (Ciranni & Shimamura, 1999) and false recognition (Starns & Hicks, 2004).

However, little research has been conducted into retrieval-induced forgetting and actions. One study which did so examined retrieval-induced forgetting and images of novel actions (Koutstaal et al., 1999), which demonstrated that memory for the Rp- items was impaired when participants were tested with a free recall test (Experiment 1). An earlier study by Koutstaal et al. (1998) involved showing participants everyday events on a videotape, and participants then completed retrieval practice through seeing a sub-section of images as photographs (the review condition). Other participants completed a control condition during which no images were shown again. In experiment 1, a suggestive retrieval-induced forgetting effect was found, however, in experiment 2, no retrieval-induced forgetting effect what so ever was found. The authors noted that although no effect was found several issues in the experiment could have contributed to the lack of an effect, for example, in some conditions participants only viewed the images again once, and a sub-section of the data specifically with younger adults seem to show that the effect may be demonstrated with viewing the images more than once. Additionally, for participants who did see the images again more than once this was done altogether with no time in between each viewing and the authors questioned what effect including the time between each viewing would have (see also Launder & Bjork, 1976). A third issue noted is that the material used in the original study phase (the videotape) and the images used as part of the review conditions retrieval practice phase were from two different scenarios, which included the use of different individuals and different contexts.

Therefore, Koutstaal et al. (1999) developed a study which took into account the above, and additionally looked at self-performed actions. In experiment 1, during an initial study phase, participants performed a series of actions (involving more than one object) themselves. Two days later participants were shown images of someone else performing a sub-section of the actions that the participant had previously performed, and asked to recall when they had performed the action earlier in the study, and information about that event. This was done three times with a delay occurring between each one, unlike the method used in the previous experiment (see Koutstaal et al., 1998). A free recall test followed. In this case, a significant retrieval-induced forgetting effect was found. This effect was not replicated in experiment 2 when retrieval cues were provided. More recently, Sharman (2011) found a retrieval-induced forgetting effect for self-performed bizarre and familiar actions; however the effect was not present for observed actions. These findings suggest that it is possible for retrieval-induced forgetting to occur for actions.

Findings from interference studies also suggest that an interference effect can be found in terms of actions. Jax and Buxbaum (2010) noted that one object can be linked with more than one action (see also Ansuini, Giosa, Turella, Altoe, & Castiello, 2008), for example, two actions which could be associated with a calculator could be grasp (e.g. when picking the item up) and poke (e.g. when pressing the buttons). The authors propose that this is a 'conflict' for actions involving the calculator. Additionally, one action is related to the structure of the object, whereas the other is related to the function of the object. Other objects however have one action which is based both on the structure and function of objects, for example, a glass. Participants completed two types of tasks, a grasp (i.e. structure) task during which participants were asked to put their hand on the object as if they were going to grasp the object to hand it to another person, and a use (i.e. function) task, during which participants placed their hand on the object as they would if they were going to use the object. When the positioning of the hand was different for grasp and use tasks participants responded slower than when the positioning of the hand was the same for both grasp and use tasks. Additionally, the use tasks interfered with the grasp tasks. Jax and Buxbaum refer to this as a race involving structural (i.e. grasp) and functional (i.e. use) related actions, and because functional related actions require the conceptual aspects to be represented, structural responses are likely to be completed more quickly. The authors also propose two explanations for why the interference occurs. Firstly, information which is specific to that object may continue to be active after use. Secondly, the effect could be due to task-level interference. Although this study does not involve retrieval-induced forgetting, it does demonstrate that competition and interference can occur with regards to actions.

Additionally, interference has been suggested as playing a role in memory for tasks learnt closely together. Research suggests that learning two tasks close together time wise can cause interference with regards to the first task learnt. Walker et al. (2003) demonstrated that learning a second task can interfere with performance of a first task which participants had also learnt. Walker et al. found that participants who had slept demonstrated enhanced performance for a task, suggesting that consolidation had occurred. However, participants in a second condition who were also trained on a second task, which occurred immediately following the first task, demonstrated an interference effect for the first task. In this case enhanced performance was only seen with regards to the second task the participants had learnt, and not the first. One possible reason for this is that the second task may stop the first task being consolidated into memory (Tong, Wolpert, & Flanagan, 2002).

However, Walker et al. (2003) found that the amount of time that occurs between learning task one and learning task two is important. A group of participants in the study were trained in the second task six hours after they had learnt the first task. Unlike those in the group who were trained in the second task immediately after the first task, the interference effects were not replicated (see also Shadmehr & Brashers-Krug, 1997). The authors suggest that this could mean that the space of six hours (during which the participant was awake) between learning tasks one and two could stabilise the memory of the first task, reducing the vulnerability of the memory and resulting in no interference effect. Shadmehr and Holcomb (1999) trained participants in a second task either ten minutes or five and a half hours after the learning of the first task. For participants in the ten minute condition poorer performance for task one was demonstrated, suggesting that learning the second task had interfered with the memory for the first task, however, this was not the case when five and half hours had occurred between the learning of both tasks (see also Shadmehr & Holcomb, 1997; Tong, Miall, Jenkinson, & Kulkarni, 2004; Tong, Wolpert, & Flanagan, 2002; Wigmore, Tong, & Flanagan, 2002). This has been the case with several different types of tests such as visuomotor rotations (Shadmehr & Brashers-Krug, 1997; Shadmehr & Holcomb, 1997; Shadmehr & Holcomb, 1999), and kinematic transformations (Krakauer, Ghilardi, & Ghez, 1999). These studies demonstrate how susceptible newly learnt actions for a task are to interference especially if a second task or action is learnt in a short period of time following the learning for the first task.

Findings also suggest that if a memory is recalled after it has been consolidated then that memory may once again be vulnerable (Walker et al., 2003; see also Misanin, Miller, & Lewis, 1968). An additional group of participants in the Walker et al. (2003) experiment were trained in the first task on day one, and on day two participants were asked to practice the first task prior to learning the second task. When participants were tested, participant's performance decreased for the first task suggesting that interference had occurred. This suggests that retrieving the memory (during practice on day two) left that memory vulnerable to interference by the second task (see also Krakauer & Shadmehr, 2006). Brashers-Krug, Shadmehr, and Bizzi (1996) also demonstrated how memories may change from a vulnerable state when they are first learnt or experienced, to more solid memories as they are stabilised and consolidated (see also Shadmehr & Holcomb, 1997). Consolidation may also play a role in generalisation, for example, Witt, Margraf, Bieber, Born, and Deuschl (2010) found that after learning a sequential finger tap task participants were able to generalise that to their right hand after consolidation.

The study of actions and the possibility of being able to inhibit actions is a timely question. If unwanted memories were able to flood into the mind when an individual is attempting to access a target memory then this may make successfully retrieving the item very difficult. Additionally, if no mechanism is in place to stop unwanted memories accessing the mind then the mind may become flooded with information, therefore the mind will be more error prone than it currently is (Anderson, 2003). This may also apply to memories related to actions. For example, if a pen is presented to an individual, some possible actions that the individual may be able to complete would be to write a letter, stir a drink, or poke a table. The context will aid the choice of which action the individual needs to use, for example, if a piece of paper was present then it would suggest that the individual should use the pen to write. In order to allow that action to be completed other actions would need to be 'temporarily forgotten'. If this was not the case, then it would be possible for the other actions to flood the mind when the individual attempts to retrieve the target item, this in turn may make completing the task of writing a note more difficult, and could mean that the task is not completed, or completed incorrectly. Additionally, actions usually need to be completed in a timely manner, and if the target action and the unwanted information are also in the mind, then the action may not be completed in a timely manner. Actions typically consist of several motor sequences, for example, if the action were to boil the kettle, several motor sequences would be involved. For example some of the motor sequences would include lift the kettle, turn the tap and so on. These motor sequences would come together to form an action, and actions would come together in order to allow a task to be completed. Therefore in order to examine retrieval-induced forgetting and actions it is necessary to look at motor sequences, actions and goal-orientated actions. This first experiment will therefore look at whether retrieval-induced forgetting occurs for motor sequences.

Aims and Predictions

A natural progression from previous research (e.g. Koutstaal et al., 1999) may be to study retrieval-induced forgetting in actions themselves and one place to start may be with motor sequences. The aim of the present experiment was to examine retrieval-induced forgetting in memory for actions; specifically whether retrieval-induced forgetting occurs for novel motor sequences. The experiment also aimed to examine cross-category inhibition that is, whether unpracticed items from an unpracticed category which only differed from the practice items in one aspect, would also be subject to retrieval-induced forgetting (Anderson & Spellman, 1995; see also Saunders & MacLeod, 2006). In this experiment this would be done through training participants in motor sequences, and then rehearsing a sub-section of the motor sequences that they had been trained in. Participants were asked to respond to images on the computer screen with a specific hand and thumb orientation, meaning that participants had to use either their left or right hand to touch the response box, and place their thumb either on the top, bottom, left or right position on a touch screen computer.

Retrieval practice led to several item types of interest. Items which were practiced are known as Rp+ items which require a certain hand and thumb orientation (e.g. right hand-thumb left) as a response. Rp- items require the same hand and thumb orientation as Rp+ items but were not practiced and so should create retrieval competition on both dimensions. There were also Nrp items which are items which are not practiced and the hand and thumb orientation combinations may differ to the combinations used for the Rp+ items and the Rp- items. Nrp items were further divided into three subcategories. These were Nrp-orientation (Nrp-O), Nrp-handedness (Nrp-H), and Nrp-dissimilar items (Nrp-D). Nrp-orientation items were items which differed to the Rp+ items on the thumb orientation variable (i.e., top, bottom, left or right) but shared the same hand with the Rp+ items. Nrp-handedness items differed from Rp+ items on the hand variable (i.e., left or right) but shared thumb orientation with the Rp+ items. Nrp-dissimilar items differed from Rp+ items on both the thumb orientation and hand variable and, thus, should not create retrieval interference with regards to the Nrp-dissimilar items.

It was predicted that participants would accurately recall more motor sequences and also perform the motor sequences quicker for Rp+ items compared to Nrp-dissimilar items. It was also predicted that participants would demonstrate less accurate recall along with slower reaction times for Rp- items compared to Nrp-dissimilar items due to these items competing with the practiced items as they share both the hand and thumb orientation variables with the Rp+ items. Additionally, it was predicted that Nrp-handedness and Nrp-orientation items would be recalled less accurately, and also demonstrate slower reactions, compared to Nrp-dissimilar items as these compete with Rp+ items on either the hand or the orientation variable.

Method

Participants and Design

One hundred and thirty participants took part in the experiment (105 female, 25 male participants, *M* age = 28.09) in exchange for four course credits or £5. A within subjects design was employed whereby item type had five levels: Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category), Nrp-orientation items (unpracticed items from an unpracticed category, differing from Rp+ items in thumb orientation), Nrp-handedness items (unpracticed items from an unpracticed category, differing from Rp+ items in the hand variable), and Nrp-dissimilar items (unpracticed items from an unpracticed category, differing from Rp+ items in both the hand and thumb orientation variables) in the retrieval practice condition (see Figure 15). The data collected from participants in the control condition was represented by one figure as different levels of item types were not used. Each condition contained sixty-five participants.

Figure 15: Example of Image and Responses Used as Stimuli in Experiment 1

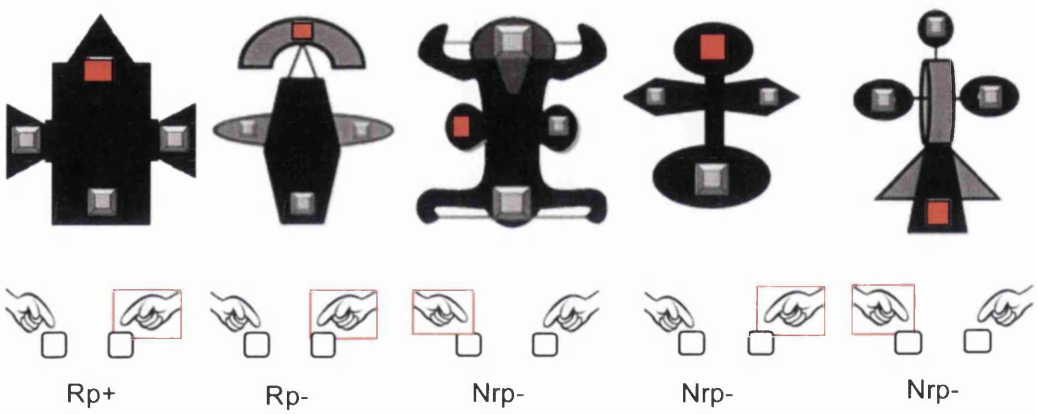


Figure 15. The objects in this figure represent five out of the ten objects used during the experiment. Each object represents an item type (i.e. Rp+, Rp-, Nrp-O, Nrp-H or Nrp-D). Participants were required to use their right or left hand to press a response box (demonstrated by the hand in the figure above) and the press one of four buttons on the screen (i.e. right, left, top or bottom) (demonstrated by the red boxes on the image).

Stimuli

The stimuli were constructed in Adobe Photoshop GS2. Each stimulus consisted of four buttons (top, bottom, right, and left) (see Figure 15 for examples and Appendix A for full list of stimuli). For each stimulus one of the buttons on the image was correct, whilst the other three buttons were incorrect. Correct and incorrect responses were indicated through auditory feedback. Prior to pressing a button on the image on the computer screen participants were required to use their left or right hand to press the left most or right most buttons on a response box. The experiment was designed and run on E-Prime software.

Apparatus

The experiment was presented to participants on a Mitsubishi NEC MultiSync high-resolution 15-inch LCD touch-screen monitor. Participants were seated approximately 60cm away from the screen on an adjustable chair. A serial response box was used to record which hand the participant was using for the stimuli presented on screen.

Procedure

Participants arrived at the laboratory and were greeted by a female researcher. Participants began by completing a learning (i.e. study) phase that required the participants to learn the correct hand and thumb orientation response, which included pressing a button on a response box and a button on the monitor in response to different images. Participants were required to press the left or right button on the response box with either their left or right hand, and then press the top, bottom, left or right button on the screen with their thumb. Participants were provided with a cue at the bottom of the screen stating which hand and thumb orientation they should use (e.g., right hand-bottom button), and were also given auditory feedback which told them if the response they had made was correct or incorrect. If participants gave an incorrect response, they were required to try again, and to continue trying until a correct response was made. A correct response required the participants to press the correct button on the response box and press the correct button on the image on screen. An error on either the response box or on the screen would constitute an incorrect response. The learning phase did not proceed to the next image until the participant performed the correct motor sequence. Ten different images were presented three times, a total of thirty, and the order was randomised.

On completion of the first trial of the learning phase participants then took part in a test phase, where they were required to score 70% or more correct in order to continue to the retrieval practice phase. During this test phase participants were given auditory feedback in order for the participants to track their performance, however, the screen progressed to the next image regardless of whether or not the answer given for the previous image was correct or not. Participants were shown each image once (a total of ten). If participants failed to score 70% or more correct they were required to complete the learning phase again. After the first learning trial, all further trials were only guided by auditory feedback (i.e., no cue appeared at the bottom of the screen) in order to encourage the use of retrieval strategies to learn the motor sequences. The stimulus continued to be displayed until participants made the correct responses. At the end of this retrieval practice phase participants were tested again. This pattern of learning trial and test phase continued until the participant achieved 70% or more correct in the test phase.

After participants achieved 70% or more correct responses in the test phase, participants in the retrieval practice condition continued onto the retrieval practice phase. During this phase participants were asked to respond to two of the previously studied images with the correct hand and thumb orientation combination. Participants were provided with auditory feedback indicating if the response provided was correct or incorrect. If participants did provide an incorrect response participants were required to continue trying until a correct response was given, at which point, the next image would then be displayed. No written cue was provided. The two images were presented three times during each retrieval practice phase, and each phase was interleaved with verbal word generation tasks. These word generation tasks were verbal in nature so that participants did not perform the action of writing or typing which may have contaminated the actions. Each participant completed three retrieval practice phases, therefore, participants saw the images a total eighteen times during retrieval practice, a total of nine for each image. Participants in the control condition did not complete retrieval practice but were asked to complete a series of verbal word generation tasks.

All participants then completed a final test for all the images which was identical to the test phase of the learning trials; that is, auditory feedback was provided to allow participants to track their own progress; however, the screen progressed to the next image even if the response provided by the participant for the previous image was incorrect (see Figure 16 for summary of the method used during the experiment). Participants were shown each of the ten images once. During this test phase the computer recorded the participants' performance, recording whether their response was correct or incorrect and their reaction time for each item. Participants were thanked for their participation and debriefed fully at the end of the experiment.

Figure 16: Summary of Method Used and the Trails/Items Involved in the Experiment 1

Method	Trials
Learning Phase (Study) Participants asked to respond to images on the screen with specific hand and thumb orientation.	**Trials (Learning Phase)** There were 10 images and each image was shown 3 times, a total of 30. Of the 10 images there were 2 Rp+, 2 Rp-, 2 Nrp-O, 2 Nrp-H and 2 Nrp-D. Each item type was shown 6 items.
Test Phase Participants tested on memory of actions for the images. Participants required to achieve 70% correct to progress. If they failed to score 70% or more they returned to the learning phase. This pattern continued until 70% or more was achieved in this test phase.	**Trials (Test Phase)** Participants were shown each image only once, therefore, participants were shown a total of 10 images. Of the 10 images there were 2 Rp+, 2 Rp-. 2 Nrp-O, 2 Nrp-H, and 2 Nrp-D items. Each item type was therefore shown twice.
Retrieval Practice Phase Participants practised two images from the learning phase. Control participants did not complete retrieval practice.	**Trials (Retrieval Practice)** Participants practice 2 Rp+ items three times per retrieval practice phase, a total of 6. Retrieval practice was completed a further two times, a total of 18. That is 9 for each Rp+ item.
Recall Phase Participants tested on memory of actions for the images. Data on number of errors and reaction times collected.	**Trials (Recall Phase)** Participants were shown each image only once, therefore, participants were shown a total of 10 images. Of the 10 images there were 2 Rp+, 2 Rp-. 2 Nrp-O, 2 Nrp-H, and 2 Nrp-D items. Each item type was therefore shown twice.

Figure 16. The left hand side of the figure shows a summary of the method used and the right hand side shows the trial and item type information for experiment 1.

Results

Recall Accuracy

Recall data was collected via successful execution of the motor sequence which required both the correct hand and thumb orientation to be selected. The results were analysed through comparing participant's results in the retrieval practice condition for Rp+ items, Rp- items, Nrp-orientation items, and Nrp-handedness items with Nrp-dissimilar items (baseline measure). A total score for all items (Rp+, Rp-, Nrp-orientation, Nrp-handedness and Nrp-dissimilar items) in the retrieval practice condition was compared with the total score for the control condition as no individual items were present in the control condition as participants did not complete retrieval practice. In order to examine reaction times response times for the correct answers were examined. In addition, participants who took more than 4000ms to complete an action were removed from the analysis ($N = 53$). As those participants were removed from the reaction time data they were also removed from the accuracy data.

Table 1: Mean Proportion Recall Performance for Participants in the Retrieval Practice Condition for Each Item Type

	Rp+	Rp-	Nrp-O	Nrp-H	Nrp-D	Total
Retrieval Practice	0.91	0.60	0.58	0.54	0.76	0.68
Condition	(.26)	(.41)	(.39)	(.35)	(.33)	(.19)

Note. Retrieval practice condition item type: Rp+ items (practiced items from a practiced category), Rp- items (required the same hand and thumb orientation as Rp+ items but were not practiced), Nrp-orientation (Nrp-O) items (differed to Rp+ items on the thumb orientation variable (i.e., top, bottom, left or right)), Nrp-handedness (Nrp-H) items (differed from Rp+ items on the hand variable (i.e., left or right)), and Nrp-dissimilar (Nrp-D) items (differed from Rp+ items on both the thumb orientation and hand variable). None of the Nrp items were practiced. The total score for the retrieval practice condition were calculated by collapsing the scores of all five item types. No separate item types were used in the control condition. Ten participants were removed from the control condition (RT for correct actions > 4000ms) (N = 55). Control condition M = .65 (SD = .18). Standard deviations are presented in parentheses (see Appendix B for raw data).

Facilitation effects were examined through comparing Rp+ items with Nrp-dissimilar items. In the retrieval practice condition mean recall performance was higher for Rp+ items compared to Nrp-dissimilar items, suggesting that performance for Rp+ items was facilitated. Paired-samples t-test analysis demonstrated that this facilitation effect was significant, $t\ (52) = 2.39, p < .05$, supporting the notion that practice facilitates memory.

In order to examine retrieval-induced forgetting effects a within subjects ANOVA for the retrieval practice condition was conducted to begin with consisting of Rp- items, Nrp-orientation items, Nrp-handedness items and Nrp-dissimilar items. A significant main effect of item type was found, $F(3, 156) = 4.42, p < .001$. Rp- items, Nrp-orientation items, and Nrp-handedness items were compared separately to Nrp-dissimilar items to examine retrieval-induced forgetting and cross-category inhibition effects. Participants mean recall performance for Rp- items was less than that of Nrp-dissimilar items. A paired samples t-test demonstrated that the difference was significant, $t(52) = -2.26, p < .05$, suggesting that retrieval-induced forgetting occurred with Rp- items did occur, when compared to Nrp-dissimilar items.

Nrp-orientation and Nrp-handedness items were compared to Nrp-dissimilar items to examine cross-category inhibition effects. Nrp-orientation items utilised the same hand as Rp+ items but differed on the thumb orientation variable. Mean recall performance for Nrp-orientation items was lower than Nrp-dissimilar items. This difference was significant, $t(52) = -2.66, p = .01$. Nrp-handedness items utilised the same thumb orientation as Rp+ items but differed on the hand variable used. Participants correctly recalled fewer Nrp-handedness items compared to Nrp-dissimilar items. This difference was significant, $t(52) = -3.80, p < .001$. This suggests that cross-category inhibition occurred for Nrp-orientation and Nrp-handedness items.

Recall data for the five item types (Rp+, Rp-, Nrp-orientation, Nrp-handedness and Nrp-dissimilar items) in the retrieval practice condition was combined and compared to data from the control condition (no item types existed for the control condition as no retrieval practice occurred). Recall performance in the retrieval practice condition (M = .68) on the whole slightly better than the control condition (M = .65). This difference was not significant, $t(106) = .43$, *n.s.*

Reaction Times

It is not only important to correctly execute a motor sequence but also to do so in an efficient and timely manner. The length of time taken to execute the actions was also examined using reaction times for each item. As with the recall data Rp+, Rp-, Nrp-orientation, and Nrp-handedness items were compared with Nrp-dissimilar items (see Table 2) in the retrieval practice condition. Mean reaction time for the items in the retrieval practice condition were combined and compared with the mean reaction time in the control condition. Reaction times were split into three categories: hand only (reaction time for pressing the response box), orientation only (reaction time for pressing the button on the screen) and combined (reaction time for both the hand and orientation). In order to examine reaction times response times for the correct answers were examined. In addition, participants who took more than 4000ms to complete an action were removed from the analysis.

Table 2: Mean Proportion Reaction Times for Participants in the Retrieval Practice Condition for Each Item Type for Correct Responses

	Rp+	Rp-	Nrp-O	Nrp-H	Nrp-D	Total
Retrieval Practice Hand	1356.50 (851.32	1585.01 (1181.11)	1691.04 (1395.49)	1667.99 (1145.84)	1748.26 (1056.47)	1609.76 (654.56)
Retrieval Practice Orientation	883.05 (492.41)	847.61 (681.43)	891.69 (729.81)	949.24 (881.63)	962.67 (719.15)	891.24 (437.93)
Retrieval Practice Combined	1139.55 (578.61)	1199.92 (826.06)	1289.05 (900.62)	1308.62 (856.69)	1355.47 (692.52)	1250.85 (439.85)

Note. Reaction times in the table are measured in milliseconds. Five items on interest in the retrieval practice condition: Rp+ items (practiced items from a practiced category), Rp- items (required the same hand and thumb orientation as Rp+ items but were not practiced), Nrp-orientation items (differed to Rp+ items on the thumb orientation variable (i.e., top, bottom, left or right)), Nrp-handedness items (differed from Rp+ items on the hand variable (i.e., left or right)), and Nrp-dissimilar items (differed from Rp+ items on both the thumb orientation and hand variable). Nrp items were not practiced. The total score (retrieval practice condition) were calculated by collapsing the scores for all five item types. No separate item types were used in the control condition. Control condition hand reaction time M = 2107.52ms (SD = 779.88); orientation reaction time M = 877.68ms (SD = 1262.88); and combined reaction time M = 1507.09ms (SD = 403.48). Standard deviations are presented in parentheses.

Hand Reaction Times

In order to determine whether retrieval practice increases the speed of execution of motor sequences, reaction times for Rp+ items was compared to reaction times of Nrp-dissimilar items. Mean reaction times for Rp+ items were quicker than Nrp-dissimilar items. A t-test found that the difference was significant, t (52) = -2.21, $p < .05$, suggesting that practice not only facilitates the accurate recall of items but also facilitates the speed to execution of response.

A within subjects ANOVA for the retrieval practice condition including Rp-, Nrp-orientation, Nrp-handedness and Nrp-dissimilar items was conducted to examine retrieval-induced forgetting and cross-category inhibition effects. No significant main effect of item type was found F (3, 156) = 2.02, *n.s.* This suggests that no retrieval-induced forgetting or cross-category inhibition occurred for the hand only data. As with the recall data, all five item types were combined in terms of reaction time data and compared with the hand data collected from the control condition. Participants in the retrieval practice condition performed quicker than participants in the control condition with regards to response box (i.e. hand) reaction time. This difference was significant, t (106) = -3.59, $p < .05$.

Orientation Reaction Times

Orientation reaction times (reaction times for pressing the button on the screen) were also analysed. Mean reaction times (retrieval practice condition) for Rp+ items were quicker than mean reaction times for Nrp-dissimilar items, suggesting that facilitation had occurred for the practiced items. This difference was found to be significant in a paired sample t-test, t (52) = -4.83, $p < .001$.

A within subject ANOVA examining retrieval-induced forgetting and cross-category inhibition in the retrieval practice condition was performed. Included were reaction times for Rp-, Nrp-orientation, Nrp-handedness and Nrp-dissimilar items. The results demonstrated no significant effect of item type F (3, 156) = .38, *n.s.* This suggests that as with the hand only reaction time data no retrieval-induced forgetting or cross-category inhibition seems to have occurred in relation to the orientation only reaction time data. Orientation reaction times for all five items were also combined and compared to orientation reaction times for the control condition. Participants in the control condition performed slower than participants in the retrieval practice condition. An independent samples t-test found that this difference was not significant, t (106) = .20, *n.s.*

Hand and Orientation Combined Reaction Times

Reaction time data for hand and thumb orientation were also combined to provide an overall figure of the participants' reaction time. Rp+ items were compared with Nrp-dissimilar items to determine whether retrieval practice increases the speed of execution of motor sequences. The descriptive data suggests that participants in the retrieval practice condition performed quicker for Rp+ items compared to Nrp-dissimilar items. A paired-samples t-test found that this difference was significant, t (52) = -2.40, $p < .05$. These results suggest practice facilitates memory in terms of reaction times.

A second within subjects ANOVA for the retrieval practice condition was performed including Rp-, Nrp-orientation, Nrp-handedness, and Nrp-dissimilar items. A significant effect of item type was found F (3, 156) = .29, *n.s.* This may suggest that no retrieval-induced forgetting or cross-category inhibition effect were found for the combined reaction time data. Reaction time data for the combined hand and thumb orientation for the five item types in the retrieval practice condition were combined and compared with the reaction time data for combined reaction time of hand and orientation in the control condition. Participants in the control condition performed slightly slower compared to the retrieval practice condition. An independent t-test found a statistical difference between the two conditions, t (106) = -3.16, $p < .05$.

Discussion

Previous research has demonstrated a retrieval-induced forgetting effect with a wide range of different stimuli, for example words (Anderson et al., 1994; Anderson & Spellman, 1995), coloured objects and shapes (Ciranni & Shimamura, 1999), photographs of actions (Koutstaal et al., 1999), false recognition (Starns & Hicks, 2004) and eyewitness memory (Shaw et al., 1995; MacLeod, 2002). The aim of the current experiment was to examine retrieval-induced forgetting in memory for actions, specifically motor sequences. Additionally, cross-category inhibition effects, that is whether items which differed from the practiced items in one aspect (i.e. either the hand or thumb orientation variables) were examined. It was predicted that participants would correctly recall and respond quicker to motor sequences that they had practiced (i.e. Rp+ items) compared to the Nrp-dissimilar items (items which differed to the Rp+ items in both the hand and orientation variable, and were not practiced). It was also predicted that participants would demonstrate poorer recall performance, and slower reaction times for Rp- items (items which required the same hand and thumb orientation response as Rp+ items but were not practiced) when compared to the Nrp-dissimilar items. Nrp-handedness items (which differed from Rp+ items on the hand variable i.e. left or right) and Nrp-orientation items (which differed to Rp+ items on the orientation variable i.e. top, bottom, left or right) were expected to be remembered more poorly, with slower reaction times compared to Nrp-dissimilar items as these items compete with Rp+ items on the hand or orientation variable.

Analysis of the reaction time data found that participants had responded significantly quicker for Rp+ items compared to Nrp-dissimilar items. Participants also accurately recalled more Rp+ items compared to Nrp-dissimilar items. Participants also responded slower to, and remembered fewer Rp- items compared to Nrp-dissimilar items. These findings suggest that a facilitation effect occurred for Rp+ items, whilst retrieval-induced forgetting occurred for Rp- items. These findings of a facilitation effect and a retrieval-induced forgetting effect are in line with previous retrieval-induced forgetting research (Anderson et al., 1994; see also Anderson & Spellman, 1995). The findings of the accuracy and reaction time data therefore suggest that practice of items not only improves recall for those times but also facilitates the speed at which we are able to recall the items. However differences were found between the results for the accuracy data and the reaction time data.

Additionally, cross-category inhibition effects were seen during the experiment. Cross-category inhibition refers to items from an unpracticed category which may have been impacted upon due to their relationship with the practiced category, for example, in the current experiment through either the hand or orientation variable. These cross-category inhibition effects were found for Nrp-handedness items, where participants performed slower in terms of reaction times and also demonstrated poorer recall suggesting that cross-category inhibition had occurred, and that this may have occurred because these items shared the orientation variable with Rp+ items. This was also the case with Nrp-orientation items with regards to the recall performance. Nrp-orientation items shared the hand variable with the practiced items (i.e. Rp+ items). These findings suggest that orientation and handedness may be a potent source of interference in performing actions correctly which can be resolved through retrieval-induced forgetting. These findings of cross-category inhibition for recall performance supports previous studies such as Anderson and Spellman (1995), and Saunders and MacLeod (2006) and extend to memory for more complex items such as memory for motor sequences. These findings suggest that retrieval competition occurred between items that shared both the hand and orientation variables, or shared either the hand or orientation variables with the Rp+ items. In order to resolve this competition, inhibitory processes may inhibit the competing items, resulting in a less accurate recall performance. The lack of retrieval-induced forgetting and cross-category inhibition effects for reaction times were not in line with the predictions of the experiment. There may be several possible reasons for why this occurred. Firstly, there may genuinely be no effect for the data in the current experiment. Secondly, removal of incorrect data may have decreased the chances of finding an effect. Finally, participants may have responded as quickly as possible in their response (as instructed in the instructions of the experiment). The descriptive data however suggest a possible trend for items involved in retrieval-induced forgetting and cross-category inhibition, although these trends were small. This may suggest that further research in the area may be required. A limitation of the current experiment may also include that there were only two images (therefore two responses) for each item type. For example, there were two Rp+ items. This may have also have had an impact on the findings. Future research may also examine this aspect, for example, considering increasing the number of trials and number of stimuli per item type.

As previously mentioned however the finding of a retrieval-induced forgetting effect and cross-category inhibition effects for accuracy data would seem to support the inhibitory theory. Two models of inhibition which have been put forward which may explain retrieval-induced forgetting and cross-category inhibition effects are the lateral inhibition and the pattern suppression accounts. The lateral inhibition account (Blaxton & Neely, 1983) suggests that activation spreads from the retrieval cue associated with a category to exemplars, and the account can also account for cross-category inhibition. For example, if a participant is given the pairing Red-Blood during the retrieval practice phase then the activation may spread from this pairing to other items which may be related to Red, for example, Food-Strawberry. Anderson and Spellman (1995) have suggested that strawberry might also be affected, even though it was studied under a different category cue, as it is also Red; that is that retrieval of Food-strawberry may be affected through lateral inhibition (Anderson & Spellman, 1995).

Although lateral inhibition seems to be a better account for these findings than non-inhibitory theories, there is also a second inhibitory theory, the pattern suppression account, which can account for these findings. Pattern suppression suggests that whether an Rp- item is retrieved is dependent upon its net facilitation from its associations with the Rp+ item and its net inhibition. For example, if more semantic features are facilitated than forgotten then the item will be recalled. This account also explains cross-category inhibition as the account assumes that memories are composed of semantic feature units meaning that Nrp items may be inhibited if the items shared some inhibited features with the Rp- items or were inhibited due to their competition with the Rp+ item (Saunders & MacLeod, 2006). In this case the current experiment may provide some support for the pattern suppression account. If it is assumed that memory for motor sequences is also composed of feature units in the same way as semantic verbal memory then the Nrp-handedness and Nrp-orientation items may have shared some features with the Rp+ and Rp- items, sharing either the hand or orientation variables (Saunders & MacLeod, 2006). This is supported by the finding of a cross-category inhibition for both the Nrp-handedness and the Nrp-orientation items, and retrieval-induced forgetting for the Rp- items.

Previous research has demonstrated that interference can occur with regards to objects and actions. For example, Jax and Buxbaum (2010) (see also Ansuini, Giosa, Turella, Altoe, & Castiello, 2008) proposed that more than one action can be associated with an object, and that these actions can have different functions, for example, a functional action (e.g. using the object) and a structural action (e.g. grasping the object). The data suggested that interference could occur for the actions, and although the study did not use retrieval-induced forgetting as done in this particular experiment, it does suggest that interference can occur for actions and objects. Additionally, previous research with photographs of novel actions (Koutstaal et al., 1999) seems to demonstrate a retrieval-induced forgetting effect. Participants in the Koutstaal et al. (1999) study viewed photographs of novel actions in the retrieval practice condition; therefore a progression of this would be to have participants perform actions themselves during retrieval practice. Furthermore, Sharman (2011) has demonstrated a retrieval-induced forgetting effect for bizarre and familiar self-performed actions, although no effect was found for observed actions. These findings along with those of the current experiment therefore suggest that retrieval-induced forgetting can occur for actions.

The findings of the current experiment also support the notion that motor sequences which have recently been learnt are susceptible to interference (Walker et al., 2003; see also Shadmehr & Brashers-Krug, 1997; Tong, Wolpert, & Flanagan, 2002). This suggests that learning several actions in a short period of time can cause interference for some of those actions. Previous research has demonstrated that learning a second task a short time after learning a previous task can cause interference for the first task (Tong, Wolpert, & Flanagan, 2002; Walker et al., 2003). Research has also suggested that if a period of time occurs between the two tasks then this interference does not occur, and performance on the first task is not hindered. For example, Walker et al. (2003) found that this was the case if six hours occurred between learning task one and learning task two. Walker et al. suggests that this period allows the memory of the first task to be stabilised. Additionally, Walker et al. found that if participants recalled the first task (which had been stabilised or consolidated) shortly before learning the second task then, the first task would again become vulnerable.

The study of inhibition in behaviour is an important and timely one given that adaptive functions have been proposed and suggests that this may play a role in forgetting everyday memory. Inhibition in memory for actions may allow the contextually inappropriate actions to be inhibited allowing the appropriate actions to be carried out. For example a pen could be used in several ways depending on the context. A pen could be used to write a letter or stir a cup of tea. If the contextually appropriate action is to use the pen to write then the inappropriate action (i.e. stirring a cup of tea) would need to be inhibited. More importantly, however, inhibition would allow the more typical use of the pen to be inhibited if one was presented with a cup of tea and no spoon, and would be a prediction which would be consistent with the inhibitory theory (Anderson et al., 1994). However, at present there is little research into inhibitory mechanisms and actions, although it is essential to discover if retrieval-induced forgetting plays a role with actions, especially to see the role of inhibition in inhibiting contextually inappropriate actions for several reasons. Firstly, using an inappropriate action could lead to social conflict, and secondly, using a contextually appropriate action could lead to harm.

In conclusion, the experiment found evidence of facilitation for Rp+ items in terms of both recall performance and speed of response. Retrieval-induced forgetting occurred for Rp- items with regards to recall performance. Cross-category inhibition effects were also found with participants demonstrating poorer performance Nrp-handedness and Nrp-orientation items suggesting that the use of a different hand and thumb orientation impacts on both recall performance. However no retrieval-induced forgetting or cross-category inhibition effects were seen in terms of reaction times. This may suggest an interesting dichotomy between performance for recall performance and reaction times, which may be a focus of future research. However future studies would also have to take into account the value of the reaction time data given the large standard deviations found in the current experiment. The findings support the notion of inhibitory mechanisms playing a role in memory for actions, allowing inappropriate actions to be inhibited and appropriate actions to be expressed. However, the motor sequences used in the current experiment were newly learnt motor sequences; therefore, it could be argued that retrieval-induced forgetting only occurs in the case of newly learnt motor sequences. Future research could examine whether retrieval-induced forgetting would also occur for more established actions.

Chapter 4

Retrieval-Induced Forgetting and Objects and Actions

Experiment 2A

Background

The previous experiment examined whether retrieval-induced forgetting may occur for novel motor sequences. The findings demonstrated retrieval-induced forgetting, suggesting that retrieval-induced forgetting may occur for motor sequences. As these were novel motor sequences, and were newly learnt, it could be argued that retrieval-induced forgetting may only occur for newly learnt motor sequences and not for actions or more familiar actions. Many of the actions individuals perform as part of daily life are not necessarily novel in nature. This suggests that it is important to also examine retrieval-induced forgetting in terms actions which are less novel in nature. In addition, several motor sequences come together to form an action, and several actions come together to allow individuals to perform and complete tasks. As such it is necessary to examine retrieval-induced forgetting in terms of motor sequences, actions, and goal-orientated actions. Actions performed by individuals every day are likely to be performed with the objects physically present, with the individual able to interact and use the object in order to successfully complete the actions (e.g. pen, saucepan, and string). Experiment 1 looked at retrieval-induced forgetting and motor sequences; therefore for experiment 2 will expand on the findings of experiment 1 and begin to look at retrieval-induced forgetting actions, specifically through examining whether retrieval-induced forgetting occurs for the objects used with actions.

Previous research into retrieval-induced forgetting and actions have found a retrieval-induced forgetting effect with images of novel actions (Koutstaal et al., 1999) and self-performed familiar and bizarre actions (Sharman, 2011). The possibility of being able to inhibit or 'temporarily forget' actions is an important question, as is the possibility of being able to inhibit the related but unwanted objects. For example, if an individual wanted to perform the action of write, and was presented with a pen or a stick, then the most appropriate object to use to complete the task would be the pen, therefore the question posed is whether it is possible that the unwanted objects can be suppressed allowing the most appropriate and target objects to be selected to allow the action to be completed.

The current experiment will involve objects being physically present during the experiment. The objects will be presented to the individual as and when the object is required during the course of the experiment. However, the use and role of objects in memory for action research is somewhat debated. Memory for action studies often either involve the use of actual objects (Backman et al., 1986; Kormi-Nouri & Nilsson, 1999; Nilsson & Backman, 1989), or imagined objects (Engelkamp & Zimmer, 1983; Engelkamp & Zimmer, 1996; Kormi-Nouri, 2000). Several studies have demonstrated that self-performed actions with the objects present have a greater enactment effect compared to actions involving imagined objects (Backman & Nilsson, 1984; see also Hornstein & Mulligan, 2004). Other findings have suggested that the presence of objects may not influence the size of the enactment effect (Engelkamp & Zimmer, 1983; Engelkamp & Zimmer, 1997). The episodic integration account of the enactment effect proposes that during self-performance actions and objects may become integrated (Kormi-Nouri, 1995; see also Kormi-Nouri & Nilsson, 1998). This suggests that a relationship exists between the action and the object. As objects are key components of actions and in light of the likelihood that in everyday life the necessary objects would more often than not be present to complete actions with, it seems appropriate that actual objects are used in the current and following experiments, and the object (Experiment 2) and action (Experiments 3 and 4) components are both considered.

In addition to examining retrieval-induced forgetting and objects the current experiment will also examine whether an enactment effect occurs for self-performed items compared to observed items. Previous memory for action research has demonstrated better recall performance for self-performed actions (i.e. SPT) compared to observed actions (i.e. EPT) (Hornstein & Mulligan, 2004; Engelkamp & Zimmer, 1989). Steffens (2007) however failed to find a difference between the self-performed and observed conditions (see also Cohen, 1981; Cohen & Bean, 1983). Therefore there is a mixture of findings relating to whether an enactment occurs for self-performed actions compared to observed actions. One proposed reason suggested for this is difference in methodology such as the length of lists used in different experiments (Engelkamp & Dehn, 2000). Participants in the current experiment will either self-perform the action with each of the objects during the study and retrieval practice phases, observe the actions being performed with each object by the researcher during the study and retrieval practice phases, self-perform the actions with the objects in the study phase and observe them during retrieval practice phase, or observe the actions being performed with the objects in the study phase and self-perform them during the retrieval practice phase. The above research demonstrates the possible differences which could occur between actions which are performed by the individual themselves and those where individuals observe them being performed by others, and the role that having objects present may play.

Aims and Predictions

The aim of the current experiment was to examine retrieval-induced forgetting in memory for the objects used with actions. During the experiment participants would be asked to either self-perform or observe eight actions being performed with four different objects (e.g. wipe-dish, screen, mirror and table). Retrieval practice led to several item types of interest: Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category), and Nrp items (unpracticed items from an unpracticed category). It was predicted that participants would correctly recall more Rp+ items compared to Nrp items (baseline measure), demonstrating a facilitation effect. It was also predicted that participants would recall fewer Rp- items compared to Nrp items, demonstrating a retrieval-induced forgetting effect. It was also predicted that a difference may occur between the recall performance of participants in the self-performed and observation conditions.

Method

Participants and Design

One hundred participants (64 females, 36 males, *M* age = 22.08) completed the experiment in exchange for two course credits or £3. A mixed design was employed with one within subject factor and one between subject factor. The within subject factor of item type consisted of three levels: Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category), and Nrp items (unpracticed items from an unpractised category). The between subject factor of action task (i.e. condition) consisted of four levels: a self-performed/self-performed condition during which participants performed the actions with each object themselves during the study and retrieval practice phases, a observation/observation condition where participants observed the researcher perform the actions with each object during both the study and retrieval practice phases, a self-performed/observation condition during which participants performed the actions themselves in the study phase and observed the researcher perform the actions in the retrieval practice phase, and a observation/self-performed condition during which participants observed the actions being performed in the study phase and self-performed the actions in the retrieval practice phases. Each condition contained twenty-five participants.

Stimuli and Materials

Stimuli included eight actions with four objects for each action (e.g. knot-string, knot-ribbon, knot-shoelace, and knot-scarf). This gave rise to a total of thirty-two action-object pairs (see Appendix C for a full list of the actions and objects).

Procedure

Upon arrival at the laboratory participants were greeted by a female researcher. During the study phase participants in the self-performed/self-performed and self-performed/observation conditions performed an action with four different objects (e.g. knot-string, knot-ribbon, knot-shoelace, and knot-scarf). Participants in the observation/observation and observation/self-performed conditions observed the researcher perform the actions. The actions were read out to the participants by the researcher. All actions and objects were counterbalanced and all objects were hidden from the participants' line of sight behind a partition during the course of the experiment. Participants were presented with each object individually as and when the object was required. There were eight actions, and four objects for each action, a total of thirty-two action-object pairs.

Following the study phase participants completed the retrieval practice phase. Participants in the self-performed/self-performed and observation/self-performed conditions practiced a subset of previously studied actions and objects; practicing half of the objects from half of the action categories, meaning that the participant practiced two objects with four actions (e.g. knot-string, knot-ribbon), a total of eight action-object pairs. Participant then completed a two-minute verbal word generation task. A verbal task was used in order to ensure that no contamination of the items occurred as may have been the case if participants have completed a written task in place of a verbal task. Participants completed retrieval practice a further two times. Participants in the observation/observation and self-performed/observation conditions observed the researcher perform the actions with the objects during the retrieval practice phase and also completed the verbal word generation tasks. Participants therefore practiced right action-object pairs three times, a total twenty-four. Participants then progressed to the test phase.

During the test phase all participants were shown a written cue consisting of the name of an action and the first two letters of an object used with that action seen during the experiment (e.g. knot-st__). Each cue was presented individually to the participants on a piece of A4 card for 10 seconds. Participants were shown a cue for each of the action-object pairs; therefore, there were thirty-two in total. Rp- items were presented first, followed by the Nrp items and finally the Rp+ items. This was done in order to prevent output interference effects (Perfect et al., 2004; Racsmany, Conway, & Demeter, 2009). Participants were asked to write down the name of the object if they were able to remember it (see Figure 17 for summary of the method used). Participants were thanked for their participation in the experiment and debriefed.

Figure 17: Summary of Method Used and Trials/Items Used in Experiment 2A

Study Phase

Participants studied the action-objects either through performing the action themselves or observing the researcher perform the actions.

Trials (Study Phase)

There were 32 action-object pairs (e.g. knot-string). Each pair was performed once. There were 32 in total. Of the 32, 8 were Rp+, 8 were Rp- and 16 were Nrp.

Retrieval Practice Phase

Half the objects for half the action were practiced. Participants either observed the researcher perform the actions or self-performed the actions. A two-minute distracter task followed. This pattern was repeated a further two times.

Trials (Retrieval Practice Phase)

Participants practiced two objects for four actions. There were therefore 8 Rp+ items. The 8 Rp+ items were practiced 3 times, a total of 24.

Test Phase (Session Two)

Participants were presented with a written cue consisting of the name of the action and first two letters of an object, and asked to write the name of the object down if they could remember it.

Trials (Test Phase)

Participants were presented with each item once (e.g. knot –st). There was one for each action-object pair, a total of 32. There were 8 Rp+ items, 8 Rp- items, and 16 Nrp items.

Figure 17. The above figure shows a summary of the method used (left hand side of the column) and trial and item type information (right hand side of the column) in experiment 2A.

Results

The retrieval practice success rate in the self-performed/self-performed and observation/self-performed conditions was 100%. Memory performance was calculated through successful recollection of the object for an action (see Table 3). Results were calculated through comparing Rp+ items with Nrp items in order to examine a facilitation effect, and comparing Rp- items with Nrp items to examine a retrieval-induced forgetting effect.

Table 3: Mean Proportion Recall Performance for Participants in Each Condition and for Each Item Type

	Item type			Facilitation	Retrieval-induced forgetting
	Rp+	Rp-	Nrp		
Self-performed/	.90	.63	.77	+.13	-.14
Self-performed	(.12)	(.21)	(.12)		
Observation/	.90	.76	.73	+.17	+.03
Observation	(.12)	(.22)	(.15)		
Self-Performed/	.90	.61	.70	+.20	-.9
Observation	(.15)	(.19)	(.16)		
Observation/	.89	.59	.71	+.16	-.12
Self-Performed	(.20)	(.23)	(.17)		

Table 3. There were three item types of interest in each condition, these were Rp+ items (practiced items from a practiced category), Rp- items (unpractised items from a practiced category) and Nrp items (unpractised items from an unpractised category). The difference between Rp+ and Nrp items represents a facilitation effect and the difference between Rp- and Nrp items represents a retrieval-induced forgetting effect. Standard deviations are presented in parentheses (see Appendix D for raw data).

Facilitation effects

When examining a facilitation effect mean recall performance for Rp+ items were compared with the mean recall performance of Nrp items. If a facilitation effect had occurred it would be expected that participants would correctly recall more Rp+ items compared to Nrp items. Table 3 demonstrates that mean recall performance for Rp+ items was higher than Nrp items across all four conditions. The results suggest that a facilitation effect had occurred and that memory for the practiced items (Rp+ items) was facilitated. A 4 (action task: self-performed/self-performed, observation/observation, self-performed/observation or observation/self-performed conditions) x 2 (item type: Rp+ or Nrp) analysis of variance (ANOVA) was performed. A bonferroni correction was applied to account for issues with multiple comparisons.

A significant main effect of item type was found $F(1, 96) = 79.20, p < .001$. There was no significant effect of action task, $F(3, 96) = .58$, *n.s.* No significant item type x action task interaction occurred, $F(3, 96) = .52$, *n.s.* Pairwise comparisons (using bonferroni correction) were performed to further examine these effects. A significant difference occurred between Rp+ and Nrp items (.17, $p < .05$), which demonstrate that mean recall performance was better for Rp+ items compared to Nrp items. These results support the suggestion that a facilitation effect had occurred regardless of whether participants performed the actions themselves or observed the actions being performed.

Retrieval-Induced Forgetting Effects

Retrieval-induced forgetting effects were examined through comparing mean recall performance for Rp- item items with mean recall performance for Nrp items; if retrieval-induced forgetting had occurred it would be expected that mean recall performance for Rp- items would be poorer than Nrp items. Mean recall performance for Rp- items was poorer compared to Nrp items in the self-performed/self-performed, self-performed/observation, and observation/self-performed conditions, suggesting that retrieval-induced forgetting may have occurred in those three conditions. However in the observation/observation condition, mean recall performance for Rp- items was higher than mean recall performance for Nrp items suggesting that no retrieval-induced forgetting occurred in the observation/observation condition.

A 4 (action task: self-performed/self-performed, observation/observation, self-performed/observation, or observation/self-performed conditions) x 2 (item type: Rp- or Nrp) ANOVA was conducted with bonferroni correction applied to account for issues with multiple corrections. A significant main effect of item type, $F(1, 96) = 10.63$, $p < .01$ was found. There was also a significant effect of action task, $F(3, 96) = 2.70$ $p = .05$. No significant two-way interaction occurred between item type and action task, $F(3, 39) = 2.38$, $p = .07$, A series of pairwise comparison tests (using bonferroni corrections) comparing Rp-items with Nrp items were conducted. No significant difference was found in the pairwise comparisons was found between any of the conditions. A significant difference however did occur between Rp- and Nrp items (-.08, $p < .01$), suggesting that on the whole fewer Rp- items were recalled compared to Nrp items suggesting that retrieval-induced forgetting may have occurred.

No significant interaction item type x action task occurred however as the p value was .07 further analysis was conducted. Significant differences occurred between action task (conditions) and item types between the observation/self-performed and observation/observation conditions for Rp- items (.17, $p < .05$). Furthermore a significant difference occurred between Rp- and Nrp items in the self-performed/self-performed condition (-.14, $p < .05$), observation/self-performed condition (-.12, $p < .05$) and self-performed/observation condition (-.12, $p < .05$).

Effect of Action Task on Memory for Control Items (Nrp Items)
In order to determine if asking participants to self-perform the actions with objects benefited memory of the objects more so than observation a between-subject ANOVA was conducted involving only the Nrp recall rates. The main effect of action task was not significant, $F(3, 96) = 1.08$, *n.s*, suggesting that self-performing actions did not improve participant's recall performance for the Nrp items compared to observation of the actions.

Discussion

The aim of the current experiment was to examine whether retrieval-induced forgetting occurred for objects used with actions. Actions performed by individuals as part of their daily lives are likely to be performed with the object physically present. Individuals then interact and use the object in order to complete actions, for example, using a pen to write a note or a spoon to stir a cup of tea. Studying retrieval-induced forgetting in objects is important as selecting the correct or most appropriate object is necessary to aid the successful completion of actions. The current experiment involved objects being physically present during the experiment. Several memory for action experiments have involved the using the objects (Backman et al., 1986; Kormi-Nouri, 1999). Additionally several experiments have involved imagined objects (Engelkamp & Zimmer, 1983; Kormi-Nouri, 2000). It was predicted that in the current experiment participants would correctly recall more Rp+ items compared to Nrp items, demonstrating a facilitation effect. It was also predicted that participants would recall fewer Rp- items compared to Nrp items, demonstrating a retrieval-induced forgetting effect. Additionally, it was predicted that a difference may occur between mean recall performance for self-performed and observed actions.

In addition to examining retrieval-induced forgetting and objects the current experiment also examined whether an enactment effect occurred for self-performed items compared to observed items. A comparison of the mean recall performance for Nrp items in the four conditions demonstrated no significant effect of action task, suggesting that performing the actions during the study phases did not lead to an improvement in recall performance for Nrp items compared to observing the actions being performed. This suggests that no enactment effect had occurred. These findings support the findings of several other studies which have failed to find a difference between self-performed and observed conditions. For example, Steffens (2007) did not find a difference between the self-performed and observation conditions in two experiments (see also Cohen, 1981; Cohen & Bean, 1983), although both conditions demonstrated better recall performance compared to a verbal learning condition. The findings of the current may therefore support the findings of Steffens (2007). However, there are also a number of experiments which have found an enactment effect for self-performed actions compared with observed actions (see Engelkamp & Zimmer, 1989; Hornstein & Mulligan, 2004).

In order to examine whether a facilitation effect had occurred mean recall performance for Rp+ items were compared with Nrp items. In the current experiment the findings suggest that participants correctly recalled more Rp+ items, the practiced items, compared to Nrp items suggesting that a facilitation effect occurred. Previous retrieval-induced forgetting research (see Anderson et al., 1994; Anderson & Spellman, 1995) have found better memory performance for Rp+ items compared to Nrp items. The findings of the current experiment therefore support previous findings. In the current experiment facilitation occurred regardless of whether participants had self-performed or observed the actions being performed by the researcher.

The results also demonstrated a retrieval-induced forgetting effect for Rp- items. A retrieval-induced forgetting effect was found in the self-performed/self-performed, self-performed/observation and observation/self-performed conditions. No retrieval-induced forgetting seems to have occurred in the observation/observation condition. The finding of a retrieval-induced forgetting effect would support the findings of Koutstaal et al. (1999) who found a retrieval-induced forgetting effect with images of actions. These findings may also support more recent research by Sharman (2011) who found a retrieval-induced forgetting effect for self-performed bizarre and familiar actions. The findings of the current experiment may also support previous interference in action research which has demonstrated that interference can occur with regards to actions, and that an action can interfere with another action (Jax & Buxbaum, 2010).

The lack of a retrieval-induced forgetting effect in the observation/observation condition and the observation of an effect in the self-performed/self-performed and the observation/self-performed conditions may support the findings of Sharman (2011). Sharman examined retrieval-induced forgetting with bizarre and familiar actions, and found that retrieval-induced forgetting only occurred when participants performed the actions themselves and not when participants observed the actions being performed.

Research examining re-presentation and active retrieval may also help to explain the findings of the current experiment. For example, observation may be seen as a form of re-presentation as participants were only required to observe the researcher perform the actions (observation/observation condition). Self-performance for actions may be seen as active retrieval as participants retrieve the action in order to perform the action. Self-performance occurred during the retrieval practice phase of the self-performed/self-performed and observation/self-performed conditions. Anderson, Bjork, et al. (2000) compared re-presentation with retrieval practice in terms of retrieval-induced forgetting, and found that re-presentation was not sufficient to initiate retrieval-induced forgetting; however retrieval was, suggesting that retrieval and retrieval competition may be a key component in retrieval-induced forgetting (see also Campbell & Phenix, 2009). As the self-performed/self-performed and observation/self-performed conditions involved retrieval whereas the observation/observation condition involved re-representation rather than retrieval, the findings of Anderson, Bjork et al. may help to explain these effects. These findings would support the predictions of the inhibitory theory which would suggest that retrieval competition (e.g. active retrieval) is essential in retrieval-induced forgetting. However, this may not explain why retrieval-induced forgetting also found in the self-performed/observation condition. This was a slightly unexpected finding as it may have been expected that as observation (i.e. re-presentation) occurred during the retrieval practice phase no retrieval-induced forgetting would be seen in that condition.

One possible explanation for why retrieval-induced forgetting was found in the self-performed/observation condition may be that during the retrieval practice phase participants imagined themselves performing the actions as they had previously performed the actions during the study phase, perhaps retrieving the memory of having performed the action earlier on in the experiment. This may not have been the case for participants in the observation/observation condition as the participants had not performed the actions themselves in the study phase and as such had no memory of the actions to retrieve. Koutstaal et al. (1999) found retrieval-induced forgetting (Experiment 1) when participants performed a series of actions in the study phase and then looked at images of other individuals performing a sub-section of the actions they had performed in the study phase. Although participants in the Koutstaal et al. experiment were specifically told to think about when they had performed the actions whilst viewing the images, it may be possible that participants in the current experiment imagined their performance of the action whilst observing the researcher perform the action. If participants had imagined themselves performing the actions and retrieved the memory this may support the inhibitory theory which suggests that retrieval is a key component in retrieval-induced forgetting (see Anderson, Bjork, et al., 2000; Bauml, 2002; Storm et al., 2006).

A second possibility regarding finding retrieval-induced forgetting in the self-performed/observation condition could be that during the study phase where participants self-performed the actions, the level of activation concerning the items was raised, and during the retrieval practice phase the raised activation levels were transferred. This could have led to items in the retrieval practice phase becoming a source of competition, which led to the demonstrated retrieval-induced forgetting effect in the self-performed/observation condition. With this in mind a second experiment was designed to test this possibility, during which a twenty-four hour delay would be introduced between the study and retrieval practice phases. The introduction of a delay between the two phases may allow time for the activation levels to be reduced, eliminating the transfer of activation from the study phase to the retrieval practice phase, which may result in no retrieval-induced forgetting being found. Previous research has demonstrated that retrieval-induced forgetting may continue to be seen even after a twenty-four hour delay has been introduced between the study and retrieval practice phases (MacLeod & Macrae, 2000; Saunders & MacLeod, 2002). These findings suggest that it is possible for retrieval-induced forgetting to occur following a twenty-four hour delay. If the retrieval-induced forgetting continued to be found in the self-performed/observation condition in the following experiment this may suggest that the effect was not due to raised and transferred activation levels. If no retrieval-induced forgetting effect was found then this may suggest that raised activation levels were involved. In the following experiments therefore participants will self-perform the actions during the study phase, and twenty-four hours later participants will observe the researcher perform a sub-section of the actions and then complete the test phase.

In conclusion, the current experiment found evidence of a facilitation effect for Rp+ items with better recall performance for Rp+ items compared to Nrp items. This was the case regardless of whether the participant had performed the actions themselves or observed the actions being performed by the researcher. Retrieval-induced forgetting was found in the self-performed/self-performed, self-performed/observation, and observation/self-performed conditions, however the effect was not found in the observation/observation condition. A possible suggestion for why the effect was also found in the self-performed/observation condition relates to the level of and transfer of activation, therefore the following experiment was designed in order to further examine this possibility.

Experiment 2B

Background

An unexpected finding of experiment 2A was that a retrieval-induced forgetting effect was found in the self-performed/observation condition. In the previous experiment participants performed the actions themselves in the study phase and observed the researcher perform the actions during the retrieval practice phase. In this condition a retrieval-induced forgetting effect was found. This finding may be unexpected as no active retrieval took place in the retrieval practice phase. Previous research suggests that retrieval-induced forgetting may only occur in situations where active retrieval takes place during retrieval practice (Anderson, Bjork, et al., 2000). One suggested reason for finding retrieval-induced forgetting in the self-performed/observation may be that during the study phase the activation level of the items had been increased, this raised activation was then transferred from the study phase to the retrieval practice phase, creating competition between the items, as demonstrated by the retrieval-induced forgetting effect. In order to further examine this possibility a twenty-four hour delay was introduced between the study and retrieval practice phases.

Previous research has demonstrated that retrieval-induced forgetting can continue to be seen after a twenty-four hour delay has been introduced between the study and retrieval practice phases (MacLeod & Macrae, 2001). In the study phase of the MacLeod and Macrae experiment participants were asked to study the traits of two individuals (John and Bill- see Macrae & MacLeod, 1999). This was followed twenty-four hours later by the retrieval practice phase during which participants retrieved some of the traits seen in the study phase. The results demonstrated that retrieval-induced forgetting continued to be seen, despite the introduction of a twenty-four hour delay. Saunders and MacLeod (2002) also demonstrated retrieval-induced forgetting following a twenty-four hour delay occurred between the study and retrieval practice phases (see also Saunders, Fernandes, & Kosnes, 2009). These findings suggest that it is possible for retrieval-induced forgetting to occur following a twenty-four hour delay. Therefore, it could be suggested that if the retrieval-induced forgetting found in the self-performed/observation condition was not due to activation levels being raised and transferred when no delay occurred, then when a twenty-four hour delay was introduced the retrieval-induced forgetting effect should continue to be seen. If the finding was due to raised activation levels then the retrieval-induced forgetting effect may disappear.

Previous interference and consolidation research may also support this suggestion and have demonstrated that memories which have already been consolidated can become susceptible to interference again if the memory is recalled (Misanin, Miller, & Lewis, 1968; Walker et al., 2003). Walker et al. (2003) trained participants in task one on day one. On day two participants were asked to practice task one prior to learning task two. When participants were then tested on task one, participants performance had decreased, suggesting that retrieving the memory (during the practice on day two) left the memories related to task one vulnerable to interference by the second task (see also Krakauer & Shadmehr, 2006). These findings suggest that it is possible for memories to suffer from interference even after a period of time has passed since the original learning phase. The current experiment therefore will introduce a twenty-four hour delay in the self-performed/observation condition to further examine with retrieval-induced forgetting effect in the condition.

Aims and Predictions

The aim of the current experiment was to see if retrieval-induced forgetting continued to be seen in the self-performed/observation condition when a twenty-four hour delay was introduced between the study and retrieval practice phases. Participants would self-perform the actions during the study phase and observe the actions being performed in the retrieval practice phase. The retrieval practice and test phases took place twenty-four hours after the initial study phase. Retrieval practice led to several item types of interest: Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category), and Nrp items (unpracticed items from an unpracticed category). It was predicted that participants would accurately recall more Rp+ items compared to Nrp items and that no retrieval-induced forgetting effect would be found.

Method

Participants and Design

Twenty-five undergraduate students (20 females, 5 males *M*age = 25.36) participated in the experiment in exchange for two course credits. A within subjects design was employed with one within subject factor of item type. Item type consisted of three levels. Rp+ items (practiced items from a practiced category), Rp- items (unpractised items from a practiced category), and Nrp items (unpractised items from an unpracticed category).

Stimuli and Materials

The stimuli and materials used in experiment 2B were the same as those used in experiment 2A. Stimuli included eight actions with four objects for each action (e.g. knot-string, knot-ribbon, knot-shoelace, and knot-scarf). This gave rise to a total of thirty-two action-object pairs (see Appendix C for a full list of actions and objects).

Procedure

Participants arrived at the laboratory individually and were greeted by a female researcher. The experiment was designed so that during session one the actions and objects were studied and then twenty-four hours later in the second session the retrieval practice and test phases took place. During the first session in the study phase, participants were instructed that they would be required to perform a range of actions with a variety of different objects. Participants performed all of the actions themselves during the study phase. The order of presentation of the actions and objects were counterbalanced throughout the experiment. Participants were instructed by the researcher as to which action to perform and presented with each object individually to perform the action with (e.g. knot-string, knot-scarf). This pattern continued until the participant had completed all of thirty-two action-object pairs. All objects were hidden from the participants' sight behind a partition during all phases of the experiment. Participants were presented with each object individually when the object was required.

Participants returned to the laboratory twenty-four hours later for the second session. In the second session, participants completed retrieval practice and test phases. Retrieval practice involved the participants observing the researcher practice two actions with four objects (e.g. knot-string, knot-shoelace, pour-glass, and pour-flask). After completing retrieval practice once, participants completed a two-minute verbal word generation task. A verbal word generation task was used in order to ensure that no contamination of the actions occurred. This may have occurred if a written word generation task had been used. All objects were kept out of sight until they were required, and each object was presented individually. Participants completed retrieval practice a further two times before progressing to the test phase of the experiment. In total participants practiced eight action-object pairs, and these eight were practiced three times.

The test phase followed the retrieval practice phase. During the test phase participants were shown a written cue consisting of the name of an action and the first two letters of an object used with that action that the participants had seen during the course of the experiment (e.g. knot-st___). There was one of these for each action-object pair (total of thirty-two). Each cue was presented to the participant individually on an A4 piece of card and shown to the participant for 10 seconds. Rp- items were presented first, followed by Nrp items and finally the Rp+ items. This was done in order to prevent output interference effects (Perfect et al., 2004; Racsmany, Conway, & Demeter, 2009). Participants were asked to write down the name of the object if they were able to remember it (see Figure 18 for summary of the method). Participants were thanked for their participation in the experiment and debriefed.

Figure 18: Summary of Method and Trials/Items Used in Experiment 2B

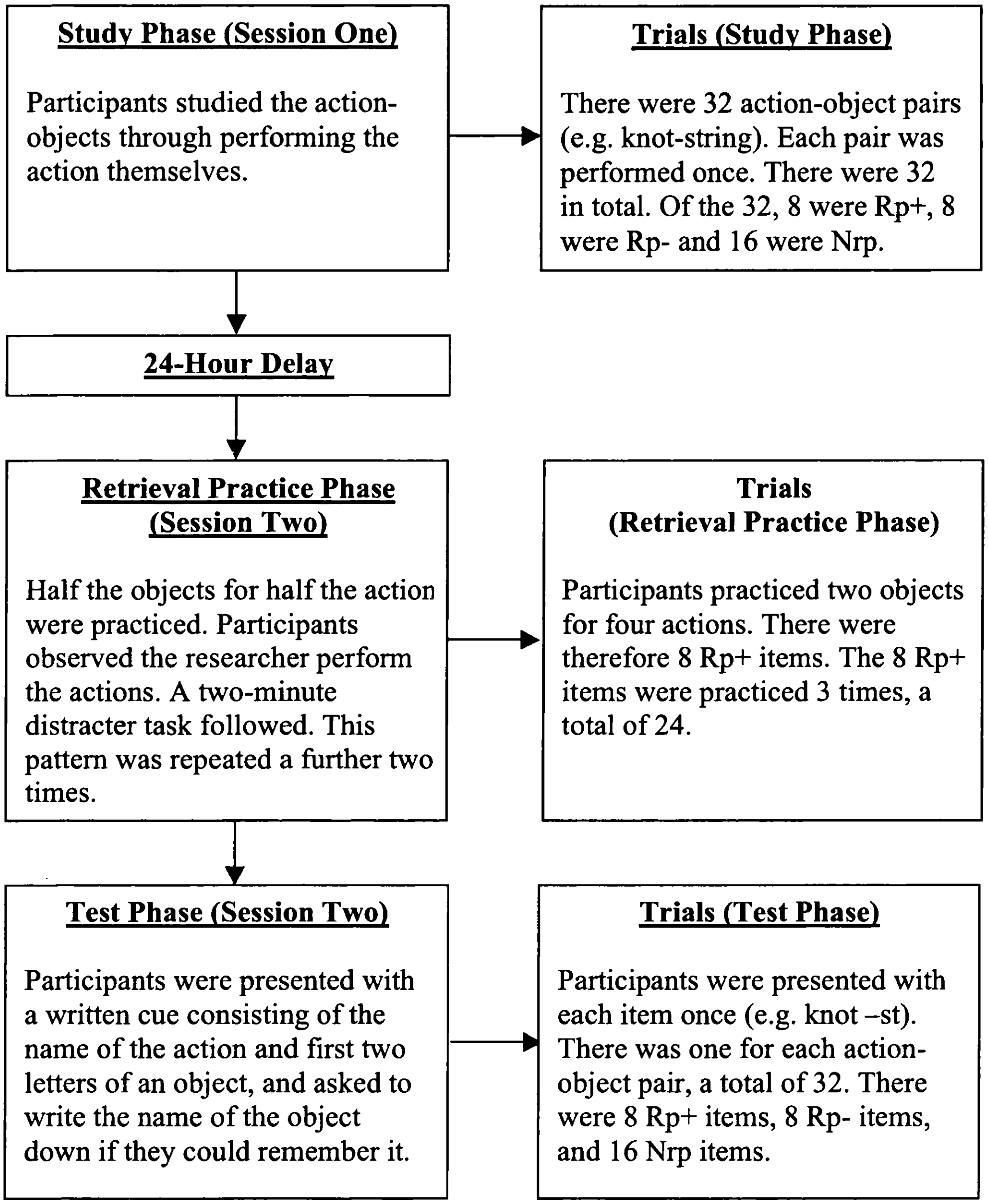


Figure 18. The above figure is a summary of the method used in experiment 2B. The left hand side of the diagram provides a summary of the method. The right hand side of the diagram provides information on the items involved in each phase of the experiment.

Results

Memory performance was calculated through the successful recollection of the object for the action (see Table 4). Results were calculated through comparing Rp+ items with Nrp items in order to examine a facilitation effect, and comparing Rp- items with Nrp items to examine a retrieval-induced forgetting effect.

Table 4: Mean Proportion of Recall Performance for each Item Type in the Self-Performed/Observation Condition

	Item type			Facilitation	Retrieval-induced forgetting
	Rp+	Rp-	Nrp		
Self-Performed/ Observation	.89	.79	.78	+.11	+.01
	(.14)	(.20)	(.15)		

Note. There were three item types of interest. Rp+ items (practiced items from a practiced category), Rp- items (unpractised items from a practiced category), and Nrp items (unpractised items from an unpractised category). Rp+ items were compared with Nrp items to examine facilitation effects, and Rp- items were compared with Nrp items to examine retrieval-induced forgetting effects (see Appendix E for raw data). Standard deviations are presented in parenthesis.

Facilitation effects

Mean recall performance for Rp+ items was higher than mean recall performance for Nrp items in the current experiment suggesting that recall of the practiced items was facilitated. This difference was found to be significant in a paired sample t-test, t (24) = 3.28, $p < .01$. These results support the notion that practice facilitates memory resulting in higher recall performance for Rp+ items compared to Nrp items, replicating the findings of experiment 2A.

Retrieval-Induced Forgetting Effects

Retrieval-induced forgetting effects were examined through comparing mean recall performance for Rp- items with Nrp items. Mean recall performance for Rp- items was higher than that of the Nrp items, suggesting that no retrieval-induced forgetting had occurred. This difference was not significant, $t\ (24) = .35$, *n.s.* suggesting that no retrieval-induced had occurred in the current experiment.

Discussion

The finding in experiment 2A of retrieval-induced forgetting in the self-performed/observation condition was somewhat surprising. Previous research suggests that retrieval-induced forgetting may only occur in situations where active retrieval takes place during retrieval practice (Anderson, Bjork, et al., 2000), as such it may be expected that no retrieval-induced forgetting would have been found in the self-performed/observation condition. However retrieval-induced forgetting was found in experiment 2A. One possible reason for this is related to the activation levels of the items. Items in the study phase were performed by the individual themselves and the activation levels of the items may have been increased. The heightened activation levels may then have been transferred to the retrieval practice phase. This could have produced competition between items even participants only observed the actions being performed by the researcher in the retrieval practice phase, leading to the demonstrated retrieval-induced forgetting effect. The introduction of a twenty-four hour delay may provide time for the activation levels which were raised after the study phase to decrease therefore no retrieval-induced forgetting would occur. If however the effect had not appeared because of raised activation levels a retrieval-induced forgetting effect would continue to be seen.

As in experiment 2A participants self-performed the actions during the study phase, and observed the actions being performed by the researcher twenty-four hours later in the retrieval practice phase. As in experiment 2A participants in the self-performed/observation condition demonstrated higher recall performance for Rp+ items compared to Nrp items suggesting that a facilitation effect had occurred (see also Anderson et al., 1994; Anderson & Spellman, 1995). However unlike the findings of experiment 2A participants in the self-performed/observation condition no retrieval-induced forgetting seems to have occurred. This may suggest that the introduction of a twenty-four hour delay allowed activation levels to be reduced resulting in no retrieval-inducing forgetting.

This suggests that retrieval-induced forgetting can occur with regards to the objects used with actions. The finding of a lack of retrieval-induced forgetting in the current experiment, along with those of experiment 2A, may suggest that retrieval-induced forgetting occurs in situations where participants perform the actions themselves during the retrieval practice phase, and not when participants observe the researcher perform the actions during the retrieval practice phase. Although retrieval-induced forgetting occurred in the self-performed/observation condition in experiment 2A; this may have occurred because of increased activation levels in the study phase which were transferred to the retrieval practice phase. Retrieval-induced forgetting was not found after the introduction of a twenty-four hour delay which may have allowed the activation levels to be reduced. If this were the case this may suggest that retrieval-induced forgetting may occur only in conditions where active retrieval takes place during retrieval practice (Anderson, Bjork, et al. 2000; see also Campbell & Phenix, 2009). However the current experiment did not include positive controls. As such it could be argued that retrieval-induced forgetting would not be found in any of the conditions if a twenty-four hour was included in all the conditions. If retrieval-induced forgetting continued to be seen in the self-performed/self-performed and observation/self-performed condition even after the introduction of a twenty-four delay this may support the suggestion that retrieval-induced forgetting occurs in conditions involving the self-performance of actions during retrieval practice, and that active retrieval is a key component of retrieval-induced forgetting. It may also suggest that retrieval-induced forgetting occurred in the self-performed/observation condition (prior to the introduction of a twenty-four delay) because activation levels were increased in the study phase and transferred to the retrieval practice phase resulting in the retrieval-induced forgetting which was found in experiment 2A. Future research would include running the positive controls in order to further examine this possibility. In addition, mean recall performance for some of the items is quite high for example mean recall performance for the Rp+ items was .89. One proposed reason for this is that there are few trials, for example, for the Rp+ items there were only eight. This may also have occurred in experiment 2A where mean recall performance, for example, for Rp+ items was .90. In this case future research may include increasing the number of trials for each item type.

A recent study by Sharman (2011) demonstrated that retrieval-induced forgetting could occur for actions in an experiment where participants either self-performed the actions or observed the actions being performed with bizarre and familiar actions. Sharman also found that retrieval-induced forgetting was only found for actions which the participants performed themselves and not during observation. Furthermore, Koutstaal et al. (1999) found retrieval-induced forgetting in a study involving images of novel actions suggesting that retrieval-induced forgetting can occur for actions. However these findings may not support the findings of Migueles and Garcia-Bajos (2007) who did not find a retrieval-induced forgetting effect with regards to actions (Migueles & Garcia-Bajos, 2007). One possible suggestion for the lack of retrieval-induced forgetting in Migueles and Garcia-Bajos experiment is integration. Migueles and Garcia-Bajos note that the actions shown to the participants in their experiment were part of the same sequence, specifically a video clip of a robbery, and could be seen as being together; that is they were not individual, separate actions. In the current experiment separate actions were used, and therefore, it may not have been possible for individuals to integrate the items.

In conclusion, experiment 2A and 2B found evidence of a facilitation effect for Rp+ items with participants demonstrating better recall for practiced items (Rp+ items) compared to unrelated and unpractised items (Nrp items). Facilitation occurred regardless of whether items were items were typical or non-typical or whether the items were self-performed or observation. Retrieval-induced forgetting was not found in the observation/observation condition. A retrieval-induced forgetting effect was found in the self-performed/self-performed, observation/self-performed and self-performed/observation conditions. Following the addition of a twenty-four hour delay between the study and retrieval-practice phases in the self-performed/observation condition no retrieval-induced forgetting was found. These findings may suggest that retrieval-induced forgetting can occur for objects involved with actions, therefore, it is possible that suppression of objects which are related to the required or target items but which are currently not required may occur. This may be extremely beneficial when performing actions during everyday life, as not only is it important to complete the correct action correctly and in a timely manner, but it is also essential to complete the action with the correct and appropriate object. For example, if an individual wanted to complete the action of write a note and were presented with a pen and a stick then the most appropriate object to use would be the pen, therefore, suppression of stick may occur allowing pen to be successfully selected.

The following experiments will examine whether retrieval-induced forgetting may also occur for actions. Kormi-Nouri (1995) demonstrated that during self-performance of actions, the action and the object may be encoded together or integrated (see also Kormi-Nouri & Nilsson, 1998), and has also been suggested as an explanation for the enactment effect. The motor code theory (Engelkamp & Krumnacker, 1980) places emphasis on the motor aspect of actions in terms of an explanation of the enactment effect (although the theory does not rule out the impact or role of other aspects). This suggests that the action is important, and may also provide some explanation of why memory for self-performed actions is better than memory for observed actions. Therefore these theories may suggest that both the actions and the objects are important. As such it is essential to look at retrieval-induced forgetting in terms of actions and also in terms of objects. Experiment 3A will therefore look at the action as experiments 2A and 2B looked at the object.

The following experiments will also aim to examine some key differences between inhibitory and non-inhibitory theories of retrieval-induced forgetting, in the first instance; this will include looking at item strength. The inhibitory theory has proposed that retrieval-induced forgetting is more likely to occur for strong items than weak items as strong items are more likely to intrude into conscious awareness. Non-inhibitory theories on the other hand suggest that retrieval-induced forgetting can also occur for weak items. Examining item strength will allow the predictions made by the inhibitory and non-inhibitory theory in terms of item strength to be examined. The following experiment will examine actions and item strength in terms of typical (i.e. strong items) and non-typical (i.e. weak items) actions. As in the current experiment participants will be assigned to one of four conditions (self-performed/self-performed, observation/observation, self-performed/observation and observation/self-performed conditions) in order to look at retrieval-induced forgetting and actions. Participants will be asked to perform either typical (e.g. pen-write) or non-typical (e.g. pen-poke) actions in order to examine item strength.

Chapter 5
Retrieval-Induced Forgetting and Typicality

Experiment 3A

Background

The previous experiments demonstrated a retrieval-induced forgetting effect for objects which were used with the actions (Experiments 2A and 2B). For example, participants may have completed retrieval practice on a dish and a table with the action wipe, therefore forgetting the other objects which were also used with the action wipe (i.e. screen and mirror). However it is important to look at both the objects as done in the previous experiment and the actions as will be done in the current experiment. It is important to be able to successfully recall the necessary object in order to complete an action, however, it is just as important to be able to select the correct action if presented with several possible actions. The previous experiments focussed on the object whereas the current experiment will focus on the action. Specifically, the aim of the current experiment is to see if retrieval-induced forgetting will also occur with regards to actions. For example, if participants completed retrieval practice with the actions fill and roll for the object flask, would the participants then forget the other actions used with the flask (i.e. pour and knock).

Previous memory for action research suggests that actions and objects may be integrated during the self-performance of the actions (Kormi-Nouri, 1995; see also Kormi-Nouri & Nilsson, 1998). During self-performance of actions, the action may become integrated the object and the action-object becomes integrated with the individual (Kormi-Nouri, 1995). This may suggest that a relationship exists between the action and the object. Alternative theories however, for example, the motor code theory suggest that the motor aspect of self-performed actions is essential (Engelkamp & Krumnacker, 1980). If both the action and the object are important then it is necessary to look at both of these components in terms of retrieval-induced forgetting. Experiments 2A and 2B looked at the object component the current experiment will look at the action component.

Inhibitory and non-inhibitory theories have been proposed as explanations of retrieval-induced forgetting. These theories differ in terms of the predictions each theory makes. One of the predictions the theories differ on is that of item strength. Inhibitory theories suggest that stronger items are more likely to demonstrate retrieval-induced forgetting as they are more likely to be a source of competition due to their strength. Retrieval-induced forgetting therefore is less likely to occur with weak items. Non-inhibitory theories suggest that retrieval-induced forgetting can occur when the Rp- items are weak Several studies have examined item strength and retrieval-induced forgetting, for example, Anderson et al. (1994) manipulated the strength of the Rp- items, varying from weak Rp- items to strong Rp- items, and found that retrieval-induced forgetting was greatest when Rp- items were strong supporting the inhibitory and suggesting that retrieval-induced forgetting is more likely to occur from strong items. However, Major et al. (2008) did not find an effect relating to the strength of items using read items compared to generated items (see also Jakab & Raajmakers, 2009). Experiments looking at item strength have used several measures of strength including frequency, generation of items, order of presentation and number of presentations. The current experiment will use typicality as a measure of strength. Typical items will be considered as strong items and non-typical items as weak items. Typical items will be actions that the majority of participants in a pilot study would perform with the object that is these actions will be those which would most likely be performed with the object. Non-typical items will be actions that the least number of participants in the pilot study would perform with object that is these actions would be those which would be less likely to be performed with the object. Examining item strength allows the predictions of the inhibitory and non-inhibitory theories to be compared. The current experiment will therefore examine retrieval-induced forgetting in terms of actions and item strength.

An additional change to the current experiment relates to the test phase. In the previous experiment a written recall test was used. Participants were shown the name of the action and the first two letters of an object used with the action. However, participants in the current experiment will perform the actions during the test phase. Participants will be given the object and asked to perform the actions they are able to remember with each object. Actions which are part individuals everyday lives are more likely to be performed, both in terms of learning or studying actions and also when recalling or using the actions. As such it is necessary to examine not only their ability to recall the information in a written test but also their ability to successfully recall and perform the actions. This method may therefore be more ecologically valid in that sense. In addition, theories explaining the enactment effect suggest that the motor component may play a key role, for example, the motor code theory suggests that self-performance of the actions may establish an additional motor code in memory which aids the individual's recall of those actions (see Engelkamp & Krumnacker, 1980; Engelkamp & Zimmer, 1983). This suggests that the action aspect is important. This may be an additional reason to consider using a performance test in the test phase in place of a written test. Furthermore previous research has also made use of both written and performance tests. For example, Steffens (2007) made use of a written test and a performance test as measures of memory for actions. In that particular experiment an enactment effect was found both when participants completed a written test and when a performance test was completed.

The current experiment will examine whether retrieval-induced forgetting occurs for actions. Previous research has demonstrated that retrieval-induced forgetting can occur for images of actions (Koutstaal et al., 1999). A recent study by Sharman (2011) found that retrieval-induced forgetting occurred when the actions were self-performed by participants. As in the previous experiment, participants in the current experiment either performed the actions themselves during the study and retrieval practice phases or observed the researcher perform the actions during both the study and retrieval practice phases. Two additional conditions involved either self-performing the actions during the study phase and observing the researcher during the retrieval practice phase or observing the researcher perform the actions in the study phase and self-performing the actions in the retrieval practice phase. The results of the participants in these conditions will be used in order to examine whether retrieval-induced forgetting may occur for actions. Memory for action research suggests that when participants perform actions themselves participants remember those actions better than the actions they observed others performing (see Engelkamp & Zimmer, 1989; Hornstein & Mulligan, 2004). However, other studies have not found a difference between self-performed and observed actions in terms of the enactment effect (see Cohen, 1981; Cohen & Bean, 1983; Steffens, 2007). A comparison of self-performed and observed actions in the current experiment will be conducted in order to examine if an enactment effect may have occurred.

Aims and Predictions

The aim of the current experiment was to examine retrieval-induced forgetting in memory for actions. During the experiment participants would be asked to either self-perform or observe four different actions being performed with an object (e.g. cards-shuffle, deal, slice and flick). There were eight objects and four actions for each object, a total of thirty-two object-action phrases. Retrieval practice led to several item types of interest: Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category) and Nrp items (unpracticed items from an unpracticed category).

It was predicted that participants would correctly recall more Rp+ items compared to Nrp items (baseline measure), demonstrating a facilitation effect. It was also predicted that participants would recall fewer Rp- items compared to Nrp items, demonstrating a retrieval-induced forgetting effect. Additionally, it was predicted that a difference would occur between typical and non-typical actions. Previous research suggests that the strength of items can influence retrieval-induced forgetting (see Anderson et al., 1994). Research into action memory also suggests that a difference occurs between self-performed and observed actions (Engelkamp & Zimmer, 1989; Hornstein & Mulligan, 2004). It was also predicted that a difference may occur between self-performed and observed actions in terms of participants recall performance.

Method

Participants and Design

Ninety-six undergraduate students (57 females, 39 males, *M* age = 24.01) participated in the experiment in exchange for either two course credits or £3. A mixed design was employed with two within subject factors: item type (Rp+ items (practiced items from a practiced category), Rp- items (unpractised items from a practiced category) and Nrp items (unpractised items from an unpractised category)) and action type (typical and non-typical items). The between subject factor consisted of four levels: a self-performed/self-performed condition during which participants performed the actions themselves during the study and retrieval practice phases, a observation/observation condition where participants observed the researcher perform the actions during the study and retrieval practice phases, a self-performed/observation condition during which participants performed the actions themselves during the study phase and observed the researcher perform the actions in the retrieval practice phase, and a observation/self-performed condition during which participants observed the actions being performed in the study phase and self-performed the actions during in the retrieval practice phase. Each condition contained twenty-four participants.

Stimuli and Materials

Stimuli were chosen based on the results of a pilot study, during which participants were asked to perform all the actions they could think of for ten everyday objects. Actions which were performed by most of the participants were chosen as typical items for the main experiment. The typical items were actions which were most likely to be performed with the object. Actions which were performed by the least number of participants were chosen as non-typical items. The non-typical items were actions which were least likely to be performed with the object. Items included as typical items were the two actions for each object which were performed by the greatest number of participants. The actions must have been performed by nine or more of the fifteen participants to be considered typical items. The non-typical items were the two actions per object performed by the fewest number of participants. The actions must have been performed by six or less of the ten participants. Materials in the main experiment included eight objects (a compact disc, a feather, string, a pack of cards, a saucepan, a football, a teaspoon, and a tissue), with four actions associated with each object, giving rise to thirty-two different object-action pairs (see Appendix F for full list of objects and actions). Two objects (a banana, and a glove) were removed after the pilot study as they did not provide enough typical and non-typical actions.

Procedure

Participants arrived at the laboratory individually and were greeted by a female researcher. The method followed the procedure of a retrieval practice paradigm. Participants in the self-performed/self-performed condition performed the actions themselves during the study and retrieval practice phases, whereas participants in the observation/observation condition observed the actions being performed during the study and retrieval practice phases. Participants in the self-performed/observation condition performed the actions themselves in the study phase, and observed the actions being performed in the retrieval practice phase. Participants in the observation/self-performed condition observed the actions being performed during the study phase and performed the actions themselves during the retrieval practice phase. Participants were instructed, depending on which condition they had been assigned to, that they would either be required to perform a range of actions with a variety of different objects during the study phase (e.g. CD-slide, ball-bounce, spoon-mix) (self-performed/self-performed, and self-performed/observation conditions), or observe the researcher perform the actions during the study phase (observation/observation and observation/self-performed conditions). Participants either performed all the actions themselves or observed all of the actions being performed during the study phase. The order of presentation of the objects and actions was counterbalanced throughout the study. All objects were hidden behind a partition in the laboratory until the objects were required.

For participants in the self-performed/self-performed and self-performed/observation condition, during the initial study phase participants were presented with each object individually and asked to perform four actions per object. Participants in the observation/observation and observation/self-performed conditions observed the researcher perform the actions (see Figure 19 for summary of method used). The researcher instructed the participants as to which actions to perform (e.g. CD-roll, CD-spin; ball-bounce; ball-push). This pattern continued until the participant had completed all of the actions for all of the objects. All objects were kept hidden from the participants' line of sight when not in use. Participants in the observation/observation and observation/self-performed conditions followed the same procedure as described above however the researcher performed the actions whilst the participant observed. There were eight objects, and four actions for each object, giving rise to thirty-two object-action pairs. Participants self-performed or observed the researcher perform each of the thirty-two object-action pairs once during the study phase.

Participants then progressed to the retrieval practice phase where those in the self-performed/self-performed and observation/self-performed conditions practiced two actions for four objects (e.g. spoon-scoop, spoon-tap), a total of eight object-action pairs (Rp+ items). Of the eight, four of these were typical items and four were non-typical items. Participants in the self-performed/observation and observation/observation conditions observed the researcher performing the actions. After completing retrieval practice once, all participants completed a two minute verbal word generation task. A verbal task was used in order to ensure that no contamination of the actions occurred, which may have occurred if a written task had been presented to the participants. As with the study phase all objects were kept out of sight until they were required. This pattern was then repeated a further two times with participants completing retrieval practice of the eight object-action pairs three times, a total of twenty-four in the retrieval practice phase. Of these twenty-four, twelve were typical items and twelve were non-typical items.

Following the retrieval practice phase, participants were asked to perform all of the actions that they were able to remember that they had encountered during the course of the experiment (see also Steffens, 2007). All participants, regardless of which condition the participants had been assigned to were asked to perform the actions during the test phase. Each object was presented to the participant individually and all other objects were kept out of the participants view when not in use. Each of the eight objects were presented to the participant once during the test phase and participants were asked to recall the four actions for the object. The researcher recorded the participants' responses on a response sheet. Upon completion of the experiment participants were debriefed and thanked for their participation in the experiment.

Figure 19: Summary of Method Used and Trials/Items Involved in Experiment 3A

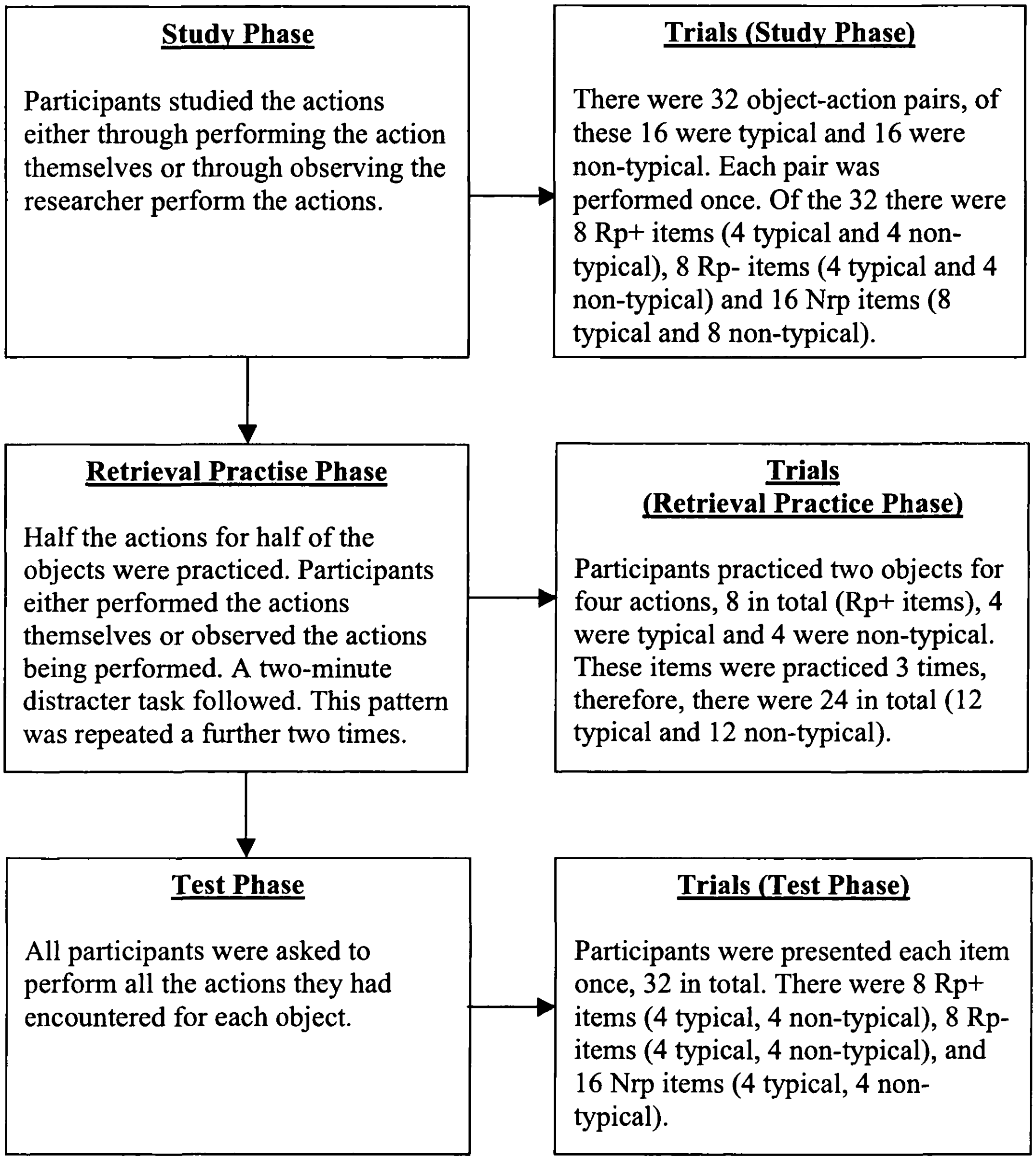


Figure 19. The above figure is a summary of the method used in experiment 3A. The left hand side shows a summary of the method used and the right hand side shows the trials and information used in experiment 3A.

Results

The retrieval practice success rate in the self-performed/self-performed and observation/self-performed conditions was 100%. Memory performance was calculated through the successful recollection of the actions (see Table 5). Results were calculated through comparing Rp+ items with Nrp items in order to examine a facilitation effect, and Rp- items with Nrp items to examine retrieval-induced forgetting. Each action type (typical and non-typical items) was examined individually, as were the action tasks (self-performed/self-performed, observation/observation, self-performed/observation and observation/self-performed conditions).

Table 5: Mean Proportion Recall Performance for Each Condition and Each Item Type

	Rp+		Rp-		Nrp	
	T	NT	T	NT	T	NT
Self-Performed/	1.00	1.00	.80	.73	.90	.84
Self-Performed	(.00)	(.00)	(.18)	(.21)	(.10)	(.13)
Observation/	.97	.98	.84	.79	.83	.78
Observation	(.08)	(.07)	(.25)	(.23)	(.10)	(.14)
Self-Performed/	.97	.97	.73	.73	.87	.86
Observation	(.11)	.(08)	(.22)	(.16)	(.14)	(.16)
Observation/	.98	.96	.69	.70	.84	.82
Self-Performed	(.07)	(.10)	(.30)	(.23)	(.14)	(18)

Note. There were three item types of interest in the experiment. Rp+ items (practiced items from a practiced category), Rp- items (practiced items from a practiced category), and Nrp items (unpracticed items from an unpracticed category). Items also had two levels of typicality: typical items (T) and non-typical items (NT). Standard deviations are presented in parentheses (see Appendix G for raw data).

Facilitation effects

Table 5 demonstrates that the mean recall performance for Rp+ typical and non-typical items was higher than mean recall performance for Nrp typical and non-typical items in the self-performed/self-performed, self-performed/observation, observation/self-performed and observation/observation conditions. The descriptive statistics suggest that a facilitation effect may have occurred in all four conditions. A 4 (action task: self-performed/self-performed, observation/observation, self-performed/observation or observation/self-performed conditions) x 2 (item type: Rp+ or Nrp) x 2 (action type: typical or non-typical) analysis of variance (ANOVA) was performed. A bonferroni correction was also included in order to account for issues with multiple comparisons. The ANOVA showed a significant main effect of item type, $F(1, 92) = 127.37, p < .001$. There was no significant effect of action type $F(1, 92) = 2.28$, *n.s.* There was a significant effect of action task $F(3, 92) = 3.39, p = .01$. There was no significant two-way interaction between item type and action task, $F(3, 92) = 1.29$, *n.s*, nor was there a significant two-way action task x action type interaction, $F(3, 92) = .19$, *n.s*, and there was no significant two-way item type x action type interaction, $F(3, 92) = 2.25$, *n.s.* There was no significant three way interaction of item type, action task, and action type, $F(3, 92) = .54$, *n.s.*

A pairwise comparison of Rp+ items with Nrp items was found to be significant (.14, $p < .001$) suggesting that facilitation had occurred for R+ items regardless of whether the items were typical or non-typical. Additionally, a significant difference occurred between the self-performed/self-performed and observation/observation condition (-.05, $p < .05$). No significant difference occurred between the self-performed/self-performed and self-performed/observation conditions, and the self-performed/self-performed and observation/self-performed conditions. No significant difference occurred between the observation/observation and self-performed/observation conditions and the observation/observation and observation/self-performed conditions. No significant difference occurred between the self-performed/observation and observation/self-performed conditions. These findings suggest that facilitation occurred regardless of action task in the current experiment.

Retrieval-Induced Forgetting Effects

Retrieval-induced forgetting effects were examined through comparing mean recall performance for Rp- items with mean recall performance for Nrp items for both the typical and non-typical items in all four conditions. In the self-performed/self-performed, self-performed/observation, and observation/self-performed conditions mean recall performance for Rp- items was lower than mean recall performance for Nrp items, for both the typical and non-typical items, this suggests retrieval-induced forgetting may have occurred in these three conditions. However in the observation/observation condition mean recall performance for Rp- items was higher than mean recall performance for Nrp items, for both the typical and non-typical items. This is the opposite too what would be expected if retrieval-induced forgetting had occurred, therefore, this suggests that no retrieval-induced forgetting occurred in the observation/observation condition.

A 4 (action task: self-performed/self-performed, observation/observation, self-performed/observation or observation/self-performed conditions) x 2 (item type: Rp- or Nrp) x 2 (action type: typical or non-typical) analysis of variance was conducted in order to examine retrieval-induced forgetting. A bonferroni correction was also applied in order to account for issues of multiple comparisons. A significant main effect for item type was found, $F\,(1, 92) = 21.28, p < .001$. No significant effect of action type, $F\,(1, 92) = 3.01, p = n.s.$ was found. There was no significant effect of action task, $F\,(3, 92) = 1.62$, *n.s.* A significant two way interaction was found between item type x action task, $F\,(3, 92) = 3.22, p < .05$. However, no significant two-way interactions were found for action task x action type, $F\,(3, 92) = .72$, *n.s.*, and item type x action type, $F\,(3, 92) = .03$, *n.s.* No significant three way interaction of item type action task, and action type was found, $F\,(3, 92) = .08$, *n.s.* A pairwise comparison of Rp- items with Nrp items was significant ($-.09, p < .001$) suggesting that fewer Rp- were recalled compared to Nrp items suggesting that retrieval-induced forgetting may have occurred. Furthermore no significant ANOVA result for action type suggests that no difference occurred between typical and non-typical items suggesting that retrieval-induced forgetting occurred for both typical and non-typical items.

Pairwise comparisons exploring the significant interaction between item type and action task found a significant difference between Rp- and Nrp items in the self-performed/self-performed (-.11, $p < .01$), observation/observation (-.14, $p < .01$) and self-performed/observation conditions (-.08, $p < .01$). No significant difference occurred for the observation/observation conditions. These findings suggest that retrieval-induced forgetting occurred in the self-performed/self-performed, observation/self-performed, and self-performed/observation conditions.

The above findings seem to suggest that retrieval-induced forgetting may occur for actions. However, as free recall was used during the test phase, it is not possible to eliminate non-inhibitory theories as an explanation for these findings. For example, the findings could be attributed to interference as well as inhibition. Therefore the output was examined to determine if output interference effect had occurred. If no output interference had occurred then retrieval-induced forgetting should occur in both the data where Rp+ items were retrieved early and where Rp+ items were retrieved late. If interference had occurred retrieval-induced forgetting should only be demonstrated when Rp+ items were retrieved early.

To examine any potential effect that output interference may have had on the results, a procedure outlined by Macrae and MacLeod (1999) was used (see also Saunders & MacLeod, 2002). During this procedure participants were given a score determined by whether their recall had began with Rp+ or Rp- items. These scores were determined by subtracting the mean recall position of the Rp+ items from those of the Rp- items, therefore, negative scores represented early Rp- recall (i.e. late Rp+ recall) whilst positive scores represented early Rp+ recall (i.e. late Rp- recall). The scores were then ranked (highest to lowest). Retrieval-induced forgetting effects were calculated for both the early Rp+ recall and early Rp- recall. The results suggested no significantly larger retrieval-induced forgetting effect for the early Rp+ recall group compared to the early Rp- recall group, $t\,(22) = -.65$, *n.s.* in the self-performed/self-performed condition. This was also demonstrated in the self-performed/observation condition, $t\,(22) = .66$, *n.s.* No significant difference was found for the early Rp+ group compared to the early Rp-recall group, t (22) = - .63, *n.s.* in the observation/self-performed condition. This would indicate that output interference was unlikely to have significantly contributed to the retrieval-induced forgetting effect found in the experiment.

Effect of Action Task on Memory for Control Items (Nrp Items)

In order to determine whether self-performance and observation during the study phase impacts on recall performance for the Nrp actions a 4 (action task: self-performed/self-performed, observation/observation, self-performed/observation or observation/self-performed conditions) x 2 (action type: typical or non-typical) mixed ANOVA was conducted on the mean recall performance of Nrp items. No significant main effect of action type was found, F (1, 92) = 3.10, *n.s.* There was also no significant main effect of action task, F (3, 92) = 2.57, *n.s.* No significant action task x item type interaction, F (3, 92) = .32, *n.s.* This suggests that no enactment effect occurred in the current experiment.

Discussion

The current experiment aimed to examine whether retrieval-induced forgetting also occurred for actions. The previous experiment demonstrated that retrieval-induced forgetting may occur for objects used with actions. However it is important not only to remember the appropriate object for the action but also to be able to select the appropriate action for an object. For example, to correctly select the action write for pen, or select stir for spoon. Therefore examining whether retrieval-induced forgetting occurs for actions, as well as examining whether retrieval-induced forgetting occurs for objects is important. In the current experiment it was predicated that participants would correctly recall more Rp+ items compared to Nrp items, demonstrating a facilitation effect. It was also predicted that participants would recall fewer Rp- items compared to Nrp items, demonstrating a retrieval-induced forgetting effect. The current experiment also examined item strength through using typical (i.e. strong) and non-typical (i.e. weak) items. It was predicted that a difference in recall performance would occur between typical and non-typical items in terms of retrieval-induced forgetting effect. Additionally, it was predicted that a difference may occur between the performance of participants who performed the actions themselves, and those who observed the researcher perform the actions.

In addition to examining retrieval-induced forgetting for actions the current experiment also examined whether an enactment effect occurred for self-performed items compared to observed items. A comparison of recall performance for Nrp items demonstrated that no enactment effect occurred in the current experiment. These findings may support the findings of Steffens (2007) (see also Cohen, 1981; Cohen & Bean, 1983) who also found no difference between self-performed and observed actions which would be in line with the findings of the current experiment. These findings would also support the findings of experiment 2 which also demonstrated no enactment effect for self-performed actions compared to observed actions. Previous research however by Engelkamp and Zimmer (1989) (see also Hornstein & Mulligan, 2004) have found an enactment effect for self-performed actions compared to observed actions. The findings of the experiment also supported the prediction that a facilitation effect would occur.

The findings suggest that participants recalled more Rp+ items compared to Nrp items. This would also support previous research which also found a facilitation effect.

The results also demonstrated retrieval-induced forgetting for actions which were not practiced but belonged to the same category as the practiced items (Rp- items), for both the typical and the non-typical items. This occurred in the self-performed/self-performed, self-performed/observation, and observation/self-performed conditions. However, no retrieval-induced forgetting was found in the observation/observation condition. The finding of a retrieval-induced forgetting effect for actions supports previous research which suggests that retrieval-induced forgetting may occur with regards to actions. For example, Koutstaal et al. (1999) demonstrated retrieval-induced forgetting with regards to images of actions, whilst Sharman (2011) found a retrieval-induced forgetting effect with regards to actions in a study examining both bizarre and familiar actions. The results demonstrated a retrieval-induced forgetting effect for both bizarre and familiar actions, but only for the self-performed actions, and not for the observed actions (Sharman, 2011). This may support the current experiments findings of a lack of a retrieval-induced forgetting effect in the observation/observation condition.

As in the previous experiment, no retrieval-induced forgetting was found in the observation/observation condition. Previous research has also demonstrated that re-presentation (i.e. observation) does not give rise to retrieval-induced forgetting, whereas retrieval may (Anderson, Bjork, et al., 2000; see also Campbell & Phenix, 2009). Sharman (2011; experiment 3) demonstrated that the lack of a retrieval-induced forgetting effect for the observed actions was due to a lack of active retrieval. Anderson, Bjork, et al. (2000) compared re-presentation with retrieval practice in terms of retrieval-induced forgetting, and found that re-presentation was not sufficient to initiate retrieval-induced forgetting; however retrieval was, suggesting that retrieval and retrieval competition may be a key component in retrieval-induced forgetting (see also Campbell & Phenix, 2009). As the self-performed/self-performed and observation/self-performed conditions involved retrieval whereas the observation/observation condition involved re-representation rather than retrieval, the findings of Anderson, Bjork et al. may help to explain these effects. These findings would support the predictions of the inhibitory theory which would suggest that retrieval competition (e.g. active retrieval) is essential in retrieval-induced forgetting. These findings may explain why no retrieval-induced forgetting was found in the observation/observation experiment in the current experiment as observation of the actions in the current experiment does not involve retrieval, only passive observation of what action the researcher is performing. Although this can account for the lack of retrieval-induced forgetting in the observation/observation condition, this would also have suggested that no retrieval-induced forgetting would be found in the self-performed/observation condition as retrieval practice would again consist of observation. However, as in the previous experiment, a retrieval-induced forgetting effect was found in the self-performed/observation.

In the previous experiment it was suggested that one possible explanation for why retrieval-induced forgetting occurred in the self-performed/observation condition was because self-performance of the actions during the study phase had increased the activation levels of the items. The activation was then transferred to the retrieval practice phase, leading to competition, and the demonstrated retrieval-induced forgetting effect. If this were the case then the addition of a twenty-four hour delay between the study and retrieval practice phases may allow the activation levels to decrease, and no retrieval-induced forgetting may be found. If however retrieval-induced forgetting continued to be found then this may suggest that raised activation levels were not the cause. No retrieval-induced forgetting was found after the introduction of a twenty-four hour delay, suggesting that raised activation levels which were then transferred to the retrieval practice phase may have been the cause. This may also have been the case in the current experiment therefore a twenty-four hour delay was introduced between the study and the retrieval practice phases in the following experiment (Experiment 3B). Previous research has demonstrated that retrieval-induced forgetting may continue to be seen even after a twenty-four hour delay has been introduced between the study and retrieval practice phases (MacLeod & Macrae, 2000;

Saunders & MacLeod, 2002). These findings suggest that it is possible for retrieval-induced forgetting to occur following a twenty-four hour delay. If the retrieval-induced forgetting continued to be found in the self-performed/observation condition in the following experiment this may suggest that the effect was not due to raised and transferred activation levels. If no retrieval-induced forgetting effect was found then this may suggest that raised activation levels were involved. In the following experiments therefore participants will self-perform the actions during the study phase, and twenty-four hours later participants will observe the researcher perform a sub-section of the actions and then complete the test phase

It had also been predicted that retrieval-induced forgetting would occur only for the typical actions (i.e. strong items). Inhibitory and non-inhibitory theories differ in terms of the predictions each theory makes for item strength. Inhibitory theories suggest that stronger items are more likely to demonstrate retrieval-induced forgetting as they are more likely to be a source of competition due to their strength. Retrieval-induced forgetting therefore is less likely to occur with weak items. Non-inhibitory theories suggest that retrieval-induced forgetting can occur when the Rp- items are weak. Anderson et al. (1994) for example demonstrated retrieval-induced forgetting to a greater extent for strong Rp- items compared to weak Rp- items (see Jakab & Raajmakers, 2009 for studies which have failed to find an item strength effect). It was predicted that this may also occur in the current experiment that is that a difference may occur between strong Rp- items and weak Rp- items in terms of retrieval-induced forgetting. The inhibitory theory would suggest that strong Rp- items are more likely to be inhibited as they are more likely to compete with the retrieval of the target items. Weak Rp- items on the other hand would not be inhibited as they are less likely to be a source of competition. Non-inhibitory theories however would suggest that retrieval-induced forgetting would occur for weak items. The current experiment demonstrated retrieval-induced forgetting for both typical (i.e. strong) and non-typical (i.e. weak) items. These findings may suggest that either the findings do not support the predictions of the inhibitory theory in terms of item strength or that typicality is not an adequate measure of item strength. The following chapter will therefore consider item strength in terms of memorability rather than typicality. Experiments looking at item strength have used several measures of strength including frequency, generation of items, order of presentation and number of presentations. An associated issue may be how weak or strong items would need to be in relation to the predictions, for example, how strong does an item need to be to be susceptible to retrieval-induced forgetting. These differences in measures may also help to explain why different experiments find different experiments. The current experiment and the following twenty-four hour delay experiment will utilise typicality as a measure of item strength, however, experiment 4A will make use of memorability as a measure of item strength.

In conclusion, the current experiment found evidence of a facilitation effect for Rp+ items with better recall performance for Rp+ items compared to Nrp items. This was the case regardless of whether the participants had performed the actions themselves or observed the actions being performed by the researcher during the study and retrieval practice phases. Retrieval-induced forgetting was found in the self-performed/self-performed, self-performed/observation, and observation/self-performed conditions, although, no retrieval-induced forgetting was found in the observation/observation condition. A possible suggestion for why retrieval-induced forgetting was found in the self-performed/observation condition relates to the level of activation and the transfer of activation. The following experiment was conducted with this in mind, and with the aim of further examining this possibility.

Experiment 3B

Background

The previous experiment (Experiment 3A) demonstrated a retrieval-induced forgetting effect in the self-performed/observation condition. This unexpected finding was also demonstrated in experiment 2A. This finding is unexpected as previous research would suggest that retrieval-induced forgetting would only occur when active retrieval takes place during retrieval practice (Anderson, Bjork, et al., 2000). In this experiment this would have been in the self-performed/self-performed and observation/self-performed conditions. Retrieval-induced forgetting was found in these conditions. Retrieval-induced forgetting would not be found when re-presentation occurred during retrieval practice (Anderson, Bjork, et al. 2000), in this experiment, this would mean that no retrieval-induced forgetting would be found in the observation/observation and self-performed/observation conditions. In experiment 3A retrieval-induced forgetting was also found in the self-performed/observation condition.

It was proposed in the case of experiment 2A that one possible explanation for finding retrieval-induced forgetting in the self-performed/observation condition may be that self-performance of the actions led to an increase in the activation levels. The raised activation levels may then have been transferred to the retrieval practice phase. This may have led to competition between the items resulting in the demonstrated retrieval-induced forgetting effect. The introduction of a twenty-four delay between the study and retrieval-practice phases may have allowed the activation levels to decrease, and may have resulted in no retrieval-induced forgetting being found in the self-performed/observation condition when a twenty-four delay was introduced. It is also possible that raised activation levels which were transferred to the retrieval practice phase may explain why retrieval-induced forgetting was found in the self-performed/observation condition in experiment 3A. As such in the current experiment a twenty-four delay will be introduced between the study and retrieval practice phases.

Previous research has demonstrated that retrieval-induced forgetting can continue to be seen even after a twenty-four hour delay has been introduced between the study and retrieval practice phases (MacLeod & Macrae, 2001; see also Saunders & MacLeod, 2002). Therefore it may be suggested that if retrieval-induced forgetting was not due to raised and transferred activation levels when no delay occurred then retrieval-induced forgetting may continue to be seen even after a twenty-four hour delay had been introduced. However if no retrieval-induced forgetting was found after the introduction of a twenty-four delay this may suggest that finding of retrieval-induced forgetting in the self-performed/observation in the previous experiment was due to raised activation levels which were then transferred.

Aims and Predictions

The aim of the current experiment was to see if retrieval-induced forgetting continued to be seen in the self-performed/observation condition when a twenty-four hour delay was introduced between the study and retrieval practice phases. As in experiment 3A participants in the self-performed/observation conditions elf-performed the actions during the study phase and observed the actions being performed by the researcher in the retrieval practice phase. The study phase would take place on day one with the retrieval practice and test phases taking place twenty-four hours later. Retrieval practice led to several item types of interest: Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category), and Nrp items (unpracticed items from an unpracticed category). It was predicted that participants would correctly recall more Rp+ items compared to Nrp items demonstrating a facilitation effect. It was also predicted that no retrieval-induced forgetting occur, therefore, poorer recall performance would not be demonstrated for Rp- items compared to Nrp items.

Method

Participants and design

Twenty-four undergraduate students (14 females, 10 males, *M* age = 22.42) participated in the experiment in exchange for two course credits. A within subjects design was employed with two within subject factors: item type (Rp+ items (practiced items from a practiced category), Rp- items (unpractised items from a practiced category) and Nrp items (unpractised items from an unpracticed category)), and action type (typical and non-typical items).

Stimuli and Materials

The stimuli and materials used in experiment 3B were the same as those used in experiment 3A.

Procedure

Participants arrived at the laboratory individually and were greeted by a female researcher. The method followed the procedure of a retrieval practice paradigm. Participants were instructed that they would be required to perform a range of actions with a variety of different objects specifically four actions with eight different objects. Participants performed all the actions themselves during the study phase. All objects were hidden from the participants' line of sight when not in use. The order of presentation of the objects and actions was counterbalanced throughout the experiment. During the study phase participants were presented with each object individually and asked to perform four actions with each object. The researcher instructed the participants as to which actions to perform (e.g. CD-roll, Ball-bounce). This pattern continued until the participant had completed all of the actions for all of the objects. There were eight objects and four actions for each object, thirty-two object-action pairs in total. Of the thirty-two, sixteen of those were typical and sixteen were non-typical. This study phase took place in the first session.

Participants then progressed to the retrieval practice phase, which took place twenty-four hours later. Participants observed the researcher performing two actions for four objects (e.g. spoon-scoop, spoon-tap). Participants observed the practice of eight object-action pairs, four of these were typical and four were non-typical. After completing retrieval practice once participants completed a two minute verbal word generation task. A verbal task was used in order to ensure that no contamination of the actions occurred which may have occurred if a written task had been presented to the participants. As with the study phase all objects were kept out of sight, hidden behind a partition, until the object was required. This pattern was then repeated two more times.

Following retrieval practice participants were asked to perform all of the actions they were able to remember that they had seen during the course of the experiment for each object. All participants were asked to perform the actions during the test phase. Each of the eight objects were presented to the participant individually and asked to perform the actions for each object they were able to remember. Therefore there were a possible thirty-two object-action pairs for participants to remember. All other objects were kept out of the participants view when not in use. The researcher recorded the participants' responses on a response sheet (see Figure 20 for summary of method). Upon completion of the study participants were debriefed and thanked for their participation in the experiment.

Figure 20: Summary of the Method Used and Trials/Items Involved in Experiment 3B

Study Phase (Session One)

Participants studied the action-objects through performing the action themselves.

Trials (Study Phase)

There were 32 object-action pairs, of these 16 were typical and 16 were non-typical. Each pair was performed once. Of the 32there 8 Rp+ items (4 typical and 4 non-typical), 8 Rp- items (4 typical and 4 non-typical) and 16 Nrp items (8 typical and 8 non-typical).

24-Hour Delay

Retrieval Practice Phase (Session Two)

Half the objects for half the action were practiced. Participants observed the researcher perform the actions. A two-minute distracter task followed. This pattern was repeated a further two times.

Trials (Retrieval Practice Phase)

Participants practiced two objects for four actions, 8 in total (Rp+ items), 4 were typical and 4 were non-typical. These items were practiced 3 times, therefore, there were 24 in total (12 typical and 12 non-typical).

Test Phase (Session Two)

Participants were presented with a written cue consisting of the name of the action and first two letters of an object, and asked to write the name of the object down if they could remember it.

Trials (Test Phase)

Participants were presented each item once, 32 in total. There were 8 Rp+ items (4 typical, 4 non-typical), 8 Rp- items (4 typical, 4 non-typical), and 16 Nrp items (4 typical, 4 non-typical).

Figure 20. The above figure is a summary of the method used in experiment 3B. The left hand side of the diagram shows a summary of the method and the right hand side demonstrates the number of trials for each item type.

Results

Memory performance was calculated through the successful recollection of the action for the object (see Table 6). Results were calculated through comparing Rp+ items with Nrp items in order to examine a facilitation effect, and Rp- items with Nrp items to examine a retrieval-induced forgetting effect. Each action type (typical and non-typical items) was examined individually.

Table 6: Mean Proportion of Recall Performance for Each Item Type in the Self-Performed/Observation Condition

	Rp+		Rp-		Nrp	
	T	NT	T	NT	T	NT
Self-Performed/ Observation	.93	.90	.77	.72	.75	.61
	(.14)	(.15)	(.19)	(.25)	(.17)	(.20)

Note. There were three item types of interest: Rp+ items (practiced items from a practiced category), Rp- items (unpractised items from a practiced category), and Nrp items (unpractised items from an unpractised category). All item types had two levels of typicality: typical items (T) and non-typical items (NT) (see Appendix H for raw data).

Facilitation Effects

The descriptive statistics suggest that a facilitation effect may have occurred for Rp+ typical and Rp+ non-typical items. Mean recall performance was higher for Rp+ items compared to Nrp items for both the typical and non-typical items. This was further examined in a 2 (item type: Rp+ items or Nrp items) x 2 (action type: typical actions or non-typical actions) ANOVA which revealed a significant main effect for item type, F $(1, 23) = 61.17, p < .001$ and a significant action type effect, $F\,(1, 23) = 9.68, p < .05$. No significant interaction between item type and action type was found, $F\,(1, 23) =$ 3.01, *n.s.* Pairwise comparisons demonstrated significant difference between Rp+ and

Nrp items (23, $p < .001$) and no significant difference occurred between typical and non-typical items. This suggests that facilitation occurred for Rp+ items compared to Nrp regardless of whether the items were typical or non-typical.

Retrieval-Induced Forgetting Effects

Mean recall performance for Rp- typical and Rp- non-typical items were higher than the Nrp typical and non-typical items (see Table 6) suggesting that no retrieval-induced forgetting had occurred. A 2 (item type: Rp- items or Nrp items) x 2 (action type: typical items or non-typical items) ANOVA was conducted in order to examine retrieval-induced forgetting. There was no significant main effect for item type, F (1, 23) =2.65, *n.s.* and a significant effect of action type, F (1, 23) = 7.14, $p = .01$. There was no significant two-way interaction, F (1, 23) = .48, *n.s.* Pairwise comparisons demonstrated that the difference between typical and non-typical items was not significant. These findings suggest that no retrieval-induced forgetting occurred in the current experiment.

Discussion

The previous experiment demonstrated retrieval-induced forgetting in the self-performed/observation condition. One possible reason for finding retrieval-induced forgetting in the self-performed/observation condition is related to activation levels of the items. The activation levels of the items which were self-performed by the participants during the study phase may have risen. Following this the increased activation levels may have transferred to the retrieval practice phase. This could have produced competition between the items even though the items in the retrieval practice phase were only observed, leading to the demonstrated retrieval-induced forgetting effect. The introduction of a twenty-four hour delay may provide time for the activation levels to decrease; therefore no retrieval-induced forgetting may occur. It was predicted that in the current experiment a facilitation effect would be found for practiced items; however, no retrieval-induced forgetting would occur.

As in experiment 3A participants in the self-performed/observation condition demonstrated higher recall performance for Rp+ items compared to Nrp items was found suggesting that a facilitation effect had occurred (see also Anderson et al., 1994; Anderson & Spellman, 1995). However, unlike the findings of experiment 3A, participants in the self-performed/observation condition did not demonstrate a retrieval-induced forgetting effect. This may suggest that the introduction of a twenty-four hour delay may have reduced activation resulting in no retrieval-inducing forgetting. These findings replicate those of experiments 2A and 2B where retrieval-induced forgetting was found in the self-performed/observation condition when no twenty-four hour delay occurred, however, the effect disappeared when a twenty-four hour delay was introduced between the study and retrieval practice phases.

The current experiment also aimed to examine the item strength. The inhibitory and non-inhibitory theories have contrasting predictions in relation to item strength – the inhibitory theory suggests that retrieval-induced forgetting is more likely to occur for strong items as they are more likely to intrude into conscious awareness, whereas the inhibitory theory suggests that retrieval-induced forgetting can also occur for weak items. Experiments 3A and 3B would suggest retrieval-induced forgetting occurred for both the strong (i.e. typical items) and weak (i.e. non-typical items) items. These findings may therefore support the non-inhibitory theory. However it is also possible that typicality was not an adequate measure of item strength, therefore the following experiment will use a different measure to continue to investigate item strength, specifically, memorability will be used as a measure of item strength.

The notion that retrieval-induced forgetting can occur for actions is supported by Sharman (2011) who demonstrated that retrieval-induced forgetting could occur self-performed actions (see also Koutstaal et al., 1999). These findings, along with those of experiment 3A, suggest that retrieval-induced forgetting may occur with regards to actions. This may also suggest that retrieval-induced forgetting may occur in situations where participants perform the actions themselves in the retrieval practice phase. These findings may also suggest that active retrieval is important in retrieval-induced forgetting (see Anderson, Bjork, et al., 2000). In the current experiment self-performance during retrieval practice involves active retrieval as participants recall the actions, however observation does not and may be seen as similar to re-presentation. The finding of retrieval-induced forgetting in the self-performed/self-performed and observation/self-performed conditions, and the lack of retrieval-induced forgetting in the observation/observation condition may support this suggestion (see also Sharman, 2011). The finding of a retrieval-induced forgetting effect in the self-performed/observation condition when no twenty-four delay occurred may have occurred because activation levels were raised during the study phase and transferred to the retrieval practice phase as no retrieval-induced forgetting occurred when a twenty-four delay occurred between the study and retrieval practice phases. If this were the case then this may also support the notion that retrieval-induced forgetting may only occur in situations where active retrieval takes place during retrieval practice. However the current experiment did not include any positive controls. As such it could be argued that retrieval-induced forgetting would not be found in any of the conditions if a twenty-four hour was included in all the conditions. If retrieval-induced forgetting continued to be seen in the self-performed/self-performed and observation/self-performed conditions even after the introduction of a twenty-four hour delay this may support the suggestion that retrieval-induced forgetting occurs in conditions involving the self-performance of actions during retrieval practice, and that active retrieval is a key component of retrieval-induced forgetting. It may also suggest that retrieval-induced forgetting occurred in the self-performed/observation condition (prior to the introduction of a twenty-four hour delay) because activation levels were increased in the study phase and transferred to the retrieval practice phase resulting in the retrieval-induced forgetting which was found in experiment 3A. Future research would include running the positive controls in order to further examine this possibility. In addition, mean recall performance for some of the items was high for example recall performance for the Rp+ items was high. One proposed reason for this is that there are few trials, for example, there were only eight Rp+ items, four of these were typical items and four were non-typical items. The number of trials may have contributed to the ceiling effects. This was also the case in experiment 3A, for example, where a high score was seen for the Rp+ items. Ceiling effects may also have possibly disguised condition and item effects in these experiments. In this case future research may include increasing the number of trials for each item type.

In conclusion, experiments 3A and 3B found evidence of a facilitation effect for Rp+ items with participants correctly recalling more practiced items compared to Nrp items (unpracticed items from an unpracticed category). Retrieval-induced forgetting was not found in the observation/observation condition, although retrieval-induced forgetting did occur in the self-performed/self-performed and observation/self-performed conditions. Retrieval-induced forgetting was also found in the self-performed/observation, however, no retrieval-induced forgetting was found in this condition after a twenty-four hour delay was introduced between the study and retrieval-practice phases. These findings may suggest that retrieval-induced forgetting can occur for actions which are self-performed during the retrieval practice phases. This may also support the suggestion that retrieval gives rise to retrieval-induced forgetting whereas re-presentation does not (see Anderson, Bjork, et al., 2000). Additionally, these findings suggest that no difference occurred between the typical and non-typical actions in terms of retrieval-induced forgetting as when retrieval-induced forgetting occurred for both the typical and non-typical items. Previous research has found an item strength effect that is that a greater retrieval-induced forgetting effect was found for strong items compared to weak items (see Anderson et al., 1999). However other experiments have failed to find this effect (see Jakab & Raajmakers, 2009). Looking at item strength allows a comparison between the inhibitory and non-inhibitory theories to be compared. The inhibitory theory suggests that retrieval-induced forgetting should occur for strong items more so than weak items, however, the non-inhibitory theory suggests that retrieval-induced forgetting may occur for both strong and weak items. The findings of the current experiment therefore may support the non-inhibitory theory. An additional possibility is that typicality may not have been an adequate measure of item strength. In order to further examine this possibility an alternative measure of item strength will be used in the following experiment, in place of typicality, memorability will be used as a measure of item strength. Memorable and non-memorable items will then be examined in terms of retrieval-induced forgetting. The following experiment will follow a similar method to the one used in the current experiment, with the exception of using memorability as a measure of item strength (in place of typicality) and will continue to examine retrieval-induced forgetting and actions.

Chapter 6
Retrieval-Induced Forgetting and Memorability

Experiment 4A

Background

The previous experiments suggest that retrieval-induced forgetting may occur for objects the actions utilise (Experiments 2A and 2B) and typical and non-typical actions (Experiments 3A and 3B). This may be adaptive allowing individuals to correctly select the appropriate object to perform an action with, and also allows individuals to select the appropriate action when presented with several possible objects. The previous experiment examined retrieval-induced forgetting in terms of actions and found retrieval-induced forgetting in the self-performed/self-performed, and observation/self-performed conditions. Retrieval-induced forgetting was also found in self-performed/observation condition when no twenty-four hour delay occurred (the effect was no longer seen following an introduction of a twenty-four delay between the study and retrieval practice phases). No retrieval-induced forgetting was found in the observation/observation condition. Retrieval-induced forgetting was found for both the typical and non-typical items.

The finding of retrieval-induced forgetting for both the typical and non-typical items in the previous experiment suggests no difference occurred in terms of item strength. Previous research by Anderson et al. (1994) involving manipulating the strength of Rp- items, found that retrieval-induced forgetting was greatest when Rp- items were strong. Anderson et al.'s findings support the inhibitory theory which predicts that strong items are more susceptible to retrieval-induced forgetting than weak items as strong items are more likely to intrude into conscious awareness. This would suggest that in the previous experiment retrieval-induced forgetting may only have been found for the strong items (i.e. typical items). However retrieval-induced forgetting occurred for both the strong (i.e. typical items) and weak (i.e. non-typical items). These findings are not in line with those of Anderson et al. or the predictions of the inhibitory theory. An alternative theory to the inhibitory theory is the non-inhibitory which in terms of item strength suggests that retrieval-induced forgetting may also occur for weak items. Jakab and Raajmakers (2009) failed to find a difference between strong and weak items in terms of retrieval-induced forgetting. These findings may therefore support the non-inhibitory theory. The findings of experiment 3A and 3B in the current thesis may therefore support the non-inhibitory theory. An alternative suggestion as to why no item strength occurred in the previous experiment may be that typicality may not be an adequate measure of item strength. Previous research examining item strength have used differing measures of item strength, for example, frequency (Anderson et al., 1994), and position of items (Jakab & Raajmakers, 2009) with differing results. This may suggest that also of importance is the type of measure used to examine item strength. For example, typicality may not have been an adequate or appropriate measure. In order to examine the possibility that typicality was not an adequate measure the current experiment will use memorability (i.e. memorable items (strong) and non-memorable items (weak)) as a measure of item strength. Memorable items will be those which are remembered well whereas non-memorable items will not be remembered well. This differs to typicality as typicality looked at actions which were most or least likely to be performed for object.

The current experiment will utilise a similar method to that used in experiment 3A with four conditions (self-performed/self-performed, self-performed/observation, observation/self-performed, and observation/observation conditions). As in the previous experiment participants will complete a study, retrieval practice and test phases. Participants either performed the actions themselves in both the study and retrieval practice phases (self-performed/self-performed condition) or observed the researcher perform the actions during both the study and retrieval practice phases (observation/observation condition). An additional two conditions involved a combination of self-performance and observation of actions in the study and retrieval phases. Participants in the self-performed/observation condition self-performed the actions during the study phase and observed the researcher perform the actions during the retrieval practice phase. Participants in the observation/self-performed condition observed the researcher perform the actions during the study phase and then performed the actions themselves during the retrieval practice phase. However in place of typical and non-typical items the current experiment will use memorable and non-memorable items.

Previous action research also suggests that when participants self-perform actions participants tend to remember those actions better than the actions they observe other individuals performing (see Engelkamp & Zimmer, 1989; Hornstein & Mulligan, 2004) which may suggest that a difference might occur between the actions participants in the current experiment perform themselves and the actions which they observe the researcher performing. However, other studies have not found a difference between self-performed and observed actions (see Cohen, 1981; Cohen & Bean, 1983; Steffens, 2007).The current experiment will therefore also examine whether any difference occurs in terms of recall performance for self-performed and observed actions, that is whether an enactment effect occurred for self-performed actions compared to observed actions.

Aims and Predictions

The aim of the current experiment was to examine retrieval-induced forgetting in memory for actions, specifically memorable and non-memorable actions. During the experiment participants would be asked to either self-perform or observe four different actions being performed with an object. There were eight objects and four actions for each object giving rise to thirty-two object-action pairs. Retrieval practice led to several item types of interest: Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category), and Nrp items (unpracticed items from an unpracticed category).

It was predicted that participants would correctly recall more Rp+ items compared to Nrp items, demonstrating a facilitation effect. It was also predicted that participants would recall fewer Rp- items compared to Nrp items, demonstrating a retrieval-induced forgetting effect. It was also predicted that a difference may occur between recall performance for self-performed actions compared to observed actions. Additionally, it was predicted that a difference would occur between memorable and non-memorable items in that retrieval-induced forgetting may occur for memorable items and not for non-memorable items.

Method

Participants and Design

Eighty four undergraduate students (47 females, 37 males, *M* age = 20.36), participated in the experiment in exchange for two course credits. A mixed design was employed with two within subject factors: item type (Rp+ items (practiced items from a practiced category), Rp- items (unpractised items from a practiced category) and Nrp items (unpractised items from an unpractised category)); and action type (memorable and non-memorable items). There was also one between subject factor: action task (self-performed/self-performed, observation/observation, self-performed/observation and observation/self-performed conditions). Participants in the self-performed/self-performed condition performed actions themselves in the study and retrieval practice phases. Those in the observation/observation condition observed actions being performed by the researcher in the study and retrieval practice phases. Participants in the self-performed/observation condition performed actions themselves in the study phase and observed actions being performed by the researcher in the retrieval practice phase. Participants in the observation/self-performed condition observed the researcher perform the actions in the study phase and performed the actions themselves in the retrieval practice phase. Each condition contained twenty one participants.

Stimuli and Materials

Stimuli were chosen based on the results of a pilot study. During the pilot study fifteen participants were asked to perform a series of actions for eleven objects as told to them by the researcher. This was followed by a five minute verbal distracter task. Participants were then asked to perform the actions they were able to remember for each object. Actions which were performed by the greatest number of participants were chosen as memorable actions and actions which were performed by the least number of participants were chosen as non-memorable actions for the main experiment. All actions chosen as memorable actions (the two highest scoring actions for each object) were recalled by nine or more of the participants (there were fifteen participants in total). All actions chosen as non-memorable actions (the two lowest actions for each object) were recalled by six or fewer of the participants. Three objects (cards, tissue and feather) did not provide any clear memorable and non-memorable actions. Memorable items are those which actions which are remember well of an object, whereas non-memorable items are those which are not remembered well. As the memorable items would be remembered well these items should be strong, as such they may be more likely to intrude into conscious awareness, and may be a source of competition. Study materials in the main experiment included eight objects (a saucepan, a spoon, a compact disc (CD), a glove, a flask, a pen, a ball, and string), with four actions associated to each object, giving rise to thirty-two different actions (see Appendix I for full list of objects and actions).

Procedure

Participants arrived at the laboratory individually and were greeted by a female researcher. Participants in the self-performed/self-performed condition performed the actions themselves during the study and retrieval practice phases, whereas participants in the observation/observation condition observed the actions being performed during the study and retrieval practice phases. Participants in the self-performed/observation condition performed the actions themselves in the study phase, and observed actions being performed in the retrieval practice phase. Participants in the observation/self-performed condition observed the actions being performed during the study phase and performed the actions themselves during the retrieval practice phase.

Participants were instructed, depending on which condition they had been assigned to, that they would either be required to perform a range of actions with a variety of different objects (e.g. CD-slide, ball-bounce, spoon-mix, string-knot) (self-performed/self-performed, and self-performed/observation conditions), or observe the researcher perform the actions during the study phase (observation/observation and observation/self-performed conditions). Participants either performed all of the actions themselves or observed all of the actions being performed during the study phase. There were eight objects and four actions for each object giving rise to thirty-two object-action pairs. Participants self-performed or observed each pair once. The order of presentation of the objects and actions was counterbalanced throughout all phases of the experiment.

Participants in the self-performed/self-performed and self-performed/observation condition, during the initial study phase were presented with each object individually and asked to perform four actions per object. Participants in the observation/observation and observation/self-performed conditions observed the researcher perform the actions (see Figure 21 for summary of method). The researcher instructed the participants as to which actions to perform (e.g. CD-roll, CD-spin; ball-bounce; ball-push). This pattern continued until the participant had completed all of the actions for all of the objects. All objects were kept hidden from the participants' line of sight when not in use hidden behind a partition. Participants in the observation/observation and observation/self-performed conditions followed the same procedure as described above however the researcher performed the actions whilst the participant observed.

Participants then progressed to the retrieval practice phase where those in the self-performed/self-performed and observation/self-performed conditions practiced two actions for four objects (e.g. spoon-scoop, spoon-tap) and participants in the self-performed/observation and observation/observation conditions observed the researcher practising the actions. Participants practiced two actions for four objects, a total of eight object-action pairs. Four of the eight object-action pairs were memorable items, and four were non-memorable items. After completing retrieval practice once, all participants completed a two minute verbal word generation task. A verbal task was used in place of a written task as written tasks may have contaminated the studied actions. As with the study phase all objects were kept out of sight until they were required. This pattern was then repeated a further two times. Throughout the retrieval practice participants practice the eight object-action pairs three times (a total of twenty-four). Of the twenty-four, twelve of those were memorable and twelve were non-memorable.

Following the retrieval practice phase, participants were asked to perform all of the actions that they were able to remember that they had encountered during the course of the experiment. All participants, regardless of which condition they had been assigned to were asked to perform the actions during the test phase. Each object was presented to the participant individually and all other objects were kept out of the participants view when not in use. There were eight objects and four actions studied for each object, therefore, there were a possible thirty-two object-action pairs for participants to recall. The researcher recorded the participants' responses on a response sheet. Upon completion of the experiment participants were debriefed and thanked for their participation in the experiment.

Figure 21: Summary of Method Used and Trials/Items Involved in Experiment 4A

Study Phase

Participants studied the actions through either performing the action themselves or observing the researcher perform the actions.

Trials (Study Phase)

There were 32 object-action pairs, 16 were memorable and 16 were non-memorable. Each pair was performed once. Of the 32 there were 8 Rp+ items (4 memorable and 4 non-memorable), 8 Rp- items (4 memorable and 4 non-memorable) and 16 Nrp items (8 memorable and 8 non-memorable).

Retrieval Practice Phase

Participants observed the researcher perform or self-perform a sub-section of the previously studied items. A two-minute verbal word generation task followed. This pattern was repeated a further two times.

Trials (Retrieval Practice Phase)

Participants practiced two objects for four actions, 8 in total (Rp+ items), 4 were memorable and 4 were non-memorable. These items were practiced 3 times, therefore, there were 24 in total (12 memorable and 12 non- memorable).

Test Phase

Participants were asked to perform the actions they could remember that they had encountered during the experiment for each object.

Trials (Test Phase)

Participants were presented each object one at a time, a total of 32. There were 8 Rp+ items (4 memorable, 4 non-memorable), 8 Rp- items (4 memorable, 4 non-memorable), and 16 Nrp items (4 memorable, 4 non-memorable).

Figure 21. The left hand side above figure shows a summary of the method and the right hand side shows information on the trials and items used in experiment 4A.

Results

The retrieval practice success rate in the self-performed/self-performed and observation/self-performed conditions was 100%. Memory performance was calculated through the successful recollection of the action for the object (see Table 7). Results were calculated through comparing Rp+ items with Nrp items in order to examine a facilitation effect, and comparing Rp- items with Nrp items to examine a retrieval-induced forgetting effect. Each action type (memorable and non-memorable items) was examined individually, as were the conditions.

Table 7: Mean Proportion Recall Performance for Each Condition and Item Type

	Rp+		Rp-		Nrp	
	M	NM	M	NM	M	NM
Self-performed/	.99	.99	.80	.67	.93	.67
Self-performed	(.05)	(.05)	(.20)	(.25)	(.10)	(.23)
Observation/	.96	.90	.80	.58	.72	.52
Observation	(.09)	(.12)	(.23)	(.22)	(.19)	(.19)
Self-Performed/	1.00	.87	.88	.71	.96	.68
Observation	(.00)	(.20)	(.17)	(.28)	(.07)	(.22)
Observation/	.96	.94	.60	.58	.77	.58
Self-Performed	(.09)	(.11)	(.30)	(.30)	(.17)	(.25)

Note. There were three item types of interest. Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category), and Nrp items (unpracticed items from an unpracticed category). Each item type had two levels of memorability (memorable items (M) and non-memorable items (NM)). Standard deviations presented in parenthesis (see Appendix J for raw data).

Facilitation Effects

Table 7 demonstrates that mean recall performance for Rp+ items was higher than Nrp items for both memorable and non-memorable items. This was the case in all of the conditions. These results suggest that practice facilitates memory. To examine a facilitation effect a 4 (action task: self-performed/self-performed, observation/observation, self-performed/observation or observation/self-performed conditions) x 2 (item type: Rp+ or Nrp) x 2 (action type: memorable or non-memorable) analysis of variance (ANOVA) was performed which revealed a significant main effect of item type, F (1, 80) = 172.92, $p < .001$. There was also a significant effect of action type, F (1, 80) = 85.87, $p < .001$. A significant effect of action task was found, F (3, 80) = 8.19, $p < .001$. A significant two way interaction was found between item type and action type, F (3, 80) = 38.55, $p < .001$. A significant interaction also occurred between item type and action task F (3, 80) = 7.06, $p < .001$. No significant two way interaction was found for action type and action task F (3, 80) = 1.71, *n.s* and there was also no significant three way interaction was found for item type, action type and action task, F (3, 80) = .81, *n.s.*

A series pairwise comparisons demonstrated a significant difference between Rp+ and Nrp items (.22, $p < .001$) suggesting Rp+ items were recalled significantly better than Nrp items. A significant difference also occurred between memorable and non-memorable items (.14, $p < .001$) suggesting that memorable items are recalled better than non-memorable items. Furthermore a significant difference occurred between the self-performed/self-performed and observation/observation conditions (.12, $p < .001$) and self-performed/self-performed and observation/self-performed conditions (.08, $p < .05$). A significant difference also occurred between the self-performed/observation and observation/observation conditions (.10, $p < .01$). To examine the significant interaction between action task and item type pairwise comparisons were conducted demonstrating a significant difference for Nrp items between the self-performed/self-performed and observation/observation conditions (.18, $p < .01$), self-performed/self-performed and observation/self-performed conditions (.13, $p < .05$), and observation/observation and self-performed/observation conditions (.19, $p < .001$). A significant difference also occurred between typical Rp+ and Nrp items (.05, $p < .01$) and non-typical Rp+ and Nrp items (.24, $p < .001$). Analysis also demonstrated a significant difference between Rp+ and Nrp items in the self-performed/self-performed (.19, $p < .001$), observation/observation (.32, $p < .001$), self-performed/observation (.11, $p < .01$) and observation/self-performed (.28, $p < .001$) conditions. These findings suggest that a facilitation effect occurred regardless of whether participants self-performed or observed the actions and whether the items were typical or non-typical.

Retrieval-Induced Forgetting Effects

Retrieval-induced forgetting effects were examined through comparing recall performance for Rp- and Nrp items. The results (see Table 7) suggest that mean recall performance for Rp- memorable items compared to Nrp memorable items in the self-performed/self-performed, observation/self-performed and self-performed/observation conditions. However mean recall performance for Rp- non-memorable items in these conditions were either the same as or higher than mean recall performance for Nrp memorable items. Mean recall performance for Rp- memorable and non-memorable items were higher than those of the Nrp memorable and non-memorable items in the observation/observation condition. These findings suggest that retrieval-induced forgetting may have occurred for Rp- memorable items in the self-performed/self-performed, observation/self-performed and self-performed/observation conditions. No retrieval-induced forgetting seems to have occurred for Rp- non-memorable items in those three conditions or for Rp- memorable and non-memorable items in the observation/observation condition.

A 4 (action task: self-performed/self-performed, observation/observation, self-performed/observation or observation/self-performed conditions) x 2 (item type: Rp- or Nrp) x 2 (action type: memorable or non-memorable) analysis of variance was conducted in order to examine retrieval-induced forgetting effects. No significant main effect of item type was found $F(1, 80) = 1.88$, *n.s.* There was however a significant effect of action type was also found $F(1, 80) = 55.04$, $p < .001$. There was also a significant effect of action task, $F(3, 80) = 8.31$, $p < .001$. A significant two way interaction was found between item type and action type, $F\ (3, 80) = 6.19, p < .05$ and item type and action task, $F\ (3, 80) = 2.97, p < .05$.No significant interaction was found between action type and action task, $F\ (3, 80) = 1.18$, *n.s.* There was also no significant three way interaction between item type, action type and action task, $F\ (3, 80) = .93$, *n.s.*

Pairwise comparisons of action type (i.e. memorability) was significant (.18, $p < .001$) suggesting that memorable items are recalled better than non-memorable items. A significant difference occurred between the self-performed/self-performed and observation/self-performed conditions (.13, $p < .05$), observation/observation and self-performed/observation conditions (.15, $p < .05$), and self-performed/observation and observation/self-performed conditions (.18, $p < .01$). Pairwise comparisons of the item type x action task interaction demonstrated a significant difference between the self-performed/observation and observation/self-performed conditions for Rp- items (.21, p <. 01). A significant difference also occurred between Nrp items for the self-performed/self-performed condition compared to the observation/observation condition (.18, $p < .01$) and self-performed/observation condition (.13, $p < .05$). This was also the case for the observation/observation condition compared to the observation/self-performed condition (.05, $p < .001$) and the observation/self-performed condition compared to the self-performed/observation condition (.15, $p < .01$). Significant retrieval-induced forgetting was found in the self-performed/self-performed (.09, $p < .05$), observation/self-performed (.21, $p < .05$) and self-performed/observation (.11, $p < .05$) conditions. Pairwise comparisons of the item type x action type interaction demonstrated a significant difference between the memorable Rp- and Nrp items (.08, $p < .01$). This was not the case for non-memorable items. A significant difference occurred between memorable and non-memorable Rp+ items (.13, $p < .01$) and memorable and non-memorable Nrp items (.23, $p < .001$). These findings suggest that retrieval-induced forgetting occurred in the self-performed/self-performed, observation/self-performed and self-performed/observation conditions.

However, as free recall was used during the test phase, it is not possible to eliminate non-inhibitory theories as an explanation for these findings. For example, the findings could be attributed to interference as well as inhibition. Output was examined to determine if an output interference effect had occurred. If no output interference had occurred then retrieval-induced forgetting should occur in both the data where the Rp+ items were retrieved early and where Rp+ items were retrieved late. If interference had occurred retrieval-induced forgetting should only be demonstrated when the Rp+ items were retrieved early.

To examine any potential effect that output interference may have had on the results, a procedure outlined by Macrae and MacLeod (1999) was used (see also Saunders & MacLeod, 2002). During this procedure participants were given a score determined by whether recall had began with Rp+ or Rp- items. These scores were determined by subtracting the mean recall position of Rp+ items from Rp- items, therefore, negative scores represented early Rp- recall (i.e. late Rp+ recall) whilst positive scores represented early Rp+ recall (i.e. late Rp- recall). The scores were then ranked (highest to lowest). Retrieval-induced forgetting effects were calculated for both the early Rp+ recall and early Rp- recall. Paired-samples t-tests indicated that the early Rp+ recall group did not elicit a significantly larger retrieval-induced forgetting effect than the early Rp- recall group, $t\,(19) = .44$, *n.s* in the self-performed/self-performed condition. This was also the case in the self-performed/observation condition, where no significant difference occurred between the early Rp- output group and early Rp+ group, $t\,(19) = .76$, *n.s.* No significant difference was found between the early Rp+ group and early Rp- group in the observation/self-performed condition, $t\,(19) = .58$, *n.s.* This would indicate that output interference was unlikely to have significantly contributed to the retrieval-induced forgetting effect found in the experiment.

Effect of Action Task on Memory for Control Items (Nrp Items)

In order to determine whether self-performance and observation during the study phase impacted on recall performance for Nrp actions a mixed ANOVA 4 (action task: self-performed/self-performed, observation/observation, self-performed/observation or observation/self-performed conditions) x 2 (action type: memorable or non-memorable) was conducted. A main effect of action type was found to be significant $F(1, 80) = 81.51$, $p < .001$. There was also a significant effect of action task, $F(3, 80) = 9.45$, $p < .001$. There was no significant action task x action type interaction, $F(3, 80) = 52$, *n.s.* Pairwise comparison demonstrated a significant difference between the self-performed/self-performed and observation/observation conditions (.18, $p < .001$), and self-performed/self-performed and observation/self-performed conditions (.13, $p < .05$). There were also significant differences between the observation/observation and self-performed/observation conditions (.31, $p < .001$), and self-performed/observation and observation/self-performed conditions (.09, $p < .01$). A significant difference also occurred between memorable and non-memorable items (.23, $p < .001$). These findings suggest that an enactment effect occurred in conditions where participants self-performed the actions during the study phase compared to conditions where participants observed the actions being performed in the study phase. Additionally the findings suggest that memorable items are recalled better than non-memorable items.

Discussion

The current experiment aimed to examine whether retrieval-induced forgetting occurred for memorable and non-memorable items. The previous experiment (Experiment 3) had demonstrated retrieval-induced forgetting for both typical and non-typical items. The finding of retrieval-induced forgetting for both the typical and non-typical items in the previous experiment suggests no difference occurred in terms of item strength. Previous research by Anderson et al. (1994) involving manipulating the strength of Rp- items, found that retrieval-induced forgetting was greatest when Rp- items were strong. Anderson et al.'s findings support the inhibitory theory which predicts that strong items are more susceptible to retrieval-induced forgetting than weak items as strong items are more likely to intrude into conscious awareness. This would suggest that in the previous experiment retrieval-induced forgetting may only have been found for the strong items (i.e. typical items). However retrieval-induced forgetting occurred for both the strong (i.e. typical items) and weak (i.e. non-typical items). These findings are not in line with those of Anderson et al. or the predictions of the inhibitory theory. An alternative suggestion as to why no item strength occurred in the previous experiment may be that typicality may not be an adequate measure of item strength. In order to examine the possibility that typicality was not an adequate measure the current experiment will use memorability (i.e. memorable items (strong) and non-memorable items (weak)) as a measure of item strength. Memorable items will be those which are remembered well whereas non-memorable items will not be remembered well. This differs to typicality as typicality looked at actions which were most or least likely to be performed for object.

It was predicted that participants would correctly recall a greater number of Rp+ items compared to Nrp items, demonstrating a facilitation effect. It was also predicted that participants would recall fewer Rp- items compared to Nrp items, demonstrating a retrieval-induced forgetting effect. Item strength was also examined through using memorable (strong) and non-memorable (weak) items and it was predicted that a difference in recall performance would occur between the memorable and non-memorable items. Additionally, it was predicted that a difference may occur between the performance of participants who performed the actions themselves, and those who observed the researcher perform the actions.

A comparison of the mean recall performance of the Nrp items demonstrated an enactment effect for actions which were self-performed during the study phase compared to actions which were observed during the study phase. These findings support previous memory for action research which has demonstrated a difference between recall performance following self-performance of actions compared to observation of the actions (see Engelkamp & Zimmer, 1989; Hornstein & Mulligan, 2004). However, these findings contradict those of experiments 2 and 3 which did not find any difference between the self-performed and observation items in terms of an enactment effect. There are several studies however which have not found a difference between self-performed and observed actions (Steffens, 2007; see also Cohen, 1981; Cohen & Bean, 1983). However the findings of the current experiment do not support the findings of Steffens (2007) who did not find a difference between the self-performed and observation conditions in two experiments (see also Cohen, 1981; Cohen & Bean, 1983). In addition the findings of the current experiment are in opposition with findings in previous experiments in this thesis where no enactment effect was found. These findings reflect the mixture of findings in the memory for action literature with several experiments finding an enactment effect and many failing to find the effect for self-performed actions compared to observed actions.

The finding of a facilitation effect for Rp+ items for memorable and non-memorable items, and across all conditions supports the notion that practice facilitates memory. This finding supports the findings of the previous experiments in the thesis and also supports the findings of previous experiments (Anderson et al., 1994; Anderson & Spellman, 1995). One limitation of the current experiment however may be that ceiling effects occurred, for example, mean recall performance for Rp+ items was high for both memorable and non-memorable items. One possible reason for this is the fewer number of trials in the current experiment. Furthermore these ceiling effects may affect the findings disguising findings relating to facilitation and conditions. Future research may therefore include considering increasing the number of trials.

The results also demonstrated retrieval-induced forgetting for actions which were not practiced but belonged to the same category as the practiced items (Rp- items). However unlike in the previous experiment a retrieval-induced forgetting effect was only found for memorable items. This effect occurred in the self-performed/self-performed, self-performed/observation and observation/self-performed conditions, however, not in the observation/observation condition. The finding of a retrieval-induced forgetting effect may support previous research which suggests that retrieval-induced forgetting may occur with regards to actions. For example, Koutstaal et al. (1999) demonstrated retrieval-induced forgetting with regards to images of actions. More recently, Sharman (2011) found retrieval-induced forgetting for actions in a study examining both bizarre and familiar actions. Retrieval-induced forgetting was found for both bizarre and familiar actions, but only for self-performed actions and not for observed actions. This may support the current experiments findings of a lack of a retrieval-induced forgetting effect for participants in the observation/observation condition.

As in the previous experiment, no retrieval-induced forgetting was found in the observation/observation condition. Previous research has also demonstrated that re-presentation may not lead to retrieval-induced forgetting (Anderson, Bjork, et al., 2000; see also Campbell & Phenix, 2009), and that active retrieval is a key component (Anderson, Bjork, et al., 2000). Sharman (2011) demonstrated that the lack of retrieval-induced forgetting for observed actions due to a lack of retrieval. As the self-performed/self-performed and observation/self-performed conditions involved retrieval whereas the observation/observation condition involved re-representation rather than retrieval, the findings of Sharman may help to explain these effects. These findings may explain why no retrieval-induced forgetting was found in the observation/observation condition in the current experiment as observation of the actions in the current experiment does not involve retrieval. Although this may account for the lack of retrieval-induced forgetting in the observation/observation condition, this would also have suggested that no retrieval-induced forgetting would be found in the self-performed/observation condition as retrieval practice would again consist of observation. However, as in the previous experiment, a retrieval-induced forgetting effect was found in the self-performed/observation.

The previous experiment demonstrated that when a twenty-four hour delay was introduced between the study and retrieval practice phases no retrieval-induced forgetting was seen in the self-performed/observation condition. A twenty-four hour delay was introduced based on the possibility that following the study phase the activation level of the items was raised, therefore, the raised activation levels were transferred to the retrieval practice phase. This may also have been the case in the current experiment therefore a twenty-four hour delay will be introduced between the study phase and the retrieval practice phase in the following experiment. The introduction of a twenty-four delay may allow the activation levels to decrease, and no retrieval-induced forgetting may be found. If retrieval-induced forgetting continued to be found this may suggest that raised activation levels were not the cause. No retrieval-induced forgetting was found after the introduction of a twenty-four hour delay in the previous experiment suggesting that raised activation levels which were then transferred to the retrieval practice phase may have been the cause. This may also have been the case in the current experiment therefore a twenty-four hour delay was introduced between the study and the retrieval practice phases in the following experiment (Experiment 4B). Previous research has demonstrated that retrieval-induced forgetting may continue to be seen even after a twenty-four hour delay has been introduced between the study and retrieval practice phases (MacLeod & Macrae, 2000; Saunders & MacLeod, 2002). In the following experiments therefore participants will self-perform the actions during the study phase, and twenty-four hours later participants will observe the researcher perform a sub-section of the actions and then complete the test phase.

In addition, no retrieval-induced forgetting was found for non-memorable items in any of the conditions in the current experiment. This finding lends support to the inhibitory theory which suggests that strong items are more likely to be inhibited than weak items. In this case the strong items are memorable items, whereas weak items are non-memorable items. Strong Rp- items are more likely to interfere with retrieval of the target items, and may be a greater source of competition, which may need to be suppressed or inhibited in order to allow the target items to be successfully recalled. Non-inhibitory theories would suggest that retrieval-induced forgetting also occurs for the weak items. As retrieval-induced forgetting was only found for Rp- memorable items, this supports the inhibitory theory and the findings of Anderson et al. (1994) who manipulated the strength of Rp- items and found that retrieval-induced forgetting was greatest when Rp- items were strong. The previous experiment using typicality failed to find a difference in terms of retrieval-induced forgetting between typical and non-typical items with retrieval-induced forgetting being demonstrated for both the typical and non-typical items. However, the current experiment did find a difference between memorable and non-memorable items. This may suggest that memorability is a more adequate or appropriate measure of item strength than typicality. These findings also suggest a difference between retrieval-induced forgetting effects in terms of typicality and memorability. Further research would also aim to further examine this possibility. As the manipulation of item strength may have been successful in the current experiment the remaining experiments in this chapter will continue to make use of memorability as a measure of item strength.

In conclusion, the current experiment found evidence of a facilitation effect for Rp+ items with better recall performance for the Rp+ items compared to the Nrp items. This was the case regardless of whether the participant had performed the actions themselves or observed the actions being performed by the researcher and whether the items were memorable or non-memorable. Retrieval-induced forgetting was found in the self-performed/self-performed, self-performed/observation and observation/self-performed conditions, however the effect was not found in the observation/observation condition. A possible suggestion for why an effect was found in the self-performed/observation condition relates to the level of activation which may have been increased during the study phase, and these levels of activation may then have been transferred to the retrieval practice phase, resulting in competition, and the demonstrated retrieval-induced forgetting effect. The following experiment was conducted with the aim of further examining this possibility, and a twenty-four hour delay was introduced between the study and the retrieval practice phases.

Experiment 4B

Background

The previous experiment (Experiment 4A) demonstrated retrieval-induced forgetting for memorable Rp- items compared to memorable Nrp items in the self-performed/observation condition. This was also demonstrated in the typicality experiment (Experiment 3A). This is a slightly unexpected finding for the self-performed/observation condition as it would be predicted that as observation (i.e. re-presentation) occurred in the retrieval-practice phrase no retrieval-induced forgetting would be found in the self-performed/observation condition. One proposed reason for finding retrieval-induced forgetting in the self-performed/observation condition is that self-performance of the actions during the study phase may have led to an increase in the activation levels of items. The raised activation levels may have been transferred to the retrieval practice phase, increasing the competition between the items, resulting in the retrieval-induced forgetting which was found. The current experiment will introduce a twenty-four hour delay between the study and retrieval practice phases to allow the activation levels to decrease. If retrieval-induced forgetting continues to be seen this may suggest that the effect had genuinely occurred. If the effect no longer occurred this may suggest that the effect found in the previous experiment was due to raised activation levels. Previous research by MacLeod and Macrae (2001) have shown that retrieval-induced forgetting can continue to be seen even after a twenty-four hour delay has occurred between the study and retrieval practice phases (see also Saunders, Fernandes, & Kosnes, 2009; Saunders & MacLeod, 2002).

Previous research into consolidation and interference may also support this suggestion. Previous research has demonstrated that memories which have been consolidated can become susceptible to interference again if the memory is recalled (Walker et al., 2003). Walker et al. (2003) found that learning a second task may also interfere with a previously learnt task, for example, if both tasks were learnt immediately after each other, if a period of time (e.g. six hours) occurred between learning the two tasks interference did not occur (see also Shadmehr & Brashers-Krug, 1997). The authors proposed that time allowed the memory for the first task to be stabilised. However, recalling a memory even following consolidation or stabilisation will make the memory vulnerable again (Misanin, Miller, & Lewis, 1968) allowing interference to occur (Walker et al., 2003; see also Krakauer & Shadmehr, 2006). It may be suggested that if retrieval-induced forgetting was not due to raised and transferred activation levels when no delay occurred, retrieval-induced forgetting may continue to be seen after a twenty-four hour delay had been introduced. However, if the finding was due to the raised activation levels retrieval-induced forgetting might disappear following the introduction of a twenty-four hour delay. In order to further examine this possibility a twenty-four delay will be introduced between the study and retrieval practice phases.

Aims and Predictions

The aim of the current experiment was to see if retrieval-induced forgetting continued to be seen in the self-performed/observation condition when a twenty-four hour delay was introduced between the study and retrieval practice phases. During the experiment participants would self-perform the actions in the study phase and observe the actions being performed by the researcher in the retrieval practice phase. Retrieval practice led to several item types of interest: Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category), and Nrp items (unpracticed items from an unpracticed category). It was predicted that no retrieval-induced forgetting would be found in this case although a facilitation effect would occur for the practiced items (Rp+ items).

Method

Participants and design

Twenty-one undergraduate students (17 females, 4 males, *M* age = 20.48) participated in the experiment in exchange for two course credits. A within subjects design was employed with two within subject factors: item type (Rp+ items (practiced items from a practiced category), Rp- items (unpractised items from a practiced category) and Nrp items (unpractised items from an unpractised category)) and action type (memorable and non-memorable items).

Stimuli and Materials

Stimuli and materials used in experiment 4B were the same as the stimuli and materials used in experiment 4A.

Procedure

Participants arrived at the laboratory individually and were greeted by a female researcher. Participants were instructed that during the first session they would be required to perform a range of actions with a variety of different objects. Participants performed all of the actions themselves throughout the study phase. The order of presentation of both the objects and actions was counterbalanced throughout all phases of the experiment. Participants were presented with each object individually and asked to perform four actions with each object. The researcher instructed all participants as to which actions to perform (e.g. CD-spin, CD-slide, and CD-bend). This pattern continued until all of the actions for all of the objects had been performed by the participant. There were eight objects and four actions for each object, a total of thirty-two object-action pairs. Of the thirty-two object-action pairs, sixteen of these were memorable and sixteen were non-memorable. All objects were kept hidden from the participants' line of sight when not in use.

Participants then progressed to the retrieval practice phase during the second session which occurred twenty-four hours after the study phase. Participants observed the researcher practising a sub set of the items (e.g. CD-slide, CD-spin). In the retrieval practice phase eight object-action pairs were practiced, these included four objects and two actions for each of those objects. Of the eight object-action pairs, four were memorable and four were non-memorable. After completing retrieval practice once participants completed a two-minute verbal word generation task. A verbal word generation task was used instead of a written task, as a written task may have contaminated the actions. As with the study phase all objects were kept out of sight until they were required. This pattern was then repeated a further two times.

Following retrieval practice participants performed all of the actions they were able to remember that they had encountered during the course of the experiment (see Figure 22 for summary of method). Each object was presented to the participant individually, and all other objects were kept out of the participant's line of sight when not in use. The researcher recorded the participants' responses on a response sheet. Upon completion of the study participants were debriefed and thanked for their participation in the experiment.

Figure 22: Summary of Method Used and Trials/Items Involved in Experiment 4B

Study Phase (Session One)

Participants studied the actions through performing the action themselves. The study phase took place in session one, 24 hours prior to the retrieval practice and test phases.

Trials (Study Phase)

There were 32 object-action pairs, 16 were memorable and 16 were non-memorable. Each pair was performed once. Of the 32 there were 8 Rp+ items (4 memorable and 4 non-memorable), 8 Rp- items (4 memorable and 4 non-memorable) and 16 Nrp items (8 memorable and 8 non-memorable).

24-Hour Delay

Retrieval Practice Phase (Session Two)

Participants observed the researcher practice a sub-section of the previously studied items. A two-minute verbal word generation task followed. This pattern was repeated a further two times.

Trials (Retrieval Practice Phase)

Participants practiced two objects for four actions, 8 in total (Rp+ items), 4 were memorable and 4 were non-memorable. These items were practiced 3 times, therefore, there were 24 in total (12 memorable and 12 non-non-memorable).

Test Phase (Session Two)

Participants were asked to perform the actions they could remember that they had encountered during the experiment for each object.

Trials (Test Phase)

Participants were presented each object one at a time, a total of 32. There were 8 Rp+ items (4 memorable, 4 non-memorable), 8 Rp-items (4 memorable, 4 non-memorable), and 16 Nrp items (4 memorable, 4 non-memorable).

Figure 22. The left hand side above figure shows a summary of the method and the right hand side shows information on the trials and items used in experiment 4B.

Results

Memory performance was calculated through successful recollection of the action for the object (see Table 8). Results were calculated through comparing Rp+ items with Nrp items in order to examine a facilitation effect, and comparing Rp- items with Nrp items to examine a retrieval-induced forgetting effect.

Table 8: Mean Proportion Recall Performance for Memorable Items in the Self-Performed/Observation Condition

	Rp+		Rp-		Nrp	
	M	NM	M	NM	M	NM
Self-Performed/ Observation	.99 (.05)	.94 (.11)	.89 (.19)	.64 (.23)	.82 (.17)	.62 (.20)

Note. There were three items of interest. Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category), and Nrp items (unpracticed items from an unpracticed category). M represents memorable items. Standard deviations presented in parenthesis (see Appendix K for raw data (memorable and non-memorable)).

Facilitation Effects

Table 8 demonstrates that mean recall performance for Rp + memorable and non-memorable items was higher compared to Nrp memorable items suggesting that a facilitation effect had occurred. A 2 (item type: Rp+ or Nrp) x 2 (action type: memorable or non-memorable) found a significant main effect of item type $F\,(1, 20) = 38.38, p < .001$ and significant effect of action type $F\,(1, 20) = 31.42, p < .001$. A significant item type x action type occurred as well, $F\,(1, 20) = 8.60, p < .01$. Pairwise comparisons demonstrated a significant difference between Rp+ and Nrp items (.12, $p < .05$) and between memorable and non-memorable items (.25, $p < .001$) suggesting that Rp+ items were remembered better than Nrp items, and memorable items were remembered better than non-memorable items. Pairwise comparisons of the significant item type x action type interaction demonstrated a significant difference between memorable Rp+ and Nrp items (.17, $p < .05$) and between non-memorable Rp+ and Nrp items (-.32, $p < .05$). These findings suggest that a facilitation effect occurred in the current experiment.

Retrieval-Induced Forgetting Effects

Retrieval-induced forgetting effects were examined through comparing mean recall performance for Rp- items with Nrp items. As no significant effects have been found for non-memorable items in the previous experiment these will not be included in the current analysis however the descriptive statistics suggest that no retrieval-induced forgetting occurred for the non-memorable or memorable items (see Table 8). A comparison of memorable Rp- items with memorable Nrp items was not significant, t (20) = 1.60, *n.s.*, supporting the suggestion that no retrieval-induced forgetting had occurred.

Discussion

Retrieval-induced forgetting was demonstrated in experiment 4A in the self-performed/observation condition. Previous research suggests that retrieval-induced forgetting may only occur in situations where active retrieval takes place during retrieval practice (Anderson, Bjork, et al., 2000), as such it may be expected that no retrieval-induced forgetting would have been found in the self-performed/observation condition. However retrieval-induced forgetting was found in the self-performed/observation condition in experiment 4A. One suggested reason for this is that activation level of the items was increased during self-performance of actions in the study phase. The raised activation levels may have been transferred to the retrieval practice phase, increasing competition between the items even though the items were only observed by the participant in the retrieval practice phase. This may have resulted in the demonstrated retrieval-induced forgetting effect. The introduction of a twenty-four hour delay may have provided time for the activation levels to decrease therefore no retrieval-induced forgetting would occur (see also experiments 2 and 3). The introduction of a twenty-four hour delay may provide time for the activation levels which were raised after the study phase to decrease therefore no retrieval-induced forgetting would occur. If however the effect had not appeared because of raised activation levels a retrieval-induced forgetting effect would continue to be seen.

As in experiment 4A participants self-performed the actions during the study phase, and observed the actions being performed by the researcher twenty-four hours later in the retrieval practice phase. Participants in the self-performed/observation condition demonstrated higher recall performance for Rp+ memorable items compared to Nrp memorable items suggesting that a facilitation effect had occurred as was seen in experiment 4A (see also Anderson et al., 1994; Anderson & Spellman, 1995). However unlike the findings of experiment 4A no retrieval-induced forgetting seems to have occurred in the self-performed/observation. This may suggest that the introduction of a twenty-four hour delay allowed activation levels to be reduced resulting in no retrieval-inducing forgetting. This may also suggest that retrieval-induced forgetting was found in the self-performed/observation condition in experiment 4A because activation levels were raised and transferred in the study and retrieval-practice phases. These findings, along with those of experiment 4A, may suggest that retrieval-induced forgetting occurs in situations where participants perform the actions themselves in the retrieval practice phase (see also Sharman, 2011). Sharman (2011) found retrieval-induced forgetting only for self-performed actions. These findings may also support the notion that active retrieval during retrieval practice is a key component in retrieval-induced forgetting whereas re-presentation does not give rise to retrieval-induced forgetting (Anderson, Bjork et al., 2000). These findings replicate those of experiments 2 and 3 where a retrieval-induced forgetting effect was found in the self-performed/observation condition when no twenty-four hour delay occurred however, no retrieval-induced forgetting occurred when a twenty-four hour delay was introduced between the study and retrieval practice phases. However as the current experiment did not involve positive controls it could be argued that retrieval-induced forgetting would not be found in any of the conditions if a twenty-four hour delay was included in all conditions. If retrieval-induced forgetting continued to be seen in the self-performed/self-performed and observation/self-performed condition after the introduction of a twenty-four hour delay this would support the suggestion that retrieval-induced forgetting occurs in conditions involving the self-performance of actions during retrieval practice, and that active retrieval is a key component of retrieval-induced forgetting. It may also suggest that retrieval-induced forgetting occurred in the self-performed/observation condition (prior to the introduction of a twenty-four hour delay) because activation levels were increased in the study phase and transferred to the retrieval practice phase resulting in the retrieval-induced forgetting which was found in experiment 4A. Future research would include running the positive controls in order to further examine this possibility. A further issue in relation of the results of the experiments is the near ceiling effects for the item types, for example, mean recall performance for the Rp+ memorable items was .99 which is high. One suggested reason for this is the smaller amount of trials in the experiment. For example, for the Rp+ memorable items there were only four. This may have provided an opportunity for participants to remember the items very well or to guess some of the items. Future research may possibly include more items than was used in the current experiment.

Experiment 4A also demonstrated an item strength effect, that is, retrieval-induced forgetting occurred only for the memorable (i.e. strong) items. No retrieval-induced forgetting occurred for the non-memorable (i.e. weak) items. These findings are in line with the inhibitory theory which suggests that retrieval-induced forgetting is more likely to occur for strong items than weak items, whereas non-inhibitory theories suggest that retrieval-induced forgetting can occur for the strong and the weak items. These findings are in contrast to those of experiment 3A where retrieval-induced forgetting was found for typical and non-typical items suggest that item strength effect occurred. This may suggest that memorability is a more adequate measure than typicality. There is a mixture of findings in retrieval-induced forgetting literature in terms of item strength. For example, Anderson et al. (1994) demonstrated an effect however Major et al. (2008) found no difference between strong and weak items in terms of retrieval-induced forgetting. Experiments 3 and 4A tested the item strength predictions of the inhibitory and non-inhibitory theories, however, the inhibitory and non-inhibitory theories also differ in terms of several other predictions.

The following experiment will look at cue independence, and the inhibitory and non-inhibitory theories differ in terms of their predictions relating to cue independence. The inhibitory theory proposes that utilising an independent cue (i.e. one which differs to the one used during the study and retrieval practice phases) will not allow the inhibited item to be successfully retrieved (see Anderson & Spellman, 1995) and retrieval-induced forgetting would continue to be demonstrated. Non-inhibitory theories on the other hand would suggest that it is possible for an independent cue to lead to the item being retrieved successfully as it would involve using an alternative retrieval route and no retrieval-induced forgetting should be found. This provides an additional opportunity to compare the predictions of the inhibitory and non-inhibitory theories. With this in mind, the following experiment will also examine cue independence. Participants will self-perform or observe actions performed with an object during the study and retrieval practice phases. In the test phase participants will be provided an alternative object to perform the actions with. If retrieval-induced forgetting continues to be found this may support the inhibitory theory whereas if no retrieval-induced forgetting is found this may support the non-inhibitory theory. The following experiment will utilise the same object-action pairs as experiment 4A and follow a similar procedure however different objects (i.e. independent cues) will be used in the test phase in order to examine cue independence and retrieval-induced forgetting and actions. If retrieval-induced forgetting was found under cue-independent conditions this may support the inhibitory theory, however, if retrieval-induced forgetting was found to be cue-dependent then this may support the predictions of the non-inhibitory theory.

In conclusion, experiment 4A and 4B found evidence of a facilitation effect for the Rp+ memorable items in all four conditions and in the twenty-four hour delay experiment. Retrieval-induced forgetting was not found in the observation/observation condition. A retrieval-induced forgetting effect was found in the self-performed/self-performed; observation/self-performed and self-performed/observation conditions (see experiment 4A). Following the addition of a twenty-four hour delay between the study and retrieval-practice phases in the self-performed/observation condition no retrieval-induced forgetting was found. These findings may suggest that retrieval-induced forgetting can occur for actions (see also Koutstaal et al., 1999; Sharman, 2011). The experiments also demonstrated a item strength effect, that is, retrieval-induced forgetting was only found memorable items. No retrieval-induced forgetting was found for non-memorable items. This suggests that memorability may be a more adequate measure of item strength than typicality (see experiments 3A and 3B), and may also support the inhibitory theory. The following experiment will examine another prediction of the inhibitory and non-inhibitory theory, cue-independence, and retrieval-induced forgetting and actions.

Experiment 4C

Background

The previous experiments demonstrated that retrieval-induced forgetting may occur with regards to actions (Experiments 3 and 4A). In addition to examining retrieval-induced forgetting the previous experiment examined whether an item strength effect occurred. Experiment 4A used memorability as a measure of item strength would seem to support the inhibitory theory and found retrieval-induced forgetting for the memorable items, and not for the non-memorable items. These findings would therefore support the inhibitory theory which suggests that strong items (i.e. memorable items) may be more susceptible to retrieval-induced forgetting compared to weaker items (i.e. non-memorable items). Strong items are more likely to be source of competition and come to mind, interfering with the recall of the target items, as such are more likely to be suppressed or inhibited. The non-inhibitory theory suggests that retrieval-induced forgetting would occur for both strong and weak items. The results of the previous experiment suggest that retrieval-induced forgetting occurred only for the memorable items therefore these findings may be more in line with the predictions of the inhibitory theory (see also Anderson et al., 1994). The results of the previous experiments suggest that strong Rp- items may cause the greatest retrieval competition, and are more likely to intrude into conscious awareness, meaning that strong Rp- items are more likely to be inhibited so as to allow the target item to be recalled, and to resolve the competition issue which has arisen between the Rp+ items and the strong Rp- items. Although these findings may support the inhibitory theory there are other key differences which also occur between the inhibitory and non-inhibitory theories.

The inhibitory and non-inhibitory theories also differ in terms of their predictions regarding independent cues. This allows an additional opportunity to compare the predictions of the two theories. An independent cue refers to different cues being used in the retrieval practice and the test phases. For example, participants may practice Glue-Chair in the retrieval practice phase, however in the test phase participants would be given the cue Table rather than Glue (see Anderson & Spellman, 1995). The inhibitory theory proposes that it is the Rp- itself which is hindered during retrieval-induced forgetting, therefore, using an independent cue in an attempt to access the item would be unsuccessful, that is that the individual would continue be unable to retrieve the item. The non-inhibitory theory however suggests that retrieval-induced forgetting may occur because of interference along the retrieval route, therefore using an independent cue (i.e. utilising an alternative retrieval route) should allow the item to be successfully retrieved. This allows the predictions of the two theories to be examined and compared to each other, and is further example of how the differences between the inhibitory and non-inhibitory theories (see also item strength).

Previous research regarding independent cues has provided a somewhat mixed picture in terms of results. For example, Anderson and Spellman (1995) found evidence of cue independence and provided some support for the inhibitory theory. During the study phase participants in Anderson and Spellman's study studied categories of exemplars, some of which had a pre-existing association with a second category. For example, under the category Red participants studied the word tomato (which also belonged to the Food category). Tomato would continue to be inhibited even when tested with the Food category instead of Red (Anderson & Spellman, 1995). These findings support the inhibitory theory, suggesting that it is the item itself which is affected. Cue independence has been replicated in a number of other studies (MacLeod & Saunders, 2005; see also Anderson & Green, 2001; Saunders & MacLeod, 2006; Veiling & van Knippenberg, 2004).

Several studies however have failed to find a cue independence effect. For example, Perfect et al. (2004) conducted a number of experiments and only found retrieval-induced forgetting under cue dependent conditions (see also Camp et al., 2007; Williams & Zacks, 2001). The findings of retrieval-induced forgetting only under cue dependent conditions would support the non-inhibitory theory, for example, suggesting that retrieval-induced forgetting occurs due to, for example, interference occurring along the retrieval route, and not the item itself being affected. More recently research has examined whether independent cues are truly independent (Camp et al., 2009). The authors concluded that it is not always the case that independent cues are truly independent, for example, participants may make use of covert cues, even when independent cues are used. This mixture of results concerning retrieval-induced forgetting and independent cues suggests that cue independence may be a fragile effect to find, and perhaps a more sensitive measure is required in order to accurately study the role of cue independence/cue dependence and retrieval-induced forgetting.

The aim of the current experiment will be to examine retrieval-induced forgetting for actions under independent cue conditions, that is, will retrieval-induced forgetting continue to be seen under cue independent conditions. If retrieval-induced forgetting continued to be seen then this may support the inhibitory theory, however if no retrieval-induced forgetting occurred this may support the non-inhibitory theories. As in the previous two experiments items will be either memorable or non-memorable in nature and participants will be asked to either self-perform the actions during the study and retrieval practice phases (self-performed/self-performed condition), observe the actions being performed by the researcher during the study and retrieval practice phases (observation/observation condition) self-perform the actions in the study phase and observe the actions in the retrieval practice phase (self-performed/observation condition) or observe the actions being performed in the study phase and self-perform the actions in the retrieval practice phase (observation/self-performed condition).A different cue will be used during the test phase to the one used in the study and retrieval practice phases in order to investigate cue independence in relation to retrieval-induced forgetting.

As in previous experiments the current experiment will also consider whether an enactment effect occurred. Previous action research also suggests that when participants self-perform actions participants tend to remember those actions better than the actions they observe other individuals performing (see Engelkamp & Zimmer, 1989; Hornstein & Mulligan, 2004) which may suggest that a difference might occur between the actions participants in the current experiment perform themselves and the actions which they observe the researcher performing. However, other studies have not found a difference between self-performed and observed actions (see Cohen, 1981; Cohen & Bean, 1983;

Steffens, 2007). The current experiment will therefore also examine whether any difference occurs in terms of recall performance for self-performed and observed actions, that is whether an enactment effect occurred for self-performed actions compared to observed actions.

Aims and Predictions

The aim of the current experiment was to examine retrieval-induced forgetting for actions in terms of cue independence. Participants in the current experiment will be asked to self-perform or observe a number of actions during the study phase. As in the previous experiments the objects will be present and available to the participants to use with the actions. Retrieval practice will follow during which participants will self-perform or observe a sub-section of the previously studied items. During the test phase participants will be provided with a related but alternative object. For example, during the study and retrieval practice phases participants may have used a saucepan to perform the actions with (e.g. saucepan-lift). During the test phase participants would be given a wok and asked to recall the actions (i.e. the actions performed with saucepan).As in experiment 4A and 4B the strength of the items was manipulated. In order to do this, items were classed as either memorable or non-memorable. Retrieval practice gave rise to several items of interest. Items which were practiced were known as the Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category) and Nrp items (unpracticed items from an unpracticed category).

It was predicted that participants would correctly recall more Rp+ items compared to Nrp items, demonstrating a facilitation effect. It was also predicted that participants would recall fewer Rp- items compared to Nrp items, demonstrating a retrieval-induced forgetting effect. Additionally, it was predicted that a difference may occur between memorable and non-memorable actions as previous research suggests that the strength of items can influence the retrieval-induced forgetting effect (see Anderson, Bjork, et al., 2000). In terms of cue independence it was predicted that retrieval-induced forgetting would continue to be demonstrated even under cue independent conditions. A final prediction may be that a difference may occur between the performance of participants who self-performed and observed the actions being performed.

Method

Participants and Design

Eighty-four undergraduate students (51 females, 33 males, *M* age = 26.35), participated in the experiment in exchange for either two course credits or £3. A mixed subjects design was employed with two within subject factors: item type (Rp+ items (practiced items a practiced category), Rp- items (unpracticed items from a practiced category) and Nrp items (unpracticed items from an unpracticed category)) and action type (memorable and non-memorable items). The between subjects factor was action task (i.e. conditions) which had four levels: self-performed/self-performed, observation/observation, self-performed/observation and observation/self-performed. Twenty-one participants completed each condition.

Stimuli and Materials

The stimuli for the study and retrieval practice phases were the same as those in experiment 4A. In order to determine stimuli for the test phase two additional pilot studies were conducted. As this experiment dealt with using independent cues it was also important to choose appropriate alternative objects to the objects used in the main part of the experiment. During the first pilot study, ten participants were given a list of the objects above and asked to come up with alternatives to them. Participants were allowed to include as many alternatives to the object as they were able to think of. In the next pilot study, ten participants were shown an image of the original object, and images of all the alternative objects the participants in the previous pilot study had come up with, and asked to rank the images of the alternative objects with 1 being the object that was most similar to the original object. The alternative objects which were ranked as being most similar to the original object were chosen as alternative objects in the test phase. All participants ranked the alternative as either the most similar or the second most similar alternative object to the original objects. After these pilot studies the alternative objects chosen were: wok, trowel, a vinyl record, washing up glove, bottle, tire pressure gauge, disco ball, and wire (see Appendix L for full list).

Procedure

Participants arrived at the laboratory individually and were greeted by a female researcher. Participants were instructed that during the study phase they would be required to either perform a range of actions with a variety of different objects or observe the researcher perform the actions with the objects. Participants in the self-performed/self-performed and self-performed/observation conditions performed all the actions themselves throughout the study phase. Participants in the observation/observation and observation/self-performed conditions observed the researcher perform the actions throughout the study phase. The order of presentation of both the objects and the actions was counterbalanced throughout all phases of the experiment. Participants were presented with each object individually and asked to perform four actions for each object. The researcher instructed all participants as to which actions to perform (e.g. CD-spin, CD-slide, CD-blow and CD-bend). This pattern continued until all of the actions for all of the objects had been performed by the participant. There were eight objects and four actions associated with each object therefore in total there were thirty-two object-action pairs. Of the thirty-two object-action pairs, sixteen of these were memorable items and sixteen were non-memorable items. All objects were kept hidden from the participants' line of sight when not in use, hidden behind a partition in the laboratory. Each object was only presented for as long as it took the participant to complete the actions, and actions which involved the same object were studied together.

Participants then progressed to the retrieval practice phase. Participants either self-performed (self-performed/self-performed and observation/self-performed conditions) or observed (observation/observation and self-performed/observation conditions) the researcher practicing a sub-section of the previously studied items (e.g. CD-slide, CD-spin). After completing retrieval practice once, participants completed a two-minute verbal word generation task. Verbal tasks were used in place of written tasks as written tasks may have contaminated the actions. As with the study phase all of the objects were kept out of sight until they were required. Participants practiced two actions for four objects, a total of eight object-action pairs. Of these four were memorable items and four were non-memorable items. This pattern was then repeated a further two times, therefore, participants practiced the eight object-action pairs three times.

Following the retrieval practice phase, all participants regardless of the condition they were assigned to were asked to perform all the actions they were able to remember that they had encountered during the course of the study. However, during this phase participants were presented with the alternative object (independent cue) in place of the original object. During the test phase participants were presented with the following instructions: "*In the first part of this experiment you were given a set of everyday objects and asked to perform certain actions with them. Now, in the following phase we will test your memory for those actions. However, we will not give you the same objects as we did in the first phase. Instead, we will give you objects that are visually similar to the objects you saw in the study phase. For each object please carry out as many actions as you can for that object. For example, say that in the study phase you were given a BOOK (object) and asked to do four different actions with it, e.g., BOOK-open, BOOK -wave, BOOK-place on your head). Then, in this phase we will give you a MAGAZINE (which is visually similar to a book) and ask you recall all the four actions that you learnt to do with its cousin (the book) including placing it on your head! Now, to recap: In this phase we will be testing your memory for the actions you learned on the objects in the first phase (despite the fact that we will give you similar but not the exact same objects to perform them with)*". There was one alternative for each of the original objects therefore there were eight alternative objects in total and four possible actions for each object for participants to recall. In total participants had thirty-two object-action pairs to attempt to recall. Each object was presented to the participant individually and the other objects were kept out of the participant's line of sight when not in use. The researcher recorded the participants' responses on a response sheet. Upon completion of the experiment participants were debriefed and thanked for their participation in the experiment (see Figure 23 for summary of the method used).

Figure 23: Summary of Method Used and Trials/Items Involved in Experiment 4C

Study Phase

Participants studied the actions through either performing the action themselves or observing the researcher perform the actions.

Trials (Study Phase)

There were 32 object-action pairs, 16 were memorable and 16 were non-memorable. Each pair was performed once. Of the 32 there were 8 Rp+ items (4 memorable and 4 non-memorable), 8 Rp- items (4 memorable and 4 non-memorable) and 16 Nrp items (8 memorable and 8 non-memorable).

Retrieval Practice Phase

Participants observed the researcher perform or self-perform a sub-section of the previously studied items. A two-minute verbal word generation task followed. This pattern was repeated a further two times.

Trials (Retrieval Practice Phase)

Participants practiced two objects for four actions, 8 in total (Rp+ items), 4 were memorable and 4 were non-memorable. These items were practiced 3 times, therefore, there were 24 in total (12 memorable and 12 non-non-memorable).

Test Phase

Participants were asked to perform the actions they could remember that they had encountered during the experiment for each object.

Trials (Test Phase)

Participants were presented each object one at a time, a total of 32. There were 8 Rp+ items (4 memorable, 4 non-memorable), 8 Rp- items (4 memorable, 4 non-memorable), and 16 Nrp items (4 memorable, 4 non-memorable).

Figure 23. The left hand side above figure shows a summary of the method and the right hand side shows information on the trials and items used in experiment 4C.

Results

Memory performance was calculated through the successful recollection of the action for the object (see Table 9). The retrieval success rate for participants in the self-performed/self-performed and observation/self-performed conditions was 100%. Results were calculated through comparing Rp+ items with Nrp items in order to examine a facilitation effect, and Rp- items with Nrp items to examine a retrieval-induced forgetting effect.

Table 9: Mean Proportion Recall Performance for All Conditions and for Each Item Type

	Rp+		Rp-		Nrp	
	M	NM	M	NM	M	NM
Self-performed/	.98	.94	.69	.63	.86	.61
Self-performed	(.11)	(.16)	(.22)	(.20)	(.16)	(.16)
Observation/	.92	.90	.72	.58	.70	.52
Observation	(.14)	(.15)	(.29)	(.30)	(.19)	(.19)
Self-Performed/	.96	.93	.85	.67	.83	.59
Observation	(.09)	(.14)	(.17)	(.20)	(.16)	(.24)
Observation/	.93	.90	.68	.61	.83	.59
Self-Performed	(.12)	(.19)	(.26)	(.27)	(.13)	(.16)

Note. There were three item types of interest: Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category), and Nrp items (unpracticed items from an unpracticed category). M refers to memorable items. NM refers to non-memorable items. Standard deviations presented in parenthesis (see Appendix M for raw data).

Facilitation Effects

Table 9 demonstrates that mean recall performance for Rp + items was higher than Nrp items across all four conditions. This suggests that practice facilitates memory. In order to examine this facilitation effect a 4 (action task: self-performed/self-performed, observation/observation, self-performed/observation and observation/self-performed) x 2 (item type: Rp+ and Nrp) x 2 (action type: memorable and non-memorable) analysis of variance (ANOVA) was performed which revealed a significant effect of item type, F (1, 80) = 245.81, $p < .001$. There was also a significant effect for action type, F (1, 80) = 62.28, $p < .001$. A significant effect of action task was also found, F (3, 80) = 2.87, $p < .05$. A significant two way interaction was found between item type and action type, F (3, 80) = 38.07, $p < .01$. There was no significant two-way interaction between action type and action task, F (3, 80) = .46, *n.s.*, or item type and action task, F (3, 80) = 1.59, *n.s.* There was also no significant three way interaction between item type, action type, and action task, F (3, 80) = .13, *n.s.*

Pairwise comparisons demonstrate that the difference between the Rp+ and Nrp items is significant (.13, $p < .001$) suggesting that facilitation did occur for the Rp+ items. The difference between memorable and non-memorable items was also significant (.24, $p < .05$) suggesting that memorable items are recalled better than non-memorable items. No significant differences occurred between the conditions asides from between the self-performed/self-performed and observation/observation conditions (.08, $p < .05$). A significant difference also occurred between memorable Rp+ and Nrp items (.14, $p < .05$) and also between non-memorable Rp+ and Nrp items (.34, $p < .05$). These results suggest that a facilitation effect occurred regardless whether actions were memorable or non-memorable, and regardless of whether the participants performed the items themselves or observed the researcher.

Retrieval-Induced Forgetting Effects

As in the previous experiments non-memorable data was removed from the retrieval-induced forgetting comparisons. Retrieval-induced effects were examined through comparing Rp- items with Nrp items in terms of recall performance. The mean recall performance for Rp- items was lower than Nrp items in the self-performed/self-performed and observation/self-performed conditions (see Table 9). These results suggest that retrieval-induced forgetting occurred in these conditions. This was not the case in the observation/observation and self-performed/observation conditions. In both of these conditions mean recall performance for Rp- items was higher than mean recall performance for Nrp items. The non-memorable data suggests that no retrieval-induced forgetting occurred for the Rp- non-memorable items as mean recall performance for the Rp- non-memorable items was higher than mean recall performance for Nrp non-memorable items. This would be the opposite of what would be expected if retrieval-induced forgetting had occurred in the observation/observation and self-performed/observation conditions. In this case it would be suggested that participants performing actions themselves in the retrieval practice phase (i.e. retrieval), may be an important component, whereas re-presentation as occurred in the observation/observation and self-performed/observation conditions does not require retrieval and as such does not give rise to retrieval-induced forgetting.

In order to examine this retrieval-induced forgetting effect a 4 (action task: self-performed/self-performed, observation/observation, self-performed/observation and observation/self-performed conditions) x 2 (item type: Rp- and Nrp) analysis of variance (ANOVA) was performed which revealed no significant effect of item type, $F(1, 80) = .960$, *n.s.* A significant main effect of action task was found $F(3, 80) = 7.20$, $p < .01$. A significant two way interaction was found between item type and action task, $F(3, 80) = 8.80$, $p < .001$. Pairwise analysis of the action task finding demonstrated a significant difference between the self-performed/self-performed and observation/observation conditions ($p < .05$). A significant difference also occurred between the observation/observation and self-performed/observation conditions ($p < .01$) and observation/observation and observation/self-performed conditions ($p < .01$).

Pairwise comparison of the significant item type x action task interaction found no significant difference between conditions in terms of Rp- items. However a significant difference occurred between conditions for Nrp items. A significant difference occurred between the observation/observation condition and the self-performed/self-performed condition (.10, $p < .05$), and self-performed/observation (.16, $p < .001$). Furthermore the findings demonstrate significant retrieval-induced forgetting in the self-performed/self-performed (.12, $p < .01$) and observation/self-performed conditions (.06, $p < .05$) suggesting that participants had recalled significantly fewer Rp- items compared to Nrp items in both conditions. These findings therefore suggest that retrieval-induced forgetting occurred in two conditions (self-performed/self-performed and observation/self-performed conditions) in the current experiment.

Effect of Action Task on Memory for Control Items (Nrp Items)

In order to determine whether self-performance and observation during the study phase impacted on the recall performance for the Nrp actions a between subjects ANOVA was conducted including all four conditions (action task: self-performed/self-performed, observation/observation, self-performed/observation or observation/self-performed conditions) was conducted. A main effect of action type was found to be significant F (1, 80) = 83.22, $p < .001$. There was also a significant effect of action task, F (3, 80) = 3.17, $p < .05$. There was no significant action task x action type interaction, F (3, 80) = .44, *n.s.* Pairwise comparisons demonstrate that the difference between the memorable and non-memorable items is significant (.09, $p < .001$) suggesting that recall performance for memorable items was better than recall performance for non-memorable items. Pairwise comparisons also demonstrated no significant between the groups asides from a significant difference between the self-performed/self-performed and observation/observation conditions (.18, $p < .05$). This suggests that on the whole no enactment effect occurred in the current experiment apart from the one exception of the self-performed/self-performed condition compared to the observation/observation condition.

Discussion

The previous experiments demonstrated that retrieval-induced forgetting can occur with regards to actions (Experiments 3A and 4A). Experiment 4A further demonstrated that retrieval-induced forgetting may only be found for memorable Rp- items, which may support the predictions of the inhibitory theory. The inhibitory theory suggests that strong items (i.e. memorable items) would be more susceptible to retrieval-induced forgetting compared to weaker items (i.e. non-memorable items). These items are more likely to be source of competition and come to mind, interfering with the recall of the target items. As such strong items are more likely to be suppressed or inhibited. In the previous experiment strong items were memorable items. No retrieval-induced forgetting was found for the non-memorable items (i.e. weak items). Although these findings may support the inhibitory theory, there are other key differences which may occur between the inhibitory and non-inhibitory theories. One of these relates to cue independence. For example, the inhibitory theory proposes that it is the Rp- itself which is affected, therefore, using an independent cue should continue to mean that the item cannot be successfully retrieved. The non-inhibitory theory however suggests that retrieval-induced forgetting may occur because of interference along the retrieval route, therefore using an independent cue should allow the item to be successfully retrieved.

The aim of the current experiment therefore was to examine retrieval-induced forgetting for actions in terms of cue independence. Participants were asked to self-perform or observe a number of actions during the study phase. Retrieval practice followed during which participants self-performed or observed a sub-section of the previously studied items. During the test phase participants were provided with a related but alternative object. For example, during the study and retrieval practice phase participants may have used a saucepan to perform the actions with. During the test phase participants would be given a wok and asked to recall the actions in place of the saucepan. Retrieval practice gave rise to several items of interest. Items which were practiced were known as Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category) and Nrp items (unpracticed items from an unpracticed category). It was predicted that participants would correctly recall more Rp+ items compared to Nrp items, demonstrating a facilitation effect. It was also predicted that participants would recall fewer Rp- items compared to Nrp items, demonstrating a retrieval-induced forgetting effect. In terms of cue independence it was predicted that retrieval-induced forgetting would continue to be demonstrated even under cue independent conditions (see Anderson & Spellman, 1995). Additionally, it was predicted that a difference may occur between the memorable and non-memorable items. A final prediction was that a difference may occur between the performance of participants who self-performed and observed the actions being performed.

A comparison of mean recall performance for Nrp items suggests that no enactment effect was found in the current experiment for self-performed actions compared to observed actions. These findings therefore support those of experiments 2 and 3, which also failed to find an enactment effect. Furthermore, these findings also support several studies which have not demonstrated an enactment effect (Steffens, 2007; see also Cohen, 1981; Cohen & Bean, 1983). However also in the current experiments an enactment effect may have occurred between the self-performed/self-performed observation/observation conditions, this was not the case with other conditions in the current experiment. This may have occurred because these two conditions involve purely only self-performance or observation. However the findings relating to the enactment effect represents the mixture of findings in the memory for actions literature with studies having found an enactment effect (see Engelkamp & Zimmer, 1989) whilst others have not found an enactment effect (see Steffens, 2007). As in the previous experiments a facilitation effect was found for Rp+ items compared to Nrp items across all four conditions. These findings suggest that practice facilitates memory and supports the findings previous experiments in this thesis and previous research (see Anderson et al., 1994; Anderson & Spellman, 1995). The results also demonstrated retrieval-induced forgetting for Rp- items. As in experiment 4A no retrieval-induced forgetting seems to have occurred for the non-memorable items. The descriptive statistics suggest that mean recall performance for Rp- items was not lower than mean recall performance for Nrp items in terms of non-memorable items. Retrieval-induced forgetting however was found for memorable items. These findings suggest that an item strength effect may occurred and differ to the findings of experiment 3A which found retrieval-induced forgetting for both typical and non-typical items suggesting that no item strength effect. The finding of item strength for memorability may support the inhibitory theory and may also suggest that memorability is a more appropriate method for measuring item strength than typicality.

In the current experiment retrieval-induced forgetting was found in the self-performed/self-performed, and observation/self-performed conditions, however, not in the observation/observation and self-performed/observation condition. Firstly, this finding of retrieval-induced forgetting supports previous research which suggests that retrieval-induced forgetting may occur with regards to actions. For example, Koutstaal et al. (1999) demonstrated retrieval-induced forgetting with regards to images of actions. More recently, Sharman (2011) found a retrieval-induced forgetting effect for actions in a study examining both bizarre and familiar actions. Retrieval-induced forgetting was found for both bizarre and familiar actions, but only for self-performed actions and not for the observed actions. Therefore in addition the findings of the current experiment support the suggestion that retrieval-induced forgetting may only occur in cases where active retrieval takes place during retrieval practice (i.e. during self-performance of actions in the self-performed/self-performed and observation/self-performed conditions). This may also be supported by a lack of retrieval-induced forgetting in the self-performed/observation and observation/observation condition. These findings support the findings of Sharman who found retrieval-induced forgetting only for self-performed actions.

The inhibitory theory also suggests that the forgetting of Rp- items is specific to retrieval processes, meaning that the general strengthening of the association between the cue and Rp+ items via other methods such as extra study time is inadequate to initiate retrieval competition and inhibition. However, non-inhibitory theories propose that retrieval-induced forgetting emanates from strengthening Rp+ items, and retrieval may not be necessary for this to occur. For example, other techniques such as, extra study time or re-presentation are suggested as methods which could strengthen the Rp+

items leading to the forgetting of the Rp- items. The findings of the current experiment may therefore support the inhibitory theory, and may also supports the findings of Anderson, Bjork et al. (2000), and Sharman (2011) who demonstrated that observation (i.e. re-presentation) may not be sufficient to give rise to retrieval-induced forgetting (see also Bauml, 2002; Campbell & Phenix, 2009). This may support the findings of a lack of a retrieval-induced forgetting effect in conditions involving observation in the retrieval practice phase (i.e. observation/observation and self-performed/observation conditions) in the current experiment. As retrieval-induced forgetting was only found in the two conditions involving active retrieval during the retrieval practice phase (i.e. self-performed/self-performed and observation/self-performed condition) these findings support the inhibitory theory more so than the non-inhibitory theory.

In addition, the descriptive statistics, and data from experiment 4A suggest that retrieval-induced forgetting may not have occurred for non-memorable items in any of the conditions. This finding also lends support to the inhibitory theory which suggests that strong items are more likely to be inhibited than weak items. In this case the strong items would be the memorable items, whereas the weak items would be the non-memorable items. Strong Rp- items are more likely to interfere with retrieval of the target items, and are therefore a greater source of competition, which may need to be suppressed or inhibited in order to allow the target items to be successfully recalled. Non-inhibitory theories however would suggest that retrieval-induced forgetting also occurs for the weak items. As retrieval-induced forgetting was only found for the Rp-memorable items, this supports the inhibitory theory and the findings of Anderson et al. (1994) who manipulated the strength of Rp- items and found that retrieval-induced forgetting was greatest when the Rp- items were strong. These findings differ to those of experiments 3A where retrieval-induced forgetting was found for both typical (i.e. strong) and non-typical (i.e. weak) items. Firstly, this may suggest that memorability may be a more appropriate measure of item strength than typicality. Secondly, this difference in findings between the typicality and memorability in terms of item strength and retrieval-induced forgetting would be examined as part of future studies.

The current experiment also demonstrated a cue independent effect, supporting the inhibitory theory, which would suggest that retrieval-induced forgetting would continue to be seen under cue independent conditions. The non-inhibitory theories however would suggest that utilising a new cue should allow the item to be successfully retrieved. Previous findings have found evidence to support both the inhibitory and non-inhibitory evidence. For example, Anderson and Spellman (1995) found evidence of cue independence (see also Anderson & Green, 2001; MacLeod & Saunders, 2005; Saunders & MacLeod, 2006; Veiling & van Knippenberg, 2004). Several studies however have failed to find a cue independence effect. For example, Perfect et al. (2004) conducted a number of experiment and only found retrieval-induced forgetting under cue dependent conditions (see also Camp et al., 2007; Williams & Zacks, 2001). The finding of the current experiment of retrieval-induced for actions under cue independent conditions supports the inhibitory theory. Furthermore these findings may continue to support the suggestion that retrieval-induced forgetting may occur for actions. One interesting finding in the current experiment is that retrieval-induced forgetting was only found in the self-performed/self-performed and observation/self-performed conditions. No retrieval-induced forgetting was found in the observation/observation and self-performed/observation conditions. Previous experiments in this thesis (e.g. experiment 4A) found retrieval-induced forgetting in the self-performed/self-performed, observation/self-performed, and self-performed/observation conditions. No retrieval-induced forgetting had been found in the observation/observation condition. Therefore the finding of retrieval-induced forgetting in the self-performed/observation condition in previous experiments has disappeared in the current experiment. The only change between these experiments (e.g. experiment 4A and 4C) is the introduction of independent cues in the test phase. It may be proposed then that this difference in findings may have been due to the introduction of independent cues, however, future research would need to be conducted in future to further explore this possibility. A limitation of the current experiment is ceiling effects, for example, for the memorable Rp+ items, which may be due to the fewer number of trials. Future research may also take this into consideration, for example, increasing the number of trials.

This experiment and the previous experiments both in this chapter and the previous chapter utilised a performance test in that participants were asked to perform actions they were able to remember for each action. The following experiment will follow a similar procedure in that participants will perform the actions themselves or observe the researcher perform the actions during the study and retrieval practice phases; however, in place of a performance test participants will be asked to complete a written test. Previous research have also made use of both performance and written tests. Steffens (2007) for example used both a written test and a performance test as measures of memory for actions (see experiment 1 and 2, Steffens, 2007). Although it may be more ecologically valid to use a performance test in the final test phase it is also important to consider that when moving from experiments 2A and 2B to 3A not only did the focus of the experiment change from objects to actions but also the type of test used changed from a written test to a performance test. These two changes may have affected the results. In order to further examine this the following experiment will use a written test in line with experiment 2A and 2B but the focus will have changed from objects (experiments 2A and 2B) to actions.

In conclusion, the current experiment found evidence of a facilitation effect for Rp+ items with better recall performance for Rp+ items compared to Nrp items. This was the case regardless of whether the participant had performed the actions themselves or observed the actions being performed by the researcher. The current experiment also found retrieval-induced forgetting in the self-performed/self-performed and observation/self-performed conditions. No retrieval-induced forgetting was found in the self-performed/observation and observation/observation conditions. These findings may support the suggestion that retrieval-induced forgetting occurs in situations where participants perform the actions themselves in the retrieval practice phase (see also Sharman, 2011). In addition, these findings support the notion that active retrieval during the retrieval practice phase, in this case the self-performance of the actions, are a key component, and that re-presentation, in this case observation, does not give rise to retrieval-induced forgetting (Anderson, Bjork et al., 2000; see also Campbell & Phenix, 2009). This finding represents a difference in the comparison with the findings of retrieval-induced forgetting in the self-performed/observation condition. Retrieval-induced forgetting occurred in the self-performed/observation condition in previous experiments' but this was not the case in the current experiments. Furthermore the findings demonstrate a cue independent effect which also supports the findings of the inhibitory theory, which suggests that retrieval-induced forgetting is more likely to occur for strong items than weak items, whereas the non-inhibitory theories suggests that retrieval-induced forgetting would occur for both the strong and the weak items. The following experiment will continue to examine retrieval-induced forgetting and actions utilising a written test phase.

Experiment 4D

Background

The previous experiments have demonstrated that retrieval-induced forgetting can occur for actions. This was the case for typical and non-typical items (Experiment 3) and also for memorable items (Experiment 4A). Furthermore the previous experiments in this chapter have examined retrieval-induced forgetting through comparing several predictions made by the inhibitory and non-inhibitory theories. The findings from a previous experiment in this chapter (Experiment 4A) looked at memorability as a measure of item strength would seem to support the inhibitory theory and found retrieval-induced forgetting for the memorable items only which would support the predictions of the inhibitory theory. Furthermore experiment 4C considered cue independence. During the previous experiments participants self-performed or observed the actions being performed during the study and retrieval practice phases. This was followed by a performance test during which participants self-performed all the actions they were able to recall, to see which actions participants were able to remember for each object. Previous research has also made use of both written tests and performance tests. For example, Steffens (2007) utilised both a written test and a performance test as measures of memory for actions (see experiment 1 and 2, Steffens, 2007). Steffens asked participants to perform, observe or verbally learn actions during a study phase. In the written test participants were asked to recall all the objects that they had been asked to pack. In the performance test participants were asked to pack the bag as they had been instructed to do in the study phase. In both experiments memory performance for self-performed and observed actions was better than memory performance for verbally learnt materials. Also in both experiments participants no enactment effect occurred for self-performed actions compared to observed actions. Previous experiment in the thesis relating to actions have made use of actions have made use of a performance test in the final test phase. However, in order to complete the picture, the current experiment will utilise a written cued recall test during the test phase in place of the performance test.

In addition to testing participants for memory for actions using a written test, memorability will also be examined as a measure of item strength, as was done in experiment 4A. In addition to finding an item strength effect in experiment 4A several other studies have found an item strength effect (see Anderson, Bjork, et al., 2000). These findings may support the inhibitory theory which would suggest that retrieval-induced forgetting would more likely occur for strong items compared to weak items as strong items are more likely to intrude into conscious awareness. Participants in the current experiment will either self-perform or observe actions being performed by the researcher during the study and retrieval practice phases. The actions used will be either memorable or non-memorable in nature as was found by pilot studies. The method will follow a very similar method to that of experiment 4A with four conditions. Participants will either self-perform the actions during the study and retrieval practice phases (self-performed/self-performed condition), observe the actions being performed during the study and retrieval practice phases (observation/observation condition), self-perform the actions during the study phase and observe the actions during the retrieval practice phase (self-performed/observation condition) or observe the actions during the study phase and self-perform the actions during the retrieval practice phase (observation/self-performed condition). All participants will then regardless of which conditions the participants were assigned to will be asked to complete the written cued recall test.

Aims and Predictions

The aim of the current experiment was to examine retrieval-induced forgetting for actions utilising a written test rather than a performance test. Participants were asked to self-perform or observed the actions during the study phase. As in the previous experiments objects were present and provided to the participant when the objects are required to perform the actions. Retrieval practice will follow during which participants will self-perform or observe a sub-section of the previously studied items. Two other conditions included a combination of self-performance and observation. During the test phase participants were provided with a written cue on a piece of card consisting of the name of the object and the first two letters of an action performed or observed with that particular object (e.g. flask-po__). Additionally as in experiment 4A the strength of the items was manipulated. In order to do this, items were classed as either memorable or non-memorable based on the findings of a pilot study.

Retrieval practice gave rise to several items of interest: Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category) and Nrp items (unpracticed items from an unpracticed category). It was predicted that participants would correctly recall more of the Rp+ items compared to Nrp items (baseline measure), demonstrating a facilitation effect. It was also predicted that participants would recall fewer Rp- items compared to Nrp items, demonstrating a retrieval-induced forgetting effect. Additionally, it was predicted that a difference may occur between the memorable and non-memorable actions as previous research. A final prediction may be that a difference may occur between the performance of participants who self-performed and observed the actions being performed.

Method

Participants and design

Eighty undergraduate students (45 females, 35 males, *M* age = 20.03) participated in the experiment in exchange for either two course credits or £3. A mixed subjects design was employed with two within subject factors: item type (Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category) and Nrp items (unpracticed items from an unpracticed category)) and action type (memorable and non-memorable items). The between subjects factor was action task (i.e. condition) which had four levels: self-performed/self-performed, observation/observation, self-performed/observation and observation/self-performed conditions. Twenty participants completed each condition.

Stimuli and Materials

Stimuli used were the same as those used in experiment 4A.

Procedure

Participants arrived at the laboratory individually and were greeted by a female researcher. Participants were instructed that during the study phase they would be required to perform a range of actions with a variety of different objects. Participants in the self-performed/self-performed and self-performed/observation conditions performed all the actions themselves throughout the study phase. Participants in the observation/observation and observation/self-performed conditions observed the researcher perform the actions throughout the study phase. The order of presentation of both the objects and the actions was counterbalanced throughout all phases of the experiment. Participants were presented with each object individually and asked to perform four actions for each object. The researcher instructed all participants as to which actions to perform (e.g. CD-spin, CD-slide, CD-bend, and CD-blow). This pattern continued until all of the actions for all of the objects had been performed by the participant. There were eight objects and four actions for each object, therefore in total there were thirty-two object-action pairs. Of the thirty-two sixteen were memorable and sixteen were non-memorable. All objects were kept hidden from the participants' line of sight when not in use, hidden behind a partition when not required.

Participants then progressed to the retrieval practice phase. Participants either self-performed (self-performed/self-performed and observation/self-performed conditions) or observed (observation/observation and self-performed/observation conditions) the researcher practicing a sub-section of the previously studied items (e.g. CD-slide, CD-spin). After completing retrieval practice once, participants completed a two-minute verbal word generation task. Participants practiced two actions for four objects, in total eight object-action pairs. Of the eight object-action pairs, four of these were memorable four were non-memorable. As in the previous experiments a verbal task was used in order to ensure that the actions were not contaminated which may have occurred had participants been asked to complete a written generation task. As with the study phase all objects were kept out of sight until they were required. This pattern was then repeated a further two times.

During the test phase all participants were shown a written cue consisting of the name of an object and the first two letters of an action used with that object during the experiment (e.g. flask-po__). Each cue was presented individually to the participants on a piece of A4 card for 10 seconds. There was one cue for each of the object-action pairs therefore thirty-two in total. Rp- items were presented first, followed by the Nrp items and finally the Rp+ items. This was done in order to prevent output interference effects (Racsmany, Conway, & Demeter, 2009; Perfect et al., 2004). Participants were asked to write down the name of the action if they were able to remember it (see Figure 24 for summary of the method used). Participants were thanked for their participation in the experiment and debriefed.

Figure 24: Summary of Method Used and Trials/Items Involved in Experiment 4D

Study Phase

Participants studied the actions through either performing the action themselves or observing the researcher perform the actions.

Trials (Study Phase)

There were 32 object-action pairs, 16 were memorable and 16 were non-memorable. Each pair was performed once. Of the 32 there were 8 Rp+ items (4 memorable and 4 non-memorable), 8 Rp- items (4 memorable and 4 non-memorable) and 16 Nrp items (8 memorable and 8 non-memorable).

Retrieval Practice Phase

Participants observed the researcher perform or self-perform a sub-section of the previously studied items. A two-minute verbal word generation task followed. This pattern was repeated a further two times.

Trials (Retrieval Practice Phase)

Participants practiced two objects for four actions, 8 in total (Rp+ items), 4 were memorable and 4 were non-memorable. These items were practiced 3 times, therefore, there were 24 in total (12 memorable and 12 non-non-memorable).

Test Phase

Participants were presented with a written cue consisting of the name of the action and first two letters of an object for 10 seconds each, and asked to write the name of the object down if they could remember it.

Trials (Test Phase)

Participants were presented each object one at a time, a total of 32. There were 8 Rp+ items (4 memorable, 4 non-memorable), 8 Rp- items (4 memorable, 4 non-memorable), and 16 Nrp items (4 memorable, 4 non-memorable).

Figure 24. The above figure is a summary of the method used in experiment 4D. Also included are further details on the number of trials and item types.

Results

The retrieval success rate for participants in the self-performed/self-performed and observation/self-performed conditions was 100%. Memory performance was calculated through the successful recollection of the action for the object (see Table 10). Results were calculated through comparing Rp+ items with Nrp items in order to examine a facilitation effect, and Rp- items with Nrp items to examine a retrieval-induced forgetting effect. As the previous experiments have not demonstrated a significant finding statistical analysis will focus on the memorable items.

Table 10: Mean Proportion Recall Performance for All Four Conditions for Memorable and Non-Memorable Items

	Rp+		Rp-		Nrp	
	M	NM	M	NM	M	NM
Self-performed/	.98	.94	.79	.76	.92	.68
Self-performed	(.08)	(.11)	(.25)	(.26)	(.07)	(.23)
Observation/	.93	.83	.89	.75	.81	.71
Observation	(.14)	(.20)	(.19)	(.20)	(.15)	(.18)
Self-Performed/	.96	.91	.80	.75	.89	.73
Observation	(.01)	(.19)	(.25)	(.28)	(.15)	(.20)
Observation/	.96	.88	.74	.70	.86	.68
Self-Performed	(.09)	(.21)	(.26)	(.26)	(.21)	(.25)

Note. There were three item types of interest: Rp+ items (practiced items from a practiced category), Rp- items (unpractised items from a practiced category), and Nrp items (unpractised items from an unpractised category). M represents memorable items. NM represents non-memorable data. Standard deviations presented in parenthesis (see Appendix O for raw data).

Facilitation Effects

Table 10 demonstrates that mean recall performance for Rp + items were higher than mean recall performance for Nrp items across all four conditions. In order to examine this facilitatory effect a 4 (action task: self-performed/self-performed, observation/observation, self-performed/observation and observation/self-performed) x 2 (item type: Rp+ and Nrp) x 2 (action type: memorable and non-memorable) analysis of variance (ANOVA) was performed which revealed a significant effect of item type, F (1, 76) = 56.67, $p < .001$. There was also a significant effect for action type, F (1, 76) = 51.64, $p < .001$. There was no significant effect of action task, F (3, 76) = 1.54, *n.s.* A significant two way interaction was found between item type and action type, F (3, 76) = 8.59, $p < .01$. There was however no significant two-way interaction between action type and action task, F (3, 76) = .31, *n.s.*, or item type and action task, F (3, 76) = .28, *n.s.* There was also no significant three way interaction between item type, action type, and action task, F (3, 76) = 1.37, *n.s.*

Pairwise comparison demonstrated a significant difference between memorable and non-memorable items (.12, $p < .001$) and also between Rp+ and Nrp items (.64, $p < .001$) suggesting that a facilitation effect occurred in the current experiment. Furthermore a significant difference occurred between memorable Rp+ and Nrp items (.09, $p < .001$) and non-memorable Rp+ and Nrp items (.10, $p < .001$). A significant difference occurred between the memorable Rp+ and Nrp items (.07, $p < .01$) and non-memorable Rp+ and Nrp items (.14, p < .01). No significant difference occurred between any of the conditions for either Rp+ or Nrp items. These results demonstrate a facilitation effect regardless whether items were memorable or non-memorable, and whether the actions were self-performed or observed.

Retrieval-Induced Forgetting Effects

Retrieval-induced effects were examined through comparing mean recall performance for Rp- items with Nrp items. As in the previous two experiments non-memorable data were removed from the analysis. Mean recall performance for Rp- items lower than Nrp items in the self-performed/self-performed, observation/self-performed and observation/self-performed conditions suggesting that retrieval-induced forgetting had occurred. Mean recall performance for Rp- items however was higher than Nrp in the observation/observation condition suggesting that no retrieval-induced forgetting had occurred this condition. In order to examine this retrieval-induced forgetting effect a 4 (action task: self-performed/self-performed, observation/observation, self-performed/observation and observation/self-performed conditions) x 2 (item type: Rp- and Nrp) analysis of variance (ANOVA) was performed which revealed no significant effect of item type, $F\,(1, 76) = 6.68$, $p < .05$. There was also no significant effect of action task, $F\,(3, 76) = .50$, *n.s.* A significant two way interaction was found between item type and action task, $F\,(3, 76) = 3.54$, $p < .05$. Further analysis found a significant difference between Rp- and Nrp items (-16, $p < .05$). No significant differences were found between any of the conditions in relation to Rp- or Nrp items. A significant difference also occurred between Rp- and Nrp items in the self-performed/self-performed (-.13, $p < .05$), self-performed/observation (-.22, $p < .05$) and observation/self-performed (-.12, $p < .05$) conditions. No significant difference occurred between the Rp- and Nrp items in the observation/observation condition. Additionally mean recall performance for Rp- non-memorable items were higher than for Nrp non-memorable items suggesting that no retrieval-induced forgetting had occurred for non-memorable Rp- items in any of the conditions. These findings suggest that retrieval-induced forgetting occurred in the self-performed/self-performed, observation/self-performed and self-performed/observation conditions but not in the observation/observation condition.

Effect of Action Task on Memory for Control Items (Nrp Items)

In order to determine whether self-performance and observation during the study phase impacted on the recall performance for the Nrp actions a mixed ANOVA 4 (action task: self-performed/self-performed, observation/observation, self-performed/observation or observation/self-performed conditions) x 2 (action type: memorable or non-memorable) was conducted. A main effect of action type was found to be significant $F\,(1, 80) = 39.03$, $p < .001$. There was no a significant effect of action task, $F\,(3, 80) = .49$, *n.s.* There was no significant action task x action type interaction, $F\,(3, 80) = 1.05$, *n.s.*

Pairwise comparison demonstrates that the difference between the memorable and non-memorable items was significant (.17, $p < .05$). These findings therefore suggest that no enactment effect occurred in the current experiment.

Discussion

The previous experiments demonstrated that retrieval-induced forgetting occurred for actions, which were self-performed during the retrieval practice phase and for memorable items only. No retrieval-induced forgetting was found for the non-memorable items, nor in conditions during which participants observed the actions being performed by the researcher in the retrieval practice phase. Those findings seem to support the inhibitory theory in terms of highlighting the role of retrieval and retrieval competition, and demonstrate that re-presentation does not seem to give rise to retrieval-induced forgetting. In addition, experiment 4C seems to support the inhibitory theory as it demonstrated retrieval-induced forgetting under independent cue conditions. The aim of the current experiment was to see if retrieval-induced forgetting also occurred in a written cued recall test.

It was predicted that participants would recall correctly more Rp+ items compared to Nrp items, demonstrating a facilitation effect. It was also predicted that participants would recall fewer Rp- items compared to Nrp items, demonstrating a retrieval-induced forgetting effect. It was predicted that a difference in recall performance would occur between the memorable and non-memorable items in terms of retrieval-induced forgetting. It was also predicted that a difference may occur between the performance of participants who performed the actions themselves, and those who observed the researcher perform the actions.

A comparison of the mean recall performance for Nrp items suggest that no enactment effect had occurred. These findings support several previous memory for action studies which demonstrated no significant difference between recall performance following self-performance compared to observation (Steffens, 2007; see also Cohen, 1981; Cohen & Bean, 1983). The findings also support the findings of experiment 2, and experiment 4C of the current thesis also failed to find an enactment effect for self-performed actions. However, experiments 3 and 4A have demonstrated an enactment effect which would be more in line the findings of Hornstein and Mulligan (2004) (see also Engelkamp & Zimmer, 1989). As in all the previous experiments in this thesis a facilitation effect was demonstrated, that is that participants correctly recalled Rp+ items compared to Nrp items. This effect occurred regardless of whether participants self-performed the actions or observed the actions being performed by the researcher. These findings would be line with previous research which has also demonstrated a facilitation effect for practiced items (Anderson et al., 1994; Anderson & Spellman, 1995; Ciranni & Shimamura, 1999).

Furthermore, experiments 4A and 4C demonstrated an effect of item strength in that retrieval-induced forgetting was found for memorable items only. In line with this it was predicted that retrieval-induced forgetting would also only occur for the memorable actions in the current experiment. The findings seem to support the findings of the previous experiments with retrieval-induced forgetting being found for the memorable items. Descriptive data however suggests that no retrieval-induced forgetting occurred for non-memorable items. This supports the findings of Anderson et al. (1994) who also found an item strength effect, and may also support the inhibitory theory which suggests that strong items (i.e. memorable items) are more likely to be inhibited that the weak items (i.e. non-memorable items). Strong Rp- items are more likely to interfere with retrieval of the target items, and are therefore a greater source of competition, which may need to be suppressed or inhibited in order to allow the target items to be successfully recalled. Non-inhibitory theories however would suggest that retrieval-induced forgetting also occurs for the weak items. Furthermore this may support the suggestion that memorability is a more adequate measure of item strength than typicality.

Retrieval-induced forgetting was found in the self-performed/self-performed, observation/self-performed and self-performed/observation condition. As in the previous experiment, no retrieval-induced forgetting was found in the observation/observation condition. Previous research has also demonstrated that re-presentation does not lead to retrieval-induced forgetting (Anderson, Bjork et al., 2000; see also Campbell & Phenix, 2009). Sharman (2011; experiment 3) also demonstrated that the lack of a retrieval-induced forgetting effect for observed actions may due to a lack of retrieval. The finding of a retrieval-induced forgetting effect in self-performed/self-performed and observation/self-performed conditions, and no effect in the observation/observation may be in line with those findings. As such in the current experiment it may have been expected that retrieval-induced forgetting would only be seen in conditions where participants self-performed the actions during the retrieval practice phase, however, retrieval-induced forgetting was also seen in self-performed/observation condition, during which observation took place in the retrieval practice phase. This finding may be slightly counter intuitive given that previous research suggests that re-presentation, in this case through observation, does not give rise to retrieval-induced forgetting.

The previous experiments (Experiments 2, 3 and 4) have demonstrated that when a twenty-four hour delay was introduced between the study and retrieval practice phases no retrieval-induced forgetting was seen in the self-performed/observation condition. A twenty-four hour delay was introduced based on the possibility that following the study phase the activation level of the items was raised, therefore, the raised activation levels were transferred to the retrieval practice phase. This may also have been the case in the current experiment therefore; a twenty-four hour delay will be introduced between the study phase and the retrieval practice phase in the following experiment.

In conclusion, the current experiment found evidence of a facilitation effect for Rp+ items with better recall performance for Rp+ items compared to Nrp items. A facilitation effect was found regardless of whether the participant had performed the actions themselves or observed the actions being performed by the researcher. Retrieval-induced forgetting was found only in three conditions: self-performed/self-performed, self-performed/observation and observation/self-performed conditions. One proposed reason for the unpredicted finding of a retrieval-induced forgetting effect in the self-performed/observation condition is that self-performance of the actions during the study phase increase activation levels of the items, which is then transferred to the retrieval practice phase. In order to examine this, the following study will introduce a twenty-four hour delay between the study and retrieval practice phases.

Experiment 4E

Background

Previous research would suggest that retrieval-induced forgetting would only occur in situations where active retrieval occurred during retrieval practice (Anderson, Bjork, et al., 2000). In the current experiments then it might be expected that retrieval-induced forgetting would only be found in conditions where participants self-performed actions during retrieval-practice (i.e. self-performed/self-performed and observation/self-performed condition). No retrieval-induced forgetting would then be found in the observation/observation and self-performed/observation condition. However the previous experiment demonstrated retrieval-induced forgetting in the self-performed/observation condition as well. One suggested explanation for why the effect was also found in the self-performed/observation condition is that during the study phase the activation levels of actions which were self-performed was increased, this was then transferred to the retrieval practice phase which may have created competition between the items, leading to the demonstrated retrieval-induced forgetting effect.
In order to further examine this possibility a twenty-four hour delay was introduced between the study and retrieval practice phases.

Previous research has demonstrated that retrieval-induced forgetting can continue to be seen after a twenty-four hour delay has been introduced between the study and retrieval practice phases (MacLeod & Macrae, 2001; see also Saunders & MacLeod, 2002).These findings suggest that it is possible for retrieval-induced forgetting to occur following a twenty-four hour delay. Therefore, it could be argued that if the retrieval-induced forgetting found in the self-performed/observation condition was not due to activation levels being raised and transferred when no delay occurred, then when a twenty-four hour delay was introduced the retrieval-induced forgetting effect should continue to be seen. If the finding was due to raised activation levels then the retrieval-induced forgetting effect may disappear. Previous interference and consolidation research may also support this suggestion and have demonstrated that memories which have already been consolidated can become susceptible to interference again if the memory is recalled (Misanin, Miller, & Lewis, 1968; Walker et al., 2003). These findings suggest that it is possible for memories to suffer from interference even after a period of time has passed since the original learning phase. The current experiment will introduce a twenty-four hour delay between the study and retrieval practice phases in the self-performed/observation condition to further examine with retrieval-induced forgetting effect in the condition.

Aims and Predictions

The aim of the current experiment was to see if retrieval-induced forgetting continued to be seen in the self-performed/observation condition when a twenty-four hour delay was introduced between the study phase and the retrieval practice phase. During the experiment participants would self-perform the actions during the study phase and then observe the actions being performed by the researcher in the retrieval practice phase. The retrieval practice and test phases took place twenty-four hours after the initial study phase had occurred. Retrieval practice led to several item types of interest: Rp+ items (practiced items from a practiced category), Rp- items (unpractised items from a practiced category), and Nrp items (unpractised items from an unpractised category). It was predicted that participants would accurately recall more Rp+ items compared to Nrp items. It was also predicted that no retrieval-induced forgetting would be found, regardless of whether the items were memorable or non-memorable.

Method

Participants and Design

Twenty undergraduate students (12 females, 8 males *M*age = 19.95) participated in the experiment in exchange for two course credits. A within subjects design was employed with two within subject factors: item type (Rp+ items (practiced items from a practiced category), Rp- items (unpractised items from a practiced category) and Nrp items (unpractised items from an unpractised category)); and action type (memorable actions and non-memorable actions).

Stimuli and Materials

The stimuli used in experiment 4E were the same as the stimuli and materials used in experiment 4A.

Procedure

Participants arrived at the laboratory individually and were greeted by a female researcher. Participants were instructed that during the study phase, which occurred during session one, that they would be required to perform a range of actions with a variety of different objects. Participants performed all the actions themselves throughout the study phase and the order of presentation of both the objects and the actions were counterbalanced throughout all phases of the experiment. Participants were presented with each object individually and asked to perform four actions for each object. The researcher instructed all participants as to which actions to perform (e.g. CD-spin, CD-slide, CD-bend, and CD-blow). This pattern continued until all of the actions for all of the objects had been performed by the participant. All objects were kept hidden from the participants' line of sight when not in use, hidden behind a partition when not required. There were eight objects, and four objects for each object, therefore in total there were thirty-two object-action pairs. Of the thirty-two, sixteen of these were memorable and sixteen were non-memorable.

Session two occurred twenty-four hours later during which participants completed the retrieval practice and test phases. In the retrieval practice phase, participants observed the researcher practicing a sub-section of actions (e.g. CD-slide, CD-spin). After completing the retrieval practice phase once, participants completed a two minute verbal word generation task. A verbal word generation task was used in place of written task in order to avoid possible contamination of the actions. As with the study phase all of the objects were kept out of sight until they were required as in the other phases of the experiment. This pattern was then repeated a further two times. Participants practiced two actions for four of the objects, a total eight object-action pairs. Of these eight, four of these were memorable and four were non-memorable. These eight were practiced three times, a total of twenty-four times.

During the test phase, which also occurred during session two, participants were shown a written cue consisting of the name of an object and the first two letters of an action used with that object during the experiment (e.g. flask-po__). Each cue was presented individually to the participants on a piece of A4 card for 10 seconds. There was one cue for each object-action pair therefore there were a total of thirty-two. Rp- items were presented first, followed by the Nrp items and finally the Rp+ items. This was done in order to prevent output interference effects (Racsmany, Conway, & Demeter, 2009; Perfect et al., 2004). Participants were asked to write down the name of the object if they were able to remember it (see Figure 25 for summary of the method used). Participants were thanked for their participation in the experiment and debriefed.

Figure 25: Summary of Method Used and Trials/Items Included in the Experiment 4E

Study Phase (Session One)

Participants studied the actions through performing the action themselves. The study phase took place in session one, 24 hours prior to the retrieval practice and test phases.

Trials (Study Phase)

There were 32 object-action pairs, 16 were memorable and 16 were non-memorable. Each pair was performed once. Of the 32there were 8 Rp+ items (4 memorable and 4 non-memorable), 8 Rp- items (4 memorable and 4 non-memorable) and 16 Nrp items (8 memorable and 8 non-memorable).

24-Hour Delay

Retrieval Practice Phase (Session Two)

Participants observed the researcher practice a sub-section of the previously studied items. A two-minute verbal word generation task followed. This pattern was repeated a further two times.

Trials (Retrieval Practice Phase)

Participants practiced two objects for four actions, 8 in total (Rp+ items), 4 were memorable and 4 were non-memorable. These items were practiced 3 times, therefore, there were 24 in total (12 memorable and 12 non-non-memorable).

Test Phase (Session Two)

Participants were asked to perform the actions they could remember that they had encountered during the experiment for each object.

Trials (Test Phase)

Participants were presented each object one at a time, a total of 32. There were 8 Rp+ items (4 memorable, 4 non-memorable), 8 Rp- items (4 memorable, 4 non-memorable), and 16 Nrp items (4 memorable, 4 non-memorable).

Figure 25. The left hand side of above figure shows a summary of the method and the right hand side shows trial and item information for experiment 4E.

Results

Memory performance was calculated through the successful recollection of the object for the action (see Table 11). Results were calculated through comparing Rp+ items with the Nrp items in order to examine a facilitation effect, and comparing Rp- items with the Nrp items to examine a retrieval-induced forgetting effect. As no retrieval-induced finding was found in the previous experiment with non-memorable actions only the data for memorable actions will be analysed.

Table 11: Mean Proportion Recall Performance for Memorable Items the Self-Performed/Observation Condition

	Rp+		Rp-		Nrp	
	M	NM	M	NM	M	NM
Self-Performed/Observation	.96 (.09)	.89 (.17)	.86 (.15)	.71 (.26)	.84 (.14)	.63 (.22)

Note. There were three item types of interest: Rp+ items (practiced items from a practiced category), Rp- items (unpractised items from a practiced category), and Nrp items (unpractised items from an unpractised category). M refers to memorable items. NM refers to non-memorable items. Standard deviations are presented in parentheses (see Appendix O for raw data).

Facilitation Effects

Mean recall performance for the Rp+ memorable and non-memorable items was higher than that of the Nrp memorable items (see Table 11). This suggests that the recall of the practiced items was facilitated .A 2 (item type: Rp+ or Nrp) x 2 (action type: memorable or non-memorable) found a significant main effect of item type (F (1, 19) = 37.23, $p < .001$) and action type (F (1, 19) = 17.22, $p < .01$. A significant item type x action type also occurred, F (1, 19) = 7.62, $p < .05$. Pairwise comparison found a significant difference between Rp+ and Nrp items (.14, $p < .001$) and memorable and non-memorable items (.19, $p < .01$) suggesting that Rp+ items were recalled better than Nrp items and memorable items were recalled better than non-memorable items. A significant difference occurred between the typical Rp+ and Nrp items (.04, $p < .01$) and non-typical Rp+ and Nrp items (.04, $p < .01$). These findings suggest that a facilitation effect occurred for Rp+ items compared to Nrp regardless of whether items were typical or non-typical and whether items were self-performed or observed.

Retrieval-Induced Forgetting Effects

As in the previous experiments non-memorable items were removed from retrieval-induced forgetting analysis. Retrieval-induced forgetting effects were examined through comparing mean recall performance for Rp- memorable items with Nrp memorable items. Mean recall performance for Rp- memorable items was slightly higher than that of the Nrp memorable items. No significant difference occurred between the Rp- memorable and the Nrp memorable items, t (19) = .57, *n.s.* These findings suggest no retrieval-induced forgetting effect occurred in the current experiment.

Discussion

The finding in experiment 4D of a retrieval-induced forgetting effect in the self-performed/observation was somewhat unpredicted given previous research in the field (see Anderson et al., 1994; Sharman, 2011), although a retrieval-induced forgetting was found in this condition in the previous experiments in this thesis. Previous research suggests that retrieval-induced forgetting may only occur in situations where active retrieval takes place during retrieval practice (Anderson, Bjork, et al., 2000), however retrieval-induced forgetting was found in experiment 4D. One suggested reason for this is that activation level of the items was increased during self-performance of actions in the study phase. The raised activation levels may have been transferred to the retrieval practice phase, increasing competition between the items even though the items were only observed by the participant in the retrieval practice phase. This may have resulted in the demonstrated retrieval-induced forgetting effect. The introduction of a twenty-four hour delay may have provided time for the activation levels to decrease therefore no retrieval-induced forgetting would occur. If however the effect had not appeared because of raised activation levels a retrieval-induced forgetting effect would continue to be seen. It was predicted that a facilitation effect would be demonstrated however there would be no retrieval-induced forgetting effect.

As in experiment 4D, as well as previous experiments in this thesis, participants in the self-performed/observation condition demonstrated higher memory recall for Rp+ memorable items compared to Nrp memorable items was found, suggesting that a facilitation effect had occurred (see also Anderson et al., 1994; Anderson & Spellman, 1995). Experiment 4D also demonstrated a retrieval-induced forgetting effect for Rp- memorable items in the self-performed/observation condition. However in the current experiment no retrieval-induced forgetting occurred for either the memorable or non-memorable items in the self-performed/observation condition. This may suggest that the introduction of a twenty-four hour delay allowed the activation levels to decrease following the study phase, which may explain why no retrieval-induced forgetting was found in the current experiment. This may also support the suggestion that a retrieval-induced forgetting effect was detected when no twenty-four hour delay occurred because of an increase in activation for the items during the self-performance of the actions during the study phase which was then transferred to the retrieval practice phase.

These findings, along with those of experiment 4B, may suggest that retrieval-induced forgetting occurs in situations where participants perform the actions themselves in the retrieval practice phase (see also Sharman, 2011), and in situations where active retrieval takes place during retrieval practice (Anderson, Bjork, et al., 2000; see also Bauml, 2002; Campbell & Phenix, 2009; Ciranni & Shimamura, 1999; Storm, Bjork, & Bjork, 2007). However as the current experiment did not involve positive controls it could be argued that retrieval-induced forgetting would not be found in any of the conditions if a twenty-four hour delay was included in all conditions. If retrieval-induced forgetting continued to be seen in the self-performed/self-performed and observation/self-performed condition after the introduction of a twenty-four hour delay this would support the suggestion that retrieval-induced forgetting occurs in conditions involving the self-performance of actions during retrieval practice, and that active retrieval is a key component of retrieval-induced forgetting. It may also be suggest that retrieval-induced forgetting occurred in the self-performed/observation condition (prior to the introduction of a twenty-four hour delay) because activation levels were increased in the study phase and transferred to the retrieval practice phase resulting in the retrieval-induced forgetting which was found in experiment 4A. Future research would include running the positive controls in order to further examine this possibility. A further issue in relation of the results of the experiments is the near ceiling effects for item types. One suggested reason for this is the smaller amount of trials in the experiment. For example, for the Rp+ memorable items there were only four. This may have provided an opportunity for participants to remember the items very well or to guess some of the items. This may also have been the case in experiment 4D. Future research may possibly include more items than was used in the current experiment.

The experiments presented in this chapter have also shown two other lines of evidence which may support the inhibitory theory. Firstly, the experiments have demonstrated an item strength effect. In the conditions where retrieval-induced forgetting did occur, the effect was only seen in relation to the memorable items, and not for the non-memorable items. The inhibitory theory would suggest that strong items would be more likely to be inhibited, for example, in these experiments memorable items would strong items, and non-memorable items would be weak items. The strong items are more likely to interfere with retrieval, competing with the target items, and are therefore more likely to be inhibited in order to resolve the competition. Alternatively, non-inhibitory theories would suggest that retrieval-induced forgetting can occur for weak and strong Rp- items. Findings by Anderson et al. (1994) would seem to support the inhibitory theory as retrieval-induced forgetting was found for the strong Rp- items only. However, several studies have also failed to find an item strength effect (Jakab & Raajmakers, 2009; Major, Camp, & MacLeod, 2008). A previous experiment (Experiment 3) as part of this thesis failed to find an item strength using typical and non-typical actions. However, using memorability as a measure did lead to the effect being demonstrated in the current experiment. Firstly, the findings of the current experiment seem to support the inhibitory theory as retrieval-induced forgetting was found for the strong Rp- items (i.e. memorable items) and not for the weak Rp- items (i.e. non-memorable items). Secondly, the findings may suggest that memorability is a more adequate measure of item strength than typicality was. Also of note is that in experiments looking at item strength the measure or definition of strength alters slightly. For example, Jakab and Raajmakers used the position of items and number of presentation as measures of item strength, whereas Major et al. used reading and generation, and Anderson et al. (1994) used frequency of items to determine whether items were strong or weak. This suggests that although each experiment studies strong and weak items in terms of retrieval-induced forgetting there is some variation in how the strong and weak items are measured or defined.

A second line of evidence to support the inhibitory theory comes from the finding of a cue independent effect. The inhibitory theory proposes that utilising an independent cue during the test phase, one which differs to those used in the study and retrieval practice phases should not allow the item to be successfully retrieved, the item should continue to be inhibited. Non-inhibitory theories however would suggest that the retrieval-induced forgetting occurs because of interference between the cue and the competitor. If this were the case then it would be expected that using a new cue would bypass the interference and allow the item to be successfully retrieved, suggesting that the effect is cue dependent rather than cue independent. Previous research has demonstrated a mixed picture. For example, Anderson and Spellman (1995) have found a cue independent effect (see also Anderson & Green, 2001; MacLeod & Saunders, 2005; Veiling & van Knippenberg, 2004). However others have failed to find the effect (Perfect et al., 2004; see also Camp et al., 2007; Williams & Zacks, 2001). Therefore, the findings of a retrieval-induced forgetting effect under independent cue conditions in experiment 4C are more in line with the inhibitory theory than the non-inhibitory theory.

In conclusion, these findings suggest that may be possible for retrieval-induced forgetting to occur with actions (see experiments 3 and 4), and the objects that are involved with actions (see experiment 2). These findings support previous research conducted by Koutstaal et al. (1999) and Sharman (2011). These findings suggest that inhibitory mechanisms may be involved in the process. However, the actions used here are individual, separate actions or 'mini-tasks' such as saucepan-lift but actions individuals perform as part of daily life are more likely to involve a goal with individuals aiming to complete a task (e.g. packing a rucksack) (Steffens, 2007). Therefore assessing whether retrieval-induced forgetting occurs under goal conditions is also important.

The role of goals in action research has been proposed as being an important aspect of actions, and has also been proposed as playing a role in the enactment effect (Ratner & Foley, 1994). Glover et al. (1987) demonstrated that this may be the case as participants were more likely to remember goal-orientated actions than actions which occur without a goal. Furthermore, Migueles and Garcia-Bajos (2007) found no retrieval-induced forgetting for actions which were viewed on a video. The actions in this study all belonged to the same sequence, specifically, a robbery. The authors note that as the actions belonged to the same sequence this may have allowed integration to take place, and previous research has demonstrated that integration can protect memories from retrieval-induced forgetting (Anderson & McCulloch, 1999). This raises the possibility that a difference may occur between 'mini-tasks' or individual, separate actions and those belonging to a goal or a sequence in that retrieval-induced forgetting seems to occur for 'mini-tasks but does not occur for goal-orientated actions. In addition as goal-orientated actions are more similar to what individuals would do as part of their daily lives, for example, it is likely that participants would pack a rucksack rather than lift the pen it is necessary to examine the role of the goal and the impact that the goal may have in terms of retrieval-induced forgetting. Therefore the following experiment will aim to examine whether retrieval-induced forgetting also occurs for goal-orientated actions.

Chapter 7
Retrieval-Induced Forgetting and Goal-Orientated Actions

Experiment 5A

Background

The role of goals in memory for actions has been highlighted by Ratner and Foley (1994) who proposed that the goal-directed aspect of actions may play a role in the enactment effect, suggesting that individuals in their everyday lives perform actions and tasks and influence their environment in order to achieve a specific goal, and as such the impact of the goal on memory for actions should also be considered. Research examining the goal aspect of actions provides evidence to support this view and demonstrate that goals may play an important role in memory for actions. Glover et al. (1987) demonstrated that actions associated with a goal were more likely to be remembered than those without a goal (see also Ratner, Padgett, & Bushney, 1988). More recently, Steffens (2007) found that both self-performance and observation of goal-orientated actions led to better recall performance compared to those which were verbally learnt, however, no difference was found in terms of recall performance between the self-performance and observation conditions (see also Fivush, Pipe, Murachver, & Reese, 1997; Ratner & Hill, 1991; Smyth, 1991). Steffens proposed that this may be because the improved recall performance following self-performance compared to verbal learning was due to improved item-specific processing, whereas the improvement in recall performance following observation compared to verbal learning may have been due to an improvement in relational processing. However these findings do suggest that goals are an important aspect of actions and may also play a role in memory for actions.

The previous experiments in this thesis have demonstrated retrieval-induced forgetting for novel motor sequences, actions (e.g. pen-write, spoon-tap) and objects associated with actions (e.g. knot-string, roll-ball). The actions used in those experiments were not goal-orientated and did not belong to the same sequence, therefore, these could be thought of more as ‘mini-tasks’. Although the use of ‘mini-tasks’ in memory for action is well documented (see experiments by Cohen, 1981; Engelkamp & Krumnacker, 1980) more recent research has also focussed on goals (Steffens, 2007). As goals also seen to plan an important role in action memory this suggested that considering whether retrieval-induced forgetting also occurred for goal-orientated actions. An additional reason for examining retrieval-induced forgetting in actions is that many of the actions individuals perform during their everyday lives have a goal attached to them (e.g. lift the pen to place it in a bag being packed for work). In contrast, many actions performed in a laboratory setting are performed without a goal attached to them (e.g. lift the pen) (Steffens, 2007). In terms of ecological validity then it is also appropriate to examine retrieval-induced forgetting and goal-orientated actions, which will be the aim of the current experiment.

Recent research into retrieval-induced forgetting and actions also suggests that a difference may occur in terms of retrieval-induced forgetting, actions and goals. For example, Sharman (2011) found retrieval-induced forgetting for actions. The actions involved used were not associated with a goal, often taking the form of separate, individual actions or ‘mini-tasks’ (e.g. sharpen the pencil). However a study by Migueles and Garcia-Bajos (2007) failed to find retrieval-induced forgetting for actions. That particular experiment utilized actions which were part of the same sequence rather than separate, individual actions. During the first experiment, Migueles and Garcia-Bajos asked participants to view a video of a robbery. All of the actions were part of the same sequence. Retrieval practice of the actions and a free recall test followed. The findings demonstrated no retrieval-induced forgetting for the actions. However, in experiment two when the focus was on the characteristics of the offenders in the robbery video and not on the actions a retrieval-induced forgetting effect was found. These findings may suggest that a difference might occur between ‘mini-tasks’ or actions not associated with a goal and goal-orientated actions in terms of retrieval-induced forgetting. Migueles and Garcia-Bajos proposed that one possible reason for a lack of retrieval-induced forgetting in terms of actions in their experiment may be that all of the actions belonged to the same sequence and as such were not viewed as separate, unique units as such this may have allowed integration of the actions to take place.

Previous research has suggested that integration may protect memories from retrieval-induced forgetting (Anderson & McCulloch, 1999; see also Anderson & Bell, 2001; Moeser, 1976). Radvansky and Zacks (1991) demonstrated that when participants learnt about many objects which were all at one location no retrieval-induced forgetting occurred, however, when participants were asked to learn about many objects in many different locations, retrieval-induced forgetting was found. The authors proposed that the many objects-one location condition allowed the participants to integrate the items to form a complete 'picture' of the location, resulting in a lack of retrieval-induced forgetting (see also Martin & Dean, 1964; Russell & Storms, 1995; Smith et al., 1978). These findings would suggest that integration has the potential to protect memories from retrieval-induced forgetting. If when a goal is attached integration can occur then this may protect the memories from retrieval-induced forgetting and may a play a role in explaining why not retrieval-induced forgetting is found under such circumstances.

Although the findings of Migueles and Garcia-Bajos (2007) may suggest that retrieval-induced forgetting may not occur for goal-orientated actions, some research has also suggested that that it may be beneficial for retrieval-induced forgetting to occur in terms of goals (McCulloch et al., 2008; see also Kuhl & Beckman, 1985; Shah et al., 2002). McCulloch et al. (2008) for example, proposed that to post a letter for work, it would be beneficial to forget other work associated goals. In their experiment the authors demonstrated a retrieval-induced forgetting effect for goals, for example, when utilizing different methods to achieve the same goal and when a higher over-arching goal involving several sub-goals was involved (see also Shah et al., 2002). Bauml et al. (2010) also suggested that *"inhibitory processes operate to serve the function of goal-directed remembering"* (Bauml, Pastotter, & Hanslmayr, 2010, p.1047). However Fishbach et al. (2003) proposed that when completing a goal then other goals or sub-goals which may be beneficial to the completion of the target goal may not be inhibited, and may even be facilitated. This may suggest that the type of goal or task involved is also important. In one of experiments reported in Steffens (2007) the task of packing a rucksack was used therefore the current experiment will also utilise a task involving packing a rucksack.

In addition as in previous experiments in the thesis an enactment effect will also be examined. Previous action research has demonstrated a mixture of findings relating to the enactment effect. For example Steffens (2007), among others, have not found an enactment effect for self-performed actions compared to observed actions. However, other studies have found that an enactment effect occurs (e.g. Engelkamp &Zimmer, 1989). This mixture of findings have also been demonstrated in the current experiment with an enactment effect found in some of the experiments (e.g. Experiment 4A) and not occurring in other experiments (e.g. Experiment 2A). Participants in the current experiment will either observe the researcher completing the task or will complete the task themselves.

Aims and Predictions

The aim of the current experiment was to examine if retrieval-induced forgetting also occurred for goal-orientated actions. Steffens (2007) asked participants to complete a goal which was packing a rucksack with a number of items and the current experiment will follow a similar idea with participants being provided with twenty objects which may be used on a camping trip. Participants were then asked to pack a rucksack with those items. Retrieval practice in the retrieval practice conditions led to two item types of interest: Rp+ items (practiced items from a practiced category), and Rp- items (unpracticed items from a practiced category). Nrp item scores (unpracticed items from an unpractised category) were collected from the control conditions during which no retrieval practice occurred. It was predicted that participants would correctly recall more of the Rp+ items compared to the Nrp items demonstrating a facilitation effect. It was also predicted that participants would recall fewer Rp- items compared to Nrp items demonstrating a retrieval-induced forgetting effect. It was also predicted that a difference may occur between the self-performed and observation condition.

Method

Participants and design

Eighty undergraduate students (50 females, 30 males, *M* age = 21.02) participated in the experiment in exchange for two course credits. A between subjects design was employed with four conditions (self-performed retrieval practice condition, self-performed control condition, observation retrieval practice condition, and observation control condition). The retrieval practice conditions for both the self-performed and observation conditions gave rise to two item types: Rp+ items (practiced items from a practiced category) and Rp- items (unpracticed items from a practiced category). The control conditions for the self-performed and observation conditions gave rise to one item type: Nrp items (unpracticed items from an unpracticed category), as no retrieval practice occurred in those conditions. Each condition contained twenty participants.

Stimuli and Materials

Stimuli included twenty objects, which could be used as part of a camping trip (see Appendix P for full list of objects).

Procedure

Participants arrived at the laboratory individually and were greeted by a female experimenter. Participants were instructed, depending on which condition they had been assigned to, that they would either be required to pack a rucksack themselves with twenty objects or to observe the researcher pack the rucksack. Participants either packed all of the objects themselves or observed all of the objects being packed. The bag contained six pockets. The order of presentation of the objects was counterbalanced throughout the study. During the initial study phase participants in the self-performed retrieval practice and self-performed control conditions were presented with each object individually and asked to place the object in one of six pockets in the rucksack. Participants in the observation retrieval practice and observation control conditions observed the researcher pack the bag (see Figure 26 for summary of method). This pattern continued until all of the objects had been presented to the participant and packed. Participants decided which pockets to place the objects in. All of the objects were kept out of the participant's line of sight, hidden behind a partition, until the object was required. This occurred during all phases of the experiment. This study phase was followed by a two-minute verbal word generation task. A verbal word generation task was used in place of written ones in order to avoid contamination of the actions, which may have occurred in a written task.

Participants then progressed to the retrieval practice phase where those in the self-performed retrieval practice condition practiced a sub-section of the previously studied actions. Participants in the observation retrieval practice condition observed the researcher completing the actions. After completing retrieval practice once, participants completed a two-minute verbal word generation task. This pattern was then repeated a further two more times. Participants in the self-performed control and observation control conditions completed verbal word generation tasks in place of retrieval practice. Following the retrieval practice phase (word generation tasks in the case of the control conditions), all participants were asked to re-pack the rucksack in the same way that had been done or observed during the study phase. All participants regardless of their condition assignment were asked to re-pack the bag themselves during the test phase. The researcher recorded the participants' responses on a response sheet. Upon completion of the study participants were debriefed and thanked for their participation in the experiment.

Figure 26: Summary of the Method and Trial/Item Information in Experiment 5A

Study Phase Participants packed twenty objects into a rucksack or observed the researcher packing the rucksack.	**Trials (Study Phase)** There were 20 objects with each object being used once during the study phase.
Retrieval Practice Phase Participants in the retrieval practice condition practiced a sub-section of the previously studied items or observed the researcher. Participants in the control condition complete verbal word generation tasks in place of retrieval practice.	**Trials (Retrieval Practice Phase)** Retrieval Practice Conditions: There were 10 Rp+ items and 10 Rp- items. Participants observed or self-performed practice with 10 Rp+ items, 3 times. Control Conditions: There were 20 Nrp items.
Test Phase All participants were asked to re-pack the rucksack themselves.	**Trials (Test Phase)** All participants re-packed the 20 objects once.

Figure 26. The above figure is a summary of the method used in experiment 5A (left hand column). The right hand column shows details on the number of trials and item types for each phase of the experiment.

Results

Memory performance was calculated through the successful recollection of the actions (see Table 12). Results were recorded as the number of correct responses made. Results were calculated through comparing Rp+ items with Nrp items in order to examine a facilitation effect. Rp- items were compared with Nrp items to examine a retrieval-induced forgetting effect.

Table 12: Mean Proportion Recall Performance for Each Item Type for the Self-performed and Observation Conditions

	Rp+	Rp-	Nrp
Self-Performed Conditions	.99 (.03)	.94 (.09)	.92 (.09)
Observation Conditions	.99 (.03)	.95 (.08)	.93 (.07)

Note. There were three item types of interest: Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category), and Nrp items (unpracticed items from an unpracticed category). Rp+ and Rp- item scores were provided by the self-performed and observed retrieval practice conditions. Nrp item scores were provided by the self-performed and observed control conditions. Standard deviations presented in parenthesis (see Appendix Q for raw data).

Facilitation Effects

Table 12 demonstrates that in the self-performed condition the mean recall performance for Rp + items was higher than Nrp items in both the self-performed and observation conditions. The descriptive data therefore suggests that a facilitation effect had occurred in both the self-performed and observation conditions. A between subjects ANOVA demonstrated a significant effect of item type, $F\,(1, 76) = 24.69, p < .001$. However, no significant effect of condition was found, $F\,(1, 76) = .03$, *n.s.* There was also no significant condition x item interaction, $F\,(1, 76) = .03$, *n.s.* These findings suggest that there was an improved recall performance for practiced items compared to a baseline measure regardless of whether the participant had self-performed or observed the actions being performed.

Retrieval-Induced Forgetting Effects

Retrieval-induced forgetting effects were examined through comparing Rp- items with Nrp items. Mean recall performance for Rp- items in both conditions were higher than mean recall performance for Nrp items suggesting that no retrieval-induced forgetting had occurred. If retrieval-induced forgetting had occurred it would be expected that mean recall performance for Rp- items would be lower than mean recall performance for Nrp items, however, the descriptive data suggests that this is not that case. To confirm this, a between subjects ANOVA was conducted which demonstrated no main effect of item type, $F\ (1, 76) = 1.53$, *n.s.* In addition there was no significant effect of condition, $F\ (1, 76) = .17$, *n.s.* There was also no significant condition x item interaction, $F\ (1, 76) = .02$, *n.s.* These findings suggest that no retrieval-induced forgetting occurred in either of the conditions.

Effects of Action Task on memory for Control Items (Nrp Items)

Additionally mean recall performance for the Nrp items for the self-performed condition were compared with those of the observation condition in order to examine whether an enactment effect had occurred. Mean recall performance for Nrp items in the self-performance condition was .92, whereas in the observation condition the mean recall performance was .93. An independent t-test demonstrated that this difference was not significant, $t\ (38) = -.20$, *n.s.* This suggests that no enactment effect had occurred between the self-performed and observation conditions.

Discussion

Previous experiments as part of this thesis have suggested that retrieval-induced forgetting can occur for actions. However, the actions used as part of those experiments occurred without a goal, therefore, the aim of the current experiment was to examine whether retrieval-induced forgetting would also occur for goal-orientated actions. This was done for two reasons. Firstly, everyday actions are more likely to be attached to a goal (Steffens, 2007) therefore it seems necessary to also consider goal-orientated actions. For example, it is more likely that an individual as part of their everyday lives would pick up a pen to place it in a bag rather than just lifting the pen. Individuals make use of actions as part of sequences everyday to successfully complete tasks. Secondly, previous memory for action research has demonstrated that actions associated with a goal are more likely to be remembered than those without a goal (Glover et al., 1987). Furthermore, Steffens (2007) recently demonstrated no enactment effect for self-performed actions compared to observed actions in two goal-orientated action experiments. These findings may suggest that the goal aspect is important in terms of actions therefore it is necessary to also see if retrieval-induced forgetting also occurs for goal-orientated actions.

It was predicted that a difference in terms of recall performance may occur between the self-performed and observation conditions. In order to examine this prediction, mean recall performance for Nrp items for the self-performed and observation conditions were compared to each other. This comparison demonstrated that no significant difference had occurred between the self-performed and observed conditions suggesting that self-performance of the task had not led to an increase in accurate recall performance compared to observation; that is that no enactment effect had occurred. These findings are in line with the results of Steffens (2007) (see also Cohen, 1981; Cohen & Bean, 1983) who found no difference between self-performed and observed actions. Steffens also utilised a goal-orientated task and asked participants to complete two goal-orientated actions in two different experiments, one was to pack a rucksack and the second was to make clay. Recall performance for both the self-performed and observation conditions was higher than the verbal learning condition however, no difference occurred between the self-performed and observed conditions. Steffens proposed that this was because the improvement in the self-performed condition was due to item-specific processing, whereas the improvement in the observation condition was due to relational processing.

It was also predicted that participants would correctly recall more Rp+ items compared to Nrp items demonstrating a facilitation effect. The results demonstrated a facilitation effect for the practiced items from a practiced category (Rp+ items). These findings support previous research (see Anderson et al., 1994) and previous experiments in this thesis which have demonstrated facilitation effect regardless of whether participants had self-performed or observed the actions. It was also predicted that participants would recall fewer Rp- items compared to Nrp items, demonstrating a retrieval-induced forgetting effect. However, no retrieval-induced forgetting was found for Rp- items. This finding differs to the findings of previous experiments in this thesis which have suggested that retrieval-induced forgetting may occur for actions.

Previous research however has suggested that it is possible for retrieval-induced forgetting to occur for images of actions (Koutstaal et al., 1999), and actions (Sharman, 2011). This notion is further supported by the findings of experiments 3 and 4 of this thesis. However, Migueles and Garcia-Bajos (2007) failed to find a retrieval-induced forgetting effect for actions when all of the actions were involved in the same sequence. One possible explanation for the lack of retrieval-induced forgetting in the Migueles and Garcia-Bajos experiment may be that as the actions were part of the same sequence, as such, integration may have occurred. Previous research has demonstrated that integration may provide some protection from retrieval-induced forgetting (Anderson & McCulloch, 1999). Individual actions or 'mini-tasks' may not allow integration to take place. This may suggest that actions which are attached to a goal are less susceptible to retrieval-induced forgetting. If this were the case then this may suggest an interesting difference between retrieval-induced forgetting in goal-orientated actions and non goal-orientated actions which would be a focus for future research in order to further examine this possibility.

Previous goal research suggests that if other goals or sub-goals are beneficial to the higher goal then forgetting may not occur (Fishbach et al., 2003) and perhaps a facilitation effect may also be seen. This may suggest that the type of goal and sub-goals involved are also important. Therefore the findings of the current experiment may suggest that a contrast in terms of retrieval-induced forgetting for goal-orientated actions and actions without a goal. One proposed reason why the presence of the effect differs in the two types of experiments is the goal itself and the addition of the goal plays a role. However, it could be also be suggested that no retrieval-induced forgetting occurred in the current experiment because participants had been allowed to decide for themselves where the items should be placed in the rucksack, for example, placing the wallet in the pocket most inside the bag for safe keeping or the aspirin in the left or right pocket for easy access. In addition participants may have placed similar objects in the same pockets. In order to further examine this possibility the following experiment will involve the same method as used in the current experiment however participants will be instructed as to which pockets to pack the items in.

In conclusion, the current experiment found evidence of a facilitation effect in line with previous research as part of this thesis. However, no retrieval-induced forgetting was found in either the self-performed or observation conditions. One proposed reason for why no retrieval-induced forgetting occurred may be that in the current experiment the actions were associated with a goal. However, a second possibility is that no retrieval-induced forgetting occurred because the participants were allowed to choose where to pack objects in the rucksack. The following experiment will aim to further examine this possibility with the researcher instructing participants as to where to pack the objects. The method will follow a similar patter to experiment 5A aside from the researcher instructing participants as to where to place the items in the rucksack.

Experiment 5B

Background

The previous experiment suggests that retrieval-induced forgetting may not occur for goal-orientated actions. One possible explanation for this is that retrieval-induced forgetting may not occur for actions associated with a goal. A second possibility is that as participants in the previous experiment were allowed to decide where to place the objects this may have allowed the participant to place similar items together or in locations which were beneficial to them in terms of memory. The current experiment, in order to further examine this possibility, will involve the researcher instructing participants as to where to place the items in the rucksack. The current experiment will therefore utilise a similar method to that used in experiment 5A, however, participants in this experiment will be in instructed as to where to place in the objects in the rucksack, rather than being allowed to choose where to place the objects. The results will then be analysed to see if a retrieval-induced forgetting effect occurred in the current experiment.

The role of goals as a research topic in terms of retrieval-induced forgetting was investigated also to provide a fuller picture. For example, experiment 1 of the thesis looked at motor sequences, whilst experiment 2 looked at objects, and experiments 3 and 5 looked at objects. However actions individuals as part of everyday life involve the use of several actions together to successfully complete a task. Therefore the actions used in this experiment will differ to those used in the previous experiments in the thesis which were not attached to a goal; instead they were individual, separate actions. The participants task in the current experiment as in experiment 5A was to pack a rucksack with twenty objects for a camping trip. If no retrieval-induced forgetting continued to be found this may suggest that the goal may play a role however if retrieval-induced forgetting occurred this may suggest that no effect was found in experiment 5A may have been due to participants being allowed to choose where to place the objects.

Aims and Predictions

The aim of the current experiment was to examine if retrieval-induced forgetting occurred for goal-orientated actions if participants were instructed as to where to place the objects in the rucksack. During the experiment participants would be provided with twenty objects which may be used on a camping trip, and asked to pack a rucksack with those items. Retrieval practice in the retrieval practice conditions led to two item types of interest: Rp+ items (practiced items from a practiced category) and Rp- items (unpracticed items from a practiced category). Nrp item scores (unpracticed items from an unpracticed category) were collected from the control conditions. It was predicted that participants would correctly recall more Rp+ items compared to Nrp items, demonstrating a facilitation effect. It was also predicted that participants would recall fewer Rp- items compared to Nrp items, demonstrating a retrieval-induced forgetting effect. It was also predicted that a difference might occur between the recall performance of participants who self-performed the actions, and those who observed the researcher perform the actions.

Method

Participants and design

Eighty undergraduate students (55 females, 25 males, *M* age = 20.61) participated in the experiment in exchange for two course credits. A between subjects design was employed with four conditions (self-performed retrieval practice, self-performed control, observation retrieval practice, and observation control conditions). The retrieval practice conditions for both the self-performed and observation conditions gave rise to two item types: Rp+ items (practiced items from a practiced category) and Rp- items (unpracticed items from a practiced category) as participants completed retrieval practice. The control conditions for the self-performed and observation conditions gave rise to one item type: Nrp items (unpracticed items from an unpracticed category), as participants did not complete retrieval practice, instead participants completed a series of verbal word generation tasks. Each condition contained twenty participants.

Stimuli and Materials

Stimuli included twenty objects which could be used as part of a camping trip (see Appendix P for full list of objects). Objects used were the same objects used during experiment 5A.

Procedure

Participants arrived at the laboratory individually and were greeted by a female researcher. Participants were instructed, depending on which condition the participant had been assigned too that they would either be required to pack a rucksack themselves with twenty objects or to observe the researcher pack the rucksack. Participants either packed all of the objects themselves or observed all of the objects being packed. The rucksack consisted of six pockets. The order of presentation of the objects was counterbalanced throughout all phases of the experiment. Participants in the self-performed retrieval practice and self-performed control conditions, during the initial study phase, were presented with each object individually and asked to place the object in one of the six pockets of the rucksack. Participants were instructed as to which pocket to place the objects in. Participants in the observation retrieval practice and observation control conditions observed the researcher pack the bag (see Figure 27 for summary of the method). This pattern continued until all of the objects had been presented to the participant. All of the objects were hidden behind a partition in order to keep the objects out of the participant's line of sight until the object was required. The study phase was followed by a two-minute verbal word generation task.

Participants then progressed to the retrieval practice phase. Participants in the self-performed retrieval practice condition practiced a sub-section of the previously studied actions. Participants in the observation retrieval practice condition observed the researcher completing retrieval practice. After completing retrieval practice once, participants completed a two-minute verbal word generation task. This pattern was then repeated a further two times. Participants in the control conditions completed verbal word generation distracter tasks in place of retrieval practice.

Following the retrieval practice phase, participants were asked to pack the rucksack and to place the objects in the same pocket as in the study phase. Each object was given to the participant individually and kept out of sight, hidden behind a partition, until required. All participants regardless of which condition they had been assigned to were asked to pack the rucksack themselves during the test phase. The researcher recorded the participants' responses on a response sheet. Upon completion of the experiment participants were debriefed and thanked for their participation in the experiment.

Figure 27: Summary of the Method and Trial/Item Information in Experiment 5B

Study Phase

Participants packed twenty objects into a rucksack or observed the researcher packing the rucksack.

Trials (Study Phase)

There were 20 objects. Each object was used once during the study phase.

Retrieval Practice Phase

Participants in the retrieval practice condition practiced a sub-section of the previously studied items or observed the researcher.

Participants in the control condition complete verbal word generation tasks in place of retrieval practice.

Trials (Retrieval Practice Phase)

Retrieval Practice Conditions: There were 10 Rp+ items and 10 Rp- items. Participants self-performed or observed practice with 10 Rp+ items, 3 times. Control Conditions: There were 20 Nrp items.

Test Phase

All participants were asked to re-pack the rucksack themselves.

Trials (Test Phase)

All participants re-packed the 20 objects once in the test phase.

Figure 27. The above figure is a summary of the method used in experiment 5B (left hand column). The right hand column shows details on the number of trials and item types for each phase of the experiment.

Results

Recall performance was calculated through the successful recollection of the actions (see Table 13). Results were recorded as the number correct responses. Results were calculated through comparing Rp+ items with Nrp items in order to examine a facilitation effect, and comparing Rp- items with Nrp items to examine a retrieval-induced forgetting effect.

Table 13: Mean Proportion Recall Performance for Each Item type for the Self-performed and Observation Conditions

	Rp+	Rp-	Nrp
Self-Performed Conditions	.99 (.05)	.73 (.15)	.70 (.14)
Observation Conditions	.98 (.06)	.70 (.17)	.68 (.13)

Note. There were three item types of interest: Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category), and Nrp items (unpracticed items from an unpracticed category). Rp+ and Rp- item scores were provided by the self-performed and observed retrieval practice conditions. Nrp item scores were provided by the self-performed and observed control conditions. Standard deviations are presented in parenthesis (see Appendix R for raw data).

Facilitation Effects

As demonstrated in table 13 the mean recall performance for Rp+ items was higher than mean recall performance for Nrp items in both the self-performed and observed conditions. The descriptive data therefore suggests that a facilitation effect did occur in the self-performed condition. A between subjects ANOVA demonstrated a significant effect of item type, $F\ (1, 76) = 161.70, p < .01$. However, there was no significant effect of condition, $F\ (1, 76) = .36$, *n.s.* There was also no significant condition x type interaction, $F\ (1, 76) = .03$, *n.s.* These findings suggest that a facilitation effect occurred for the Rp+ items compared to the Nrp items regardless of whether the actions were self-performed or observed, replicating the findings of experiment 5A.

Retrieval-Induced Forgetting Effects

Retrieval-induced forgetting effects were examined through comparing mean recall performance for Rp- items with Nrp items. In both the self-performed and observation conditions mean recall performance for Rp- items was higher than mean recall performance for Nrp items. This suggests that no retrieval-induced forgetting had occurred for the Rp- items in either the self-performed or observation conditions. If retrieval-induced forgetting had occurred it would be expected that recall performance for Rp- items would be lower than recall performance for Nrp items. A between subjects ANOVA was conducted which demonstrated no significant effect of item type, $F(1, 76) = .63$, *n.s.* In addition, no significant effect of condition was found, $F(1, 76) = .51$, *n.s.* No significant condition x item interaction was found, $F(1, 76) = .04$, *n.s.* These findings suggest that no retrieval-induced forgetting had occurred in the current experiment. These findings also support the results of experiment 5A.

Effects of Action Task on memory for Control Items (Nrp Items)

In order to examine whether an enactment effect had occurred recall performance for Nrp items in the self-performed condition were compared with the recall performance of Nrp items in the observation condition. Mean recall performance for Nrp items in the self-performed condition was .70, whereas in the observation condition this was .68. A t-test demonstrated that this difference was not significant, $t(38) = .52$, *n.s.* These findings suggest that no enactment effect had occurred in terms of the self-performed condition compared to the observation condition.

Discussion

Previous experiments as part of this thesis suggest that retrieval-induced forgetting can occur in terms of actions. However those actions occurred without a goal and the previous experiment (Experiment 5A) may suggest that retrieval-induced forgetting may not occur with regards to goal-orientated actions. This may be due to the addition of a goal. Alternatively, in experiment 5A participants were allowed to decide themselves where the objects would be placed in the rucksack and this may have had an influence on the results. The aim of the current experiment was to examine whether retrieval-induced forgetting would occur if participants were instructed where to place the objects in the rucksack by the researcher. Studying goal-orientated actions is not only important because goals are involved with many of the individuals perform in their lives (Steffens, 2007) but also because action research demonstrates that goals may be important in memory for actions. Previous research has demonstrated that actions associated with a goal are more likely to be remembered than those without a goal (Glover et al., 1987) suggesting that goals may play a role in memory for actions.

As in the other experiments in this thesis it was predicted that participants would correctly recall more Rp+ items when compared to Nrp items demonstrating a facilitation effect, and that participants would recall fewer Rp- items compared to Nrp items demonstrating a retrieval-induced forgetting effect. Additionally, it was predicted that a difference may occur between the recall performance of participants who performed the actions themselves, and those who observed the researcher perform the actions. In order to examine whether any difference occurred between the self-performed and observation conditions in terms of Nrp items, mean recall performance for Nrp items in the self-performed condition was compared to mean recall performance of the Nrp items in the observation condition. This comparison demonstrated that no significant difference had occurred between the two conditions replicating the findings of experiment 5A, suggesting that no enactment effect had occurred. These findings are in line with the results of Steffens (2007) (see also Cohen, 1981; Cohen & Bean, 1983) who found no difference between self-performed and observed actions. Specifically, Steffens demonstrated that no difference occurred in terms of recall performance for self-performed and observed goal-directed actions. Steffens suggested that this may be because self-performance of actions led to an increase in item-specific processing whereas observation led to an increase in relational processing.

As in experiment 5A the results of the current experiment demonstrated a facilitation effect for practiced items (Rp+ items) supporting the notion that retrieval practice facilitates memory (Anderson et al., 1994; see also Anderson & Spellman, 1995). However no retrieval-induced forgetting was found for items, which were not practiced but did belong to the same category as the practiced items (Rp- items). A lack of retrieval-induced forgetting effect replicated the findings of experiment 5A. As the previous experiments in the thesis found retrieval-induced forgetting for individual actions or 'mini-tasks' the findings of the current experiment and experiment 5A could suggest a contrast between the non-goal orientated and goal-orientated actions. One proposed reason why the effect differs in the two types of experiments may be the addition of a goal. However an alternative explanation may be that the objects used in the experiment did not give rise to retrieval-induced forgetting. In order to further examine this possibility the following experiment will involve the same objects as used in the current experiment however participants will not be asked to pack the objects in a rucksack as was done in the current and previous experiment. If a retrieval-induced forgetting effect occurs in the following experiment it may suggest that the addition of the goal (i.e. packing the rucksack) played a part in the findings of the current experiment, whereas if no retrieval-induced forgetting occurred this may suggest that no effect occurred because of the materials used and not because of the goal.

In conclusion the current experiment demonstrated a facilitation effect for practiced items from a practiced category with better recall performance for Rp+ items compared to Nrp items. However no retrieval-induced forgetting was found. One proposed reason for why no retrieval-induced forgetting occurred in this experiment may be that the actions were associated with a goal. This may also propose an explanation as to why the findings of the current experiment differ to those of the previous experiments in the thesis. However, it may also be suggested that no retrieval-induced forgetting was found because no retrieval-induced forgetting occurred between the objects. The following experiment was designed to further test this possibility.

Experiment 5C

Background

The previous two experiments suggest that retrieval-induced forgetting may not occur for goal-orientated actions. This occurred regardless of whether participants completed the actions themselves or observed the actions being completed and regardless of whether participants were allowed to decide where to place the object or were instructed where to place the object in the rucksack. One possible explanation for this is the addition of a goal as previous experiments in this thesis have demonstrated retrieval-induced forgetting when no goal was involved with the actions. Migueles and Garcia-Bajos (2007) demonstrated no retrieval-induced forgetting for actions, which were part of the same sequence. The authors suggested that integration may have occurred which may have protected the memories from retrieval-induced forgetting (see also Anderson & McCulloch, 1999). A second possibility which may explain why no retrieval-induced forgetting was found in the previous two experiments may be that the objects used in experiment 5A and 5B did not themselves give rise to retrieval-induced forgetting. Therefore the aim of the current experiment is to see if retrieval-induced forgetting occurs with the objects. If this is the case then it may suggest that the goal aspect of the previous experiments may play a role in why no retrieval-induced forgetting was found. In the current experiment the goal aspect from the previous two experiments will be removed and participants will only be provided with the objects and no rucksack to pack the objects in.

Aims and Predictions

The aim of the current experiment was to examine whether retrieval-induced forgetting occurred for objects used in the previous two goal-orientated actions experiments (Experiments 5A and 5B). During the current experiment participants will be provided with the objects, twenty objects in total. Retrieval practice in the retrieval practice condition led to two item types of interest: Rp+ items (practiced items from a practiced category), and Rp- items (unpracticed items from a practiced category). Nrp item scores (unpracticed items from an unpracticed category) were collected from the control condition. It was predicted that participants would recall correctly more Rp+ items when compared to Nrp items (baseline measure) demonstrating a facilitation effect. It was also predicted that fewer Rp- items would be recalled compared to Nrp items, demonstrating retrieval-induced forgetting.

Method

Participants and Design

Forty undergraduate students (36 females, 4 males, $M = 19.98$) participated in the experiment in exchange for two course credits. A between subjects design was employed with two conditions (retrieval practice and control conditions). The retrieval practice condition gave rise to two item types: Rp+ items (practiced items from a practiced category) and Rp- items (unpracticed items from a practiced category). The control condition gave rise to Nrp items (unpracticed items from an unpracticed category). Each condition contained twenty participants.

Stimuli and Materials

Stimuli included twenty objects, which could be used as part of a camping trip (see Appendix P for a complete list). The objects used were the same as those used in experiments 5A and 5B.

Procedure

Participants arrived at the laboratory individually and were greeted by a female researcher. Participants were instructed that they would be shown twenty objects (e.g. wallet, bottle, notebook, and torch) that had previously been used to pack a rucksack (see Experiments 5A and 5B). Objects were given to the participants individually. Each object was only shown when it was being used, at all other times the objects were kept out of sight hidden behind a partition in the laboratory. The order of presentation of the objects was counterbalanced throughout all phases of the experiment. Following the study phase, participants in the retrieval practice condition practiced a sub-section of the objects. Participants practiced with ten objects. This was followed by a two-minute verbal word generation task. This pattern was repeated a further two times with each of the ten objects, therefore, a total of thirty across. Participants in the control condition did not complete retrieval practice instead completing a series of verbal word generation tasks. All participants regardless of which condition the participant was assigned to be asked to complete a written free recall test during which participants wrote down the name of the objects they were able to remember (see Figure 28 for summary of the method). Upon completion of the experiment all the participants were debriefed and thanked for their participation in the experiment.

Figure 28: Summary of the Method and Trial/Item Information in Experiment 5C

Study Phase

Participants packed twenty objects into a rucksack or observed the researcher packing the rucksack.

Trials (Study Phase)

There were 20 objects with each one used once during the study phase.

Retrieval Practice Phase

Participants in the retrieval practice condition practiced a sub-section of the previously studied items or observed the researcher.

Participants in the control condition complete verbal word generation tasks in place of retrieval practice.

Trials (Retrieval Practice Phase)

Retrieval Practice Conditions: Participants practiced with 10 objects. Each object was practiced 3 times.

Test Phase

All participants were asked to recall the items they were able to remember.

Trials (Test Phase)

All participants had to try and recall the 20 objects.

Figure 28. The above figure is a summary of the method used in experiment 5C (left hand column). The right hand column shows details on the number of trials and item types for each phase of the experiment.

Results

Memory performance was calculated through the successful recollection of the objects (see Table 14). Results were recorded as the number correct answers given. Results were calculated through comparing Rp+ items with Nrp items in order to examine a facilitation effect, and comparing Rp- items with Nrp items to examine a retrieval-induced forgetting effect.

Table 14: Mean Proportion Recall Performance for Each Item Type

Item Type	Rp+	Rp-	Nrp
Score	.91 (.11)	.53 (.12)	.65 (.12)

Note. There were three item types of interest: Rp+ items (practiced items from a practiced category), Rp- items (unpracticed items from a practiced category), and Nrp items (unpracticed items from an unpracticed category). Rp + and Rp- items scores were collected from the retrieval practice condition. Nrp item scores were collected from the control condition. Standard deviations are presented in parenthesis. (see Appendix S for raw data).

Facilitation Effects

Mean recall performance for the Rp + items was higher compared to the Nrp items (see Table 14). An independent t-test demonstrated that this difference was significant, $t\,(19) = 7.07$, $p < .001$ suggesting that a facilitation effect had occurred.

Retrieval-Induced Forgetting Effects

Mean recall performance for the Rp- items was lower compared to Nrp items (see Table 14). An independent t-test demonstrated that this difference was significant, $t\,(19) = -3.66$, $p < .01$suggesting that retrieval-induced forgetting may have occurred for Rp- items.

Discussion

The previous experiments (Experiments 5A and 5B) suggest that retrieval-induced forgetting may not occur for goal-orientated actions. One possible explanation for this is that the lack of an effect may be due to the addition of a goal. A second possibility is that the objects themselves were not susceptible to retrieval-induced forgetting therefore the aim of the current experiment was to examine whether retrieval-induced forgetting occurred for the objects themselves when the goal aspect of the experiment was removed. It was predicted that participants would correctly recall more Rp+ items compared to Nrp items. It was also predicted that participants would recall fewer Rp- items compared to Nrp items demonstrating a retrieval-induced forgetting effect. If retrieval-induced forgetting occurred for the object this may suggest that the objects themselves without the goal attached may be susceptible to retrieval-induced forgetting suggesting that the lack of retrieval-induced forgetting in the previous experiments may have been due to the addition of a goal. The findings of the current experiment suggest that both facilitation and retrieval-induced forgetting effects occurred.

The findings of the current experiment, along with those of experiment 5A and 5B may suggest that facilitation effects may occur for goal-orientated actions. In addition the findings of experiments 5A and 5B suggest that facilitation may occur regardless of whether the participant self-performed the actions or observed the actions being performed by the researcher. The finding of a facilitation effect is in line with the findings of previous experiments in this these. All of the experiments in this thesis have demonstrated a facilitation effect for both self-performed and observed actions (see Experiments 2, 3, and 4). These findings may also support the findings of previous research which suggests a facilitation effect for Rp+ items compared to Nrp items (Anderson et al., 1994; Anderson & Spellman, 1995).

However the previous experiments in this thesis suggest that retrieval-induced forgetting may occur for actions, whereas the three experiments in this chapter may suggest that retrieval-induced forgetting may not be found for goal-orientated actions. This suggests that may be a difference may occur between individual actions (e.g. mini-tasks) and goal-orientated actions in terms of retrieval-induced forgetting. This suggestion may be supported by previous research. For example, Sharman (2011) recently demonstrated that retrieval-induced forgetting can occur for self-performed actions (see also Koutstaal et al., 1999). The items used in this experiment were similar to 'mini-tasks' or individuals actions. However Migueles and Garcia-Bajos (2007) found evidence to suggest that retrieval-induced forgetting may not occur when the actions form part of the same sequence or event, for example, in this particular experiment all of the actions were part of a sequence of a crime. Migueles and Garcia-Bajos proposed that a reason why no retrieval-induced forgetting had occurred was because of integration. Previous research by Anderson and McCulloch (1999) has demonstrated that integration can play a role in protecting memories from retrieval-induced forgetting. These findings contrast those of Sharman. One possible explanation for this is that there is a difference between 'mini-tasks' or individual actions (i.e. non-goal orientated) and goal-orientated or actions which are part of the same sequence in terms of retrieval-induced forgetting with the effect being found for non-goal orientated actions but no retrieval-induced forgetting being found for goal-orientated actions. Although these findings may support the possibility that the addition of a goal may be a possible explanation for why retrieval-induced forgetting occurred for the experiments involving actions in this thesis, and no retrieval-induced forgetting for goal-orientated actions (Experiments 5A, 5B and 5C).

However is also possible the lack of retrieval-induced forgetting in experiments 5A and 5B occurred for other reasons, other than the addition of a goal. For example, it may be argued that no retrieval-induced forgetting occurred because the objects used in the experiments were not themselves susceptible to retrieval-induced forgetting. The findings of experiment 5C however may suggest that the objects themselves may have been susceptible to retrieval-induced forgetting. A further possibility is that the experiments may have involved looking at locations more so than looking at goal-orientated actions. For example, actions in these experiments may have been similar to each other and it could be argued that participants were tested on their memory of the locations of the objects rather than the actions. If this were the case this may not support the suggestion that a difference occurs in terms of retrieval-induced forgetting with non goal-orientated and goal-orientated actions. Future research in this area may therefore involve using different actions as part of goal-orientated actions. For example, these actions would be more varied (see Steffens, 2007) than what used in the current experiments. This may be necessary in order to ensure that retrieval-induced forgetting in terms of goal-orientated actions. If this were the case the experiment may have been relatively easy allowing participants to remember correctly the actions for each object. Therefore in line with the above future research would aim to include more complex and varied actions and to continue to examine whether retrieval-induced forgetting continued to occur. In addition the change from within subject to between subject design from the experiments in the previous experiments in this chapter and the experiments in the current chapter. This change in design may have also had an implication on the results. Although these are limitations of the experiments in this chapter it should also be noted that these experiments are just the beginning of looking at retrieval-induced forgetting, actions and goal-orientated actions, and future experiments may be conducted to further examine retrieval-induced forgetting in terms of goal-orientated actions.

In addition, the findings of experiments 5A and 5B suggest an enactment effect may not have occurred, that is mean recall performance for self-performed Nrp actions were not higher than mean recall performance for observed Nrp actions. If an enactment effect had occurred it may be expected that recall performance for the Nrp items in the self-performed condition would be higher than the recall performance of the Nrp items in the observation condition. The lack of an enactment effect in experiments 5A and 5B may support the findings of Steffens (2007). Steffens also found no difference between mean recall performance in the self-performed and observed conditions, although mean recall performance for both the self-performed and observed conditions were higher than that of a verbal learning condition. Steffens proposed that one explanation for this may be because self-performance of the actions increases item-specific processing whilst observation of the actions increases relational processing. Experiments 5A and 5B may support the suggestion that no enactment effect occurs in terms of self-performed actions compared to observed actions (see also Cohen, 1980; Steffens, 2007).

In conclusion the findings of experiments 5A, 5B and 5C may suggest that goal-orientated actions may be less susceptible to retrieval-induced forgetting. The findings suggest retrieval-induced forgetting may not have occurred for either the self-performed or observed goal-orientated actions, regardless of whether the participants decided themselves where to place the objects or whether the participants were instructed as to where the place the objects by the researcher. The finding of a retrieval-induced forgetting effect for the objects may suggest that that the addition of a goal in this case has played a role in the lack of retrieval-induced forgetting effects in experiments 5A and 5B. These findings may suggest an interesting contrast between actions associated with a goal and those which are not associated with a goal (see also Migueles & Garcia-Bajos, 2007; Sharman, 2011). However further research will need to be conducted to further examine this possibility and alternative explanations for the findings.

Chapter 8
Discussion

Previous research into retrieval-induced forgetting has demonstrated that the effect occurs in a range of different stimuli including words (Anderson et al., 1994; Anderson & Spellman, 1995), eyewitness testimony (MacLeod, 2002), and colours and shapes (Ciranni & Shimamura, 1999). At present little research exists concerning actions which were self-performed and retrieval-induced forgetting. Previous research by Koutstaal et al. (1999) demonstrated a retrieval-induced forgetting effect using photographs of novel actions (Experiment 1) however participants only self-performed the actions during the initial study phase and not in the other phases of the study. Migueles and Garcia-Bajos (2007) however failed to find a retrieval-induced forgetting effect with regards to actions. However both the Koutstaal et al. and Migueles and Garcia-Bajos studies did not specifically look at the self-performance aspect of actions, including requiring participants to self-perform the actions during the study, retrieval practice and test phases, therefore, perhaps the next logical step may be to examine retrieval-induced forgetting and actions. For example, Sharman (2011) demonstrated a retrieval-induced forgetting effect for self-performed bizarre (e.g. place the pencil across the cup) and familiar (e.g. sharpen then pencil) actions. No retrieval-induced forgetting was demonstrated for observed actions. However, the findings of Koutstaal et al. and Sharman suggest that retrieval-induced forgetting may occur for actions.

Evidence from interference studies may also suggest that it is possible for actions to be impaired. For example, Jax and Buxbaum (2010) found slower reaction times for conflicting hand positioning for a grasp action (e.g. grasp the calculator) and a use action (e.g. use the calculator) compared to same hand positioning for a grasp action (e.g. grasp the glass) and a use action (e.g. use the glass). Use actions were also found to interfere with grasp actions. These findings suggest that it is possible for action to impair and affect each other. Further evidence for this comes from consolidation research, that is actions which have been learnt close together time wise also demonstrate that interference can occur for actions (Tong, Wolpert, & Flanagan, 2002;

Walker et al., 2003). The aim of the current thesis is to expand on some of these previous findings and examine whether retrieval-induced forgetting occurs for actions. Specifically the experiments in the these looked at retrieval-induced forgetting and motor sequences (Experiment 1), objects (Experiment 2), actions (Experiments 3 and 4), and goal-orientated actions (Experiment 5). A number of the experiments also compared predictions made by the inhibitory and non-inhibitory theories, for example, cross-category inhibition (Experiment 1), item strength (Experiments 3 and 4), and cue-independence (Experiment 4), in order to consider retrieval-induced forgetting in terms of the inhibitory and non-inhibitory theories.

Retrieval-Induced Forgetting and Motor Sequences

Motor sequences are an intricate part of actions with many motor sequences often coming together to form actions. Many actions then come together to complete a task or in order to achieve a goal. In this case it seems essential to study all aspects of actions including motor sequences (see Experiment 1). Participants were trained in how to respond to novel objects using a response consisting of specific hand and thumb orientation combination using a touch screen computer and a response box. These actions were newly acquired. Participants were required to press the response box with either their left or right hand then press either the top, bottom, left or right buttons on the object on the computer screen. It was predicted that participants would correctly recall more and respond quicker to Rp+ items compared to Nrp-dissimilar items (a baseline measure). It was also predicted that participants would demonstrate poorer recall performance and slower reaction times for Rp- items compared to Nrp-dissimilar items.

A third prediction of the experiment was that cross-category inhibition would occur that is that unpracticed items from an unpracticed category which shared one variable (i.e. either the hand variable or the thumb orientation variable) with Rp+ items would be forgotten. Nrp-handedness and Nrp-orientation items were expected to be remembered more poorly and slower compared to Nrp-dissimilar items. Cross-category inhibition effects were found for both the Nrp-handedness and Nrp-orientation items in terms of recall performance but not for reaction times. These findings suggested that it is possible for retrieval-induced forgetting to occur for motor sequences. However, as the motor sequences used in the experiment were newly learnt, this may allow for the suggestion that retrieval-induced forgetting would only occur with regards to newly learnt actions. Therefore the following set of experiments examined retrieval-induced forgetting in terms of more established actions to see whether retrieval-induced forgetting would continue to be seen. The results supported the predictions regarding facilitation demonstrating quicker reaction times and more accurate responses for Rp+ items (compared to Nrp-dissimilar items). However, retrieval-induced forgetting and cross-category inhibition effects were only found in terms of recall performance, no retrieval-induced forgetting occurred for reaction times. These results suggest that both a facilitation effect and a retrieval-induced forgetting effect occurred however a difference occurred between findings for recall performance and reaction times for retrieval-induced forgetting.

The finding of the inhibitory effects in terms of accuracy but not for reaction times suggests that an interesting difference occurs between accuracy and reaction times. If this occurs then this may be something which could be further examined in future research. However it may be argued that the reaction time data in the current experiment have relatively high standard deviations, this continued to be the case even after cases larger than 4000ms were removed therefore the impact of the reaction time data may be limited. It is none the less an intriguing question as to whether retrieval-induced forgetting and cross-category inhibition effects also occur for reaction times as it is important in everyday life that we complete actions correctly and successfully but also that the actions are completed in a timely manner. Future research may therefore attempt to look at this. A further limitation of the current experiment may be that for each item type (i.e. Rp+, Rp-, Nrp-H, Nrp-O and Nrp-D) there were only two stimuli/objects per item type. This limited number of possible responses and objects per item type is also a consideration, therefore, in future it may be possible to attempt to increase these and the number of trials in the experiment to continue to examine retrieval-induced forgetting in terms of motor sequences.

Retrieval-Induced Forgetting and Actions

In order to examine whether retrieval-induced forgetting occurs for actions experiments 3 and 4 focused on more established actions. Specifically experiment 3 looked at typical and non-typical actions and experiment 4 examined memorable and non-memorable actions. Participants either self-performed or observed a series of actions with a range of different objects during the study phase. This was followed by retrieval practice during which participants self-performed or observed a sub-section of the previously studied actions. This was followed by a recall test. It was predicted that in both experiments participants would accurately recall more Rp+ items compared to Nrp items and recall fewer Rp- items compared to Nrp items. It was also predicted that retrieval-induced forgetting would occur for strong items (i.e. typical and memorable actions) whereas retrieval-induced forgetting would not occur for the weak items (i.e. non-typical and non-memorable actions). In both experiments 3 and 4 there was a facilitation effect for all types of actions (i.e. typical, non-typical, memorable and non-memorable actions). The facilitation effect occurred regardless of whether the actions had been self-performed or observed during the retrieval practice phase. This suggests that facilitation occurs regardless of whether the items are strong or weak or who performed the actions.

However who performed the actions and the strength of the items did impact on whether retrieval-induced forgetting occurred. For example, no retrieval-induced forgetting was found in the observation/observation condition, however, retrieval-induced forgetting was found in the self-performed/self-performed condition. In addition retrieval-induced forgetting was found in the observation/self-performed condition, and in the self-performed/observation condition (the effect disappeared after twenty-four hour delay introduction in this condition). Retrieval-induced forgetting was found for both typical and non-typical actions, and memorable actions, however not for non-memorable actions.

Following this the memorability experiment was expanded to look at cue-independence in order to see if retrieval-induced forgetting continued to occur if an independent cue was presented to the participant during the test phase, a cue which differed to the one used in the study and retrieval practice phases. As in the other experiments a facilitation effect was seen. In addition, retrieval-induced forgetting was only found in the conditions where participants self-performed the actions during retrieval practice and for memorable actions only. These findings may suggest that retrieval-induced forgetting is a cue independent effect.

These findings raise a number of topics for discussion, firstly, the facilitation effect. Secondly the retrieval-induced forgetting effect. Thirdly, the question of item strength – no difference occurred between typical and non-typical actions, but a difference did occur between memorable and non-memorable actions. Finally, the cue independence effect found for memorable actions. These will be discussed in terms of the inhibitory and non-inhibitory theories, along with the cross-category inhibitory effects which were found during experiment one. Finally the limitations of the experiments and suggestions for future research will be discussed.

Facilitation Effects

Experiments 1, 3 and 4 demonstrated a facilitation effect in terms of recall performance for the practiced items (Rp+ items) compared to a baseline measure (Nrp items). These findings suggest that the practice of items during the retrieval practice phase facilitates participants memory for those items. The facilitation effect found in experiments3 and 4 was found in all four conditions (self-performed/self-performed, observation/observation, self-performed/observation, and observation/self-performed conditions). A facilitation effect was also found for memorable and non-memorable actions, as well as typical and non-typical actions. This suggests that whether the participant self-performs or observes actions being performed during retrieval practice, or the items are strong (i.e. typical or memorable) or weak (i.e. non-typical or non-memorable) does not impact on whether a facilitation effect occurs or not.

In addition, experiment 1 found quicker reaction times for the Rp+ items compared to a baseline measure was found, as well as greater accuracy for the Rp+ items. This suggests that not only does practice, facilitate accurate recall of practiced items (see also

Experiments 3 and 4), but also facilitates reaction times in terms of response. Reaction times, as well as accuracy, are an important consideration in terms of actions. When performing actions in daily life it is important not only to perform the actions correctly but also to perform them in a timely manner. Incorrectly performing actions or performing them slowly could have consequences, even if the slowly performed action is eventually performed correctly. The finding of a facilitation effect, are in line with previous research which has also demonstrated a facilitation effect (Anderson & Spellman, 1995; Koutstaal et al., 1999; Sharman, 2011). As well as facilitation effects, retrieval-induced forgetting effects were also examined.

Retrieval-Induced Forgetting Effects

As demonstrated by the overview of the findings above the results regarding retrieval-induced forgetting were less clear cut than those for facilitation effects. The finding of a retrieval-induced forgetting effect in experiments 1, 3 and 4, suggest that it is possible for retrieval-induced forgetting to occur for actions (see also Koutstaal et al., 1999; Sharman, 2011). Accuracy for the Rp- items was found to be poorer compared to Nrp items, suggesting that competing actions which belong to the same category as those which were practiced can be 'temporally forgotten' when needed. Experiment 1 also demonstrated slower reaction times for the Rp- items compared to the Nrp items, suggesting that there is an impact not only on the accuracy of the Rp- items but also on the speed of execution of the actions, therefore inhibition may be important in terms of the accuracy of the memory and the completion of the action in a timely manner. Temporary forgetting of the Rp- items may allow the appropriate action to be successfully retrieved and then performed. For example, a pen may be used to write a note or stir a drink, however, if the pen is presented along with a piece of paper, the contextually appropriate action would be to write a note, as such stir (the contextually inappropriate action) may be temporarily forgotten in order to allow the more contextually appropriate action of write to be successfully completed. More importantly, inhibition would allow the more familiar action of the pen (i.e. write) to be inhibited if an individual was presented with a cup of coffee and no spoon. This would be a prediction consistent with the inhibitory theory (Anderson et al., 1994).

Retrieval-induced forgetting effects were also demonstrated in experiments 3 and 4, however, retrieval-induced forgetting was only found in the three conditions (self-performed/self-performed, self-performed/observation and observation/self-performed conditions). The retrieval-induced forgetting effect in the self-performed/observation did not occur after a twenty-four hour delay had been introduced between the study and retrieval-practice phases. No retrieval-induced forgetting was found in the observation/observation condition. One suggestion for why this pattern of results occurred may relate to retrieval processes. Previous research has demonstrated that retrieval-induced forgetting does not occur with re-presentation (Anderson, Bjork et al., 2000). However retrieval-induced forgetting does occur in situations where active retrieval occurs (see also Bauml, 2002; Campbell & Phenix, 2009; Storm, Bjork & Bjork, 2007). Storm et al. (2006) recently found that participants do not necessarily have to correctly recall the information (see also Storm & Nestojko, 2010), suggesting that it is the attempt at retrieval and active retrieval which are key, and not whether the information recalled was correct or not.

The inhibitory theory proposes that other methods of strengthening the association between the cue and Rp+ items via other methods such as extra study time or re-presentation is not adequate to initiate retrieval competition and inhibition, suggesting that active retrieval is a key aspect (Anderson, Bjork et al., 2000; see also Campbell & Phenix, 2009; Storm, Bjork, & Bjork, 2007). Non-inhibitory theories on the other hand suggest that retrieval-induced forgetting is the result of the strengthening of the Rp+ items, for example, through extra study or re-presentation, and that retrieval may not be necessary for this to occur.

The finding of a retrieval-induced forgetting effect in the self-performed/self-performed and observation/self-performed condition could be explained by the fact that active retrieval took place in the retrieval practice phase. However in the observation/observation condition only re-presentation took place which, in line with other research does not seem to give rise to retrieval-induced forgetting. The finding of a retrieval-induced forgetting effect in the self-performed/observation condition was slightly unexpected as it would be expected that re-presentation, not active retrieval, took place in the retrieval practice phase. One proposed explanation may be that self-performance of the actions in the study phase increased activation levels of the items which was transferred to the retrieval practice phase resulting in the demonstrated retrieval-induced forgetting effect. A twenty-four hour delay was then introduced between the study and retrieval practice phase. If retrieval-induced forgetting had occurred in the self-performed/observation condition had occurred because of raised activation levels it would be expected that the effect would not occur after the delay had been introduced. The results demonstrated no retrieval-induced forgetting effect after the introduction of a twenty-four hour delay. This may support the notion that re-presentation does not give rise to retrieval-induced forgetting (i.e. observation/observation and self-performed/observation conditions) and active retrieval does (i.e. self-performed/self-performed and observation/self-performed conditions). This line of thinking is also supported by the findings of Sharman (2011) who found that no retrieval-induced forgetting occurred for observed actions; however, retrieval-induced forgetting did occur for the self-performed actions. In order to examine whether a lack of effect in the observation condition was due to a lack of retrieval, during experiment 3 participants were asked to observe the actions being performed in the study phase and then self-perform the actions in the retrieval practice phase. A retrieval-induced forgetting effect was found in experiment 3 suggesting that the lack of effect in the observation condition in experiment 2 was due to the lack of retrieval.

However the twenty-four hour delay was not introduced to any of the other conditions, therefore, there was no positive control. It is possible that retrieval-induced forgetting would not be found in any of the conditions. It would be predicted that retrieval-induced forgetting would continue to seen in the self-performed/self-performed and observation/self-performed conditions even after the introduction of the twenty-four delay due to active retrieval in the retrieval practice phase. It would be expected that no retrieval-induced forgetting would be found in the observation/observation and self-performed/observation conditions. Further experiments involving introducing a twenty-four hour delay in the other conditions will be conducted in the near future in order to further examine these effects. If the findings further suggest that retrieval-induced forgetting only occurs in situations where active retrieval takes place in the retrieval practice phase this may support the inhibitory theory. There are several other predictions which allow the inhibitory theory to be compared with the non-inhibitory theory and aspects of experiments 1, 3 and 4 also examined these predictions.

Item Strength

The aim of experiments 3 and 4 were to examine retrieval-induced forgetting and actions. The experiments also examined item strength. According to the inhibitory theory strong Rp- items would be more susceptible to retrieval-induced forgetting than weak items. As strong Rp- items are more likely to be a source of competition, they are more likely to be inhibited or 'temporarily forgotten' in order to resolve the competition. The non-inhibitory theory however would suggest the weak Rp- items would also be susceptible to retrieval-induced forgetting. Anderson et al. (1994) manipulated the strength of the Rp- items, varying from weak Rp- items to strong Rp- items, and demonstrated that retrieval-induced forgetting was more likely to be found with strong items rather than weak items, suggesting that strong Rp- items create the greatest retrieval competition, and as such are more likely to intrude into conscious awareness. This means that strong Rp- items are more likely to be inhibited so as to allow the target item to be recalled, and to resolve the competition issues which have arisen between the Rp+ items and the strong Rp- items. Major et al. (2008) however failed to find an item strength effect (see also Jakab & Raajmakers, 2009).

In experiment 3, typicality was used as a measure of item strength, with typical actions representing strong items and non-typical actions representing weak items. It was predicted that retrieval-induced forgetting would be found only for typical (i.e. strong) actions and not for non-typical (i.e. weak) actions. If this were the case then this may support the predictions of the inhibitory theory. However, the results demonstrated retrieval-induced forgetting for typical and the non-typical actions. This finding may be more in line with the non-inhibitory theory than the inhibitory theory. However an alternative explanation may be that typicality was not an adequate measure of item strength.

In light of this experiment 4 was designed, utilising memorable and non-memorable actions in place of typical and non-typical actions. Therefore, memorable actions represented strong items and non-memorable actions represented weak items. As in experiment 3 it was predicted that retrieval-induced forgetting would occur for strong items (i.e. memorable actions) whereas weak items (i.e. non-memorable actions) would not demonstrate retrieval-induced forgetting. Experiment 4 demonstrated retrieval-induced forgetting only for memorable actions and not for non-memorable actions, supporting the predictions of the inhibitory theory. In addition, this may also suggest that memorability may be a more adequate measure of item strength compared to typicality. A recent study by Bauml et al. (2010) suggested that although item strength may play a part in retrieval-induced forgetting, it may not necessarily mean that item strength plays a large part. However examining item strength is one way to compare the predictions of the inhibitory and non-inhibitory theories.

Cue Independence

A further prediction made by the inhibitory theory is that it is possible to find retrieval-induced forgetting under cue independent conditions. The inhibitory theory proposes that items should continue to be forgotten even if a new (i.e. independent cue) is used in the test phase, as it is the item itself which is inhibited, therefore, using a new retrieval route should not allow the inhibited item to be successfully retrieved. In contrast, the non-inhibitory theory would suggest that the Rp- items are forgotten because interference occurs along the retrieval route. Therefore, using another cue should allow the item to be successfully retrieved via the alternative route. The non-inhibitory theory is unable to explain why retrieval-induced forgetting may occur under independent cue conditions.

Evidence of cue independence was also found by Anderson and Spellman (1995), demonstrating that retrieving items from memory can impair the later recall of other

studied items even under independent cue conditions. For example, participants studied RED-Tomato in the study phase. Tomato also belonged to the category FOOD. Tomato continued to be inhibited even when tested under the category Food rather than the Red category. Non-inhibitory theories would suggest that under Food tomato would be successfully retrieved, and in the memorability experiment, using the new cue participants should have been able to retrieve the actions for the new cue if non-inhibitory mechanisms were involved. The results demonstrated this was not the case. The findings of this experiment therefore seem to be support the findings of Anderson and Spellman (see also Anderson & Green, 2001; MacLeod & Saunders, 2005; Veling and van Knippenberg, 2004). Findings from other research however have failed to find a retrieval-induced forgetting effect when using an independent cue (see Camp et al., 2007; Perfect et al., 2004; Williams & Zacks, 2001). An additional question which has been raised is whether independent cues are truly independent (Camp et al., 2009).
In order to examine whether retrieval-induced forgetting occurs under cue independent conditions an adapted version of the memorability experiment was conducted. The procedure of the cue-independent experiment was identical to that of the memorability experiment in the study and retrieval practice phases. However, in this experiment an independent cue was given to the participant in the test phase, a cue which differed to the one used in the study and retrieval practice phases. Retrieval-induced forgetting continued to be seen, suggesting that retrieval-induced forgetting is a cue independent effect. This finding supports the predictions of the inhibitory theory. Of note is that in the cue-independent experiment retrieval-induced forgetting was found only in the self-performed/self-performed and observation/self-performed conditions and no retrieval-induced forgetting was found in the observation/observation and self-performed/observation conditions. These findings may support the suggestion that retrieval-induced forgetting occurs in situations where active retrieval takes place during retrieval practice (i.e. self-performance in this experiment) and not when re-presentation (i.e. observation) takes place during retrieval practice. It is interesting that in all of the other experiments retrieval-induced forgetting was also found in the self-performed/observation condition (when no twenty-four hour delay occurred) but that was not the case in the independent cue experiment. One possible reason for this is the

use of independent cues in this experiment, something which did not occur in the other experiments. Further research would need to be performed in order to further examine this possibility.

Cross-Category Inhibition

A third prediction made by inhibitory theories relates to cross-category inhibition, which suggests that any Nrp item which could potentially be a source of retrieval competition may also inhibited, including items which are related to Rp+ items. Anderson and Spellman (1995) demonstrated a cross-category inhibition effect, meaning that items from one category may have inhibited the recall of items from other categories (see also Saunders & MacLeod, 2006). For example, participants may have completed retrieval practice of Red-Blood, which would inhibit performance of Red-Tomato (Rp- item) and additionally inhibited related items such as Food-Strawberry (Anderson & Spellman, 1995). A cross-category inhibition effect was also demonstrated in this thesis (Experiment 1). Participants demonstrated forgetting for items which shared either the hand or thumb orientation variable with the Rp+ items. This finding supports the predictions of the inhibitory theory. Cross-category inhibition was seen for accuracy, that is, participants performed poorer for Nrp-orientation and Nrp-handedness items compared to Nrp-dissimilar items.

The findings of experiments 1, 3 and 4 therefore seem to support the inhibitory theory rather than the non-inhibitory theory; however, there are two models of inhibition which have previously been suggested as explanations for retrieval-induced forgetting and cross-category inhibition effects. The first of these is the lateral inhibition theory (Blaxton & Neely, 1983) which suggests that activation spreads from the retrieval cue associated with a category to exemplars and can account for cross-category inhibition effects. For example, if a participant is given the pairing Red-Blood during retrieval practice the activation may spread from that pairing to other items which may be related such as Food-Strawberry.

An alternative to the lateral inhibition theory is the pattern suppression theory which suggests that whether an Rp- item is retrieved is dependent upon its net facilitation from its association with the Rp+ item and its net inhibition. For example, if more of the semantic features are facilitated than inhibited then the item will be successfully recalled. This account can also explain cross-category inhibition effects, as the theory assumes that memories are composed of semantic feature unites meaning that Nrp items can be inhibited if the items share some inhibited features with the Rp- items or were inhibited due to their competition with the Rp+ item (Saunders & MacLeod, 2006). The findings of a cross-category inhibitory effect in experiment 1 may therefore provide some support for the pattern suppression model. For example, if it is considered that memory for motor sequences and actions also compose of feature units in the same way as semantic verbal memory then Nrp-handedness and Nrp-orientation items shared features with Rp+ items, sharing either the hand or thumb orientation features (Saunders & MacLeod, 2006). Features which were likely to interfere with the correct execution of the action and features likely to interfere with the speed of execution would be most likely to be inhibited.

Retrieval-Induced Forgetting and Objects

Previous memory for action research has suggested that actions and objects (e.g. lift the pen) may become integrated (Kormi-Nouri, 1994); therefore, looking at the object component as well as the action component is essential. Experiments 3 and 4 looked at the action component whereas experiment 2 examined the object component. Participants in experiments 3 and 4 self-performed or observed four actions being performed with an object (object-action pairs), experiment 2 involved participants self-performing or observing an action being performed with four different objects (action-object pairs). The aim was to see if retrieval-induced forgetting would also occur for objects or would retrieval-induced forgetting only occur for the actions. As in experiments 3 and 4 there were four conditions (self-performed/self-performed, self-performed/observation, observation/observation, and observation/self-performed conditions). The results demonstrated a retrieval-induced forgetting effect for the objects as well suggesting that retrieval-induced forgetting may occur for both the action and the object. As in experiments 3 and 4, retrieval-induced forgetting was found in the self-performed/self-performed, observation/self-performed and self-performed/observation conditions. The retrieval-induced forgetting effect found in the self-performed/observation condition was no longer found after the introduction of a twenty-four hour delay between the study and retrieval practice phases. No retrieval-induced forgetting was found in the observation/observation condition.

These findings are in line with those of experiments 3 and 4, and may further suggest that retrieval-induced forgetting may not be found in cases of re-presentation but is found in cases of retrieval, supporting the inhibitory theory. As in experiments 3 and 4 a retrieval-induced forgetting effect was found in the self-performed/observation condition, however, as had occurred previously the effect disappeared when a twenty-four hour delay was introduced between the study and retrieval practice phases. The finding that retrieval-induced forgetting occurred for both actions and objects may suggest that there is a mechanism which allows the appropriate actions to be performed with the correct object. Retrieval-induced forgetting may allow this to occur, and without such a process the situation may arise where an incorrect action is performed with an object.

The role of objects has also been highlighted in memory for action research. For example, the episodic integration account (Kormi-Nouri, 1994) proposes that self-performance of the actions leads to integration, between the action and the object, and between the participant and the action-object (e.g. pick up the pen). Observation however may not allow the same integration to occur as might occur following self-performance (see also Kormi-Nouri, 1995; Kormi-Nouri & Nilsson, 1998). The episodic integration account further suggests that item-specific processing is enhanced during self-performance of actions, a prediction which is supported by other research (see Earles & Kersten, 2002; Einstein & Hunt, 1980; Engelkamp & Zimmer, 1997; Olfosson, 1997). However, episodic integration also proposes that relational processing should be enhanced. Although some studies have demonstrated an improvement in relational processing following self-performance (see Kormi-Nouri & Nilsson, 1999; Backman et al., 1986), other studies have failed to find this (see Engelkamp, 1986; Engelkamp & Zimmer, 1996; Zimmer & Engelkamp, 1989; Zimmer & Engelkamp, 2000).

The role of objects in self-performed actions has been the source of some debate in action research with studies varying in whether the objects were actually present during the experiment (Backman et al., 1986; Kormi-Nouri & Nilsson, 1999; Nilsson & Backman, 1989) or imagined (Engelkamp & Zimmer, 1983; Engelkamp & Zimmer, 1996; Kormi-Nouri, 2000). Kormi-Nouri (2000) asked participants to self-perform or to imagine self-performing actions with either real objects or imagined objects. The enactment effect was found to be present for self-performed and imagined actions, and when an object was physically used and imagined. This suggests that both objects and the motor component (i.e. the action) may play a role in the enactment effect. A study by Backman and Nilsson (1984) found that the enactment effect was greater when participants performed the actions with the objects present than when participants imagined the objects (see also Nyberg et al., 2001; Steffens et al., 2003; Steffens, Jelenec, Mecklenbrauker, & Thompson, 2006). However, Engelkamp and Zimmer (1983) examined whether the presence or absence of objects impacted on the size of the enactment effect. No difference was found between the objects present and the objects not present conditions (see also Engelkamp & Zimmer, 1997). This further highlights why examining both the action and object components is essential. However it is also important to note that actions and objects may be closely integrated and although the experiments attempted to study the action and the object it may also be true to suggest that the action and the object are closely related and difficult to separate.

Given that retrieval-induced forgetting was found for both the actions (Experiments 3 and 4) and the objects that actions are completed with (Experiment 2), and that retrieval-induced forgetting may occur only in conditions where self-performance took place in the retrieval practice phase this may suggest that both objects and actions are important. The actions used thus far were individual, separate however, actions individuals perform everyday are not individual, and separate actions. The actions individuals perform as part of everyday life are usually associated with a goal, and form a series of actions which are performed with the aim of successfully completing the goal or task. As such retrieval-induced forgetting for actions was also examined.

Retrieval-Induced Forgetting and Goal-Directed Actions

Actions in everyday life are more likely to be goal-orientated however actions performed as part of a laboratory experiment often are not (Steffens, 2007). There are several other reasons to consider goal-orientated actions as well. Firstly, it has been noted that goals may play a role in memory for actions (Ratner & Foley, 1994), suggesting that individuals perform actions and tasks and influence their environment in order to achieve a specific goal or complete a task (Foley & Ratner, 2001). Additionally, Glover et al. (1987) demonstrated that actions with a goal attached to them are more likely to be remembered than those without a goal, further highlighting the possible impact of a goal. Steffens (2007) recently found no difference between self-performed and observed goal-orientated actions (see also Ratner & Hill, 1991; Smyth, 1991), suggesting that self-performance increased item-specific processing whereas observation increased relational processing (Steffens, 2007). Both self-performed and observation conditions demonstrated better recall performance compared to a verbal learning condition (Steffens, 2007). These previous findings may suggest that goals are important, and as goal-orientated actions are more likely to occur in everyday life, it is necessary to consider retrieval-induced forgetting in terms of goal-orientated actions in addition to the previous experiments which have examined retrieval-induced forgetting, objects and actions.

The final experiment (Experiment 5) involved goal-orientated actions in place of the actions used in those experiments were not associated with goals (Experiments 2, 3, and 4), and it may be suggested that those actions were more similar to 'mini-tasks' or individual actions (see also Steffens, 2007). During experiment 5, participants were asked to self-perform or observe a task or goal-orientated actions, in this case, packing a rucksack. Additionally participants were either allowed to decide for themselves where to place the objects in a rucksack or were instructed where to place the objects by the researcher. The results demonstrated no retrieval-induced forgetting effect for goal-orientated actions in either the self-performed or the observed conditions, and regardless of whether the participant or the researcher decided where to place the objects in the rucksack. This result suggests a difference between goal-orientated and non goal-orientated actions, specifically, that goal-orientated actions may be less susceptible to retrieval-induced forgetting. One proposed reason for this may be that the addition of a goal in experiment 5 may have played a role in the lack of retrieval-induced forgetting. However, it may also have been suggested that the objects used themselves did not give rise to retrieval-induced forgetting, which may also explain why no retrieval-induced forgetting occurred. A follow up experiment involving the objects demonstrated that the objects did give rise to retrieval-induced forgetting, providing some support to the notion that the addition of the goal played a role.

This suggestion is further supported by previous action research which demonstrated that actions involving a goal are remembered better than actions without a goal (Glover et al., 1987). Additionally, Migueles and Garcia-Bajos (2007) failed to find a retrieval-induced forgetting effect for actions. This study involved actions which belonged to the same sequence, in a similar to the way that the actions in experiment 5 belonged to the same sequence in terms of completing the goal of packing a rucksack. Migueles and Garcia-Bajos proposed that no retrieval-induced forgetting was found in their experiment as the actions belonged to the same sequences that this may have allowed integration to take place. This may suggest that goal-orientated actions may not be susceptible to retrieval-induced forgetting.

Previous research into integration and retrieval-induced forgetting has found that integration can protect memories from retrieval-induced forgetting (Anderson & McCulloch, 1999; Radvansky & Zacks, 1991; Russell & Storms, 1955). Anderson and McCulloch (1999) found that when participants integrated items, the retrieval-induced forgetting effect was diminished, both if participants were instructed to integrate the items, and if they integrated the items spontaneously. This may explain how the goal played a role in experiment 5 and why no retrieval-induced forgetting was found for goal-orientated actions. This also provides an explanation for why some studies such as

Koutstaal et al. (1999) and Sharman (2011) have demonstrated retrieval-induced forgetting for actions which did not involve a goal, whereas Migueles and Garcia-Bajos failed to find retrieval-induced forgetting for actions.

Enactment Effects

In order to further examine the self-performance of actions, in each experiment participant's recall performance for Nrp items were compared to each other in order to examine any possible enactment effects which may have occurred. Previous research has demonstrated an enactment effect for self-performed actions compared to verbally learnt actions, with participants demonstrating improved recall performance for the self-performed actions compared to verbally learnt actions (Cohen, 1981; Backman & Nilsson, 1984; Engelkamp & Krumnacker, 1980; Kausler & Lichty, 1985; Knopf, 1981; Helstrup, 1984). An improvement was also seen in terms of false alarm rates (Engelkamp & Zimmer, 1995; Koriat et al., 1998; Leynes & Bink, 2002; Zimmer, 1996). The enactment effect has also been found for self-performed actions compared to imagined actions (Denis, Engelkamp, & Mohr, 1991; Ecker & Engelkamp, 1995; Engelkamp & Krumnacker, 1980; Engelkamp & Perrig, 1986; Perrig & Hofer, 1989; Saltz & Donnenwerth-Nolan, 1981). Of importance to this thesis are findings relating to self-performed actions compared to observed actions. Previous research has demonstrated a somewhat mixed picture of whether an enactment effect occurs for self-performed actions compared to observed actions. For example, Hornstein and Mulligan (2004) demonstrated an improved recall performance for self-performed actions compared to observed actions (see also Engelkamp & Zimmer, 1989). However, Steffens (2007) failed to find an improvement for self-performed actions compared to observed actions, with the results demonstrating no difference between the self-performed and observed actions (see also Cohen, 1981; Cohen, 1983; Cohen & Bean, 1983).

This mixture of findings regarding self-performed and observed actions somewhat reflects the findings of experiments in the thesis. For example, experiment 4A (actions and memorability) demonstrated an enactment effect in that participants in general recalled more Nrp items when the actions were self-performed during the study phase of the compared to the scores of the Nrp items when the actions were observed during the study phase. This seems to suggest an enactment effect. In addition an enactment effect occurred in experiment 4C for the self-performed/self-performed condition compared to the observation/observation condition. These results would be in line with the findings of Hornstein and Mulligan (2004) (see also Engelkamp & Zimmer, 1989). However, in experiments 2, 3 and experiment 4C and 4D no enactment effect was demonstrated. No difference occurred between conditions during which self-performance occurred during the study phase and conditions which involved observation during the study phase. There was also no difference in terms of recall performance of Nrp items of the self-performed condition compared to the observed condition in the goal-orientated experiments (experiment 5). The findings of experiment 5 are similar to those found by Steffens (2007) in that no significant difference was found between the self-performed and observed conditions in terms of an enactment effect. Steffens also found no difference between self-performed and observed goal-orientated actions. An explanation proposed by Steffens is that self-performance leads to an improvement in item-specific processing, whereas observation leads to an improvement in relation processing. Although the findings of experiment 2 and 5 are in line with the results of Steffens (2007) (see also Cohen, 1981; Cohen, 1983; Cohen & Bean, 1983), they differ to some of the other experiments in this thesis. One aspect of future research may be to further examine the enactment effect and possible reasons for why an enactment effect occurs in some situations but not in others.

The differences which have occurred between the findings of previous studies have been explained in terms of differences in experimental design and the length of lists of actions used (Engelkamp & Dehn, 2000; Engelkamp & Zimmer, 1997). In addition self-performance of actions seems to improve item-specific processing (Engelkamp & Zimmer, 1997; see also Earles & Kersten, 2002; Einstein & Hunt, 1980; Engelkamp & Dehn, 2000; Engelkamp, Mohr, & Zimmer, 1991; Olfosson, 1997; Steffens, 2007). Relational processing however does not seem to be improved by the self-performance of actions (Golly-Haring & Engelkamp, 2003; Koriat et al., 1998). However other studies have suggested that an improvement in terms of relational processing may occur (Backman et al., 1986; Kormi-Nouri & Nilsson, 1999). Steffens (2007) found evidence to suggest that self-performance leads to an improvement in item processing and observation leads to an improvement in relational processing. This may explain why Steffens may not found an enactment effect in terms of self-performed actions compared to observed actions.

There are many different theories which have been proposed to explain the enactment effect. Firstly, the motor code theory (Engelkamp & Krumnacker, 1980) highlights the role of the motor component of self-performed actions which may explain why recall performance for self-performed actions is improved compared to verbally learnt, imagined and observed actions. Although the motor code theory highlights the role of a motor component, the theory does not rule out the input of other components (such as verbal and visual components) (Engelkamp, 2001). For example, findings from studies looking at secondary tasks which are not motor in nature (i.e. are verbal or visual) have been used as evidence against the motor code theory however, Engelkamp (2001) argues that this is not necessarily evidence against the motor code theory as Engelkamp suggests that verbal, visual and motor encoding can take place independently as well as occurring together, and as such all components if used in a secondary task may impact on the primary motor task (Engelkamp, 2001).

Secondly, the episodic integration account (Kormi-Nouri, 1994) proposes that self-performance of actions can lead to integration; as such participants may be more aware of which actions have been performed. This may not occur in the observation and verbal learning conditions. Kormi-Nouri and Nilsson (2001) note that "*enactment is the glue that cements the components of actions into a single memory unit*" (Kormi-Nouri and Nilsson, 2001, in Zimmer et al., 2001, p. 105). Participants, during self-performance, may also think about self-relevant actions more so than what might occur during observation of the actions. Participants may also consider aspects such as outcomes, the success or failure of a task, monitoring and so on. However, if the tasks are mini-tasks such as 'pen-lift' or 'lift-pen' they may have little impact on the individuals. Kormi-

Nouri (1995) demonstrated an effect of semantic relation between the action and the object in self-performed actions, suggesting episodic integration (see also Kormi-Nouri & Nilsson, 1998). This only occurred for self-performed actions and not for verbally learnt or observed actions.

One key question in action research has been whether self-performance of actions during the study phase is representative of a specific encoding condition. Zimmer (2001) concludes that it is likely that self-performance of actions during the study phase may be a specific encoding condition, and one which differs to that which occurs during verbal learning. Memories for actions and memories for verbal materials differ in a number of ways. Zimmer and Cohen (2001) note three ways that memories for verbal material and memories for actions may differ (see also Cohen, 1981; Helstrup, 1986). Firstly, many actions are remembered unintentionally, often without much or any effort having to be put into remembering the actions. Secondly, a key component of many actions is that they are performed by the individual themselves. Thirdly, actions often involve an input and an output (Zimmer & Cohen, 2001). The points above may not occur for verbal material and highlight the need to study memory for actions as well as memory for verbal material.

Performance and Written Tests

A final aspect worth noting is that during these experiments both performance and written tests were used in the final test phases. The use of performance and written tests have been used in previous research (see Steffens, 2007). Experiment 2 demonstrated a retrieval-induced forgetting effect for objects, using a written cued recall test. During the test phase participants were shown the name of an action and the first two letters of one of the objects (e.g. knot-st) on a piece of card. Participants were then asked to write down the name of the object if they were able to remember it. A retrieval-induced forgetting effect was demonstrated for Rp- items in the self-performed/self-performed and observation/self-performed conditions. During the test phase, Rp- items were presented to the participant first, followed by the Nrp items and then the Rp+ items. This was done in order to prevent any output interference effects (Racsmany, Conway,

& Demeter, 2009; Perfect et al., 2004), suggesting that the findings had not occurred due to output interference.

A similar method was also used in experiment 4D which examined retrieval-induced forgetting and actions, specifically in terms of memorability. During the test phase participants were shown the name of an object and the first two letters of one of the actions used with the object (e.g. flask-po) on a piece of card. As previously mentioned a retrieval-induced forgetting effect was demonstrated for Rp- items in the self-performed/self-performed and observation/self-performed conditions, and this only occurred for the memorable actions. As in experiment 2 during the test phase, Rp- items were presented to the participant first, followed by the Nrp items and then the Rp+ items. This order was used in order to prevent any output interference effects (Racsmany, Conway, & Demeter, 2009; Perfect et al., 2004).

However as the aim of the thesis is to examine retrieval-induced forgetting and actions, it was also necessary to use a test phase where participants were asked to physically perform the actions. In everyday life, it is more likely that individuals will perform the actions rather write down the actions. In addition, the motor code theory (Engelkamp & Krumnacker, see also Engelkamp & Zimmer, 1983) has been suggested as one explanation for why participants recall more self-performed actions than other types of actions (e.g. imagined actions and observation actions) and verbal learning, suggesting that the motor component and physically being asked to self-perform the action plays a role in the improved memory.

There are also examples of previous studies which have utilised a performance test, as well as a written test. For example, Steffens (2007) used two types of recall tests: a written test and a performance test during which participants were asked to perform actions they were able to remember (see also Engelkamp et al., 1994; Norris & West, 1993; Saltz, 1988). As such in experiments 3, 4, and 5 during the test phase participants performed the actions they were able to remember. During the test phase in experiments 3 and 4 participants were given each object and asked to recall actions for that object in a free recall test. In both experiments 3 and 4, a retrieval-induced forgetting effect was demonstrated. However, as free recall procedures were used, it is also possible that output interference may have occurred during recall, as participants may have been more likely to retrieve Rp+ items earlier than Rp- items leading to interference during recall. If output interference occurred during free recall then it might be expected that retrieval-induced forgetting would only present for participants who retrieved the Rp+ items early on, and before the Rp- items. Analysis of the output order for however did not demonstrate an output interference effect.

In experiment 5 participants were again asked to perform the actions during the test phase, however, participants were presented with Rp- items first, followed by Rp+ items. As the experiment was a between-subjects design, scores for Rp+ items and Rp- items came from the retrieval practice condition, whereas Nrp items scores came from the control condition. No retrieval-induced forgetting was found in terms of goal-orientated actions during this experiment. Overall, the experiments included in this thesis suggest that retrieval-induced forgetting can occur using for both written and performance tests.

Limitations

There are several issues which run throughout the course of the experiments within the thesis and these will be discussed in this section. One of these issues involves the experiments with a twenty-four delay (experiments 2B, 3B, 4B, and 4E). In each of those experiments only a self-performed/observation condition was used, that is, participants, self-performed the actions during the study phase and then observed the actions being performed by the researcher in the retrieval practice phase which occurred twenty-four hours following the study phase. The results suggest that no retrieval-induced forgetting had occurred, although a retrieval-induced forgetting occurred in the self-performed/observation condition prior to the addition to a twenty-four delay. This was the case in all of the temporal delay experiments. This led to the suggestion that when no delay occurred the activation levels of the items was increased during self-performance of the actions in the study phase and transferred to the retrieval practice phase leading to the demonstrated retrieval-induced forgetting effect. The addition of a twenty-four hour delay may have allowed time for the activation levels to decrease following the study phase leading to finding no retrieval-induced forgetting in the twenty-four hour delay experiments. However the temporal delay experiments did not include a positive control condition, therefore, this may suggest that although it is suggested that activation played a part in finding retrieval-induced forgetting in the self-performed/observation condition there are no controls to compare this too. For example, no retrieval-induced forgetting may be found following the introduction of a twenty-four delay in the self-performed/self-performed and observation/self-performed conditions. It is suggested that retrieval-induced forgetting would continue to be seen in the self-performed/self-performed and observation/self-performed condition even after the introduction of a twenty-four hour delay. If this were the case then this may support the suggestion that retrieval-induced forgetting occurred in the self-performed/observation condition (prior to the introduction of a twenty-four delay) because of raised and transferred activation levels. However in order to discover whether that is the case, and to further examine, the possibility of retrieval-induced forgetting for actions, further experiments involving the twenty-four hour delay and positive controls would need to be conducted, and future research would certainly aim to do this The findings of those experiments would then allow a fuller answer on why no retrieval-induced forgetting effect was seen in the temporal delay experiments in the self-performed/observation condition and future research could then be planned from there depending on the findings of those experiments.

A further consideration in these experiments is the definition of item strength. In experiments 3 and 4 the item strength predictions of the inhibitory and non-inhibitory theories were examined. The inhibitory theory would suggest that retrieval-induced forgetting is more likely to occur with strong items as the strong items are more likely to intrude to conscious awareness. However non-inhibitory theories propose that retrieval-induced forgetting can occur with weak items. The aim of the experiments in this thesis, using typicality and memorability as measures of item strength, was to see if retrieval-induced forgetting occurred for strong items only or not. If retrieval-induced forgetting occurred only for the strong items then this may support this inhibitory theory. In experiments 3 typicality was used as a measure of item strength and a pilot study was used to determine which actions would be used as typical items and which would be non-typical items. Typical actions referred to actions an individual would most likely complete with the object (e.g. spoon-stir) and these were the strong items in the experiment. Non-typical actions referred to actions an individual would least likely complete with the object (e.g. spoon-tap) and these were the weak items. Retrieval-induced forgetting was found for both the typical (i.e. strong) and non-typical (i.e. weak) items. It was suggested that typicality may not have been an adequate measure of item strength therefore in experiments 4 memorability was used a measure, again using pilot studies to determine which items would be memorable and which would be unmemorable. Memorable (i.e. strong) items were those which were remembered by the most number of participants and non-memorable (i.e. weak) items were those were remembered by the least number of participants. In experiments 4 retrieval-induced forgetting was only found for strong items. The experiments in the thesis therefore used different measures of item strength: typicality for actions which are likely or not likely to be performed with objects and memorability for actions which are most likely or less likely to be remembered. However different measures of item strength also occurs in previous research for example, other experiments have used frequency (Anderson et al., 1994), generation of items (Camp et al., 2007) and placements of items (Jakab & Raajmakers, 2009) as measures of item strength. This suggests that there is no clear or finite definition of 'strength' which may contribute to the varied findings in the field of whether a difference in retrieval-induced forgetting occurs in terms of item strength. This is not to suggest that each experiment is wrong and that item strength could not be measured in different ways however there may need to be a clearer and more defined way of measuring item strength. The experiments in this thesis used pilot studies to try and ensure that the items were strong or weak. Although each experiment uses a different measure of item strength each experiment included strong and weak items therefore it may also be suggested that some measures may not be appropriate measures of item strength whereas others may be more appropriate. Future research may also consider the impact of different measures of item strength in terms of their impact on retrieval-induced forgetting.

An additional limitation or issue with the experiments used in the thesis relate to the number of trials and ceiling effects, particularly in the case of experiments 2 to 4. In each experiment the number of trials and number of items was relatively small for example in experiment 2 there were four Rp+ items which were practiced three times, in experiments 3 and 4 there were four Rp+ items but these were further divided into typical and non-typical or memorable and non-memorable. The fewer number of items and trials may have contributed to potential ceiling effects. For example across all experiments mean recall performance for Rp+ items was relatively high (less so for experiment 2 compared to experiments 3 and 4) this may have allowed participants to remember the items well or to guess responses. Therefore it may be possible that the number of trials and items played a role in the results. This may also be the case in experiment 1 where only two objects were used for each item type. This limited number of item types (e.g. two Rp+ items) may have had an impact. As such future research would look to increase the number of trials and items in the experiment. There are two further issues with experiment 5A. Firstly, is an issue relating to the design of the experiments include the change from within subjects design (prior to experiment 5) to between subjects design in experiment 5. The change in design may possibly explain why effects were found in experiments 2-4 but not in experiment 5. In future it may be possible to redesign the experiment to include a design similar to experiments 2-4 to see whether the change in design played a role in the lack of retrieval-induced forgetting in experiment 5A.

A further issue with experiment 5 outside of the change in design from within to between factors is the actions involved. This experiment suggested that retrieval-induced forgetting may not occur for goal-orientated actions however there are several limitations with the current design. As the actions were fairly simple, for example, placing the item in the bag, this may have allowed the participants to remember the actions quite well. It could also be argued that the experiments did not necessarily measure retrieval-induced forgetting and actions but instead measured location. During the test phase participants were asked to pack the rucksack and this raises the question of whether they were remembering an action or only remembering the location of objects inside the rucksack. To account for this future research may involve the use of more varied actions. For example, a rucksack packing task by Steffens (2007) involved a variety of actions. It may also be possible to examine more varied and complex actions. For example, Steffens in a second experiment asked participants to complete a task making clay. Therefore future research would look the possibility of adapting the current task of packing a rucksack or using another task. However it should be noted that despite the limitations of experiment 5 and also limitations in terms of being able to suggest that retrieval-induced forgetting may not occur for goal-orientated actions these experiments were only the beginning of examining retrieval-induced forgetting and goal-orientated actions. Future research taking into account the above points will continue to examine whether retrieval-induced forgetting occurs for goal-orientated actions.

The analysis of the experiments may also be a point for consideration. In several of the main experiments examining the results raised issues with multiple comparisons increasing the chance of type 1 errors in the experiments, that is that the results may have suggested that an effect had occurred when this may not have actually been the case. In order to account for these bonferonni pairwise corrections were completed as a measure of accounting for and dealing with the issue of multiple comparisons. However in hindsight it may also have been possible to remove some aspects of the design which may have benefited in solving this issue. For example, through each experiment no retrieval-induced forgetting has been found in the observation/observation condition and no retrieval-induced forgetting was found for Rp- non-memorable items. As such it is possible that these could have been removed from the design prior to testing. Although the bonferonni correction has been applied future research will also take into account these issues both in terms of analysis and design of the experiments.

A final issue in terms of the results may be the value of the reaction time data in experiment 1. The analysis of the reaction time data focuses on the correct responses and responses by participants which took more than 4000ms were excluded. The findings suggest that a facilitation effect for reaction times but that no retrieval-induced forgetting or cross-category inhibition effects were found. Firstly, this may suggest that although these effects for accuracy there were no effects for reaction times. Secondly, there may be an issue with the value of the data, for example, because there are quite large standard deviations in the data across all item types. This may have impacted on the findings and may also limit the value and what we are able to say about the data. However, the examination of reaction times for actions in relation to retrieval-induced forgetting is very important. Actions individuals perform everyday need to be performed correctly and successfully of course, however, they also need to be performed efficiently and in a timely manner therefore future research may continue to examine reaction times for actions taking into account the large standard deviations and the length of time participants in the current experiment took to respond.

Future Directions

The above section demonstrates some of the limitations and issues in the current experiments and these will be considered when designing future research. In terms of future research the near future for the experiments in this thesis would involve a progression and development of the goal-orientated actions experiment. For example through examining firstly more varied actions and secondly more complex goal-orientated actions. As in the current experiments the results will be examined in terms of facilitation and retrieval-induced forgetting effects. The findings of any such experiments may then aid the development of any further experiments on the topic. In addition future research will also include the addition of positive control conditions to the temporal delay experiments. As previous research (see MacLeod, 2002) suggests that retrieval-induced forgetting may continue to be seen following the introduction of a twenty-four delay, therefore, it may be predicted that in the experiments in this thesis retrieval-induced forgetting would continue to occur in for example the self-performed/self-performed condition even following the addition of a twenty-four delay.

Including positive controls in the temporal delay experiment may aid the explanation for why retrieval-induced forgetting occurred in the self-performed/observation condition without a twenty-four delay and did not occur following the introduction of a twenty-four hour delay. Examination of retrieval-induced forgetting and actions will also continue as part of future research.

Further suggestions for future research would be to further examine the item strength in relation to retrieval-induced forgetting. For example, the impact of typicality and memorability on retrieval-induced forgetting, and a possible exploration of why an item strength effect was found for memorability but not for typicality. Finally, an interesting finding in chapter 6 of this thesis was the finding that under cue independent conditions retrieval-induced forgetting did not occur in the self-performed/observation condition (without a twenty-four hour delay). This differs to the other experiments in chapter 6 which have found a retrieval-induced forgetting for the self-performed/observation condition when no twenty-four delay was introduced. This is an interesting finding and it may be suggested that one possible reason for this is the introduction of the independent cues during the test phase. This was the one difference between this experiment (experiment 4C) and the other experiments in the chapter (experiments 4A and 4D). Future research may therefore also include further examining this possibility.

Summary and Conclusion

The experiments in this thesis suggest that retrieval-induced forgetting can occur with actions (Experiments 3 and 4), and the objects involved in the actions (Experiments 2). In addition, retrieval-induced forgetting was found for motor sequences (Experiment 1). The results also suggest that active retrieval is an important component as retrieval-induced forgetting was demonstrated in conditions where participants were asked to complete retrieval (i.e. through self-performance) and not when participants completed re-presentation (i.e. observation). This finding may support the notion that inhibitory processes are involved. Further support for the inhibitory theory includes the finding of an effect of item strength in relation to memorability. Retrieval-induced forgetting was only found for the memorable actions and not the non-memorable actions, which would support the predictions of the inhibitory theory. The inhibitory theory would suggest that strong items (i.e. memorable items) should be inhibited as they are more likely to be a source of competition whereas weak items (i.e. non-memorable items). However, this effect was not demonstrated when typical and non-typical actions were utilised. This may suggest that memorability is perhaps a more adequate measure in terms of item strength than typicality.

The cue independence effect found in experiment 4C may further support the inhibitory theory. The findings demonstrated a retrieval-induced forgetting effect in the self-performed/self-performed and observation/self-performed conditions, and only for the memorable actions. As retrieval-induced forgetting seems to be cue independent this may suggest that it is the memorial representation of the actions which have been impacted upon, therefore using an independent cue did not allow the item to be retrieved, as predicted by the inhibitory theory. The non-inhibitory theory however would suggest that using an independent cue would allow the item to be successfully retrieved as it is interference along the retrieval route which is the problem and not that the item itself is impacted upon.

The findings in this thesis may also show that retrieval-induced forgetting occurs not only for novel or newly acquired motor sequences as found in experiment 1 but also with less novel actions (Experiments 3 and 4). However, the findings also suggest that no retrieval-induced forgetting occurs when a goal is included (Experiment 5). One proposed reason for why a difference occurred between actions not involving a goal and those involving a goal, maybe the role that the goal plays. For example, Migueles and Garcia-Bajos (2007) used actions which belonged to the same sequence, and failed to find a retrieval-induced forgetting effect. It was proposed that this occurred because participants were able to integrate the actions (Migueles & Garcia-Bajos, 2007). Previous research has demonstrated that integration can protect memories from retrieval-induced forgetting (Anderson & McCulloch, 1999). Further research will include examining whether retrieval-induced forgetting does not occur for goal-orientated actions. If this were to be the case then this difference in the two types of actions in terms of goals could form the basis of future investigation, in order to further examine goal-orientated actions in terms of retrieval-induced forgetting.

The study of inhibition in behaviour is important in light of the suggestion that inhibition may play a role in forgetting in everyday memory. Inhibition may play a particularly important role in the successful execution of actions, in the execution of the actions in a timely fashion, and also that actions are completed using the correct object. Specifically, inhibition in memory for actions may allow the contextually inappropriate actions to be inhibited allowing the appropriate actions to be completed. As previously noted however there is little research into retrieval-induced forgetting and actions, although it is essential to discover if retrieval-induced forgetting plays a role with actions, especially, to see the role that inhibition may play in inhibiting contextually inappropriate actions for several reasons. Firstly, using an inappropriate action can lead to social conflict, and secondly, using a contextually inappropriate action could lead to harm.

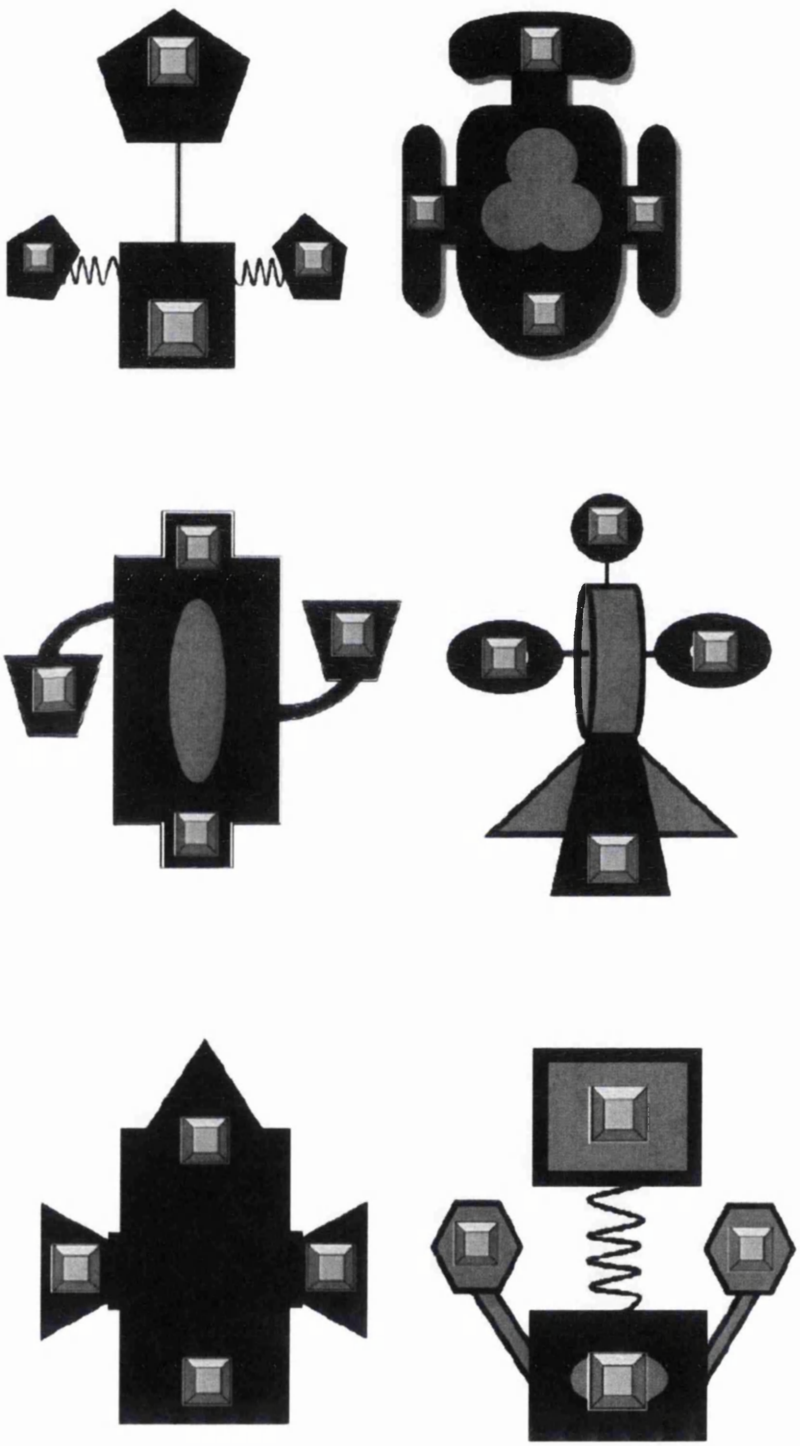
Deficits in terms of action memory have previously been demonstrated with Alzheimer patients, and the examination of inhibition in memory for actions may lead to theoretical developments of models of Alzheimer's disease. Rusted and Sheppard (2002) found that during the early stages of Alzheimer's action memory seems to be preserved, highlighted by the finding that individuals make few omissions in terms of the actions. However, as the disease progresses action memory begins to fragment leading to an increase in omissions of actions. Rusted and Sheppard found that as individuals progressed from the early stages to the later stages of the disease the number of omissions in actions increased, leading to routines becoming more fragmented. However, although individuals make more omissions and their routines became more fragmented the individuals continued to be able to complete tasks such as pouring a cup of tea. The authors proposed that this may be due to the individual's familiarity with the actions such as pouring a cup of tea. When individuals were asked to perform unfamiliar routines, the individuals did make more omissions and repetition errors, suggesting that memory for actions can be inhibited (Rusted & Sheppard, 2002). As

Alzheimer's disease is associated with inhibitory deficits this decline in action based memory could be due to deficits in the inhibition of memory, suggesting that less inhibition occurs allowing more memories for actions to flood the individual's mind, which could lead to poorer performance for actions. Studying actions and the role of inhibition may therefore be of value both theoretically and in applied terms.

To conclude, the experiments conducted as part of this thesis have demonstrated a facilitation effect for Rp+ items in terms of recall and reaction times. This effect was demonstrated regardless of whether the participant or the researcher had performed the actions, whether the actions were newly acquired or more established, and regardless of whether the actions were associated with a goal or not. Furthermore retrieval-induced forgetting effects were found for both newly acquired and less novel actions. Retrieval-induced forgetting for established actions were found for both actions and objects. A final experiment suggested that retrieval-induced forgetting may not occur for goal-orientated actions. This may suggest that actions associated with a goal are less susceptible to retrieval-induced forgetting (see also Migueles & Garcia-Bajos, 2007). These findings suggest that retrieval-induced forgetting can occur with actions (see also Sharman, 2011), expanding on the findings of Koutstaal et al. (1999). Results of the experiments also demonstrated a cross-category inhibitory effect, cue independence and an item strength effect which may support the notion that inhibitory mechanisms play a role in memory for actions, allowing the inappropriate actions to be inhibited and the appropriate actions to be expressed.

Appendices

Appendix A: The 10 Stimuli Used in Experiment 1.



Appendix A. These are the stimuli used in experiment 1. There were 10 in total. Each object has four buttons. Participants were asked to respond to the images by pressing a button on the response box and a button on the object.

Appendix B: Raw Data for Experiment 1.

Raw Data for Participants in Experimental Condition. The Data Represents Accuracy.

Rp+	Rp-	Nrp-Orientation	Nrp-Handedness	Nrp-Dissimilar
1	1	0.5	0.5	1
1	1	1	0.5	0.5
1	0.5	1	0	1
1	1	0.5	0.5	1
1	0.5	0.5	0	1
1	0.5	0.5	0.5	0.5
1	0.5	1	0.5	0.5
1	1	1	0.5	1
0.5	1	1	0	1
0	0.5	1	0.5	0
1	0.5	1	0.5	0.5
1	1	0	0.5	1
1	1	0.5	0	0
1	0.5	1	1	1
1	1	0.5	0.5	0
1	0.5	0.5	0.5	1
1	1	0	0.5	1
1	1	1	1	1
1	0.5	1	1	0.5
0.5	0.5	1	0.5	0.5
0	1	0.5	0.5	1
1	1	1	0	1
0.5	1	0.5	0.5	1
1	0.5	0.5	0.5	0.5
1	1	1	1	1
1	0.5	1	1	0.5
1	1	1	0.5	1
1	1	1	0.5	1
1	0.5	0.5	1	1
1	1	0	0.5	1
1	0	0.5	0.5	1
1	1	0.5	0	0
1	0.5	1	1	0.5
1	0	0	0.5	0.5
1	1	0.5	1	1
1	1	0.5	0	1
1	1	1	1	1
1	0.5	1	0.5	1

1	1	0	0.5	0
0.5	0.5	0.5	0	0.5
0	0	0.5	1	0.5
1	1	1	0.5	0.5
0	0.5	0	1	1
1	0	0	0.5	1
1	0.5	1	0.5	1
1	0.5	0	0	1
1	0	1	0.5	1
1	0	0	0	0.5
0.5	0	0.5	0.5	1
1	1	1	1	0
0.5	0	0	0	0.5
1	1	1	0.5	1
1	0	0.5	0.5	0.5
1	0	0.5	0	0
1	1	0	0.5	1
0.5	1	0.5	1	1
1	1	0	0	0.5
1	0	0	0.5	1
1	0.5	0.5	0.5	1
1	1	1	1	1
1	1	1	1	1
1	0.5	0.5	1	0.5
1	0.5	0.5	0.5	1
1	0	1	0.5	1
1	0	0	1	1

Appendix B. Raw data from experiment 1. The raw data represents the accuracy of participants responses for each item type. A response was considered accurate when the participants selected the correct button on the response box and the correct button on the stimuli on screen. There were five item types of interest: Rp+ items, Rp- items, Nrp-O items, Nrp-H items, and Nrp-D items.

Raw Data for Each Participant in the Experimental Condition. The Data Relates to Time Taken to Press the Button on the Response Box (Hand Reaction Time).

Rp+	Rp-	Nrp-Orientation	Nrp-Handedness	Nrp-Dissimilar
1735.5	1051.5	1253	2021.5	2213.5
2398	2201.5	3844.5	3907	3502
2207.5	2780	1367	2633	1864.5
1042	2160.5	4179	2583	2415
2004	3364	3754.5	5582	3264
1439	1190	1981	1626	7809
854	1087.5	1666.5	2197	1660
1273	2833	1427.5	2882.5	1647.5
4692	4120.5	3483.5	3230.5	2686.5
5074	6983	2432	6592	2077.5
2912	3106.5	3479.5	3911	2380
3444.5	4190.5	5715	3227	2481.5
1710.5	2073.5	2659.5	4660.5	3191.5
1453.5	2844	1605.5	1855.5	2380.5
1096	2947	2835	4951	4593
886.5	4716.5	2795.5	2395	1384
1143.5	2648.5	2238.5	2400.5	2576.5
1565	2258.5	2625	5631.5	2064.5
2264.5	942.5	1458	2153.5	1144.5
777	2119	2195.5	4355	1242
2440	1587	3071	3194	2982.5
1185.5	3835	3369	2290.5	3410
1509.5	4215	1787.5	1935.5	1410.5
1212	2515.5	1157	1520.5	1063
1187	1066.5	2681	1690.5	2586.5
1625	4612.5	7314.5	1878	2341.5
4193.5	1962	937	2092	2323.5
909.5	2562.5	5992	2388.5	2965.5
927	633.5	1766	1765.5	2326.5
1431.5	5137	2570.5	3926.5	1077.5
4334.5	3907.5	3379	2361	1932
796	2307.5	3344.5	3982.5	3463.5
856.5	3018	2606.5	2963	2442.5
1132.5	3373.5	2335	1749	2671.5
1247.5	1978	2884	1524.5	2154
1283	1549	1133	3609	1617.5
1257.5	1618.5	1793	2273.5	1867
2387.5	2993	4734	3515.5	2572

1621	1635.5	2638.5	2593	2506
750	3504.5	5359.5	1562	2610.5
1665	1281	1993.5	559	696.5
1328	1181	1172.5	1416	3065
3261	4839.5	5464.5	2304	3264.5
2234	2226	2411	3045	2079.5
786	2106.5	1522.5	2495.5	1428
586	2096	2416.5	1736	513
701.5	1273	1256.5	1858.5	564
1262.5	1267.5	1598	1753	1404
1213.5	877.5	1624.5	1267.5	1545.5
2297.5	4550	1410.5	3243	1823.5
1262.5	1267.5	1598	1753	1404
1352	1846.5	1500.5	1655.5	1279.5
964.5	2632.5	2318.5	494	1805
1279.5	2365.5	2887.5	3622	3478.5
653	2243	1962.5	2578	1401
7063	2128.5	6581	2249.5	2126
590.5	1701	3296.5	1610	1070
796	1339.5	904	1799	848
1743.5	2334	1387	2792	703
1468	1695.5	1872.5	3198.5	2554.5
1106	1585	1420.5	1645.5	1248
1144.87	2422.5	1414	2877	2159
1204.5	3242	4127	1191	4531
701.5	1273	1256.5	1858.5	564
515	3339	4282.5	4434	822.5

Appendix B. Raw data from experiment 1. The above data represents reaction times for the hand (i.e. length of time to press the button on the response box) of the participants response for each participant in the experimental condition. There were five item types of interest: Rp+ items, Rp- items, Nrp-O items, Nrp-H items, and Nrp-D items.

Raw Data for Each Participant in the Experimental Condition. The Data Relates to the Length of Time Taken to Press the Button on the Stimuli (Orientation Reaction Time).

Rp+	Rp-	Nrp-Orientation	Nrp-Handedness	Nrp-Dissimilar
944.5	860	938	904.5	906.5
996.5	689.5	673.5	745.5	800.5
1705.5	1472.5	936	1298	1011
1187	1072.5	1430.5	1034	1224
959.5	1184.5	1021.5	843	930
887	941.5	3370	704.5	756.5
727	2961.5	688.5	924.5	677
626.5	1173.5	714.5	892	1725
896	889.5	883	949	964
1021	1129	760.5	967	864
1018	903.5	760.5	995.5	1059
750	648	621.5	772.5	695.5
772.5	723.5	668	1447	928
969.5	819.5	893.5	785.5	577
772.5	832	664.5	652	755
706.5	1213	734.5	1006.5	723
788	1311.5	1334	946.5	895
1096.5	977	732	608	846.5
889.5	674.5	1363	1062.5	542.5
724.5	678.5	683.5	814	758.5
765.5	712	741.5	782	882.5
957	907	970.5	1002	953.5
801	772	732.5	718	779.5
864.5	852.5	865.5	882	709
1299.5	993.5	1412	1050.5	777.5
1638	1076	1016	777.5	1213.5
582	769.5	620	595	861
1077	1030.5	967.5	894.5	1541.5
970	632.5	615.5	657.5	688
787	1083	1263	954	828.5
1034.5	707.5	758	859.5	951.5
676	750.5	758	1214	904
983.5	891	779	811.5	860.5
638.5	653.5	572	620.5	585.5
908	926.5	888.5	843	485
729	851	736.5	802.5	853.5
610.5	1308.5	773	1949.5	854
930.5	977	955.5	1177.5	1177.5

1000.5	1126.5	1376.5	1439	1081.5
664.5	891	767	768	1424.5
637.5	767.5	607.5	577.5	1562.5
2346.5	2404	1588.5	2178	4070.5
1953	1237.5	852.5	1396.5	867.5
565.5	891.5	812	1231.5	516.5
709.5	1833.5	726.5	532.5	647.5
515	2958	2343	2358	505
542	2976	2684.5	2022.5	2139.5
765	1765	2879	1524	1269.5
844.5	1826	1854.5	2008.5	1078.5
821.5	823.5	823.5	1100.5	876
765	1765	2879	1524.5	1269.5
528	571.5	627.5	543.5	553.5
556.5	3581	1405.5	2102	1397
989.5	3296.5	3404.5	3219.5	3096
783.5	1308.5	2708.5	1935	3056.5
1841	2151.5	4077.5	5192.5	1757
595	1935.5	1905	1481	987
752.5	2541.5	949	1539.5	847
607	2054	2028.5	1244.5	637.5
632.5	584	566.5	602.5	454
1428.5	690	867.5	1527.5	1011
774	731	773	680.5	839
1150	571	597	680	688
542	2976	2684.5	2022.5	2139.5
777	1514	1098.5	1788.5	936.5

Appendix B. Raw data from experiment 1. The above data represents reaction times for orientation (i.e. length of time to press the button on the object) of each participant in the experimental condition. There were five item types of interest: Rp+ items, Rp-items, Nrp-O items, Nrp-H items, and Nrp-D items.

Raw Data for Each Participant in the Experimental Condition. The Data Relates to the Length of Time Taken by the Participant to Press the Button on the Button Box and the Stimuli on Screen (Combined Hand and Orientation Reaction Time).

Rp+	Rp-	Nrp-O	Nrp-H	NrpD
1340	955.75	1095.5	1463	1560
1697.25	1445.5	2259	2326.25	2151.25
1956.5	2126.25	1151.5	1965.5	1437.75
1114.5	1616.5	2804.75	1808.5	1819.5
1481.75	2274.25	2388	3212.5	2097
1163	1065.75	2675.5	1165.25	4282.75
790.5	2024.5	1177.5	1560.75	1168.5
949.75	2003.25	1071	1887.25	1686.25
2794	2505	2183.25	2089.75	1825.25
3047.5	4056	1596.25	3779.5	1470.75
1965	2005	2120	2453.25	1719.5
2097.25	2419.25	3168.25	1999.75	1588.5
1241.5	1398.5	1663.75	3053.75	2059.75
1211.5	1831.75	1249.5	1320.5	1478.75
934.25	1889.5	1749.75	2801.5	2674
796.5	2964.75	1765	1700.75	1053.5
965.75	1980	1786.25	1673.5	1735.75
1330.75	1617.75	1678.5	3119.75	1455.5
1577	808.5	1410.5	1608	843.5
750.75	1398.75	1439.5	2584.5	1000.25
1602.75	1149.5	1906.25	1988	1932.5
1071.25	2371	2169.75	1646.25	2181.75
1155.25	2493.5	1260	1326.75	1095
1038.25	1684	1011.25	1201.25	886
1243.25	1030	2046.5	1370.5	1682
1631.5	2844.25	4165.25	1327.75	1777.5
2387.75	1365.75	778.5	1343.5	1592.25
993.25	1796.5	3479.75	1641.5	2253.5
948.5	633	1190.75	1211.5	1507.25
1109.25	3110	1916.75	2440.25	953
2684.5	2307.5	2068.5	1610.25	1441.75
736	1529	2051.25	2598.25	2183.75
920	1954.5	1692.75	1887.25	1651.5
885.5	2013.5	1453.5	1184.75	1628.5
1077.75	1452.25	1886.25	1183.75	1319.5
1006	1200	934.75	2205.75	1235.5
934	1463.5	1283	2111.5	1360.5

1659	1985	2844.75	2346.5	1874.75
1310.75	1381	2007.5	2016	1793.75
707.25	2197.75	3063.25	1165	2017.5
1151.25	1024.25	1300.5	568.25	1129.5
1837.25	1181	1172.5	1797	3567.75
2607	3038.5	3158.5	1850.25	2066
1399.75	1558.75	1611.5	2138.25	1298
747.75	1970	1124.5	1514	1037.75
550.5	2527	2379.75	2047	509
621.75	2124.5	1970.5	1940.5	1351.75
1013.75	1516.25	2238.5	1638.5	1336.75
1029	1351.75	1739.5	1638	1312
1559.5	2686.75	1117	1100.5	876
1013.75	1516.25	2238.5	1524.5	1269.5
940	1209	1064	1099.5	916.5
760.5	3106.75	1862	1298	1601
1134.5	2831	3146	3420.75	3287.25
718.25	1775.75	2335.5	2256.5	2228.75
4452	2140	5329.25	3721	1941.5
592.75	1818.25	2600.75	1545.5	1028.5
774.25	1940.5	926.5	1669.25	847.5
1175.25	2194	1707.75	2018.25	670.25
1050.25	1139.75	1219.5	1900.5	1504.25
1267.25	1137.5	1144	1586.5	1129.5
959.435	1576.75	1093.5	1778.75	1499
1177.25	1906.5	2362	935.5	2609.5
621.75	2124.5	1970.5	1940.5	1351.75
646	2426.5	2690.5	3111.25	879.5

Appendix B. Raw data from experiment 1. The above data represents reaction times (for both the hand (i.e. length of time to press the button on the response box) and orientation (i.e. length of time to press the button on the stimuli onscreen)) for each of the participants in the experimental condition. There were five item types of interest: Rp+ items, Rp- items, Nrp-O items, Nrp-H items, and Nrp-D items.

Raw Data for Each Participant in the Control Condition. The Data Relates to the Accuracy of their Response and Length of Time (i.e. Reaction Time) taken to press the response box (Hand RT), button on the stimuli (Orientation RT) and Combination of Hand and Orientation (Combined RT).

Accuracy	Hand RT	Orientation RT	Combined RT
0.5	2134.2	667.5	1400.85
0.9	1817.1	1047.7	1432.4
0.5	2313.1	827.8	1570.45
0.5	2672	917.5	1794.75
0.4	6194.4	2023.3	4108.85
0.9	2194.8	1081.6	1638.2
0.4	1650.5	773.2	1211.85
0.4	4178.1	1045.9	2612
0.6	2200.3	778.2	1489.25
0.7	2409.1	1135.6	1772.35
0.6	2433.4	1388.8	1911.1
0.6	2129.1	712.6	1420.85
0.6	4508.2	515.2	2511.7
0.7	4595.3	1506.7	3051
0.7	5092	943.9	3017.95
0.7	1550.8	696.5	1123.65
1	2696.6	1023.1	1859.85
0.8	1732	710.8	1221.4
0.8	1129.5	763.1	946.3
0.5	2156.7	936.7	1546.7
0.8	1366.8	1699.2	1533
0.7	1136.5	2149.5	1643
0.7	818.1	3169.8	1993.95
0.7	741.5	2719.4	1730.45
0.4	1376.7	2931.2	2153.95
0.8	1161.7	1811.8	1486.75
0.8	1233.9	3825.4	2529.65
0.8	897.5	2603.3	1750.4
0.5	3269.1	7156.6	5212.85
0.7	903.8	2451.9	1677.85
0.4	4154.7	1472.1	2813.4
0.8	5778.1	690.8	3234.45
0.5	2174.6	806.8	1490.7
0.3	2277.3	943.1	1610.2
0.7	2408.5	885.1	1646.8

0.8	1239	789.6	1014.3
0.6	2878.9	1203.6	2041.25
0.7	3290.9	901.2	2096.05
0.4	1526.8	1250.2	1388.5
0.6	11615.4	1456.4	6535.9
0.6	2918.6	752.5	1835.55
0.9	5099.3	1135.1	3117.2
0.8	4488.7	1720.5	3104.6
0.6	3390.9	816.3	2103.6
0.8	2008.1	1212.5	1610.3
1	1880.1	1169.2	1524.65
0.4	1607.8	1820.8	1714.3
0.8	1650.9	1266.5	1458.7
0.8	1878.9	648.8	1263.85
0.3	5080.6	664.4	2872.5
0.5	3430.1	647.2	2038.65
1	7596.6	1314.7	4455.65
0.7	4887.2	878.4	2882.8
0.9	4414.9	1194.8	2804.85
0.6	2979.1	816.4	1897.75
0.8	2160.1	883.6	1521.85
0.4	2471	879.2	1675.1
0.6	3160.9	1047.7	2104.3
0.8	898.2	850.8	874.5
0.7	3671.5	803.9	2237.7
0.9	2469.8	613.8	1541.8
0.7	3422.4	866	2144.2
0.3	2282.2	671.2	1476.7
0.7	2202.444	318	1260.222
1	2214.4	1051.9	1633.15

Appendix B. Raw data from experiment 1. The above data represents the accuracy of each participants response in the control condition (i.e. whether the pressed the correct button on the response box and the correct button on the stimuli on screen). The reaction time data represents the length of time taken to press the button on the response box (Hand RT), length of time taken to press the button on the stimuli on screen (Orientation RT), and the combined length of time taken by the participant to press the button on the response box and the stimuli on screen (Combined RT).

Appendix C: List of Actions and Objects Used in Experiments 2A and 2B.

Action	Object
Pour	Glass
Pour	Flask
Pour	Bottle
Pour	Jar
Poke	Pen
Poke	Safety Pin
Poke	Umbrella
Poke	Fork
Wipe	Mirror
Wipe	Dish
Wipe	Table
Wipe	Computer Screen
Roll	Ball
Roll	Orange
Roll	Newspaper
Roll	Rolling Pin
Grip	Screwdriver
Grip	Knife
Grip	Teapot
Grip	Door Handle
Fold	Tissue
Fold	Table Cloth
Fold	Flannel
Fold	Paper
Knock	Door
Knock	Fan
Knock	Chair
Knock	Box
Knot	Scarf
Knot	Shoe Lace
Knot	Ribbon
Knot	String

Appendix C. List of the actions and objects used in experiments 2A and 2B.There were 8 eight action categories (left hand column in above table) and 4 objects for each action category (right hand column in the above table) giving rise to 32 action-object pairs.

Appendix D: Raw Data for Experiment 2A.The Raw Data Demonstrates the Results for Participant in Each Condition.

Raw Data for Each Participant in the Self-Performed/Self-Performed Condition. The Data Represents Accuracy for Each Item Type.

Rp+	Rp-	Nrp
1	0.75	0.75
1	0.625	0.6875
0.625	0.375	0.625
0.75	0.75	0.8125
0.875	0.875	0.8125
0.875	0.875	0.9375
0.875	0.625	0.9375
0.75	0.375	0.875
1	0.625	0.75
0.875	0.75	0.8125
1	0.625	0.75
1	1	0.8125
1	0.625	0.6875
0.75	0.75	0.8125
0.75	0.875	0.6875
1	0.625	0.75
0.875	0.375	0.6875
0.75	0.625	0.625
1	0.375	0.75
1	0.75	0.875
1	0.125	0.9375
1	0.25	0.9375
0.75	0.625	0.625
1	0.875	0.4375
1	0.625	0.875

Appendix D. Raw data from experiment 2A.The above data represents accuracy of the participants response (i.e. whether they correctly recalled the object for the action) for participants in the self-performed/self-performed condition. Participants self-performed the actions in the study phase and in the retrieval practice phase. There were three item types of interest: Rp+ items, Rp- items, and Nrp items.

Raw Data for Each Participant in the Observation/Observation Condition. The Data Represents Accuracy for Each Item Type.

Rp+	Rp-	Nrp
1	1	0.9375
1	1	0.9375
1	0.875	0.75
0.75	0.75	0.75
0.875	0.875	0.6875
0.875	0.5	0.875
0.875	0.125	0.875
1	0.625	0.875
1	0.875	0.875
0.875	0.75	0.75
1	0.75	0.875
0.625	0.625	0.8125
1	1	0.6875
0.875	0.75	0.5
0.875	1	0.8125
0.875	0.875	0.6875
1	0.5	0.625
0.75	0.75	0.5
1	0.875	0.8125
1	1	0.5
0.625	0.625	0.6875
1	0.875	0.8125
0.75	0.625	0.625
1	0.375	0.5
0.75	1	0.5

Appendix D. Raw data from experiment 2A. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the object for the action) for each participant in the observation/observation condition. Participants observed the actions being performed in the study phase and in the retrieval practice phase. There were three item types of interest: Rp+ items, Rp- items, and Nrp items.

Raw Data for Each Participant in the Self-Performed/Observation Condition. The Data Represents Accuracy for Each Item Type.

Rp+	Rp-	Nrp
1	0.5	0.75
0.875	0.75	0.6875
1	0.5	0.6875
0.625	0.75	0.5625
1	0.5	0.5625
0.875	0.625	0.6875
0.75	0.5	0.625
0.875	0.5	0.6875
1	0.75	0.875
1	0.625	0.375
1	0.5	0.6875
0.75	0.375	0.5625
0.375	0.375	0.5
1	0.875	0.75
0.875	0.5	0.5625
1	0.625	0.8125
0.875	0.875	0.875
0.875	0.5	0.6875
1	0.75	0.875
0.875	0.5	1
1	1	0.875
1	0.375	1
0.875	0.25	0.75
0.875	0.875	0.6875
1	0.75	0.4375

Appendix D. Raw data from experiment 2A. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the object for the action) for each participant in the self-performed/observation condition. Participants self-performed the actions being performed in the study phase and observed the actions being performed in the retrieval practice phase. There were three item types of interest: Rp+ items, Rp- items, and Nrp items.

Raw Data for Each Participant in the Observation/Self-Performed Condition. The Data Represents Accuracy for Each Item Type.

Rp+	Rp-	Nrp
1	0.625	0.875
1	0.625	0.75
1	0.375	0.6875
1	0.875	0.625
1	0.5	0.625
0.5	0.5	0.6875
0.75	0.5	0.75
1	1	0.6875
1	0.75	0.9375
1	0.75	0.3125
1	0.5	0.75
0.75	0.25	0.5625
1	0.25	0.5625
1	0.75	0.6875
0.25	0.5	0.5625
1	0.625	0.8125
0.875	1	0.875
0.625	0.375	0.6875
1	0.75	0.875
1	0.5	1
1	0.875	1
1	0.125	0.375
0.75	0.375	0.6875
0.625	0.75	0.6875
1	0.625	0.5625
0.885	0.59	0.705

Appendix D. Raw data from experiment 2A. The above data represents accuracy of the participants response (i.e. whether participants correctly recalled the object for the action) for each participant in the observation/self-performed condition. Participants observed the actions being performed in the study phase and self-performed in the retrieval practice phase. There were three item types of interest: Rp+ items, Rp- items, and Nrp items.

Appendix E: Raw Data (Experiment 2B) for Each Participant in the Self-Performed/Observation Condition.

Rp+	Rp-	Nrp
1	0.5	0.5625
0.625	0.75	0.75
0.625	0.625	0.8125
1	0.625	0.5625
1	1	0.875
0.625	0.375	0.5
1	1	0.9375
1	1	0.875
0.875	0.75	0.6875
0.75	0.625	0.5625
1	1	1
0.75	0.625	0.9375
0.875	0.875	0.875
0.75	0.5	0.5625
1	0.75	0.8125
1	1	0.875
1	0.875	0.9375
0.75	0.75	0.75
1	1	0.6875
1	0.75	0.625
1	1	1
1	0.875	0.875
0.75	0.5	0.6875
0.875	1	0.9375
1	1	0.8125

Appendix E. Raw data from experiment 2B. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the object for the action) for participants in the self-performed/observation condition. Participants observed the actions being performed in the study phase and in the retrieval practice phase. The study phase occurred during session one on day one and then the retrieval practice and test phases took place 24 hours later on day two. There were three item types of interest: Rp+ items, Rp- items, and Nrp items.

Appendix F: List of the Objects and Actions Used in Experiments 3A and 3B.

Object	Action
Spoon	Scoop (T)
Spoon	Tap (T)
Spoon	Balance (NT)
Spoon	Wave (NT)
Feather	Drop (T)
Feather	Tickle (T)
Feather	Weave (NT)
Feather	Write (NT)
Tissue	Fold (T)
Tissue	Scrunch (T)
Tissue	Rip (NT)
Tissue	Separate (NT)
CD	Spin (T)
CD	Roll (T)
CD	Blow (NT)
CD	Slide (NT)
Cards	Shuffle (T)
Cards	Deal (T)
Cards	Slice (NT)
Cards	Flick (NT)
Saucepan	Cover (T)
Saucepan	Lift (T)
Saucepan	Upside Down (NT)
Saucepan	Side (NT)
String	Knot (T)
String	Wind (T)
String	Wiggle (NT)
String	Lasso (NT)
Ball	Bounce (T)
Ball	Throw (T)
Ball	Push (NT)
Ball	Foot (NT)

Appendix F. List of actions and objects used in experiments 3A and 3B. There were eight objects (left column in the above table) and four actions (right column in the above table) for each object giving rise to 32 object-action pairs. T represents the typical actions and NT represents the non-typical actions. For each object there were 2 typical actions and 2 non-typical actions.

Appendix G: Raw Data for Experiment 3A.The Raw Data Demonstrates the Results for Participant in Each Condition.

Raw Data for Each Participant in the Self-Performed/Self-Performed Condition. The Data Represents Accuracy for Each Item Type.

Rp+		Rp-		Nrp	
T	NT	T	NT	T	NT
1	1	0.75	0.75	0.875	0.75
1	1	1	1	1	0.875
1	1	0.5	0.75	0.875	0.63
1	1	0.5	0.5	1	0.75
1	1	1	0.75	0.875	1
1	1	0.5	0.5	0.875	0.75
1	1	1	1	1	1
1	1	0.5	0.5	1	0.75
1	1	0.75	0.75	0.75	0.75
1	1	0.75	0.75	1	0.875
1	1	0.75	0.5	1	1
1	1	1	0.75	0.75	1
1	1	1	0.5	1	0.75
1	1	1	0.75	0.875	1
1	1	0.75	0.75	0.63	0.75
1	1	1	0.5	0.875	1
1	1	0.75	1	0.875	1
1	1	1	1	1	0.875
1	1	0.75	0.75	1	0.75
1	1	1	1	0.875	1
1	1	0.75	0.25	0.875	0.625
1	1	0.75	0.75	0.875	0.875
1	1	0.75	0.75	0.875	0.75
1	1	0.75	1	0.875	0.75

Appendix G. Raw data from experiment 3A. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for the object) for each participant in the self-performed/self-performed condition. Each object had two typical actions and two non-typical items actions. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. Each item type also had two levels of typical items (T) and non-typical items (NT).

Raw Data for Each Participant in the Observation/Observation Condition. The Data Represents Accuracy for Each Item Type.

Rp+		Rp-		Nrp	
T	NT	T	NT	T	NT
0.75	1.00	0.50	0.75	1.00	0.63
0.75	1.00	1.00	0.75	0.88	0.88
1.00	1.00	1.00	0.25	0.75	0.88
1.00	1.00	1.00	1.00	0.75	1.00
1.00	1.00	1.00	1.00	0.88	0.75
1.00	1.00	0.75	1.00	1.00	0.63
1.00	1.00	0.75	0.75	0.88	0.63
1.00	1.00	0.25	1.00	0.75	0.50
1.00	1.00	1.00	1.00	0.75	0.75
1.00	1.00	1.00	1.00	0.75	0.75
1.00	1.00	1.00	1.00	1.00	0.88
1.00	1.00	1.00	0.75	0.88	0.75
1.00	1.00	1.00	0.50	0.75	0.63
1.00	1.00	0.50	0.50	0.75	0.88
1.00	1.00	1.00	0.25	0.75	0.75
1.00	1.00	0.25	0.75	0.75	1.00
0.75	0.75	1.00	0.75	0.75	0.63
1.00	0.75	0.75	0.75	0.88	0.88
1.00	1.00	1.00	0.75	0.75	0.88
1.00	1.00	1.00	1.00	0.75	0.63
1.00	1.00	1.00	1.00	0.88	1.00
1.00	1.00	0.50	0.75	1.00	0.88
1.00	1.00	1.00	1.00	0.75	0.63
1.00	1.00	1.00	0.75	0.88	0.88

Appendix G. Raw data from experiment 3A. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalls the action for the object) for each participant in the observation/observation condition. Participants observed the actions being performed in the study phase and in the retrieval practice phase. For each object there were two typical actions and two non-typical actions. There were three item types of interest: Rp+ items, Rp- items and Nrp items. Each item type also had two levels of typicality: typical items (T) and non-typical items (NT).

Raw Data for Each Participant in the Self-Performed/Observation Condition. The Data Represents Accuracy for Each Item Type.

Rp+		Rp-		Nrp	
T	NT	T	NT	T	NT
1	1	0.75	0.5	0.875	1
0.75	1	1	0.75	0.875	1
1	1	1	1	0.75	0.625
1	1	1	0.75	0.75	0.75
1	1	0.5	0.75	0.875	1
1	1	0.75	0.75	1	0.75
1	1	0.5	0.75	0.875	1
1	1	0.75	0.75	0.875	0.875
1	1	1	0.75	0.875	0.75
1	1	1	1	1	0.5
1	1	0.5	0.75	1	0.875
1	1	0.5	0.75	0.625	0.75
1	0.75	0.75	1	0.75	1
1	1	0.5	0.5	0.875	0.75
1	1	0.75	0.5	1	1
1	0.75	0.75	0.75	1	0.625
1	0.75	0.75	1	0.75	0.625
0.5	1	0.25	0.5	1	1
1	1	1	0.5	1	1
1	1	0.5	0.75	0.75	1
1	1	0.75	0.75	1	0.75
1	1	0.5	0.75	0.5	1
1	1	0.75	0.5	0.875	1
1	1	1	0.75	1	1

Appendix G. Raw data from experiment 3A. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for the object) for each participant in the self-performed/observation condition. Participants self-performed the actions being performed in the study phase and observed the actions in the retrieval practice phase. For each object there were two typical actions and two non-typical actions. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. Each item type also had two levels of typicality: typical items (T) and non-typical items (NT).

Raw Data for Each Participant in the Observation/Self-Performed Condition. The Data Represents Accuracy for Each Item Type.

Rp+		Rp-		Nrp	
T	NT	T	NT	T	NT
1	1	1	1	1	1
0.75	0.75	0.5	0.75	0.875	1
1	1	1	1	0.625	0.875
1	1	0.75	0.5	0.75	0.875
1	1	0.75	1	0.875	0.375
1	0.75	1	0.25	0.875	0.875
1	1	0.75	0.5	0.875	0.625
1	1	0.75	0.5	0.875	0.875
1	1	0.5	0.75	0.75	1
1	1	0.5	0.5	0.5	0.75
1	1	0.25	0.5	0.875	0.625
1	1	0.25	0.75	0.75	0.625
1	1	0.75	1	0.875	0.625
1	1	0	0.75	0.625	1
1	1	1	1	0.875	0.75
1	1	1	0.75	1	1
1	1	1	0.5	0.75	1
1	1	0.75	0.5	0.75	0.625
1	1	1	0.5	1	0.75
1	0.75	1	0.5	1	0.625
0.75	0.75	0.5	0.75	0.875	0.75
1	1	0.75	1	0.75	1
1	1	0.5	1	1	1
1	1	0.25	0.5	1	1

Appendix G. Raw data from experiment 3A. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for each object) for each participant in the observation/self-performed condition. Participants observed the actions being performed in the study phase and self-performed the actions in the retrieval practice phase. For each object there were two typical actions and two non-typical actions. There were three item types of interest: Rp+ items, Rp-items, and Nrp items. Each item type also had two levels of typicality: typical items (T) and non-typical items (NT).

Appendix H: Raw Data (Experiment 3B) for Each Participant in the Self-Performed/Observation Condition. The Data Represents Accuracy for Each Item Type.

Rp+		Rp-		Nrp	
T	NT	T	NT	T	NT
1	1	1	0.75	0.875	1
1	1	1	0.5	0.625	0.75
1	1	0.75	1	0.875	0.625
1	1	0.75	1	0.875	0.5
0.75	0.75	0.5	0.75	0.375	0.625
1	0.75	0.75	0.25	0.875	0.875
0.75	0.75	0.5	0.5	0.5	0.25
1	1	0.75	0.75	0.875	0.75
0.5	0.5	0.75	0.75	0.75	0.375
0.75	0.75	1	0.75	0.875	0.5
1	1	0.5	0.5	1	0.25
1	1	0.5	0.75	0.875	0.375
1	1	0.75	1	0.875	0.5
1	1	0.5	0.5	0.875	0.5
0.75	0.75	0.75	0.25	0.875	0.75
1	1	1	1	0.875	0.5
1	1	1	1	0.75	0.75
1	1	0.5	1	0.625	0.75
1	1	0.75	0.5	0.625	0.75
1	0.75	0.75	0.5	0.625	0.5
1	0.75	1	0.75	0.375	0.5
0.75	0.75	1	0.5	0.625	0.75
1	1	0.75	1	0.625	0.875
1	1	1	1	0.875	0.75

Appendix H. Raw data from experiment 3B. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for the object) for each participant in the self-performed/observation condition. Participants self-performed the actions being performed in the study phase and observed the actions in the retrieval practice phase. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. Each item type also had two levels of typicality: typical items (T) and non-typical items (NT).

Appendix I: List of the Object and Actions Used in Experiments 4A, 4B and 4D

Object	Action
Saucepan	Put on Head (M)
Saucepan	Put on Side (M)
Saucepan	Hit (NM)
Saucepan	Lift (NM)
Spoon	Mix (M)
Spoon	Scoop (M)
Spoon	Tap (NM)
Spoon	Wave (NM)
CD	Slide (M)
CD	Spin (M)
CD	Blow (NM)
CD	Bend (NM)
Glove	Wear (M)
Glove	Tuck (M)
Glove	Brush (NM)
Glove	Spread (NM)
Flask	Pour (M)
Flask	Roll (M)
Flask	Fill (NM)
Flask	Knock (NM)
Pen	Write (M)
Pen	Unscrew (M)
Pen	Stir (NM)
Pen	Poke (NM)
Ball	Bounce (M)
Ball	Put Foot on It (M)
Ball	Push (NM)
Ball	Throw (NM)
String	Knot (M)
String	Bow (M)
String	Wind (NM)
String	Wiggle (NM)

Appendix I. The above represents the objects (left hand column in the above table) and actions (right hand column in the above table) used in experiments 4A and 4D. There were eight objects and four actions for each object giving rise to thirty two object-action pairs. The actions were either memorable (M) or non-memorable (NM). For each object there were two memorable actions and two non-memorable actions.

Appendix J: Raw Data for Experiment 4A. The Raw Data Demonstrates the Results for Participants in Each Condition.

Raw Data for Each Participant in the Self-Performed/Self-Performed Condition. The Data Represents Accuracy for Each Item Type.

Rp+		Rp-		Nrp	
M	NM	M	NM	M	NM
1	1	0.75	0.5	1	0.625
1	1	0.75	0.75	1	1
1	1	0.75	0.5	0.875	0.5
1	1	0.75	1	0.875	0.75
0.75	0.75	1	0.75	0.875	0.625
1	1	0.75	0.75	1	0.625
1	1	1	0.75	062.5	1
1	1	1	0.25	0.75	0.625
1	1	1	0.75	0.875	0.75
1	1	0.75	0.5	1	0.625
1	1	0.75	0.75	1	0.75
1	1	1	1	1	1
1	1	0.75	0.5	0.875	875
1	1	1	0.75	0.875	0.25
1	1	1	0.25	1	0.5
1	1	0.5	1	1	0.625
1	1	1	0.25	0.875	0.5
0.1	1	0.75	0.5	10	0.125
1	1	0.5	1	1	0.75
1	1	0.25	1	1	1
1	1	0.75	0.5	1	0.625

Appendix J. Raw data from experiment 4A. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. Each item type also had two levels of memorability: memorable items (M) and non-memorable items (NM). The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for the object) for each participant in the self-performed/self-performed condition. For each object there were two memorable actions and two non-memorable actions. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. Each item type also had two levels of memorability: memorable items (M) and non-memorable items (NM).

Raw Data for Each Participant in the Observation/Observation Condition. The Data Represents Accuracy for Each Item Type.

Rp+		Rp-		Nrp	
M	NM	M	NM	M	NM
0.75	1	0.75	0.5	0.875	0.5
1	1	1	0.75	0.875	0.375
0.75	1	1	0.25	0.75	0.25
0.75	1	1	0.5	0.625	0.875
1	1	1	0.75	0.875	0.75
1	0.75	0.75	1	0.5	0.625
1	0.75	0.25	0.5	0.375	0.625
1	0.75	0.5	1	0.625	0.5
1	1	1	0.5	0.875	0.625
1	1	0.75	1	0.875	0.5
1	0.75	1	0.5	0.875	0.5
1	1	0.75	0.5	0.625	0.75
1	0.75	0.75	0.75	0.75	0.25
1	1	1	0.25	0.875	0.75
1	1	0.75	0.5	0.25	0.5
1	0.75	1	0.5	0.5	0.25
1	0.75	0.75	0.25	0.875	0.625
1	1	0.75	0.5	0.875	0.5
1	1	1	0.75	0.875	0.625
1	1	0.75	0.5	0.75	0.25
1	0.75	0.25	0.5	0.75	0.25
1	1	1	1	1	1

Appendix J. Raw data from experiment 4A. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for each object) for each participant in the observation/observation condition. Participants observed the actions being performed in the study phase and in the retrieval practice phase. For each object there were two memorable actions and two non-memorable actions. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. Each item type also had two levels of memorability: memorable items (M) and non-memorable items (NM).

Raw Data for Each Participant in the Self-Performed/Observation Condition. The Data Represents Accuracy for Each Item Type.

Rp+		Rp-		Nrp	
M	NM	M	NM	M	NM
1	1	1	0.25	1	0.75
1	0.75	0.5	0.5	0.875	0.5
1	1	1	0.75	1	0.5
1	0.75	1	1	1	0.75
1	1	0.75	1	0.875	0.625
1	0.75	0.75	1	0.875	0.75
1	0.75	0.75	0.25	0.75	0.375
1	1	0.75	0.5	1	0.75
1	1	0.75	0.5	1	0.375
1	1	1	1	0.875	0.5
1	0.5	1	0.5	1	0.5
1	1	1	0.5	1	0.25
1	1	1	0.75	1	0.875
1	0.75	0.75	1	1	0.75
1	1	1	1	1	1
1	0.25	1	0.75	1	0.625
1	1	1	1	1	1
1	1	1	0.75	1	0.875
1	0.75	0.5	0.25	0.875	0.75
1	1	1	0.75	1	0.875
1	1	1	1	1	1
1	1	1	1	1	1

Appendix J. Raw data from experiment 4A. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for the object) for each participant in the self-performed/observed condition. Participants self-performed the actions being performed in the study phase and observed the actions being performed in the retrieval practice phase. For each object there were two memorable actions and two non-memorable actions. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. Each item type also had two levels of memorability: memorable items (M) and non-memorable (NM).

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Raw Data for Each Participant in the Observation/Self-Performed Condition. The Data Represents Accuracy for Each Item Type.

Rp+		Rp-		Nrp	
M	NM	M	NM	M	NM
1	1	0.25	0	0.5	0
1	1	0.75	0.75	1	1
0.75	0.75	0.5	0.5	0.875	0.625
1	1	0.25	0.75	0.625	0.75
1	1	0.75	0.25	1	0.875
1	1	0.25	0.75	0.75	0.5
1	1	0.5	0.75	0.625	0.875
1	1	0.25	0.75	0.875	0.25
1	1	0.25	0.25	0.625	0.5
1	1	1	1	0.5	0.25
1	1	1	1	1	0.75
1	1	0.75	1	0.875	0.625
1	1	0.75	1	0.75	0.75
1	1	0.5	0.5	0.625	0.375
0.75	0.75	1	0.5	0.875	0.5
0.75	0.75	1	0.5	0.75	0.5
1	1	0.75	0.75	0.875	0.625
1	1	0.25	0.25	0.5	0.5
1	1	1	0.25	1	0.875
1	0.75	0.5	0.25	0.75	0.625
1	0.75	0.25	0.5	0.875	0.375
1	0.75	0.25	0.5	0.875	0.375

Appendix J. Raw data from experiment 4A. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for each object) for each participant in the observation/self-performed condition. Participants observed the actions being performed in the study phase and self-performed the actions in the retrieval practice phase. For each object there were two memorable actions and two non-memorable actions. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. Each item type also had two levels of memorability: memorable items (M) and non-memorable items (NM).

Appendix K: Raw Data (Experiment 4B) for Each Participant in the Self-Performed/Observation Condition.

Rp+		Rp-		Nrp	
M	NM	M	NM	M	NM
1	1	1	1	0.625	0.25
1	1	0.5	0.75	0.5	0.25
1	1	1	0.5	0.875	0.75
1	1	1	0.75	0.875	0.625
1	0.75	1	0.75	0.875	0.75
1	1	1	0.5	0.875	0.75
1	1	1	0.75	1	1
1	0.75	1	0.25	0.75	0.625
1	1	1	0.25	0.75	0.75
1	0.75	1	0.5	0.5	0.5
0.75	0.75	0.75	1	1	0.75
1	1	1	0.25	1	0.75
1	1	1	0.5	1	0.5
1	0.75	0.5	0.75	1	0.75
1	1	1	0.75	1	0.5
1	1	1	1	0.875	0.25
1	1	1	0.5	0.875	0.625
1	1	1	0.5	0.75	0.75
1	1	0.75	0.75	0.5	0.625
1	1	0.75	0.75	0.75	0.75
1	1	0.5	0.75	0.75	0.5

Appendix K. Raw data from experiment 4B. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for the object) for each participant in the self-performed/observation condition. Participants self-performed the actions being performed in the study phase and observed the actions in the retrieval practice phase. The study phase took place in session one and the retrieval practice and test phases took place twenty fours later in session two. For each object there were two memorable actions and two non-memorable actions. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. Each item type also had two levels of typicality: memorable items (M) and non-memorable items (NM).

Appendix L: List of Objects, Actions and Alternative Actions Used in Experiment 4C.

Object	Action	Alternative Object
Saucepan	Put On Its Head (M)	Wok
Saucepan	Put On Its Side (M)	Wok
Saucepan	Hit (NM)	Wok
Saucepan	Lift (NM)	Wok
Spoon	Mix (M)	Trowel
Spoon	Scoop (M)	Trowel
Spoon	Tap (NM)	Trowel
Spoon	Wave (NM)	Trowel
CD	Slide (M)	Record
CD	Spin (M)	Record
CD	Blow (NM)	Record
CD	Bend (NM)	Record
Glove	Wear (M)	Washing-Up Glove
Glove	Tuck Fingers In (M)	Washing-Up Glove
Glove	Brush (NM)	Washing-Up Glove
Glove	Spread Fingers (NM)	Washing-Up Glove
Flask	Pour (M)	Bottle
Flask	Roll (M)	Bottle
Flask	Fill (NM)	Bottle
Flask	Knock (NM)	Bottle
Pen	Unscrew at Middle (M)	Tyre Pressure Gauge
Pen	Write (M)	Tyre Pressure Gauge
Pen	Stir (NM)	Tyre Pressure Gauge
Pen	Poke (NM)	Tyre Pressure Gauge
Ball	Bounce (M)	Disco Ball
Ball	Put Foot On It (M)	Disco Ball
Ball	Push (NM)	Disco Ball
Ball	Throw (NM)	Disco Ball

String	Knot (M)	Wire
String	Bow (M)	Wire
String	Wind (NM)	Wire
String	Wiggle (NM)	Wire

Appendix L. The table above shows the objects and actions used in experiment 4C. There were eight original actions and four actions for each object giving rise to thirty two object-action pairs. There were also eight alternative objects which were used as independent cues during the test phase. Actions were also either memorable (M) or non-memorable (NM). For each object there were two memorable actions and two non-memorable actions.

Appendix M: Raw Data for Experiment 4C. The Raw Data Demonstrates the Results for Participants in Each Condition.

Raw Data for Each Participant in the Self-Performed/Self-Performed Condition. The Data Represents Accuracy for Each Item Type.

Rp+		Rp-		Nrp	
M	NM	M	NM	M	NM
1	0.75	0.25	0.5	0.75	0.25
1	0.5	0.75	0.5	0.75	0.5
1	1	1	1	0.875	0.75
1	0.5	0.25	0.75	0.5	0.5
0.5	1	0.5	0.5	0.625	0.375
1	1	0.5	0.25	0.75	0.75
1	1	1	0.75	1	0.5
1	1	0.75	0.5	0.875	0.625
1	1	0.5	0.5	1	0.625
1	1	0.75	0.5	1	0.75
1	1	0.5	0.75	1	0.25
1	1	0.75	0.75	1	0.625
1	1	0.75	0.5	1	0.75
1	1	0.75	0.5	0.875	0.75
1	1	1	0.75	0.875	0.75
1	1	0.75	0.5	1	0.75
1	1	0.75	0.75	0.875	0.75
1	1	0.75	0.5	1	0.5
1	1	1	1	0.75	0.625
1	1	0.75	0.5	1	0.75
1	1	0.5	1	0.5	0.625

Appendix M. Raw data from experiment 4C. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for the object) for each participant in the self-performed/self-performed condition. Participants self-performed the actions in the study phase and in the retrieval practice phase. For each object there were two memorable (M) actions and two non-memorable (NM) actions. There were three item types of interest: Rp+ items, Rp- items, and Nrp items.

Raw Data for Each Participant in the Observation/Observation Condition. The Data Represents Accuracy for Each Item Type.

Rp+		Rp-		Nrp	
M	NM	M	NM	M	NM
0.5	1	0.75	0	0.5	0.375
1	1	0.5	0.75	1	0.75
0.75	0.75	0.75	0	0.625	0.25
1	1	0.75	0.5	0.875	0.375
0.75	0.5	0.5	0.25	0.25	0.375
1	1	0	0.25	0.5	0.625
1	1	0.25	0.5	0.75	0.375
1	1	1	0.75	0.875	0.75
1	1	1	1	0.625	0.75
1	0.75	0.75	1	0.625	0.25
0.75	1	1	0.75	0.75	0.5
1	1	1	1	0.5	0.375
0.75	1	0.8	0.75	1	0.875
1	0.75	0.5	0.5	0.5	0.5
1	1	1	0.75	0.75	0.75
1	0.75	0.25	0.5	0.625	0.25
1	1	0.75	0.5	0.875	0.625
1	0.75	1	0.25	0.875	0.5
0.75	0.75	0.75	0.75	0.625	0.5
1	1	1	0.75	0.875	0.75
1	1	0.75	0.75	0.75	0.5

Appendix M. Raw data from experiment 4C. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. Each item type also had two levels of memorability: memorable items (M) and non-memorable items (NM). The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for the object) for each participant in the observation/observation condition.

Raw Data for Each Participant in the Self-Performed/Observation Condition. The Data Represents Accuracy for Each Item Type.

Rp+		Rp-		Nrp	
M	NM	M	NM	M	NM
1	1	1	0.75	1	0.5
1	1	0.75	0.5	0.875	0.875
1	1	0.5	0.25	0.625	0.25
1	0.75	1	0.75	1	0.5
1	1	1	0.5	0.75	0.375
1	1	0.75	0.75	0.75	1
1	0.75	1	0.75	1	0.625
1	1	0.75	0.75	0.875	0.25
0.75	1	0.75	0.25	0.875	0.625
1	1	1	0.75	0.5	0.875
1	0.75	0.75	0.5	0.625	0.75
1	1	0.75	0.75	0.875	0.875
1	1	1	0.75	0.875	0.5
1	0.5	0.5	0.5	1	0.375
1	1	0.75	0.75	0.75	0.75
1	0.75	1	0.75	0.625	0.375
1	1	1	1	1	1
1	1	1	0.75	0.625	0.5
0.75	1	0.75	0.75	1	0.25
0.75	1	0.75	1	1	0.5

Appendix M. Raw data from experiment 4C. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for the object) for participants in the self-performed/observation condition. Participants self-performed the actions in the study phase and observed the actions being performed in the retrieval practice phase. There were three item types of interest: Rp+ items, Rp-items, and Nrp items. Each item type also had two levels of memorability: memorable items (M) and non-memorable items (NM). For each object there were two memorable actions and two non-memorable actions.

Raw Data for Each Participant in the Observation/Self-Performed Condition. The Data Represents Accuracy for Each Item Type.

Rp+		Rp-		Nrp	
M	NM	M	NM	M	NM
1	1	0.5	0.25	0.75	0.5
1	1	1	0.5	1	0.375
0.75	1	0.75	0.75	0.75	0.5
1	1	1	0.75	0.75	0.5
1	1	0.25	0.5	0.875	0.5
0.75	1	0.75	0.25	0.75	0.625
1	1	0.5	0.75	0.75	0.75
1	1	0.75	0.25	0.625	0.375
1	1	0.25	0.5	1	0.5
1	1	1	1	0.875	0.875
1	1	1	0.5	0.625	0.625
1	1	0.5	0.25	0.875	0.5
0.75	0.5	0.5	1	0.875	0.625
1	0.5	1	1	1	0.625
1	1	0.25	0.75	0.75	0.75
0.75	1	1	0.5	1	0.5
0.75	0.75	0.75	0.5	0.625	0.625
1	0.5	0.75	1	0.875	0.75
1	1	0.5	0.75	0.875	1
1	1	0.5	0.25	0.75	0.375
0.75	0.75	0.75	0.75	1	0.5

Appendix M. Raw data from experiment 4C. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for the object) for each participant in the observation/self-performed condition. Participants observed the actions being performed in the study phase and self-performed the actions in the retrieval practice phase. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. Each item type also had two levels of memorability: memorable items (M) and non-memorable items (NM). For each object there were two memorable actions and two non-memorable actions.

Appendix N: Raw Data for Experiment 4D. The Raw Data Demonstrates Participants Accuracy for Each Condition.

Raw Data for Each Participant in the Self-Performed/Self-Performed Condition. The Data Represents Accuracy for Each Item Type.

Rp+		Rp-		Nrp	
M	NM	M	NM	M	NM
0.75	0.75	0.75	0.5	0.875	0.5
1	1	1	1	1	1
0.75	1	0.75	1	1	1
1	1	1	0.75	0.875	0.375
1	1	1	0.25	0.75	0.875
1	1	0.75	0.25	0.875	0.75
1	1	0.5	1	0.875	0.75
1	1	1	0.75	0.875	0.25
1	0.75	0.25	1	1	0.375
1	1	0.75	0.5	0.875	0.875
1	1	1	0.75	1	0.375
1	1	0.75	1	0.875	0.375
1	1	1	0.75	1	0.625
1	1	1	1	0.875	0.75
1	0.75	0.75	1	0.875	0.75
1	1	1	1	0.875	0.625
1	0.75	1	0.5	1	0.75
1	0.75	0.75	0.75	1	0.875
1	1	0.5	1	1	1
1	1	0.25	0.5	0.875	0.625

Appendix N. Raw data from experiment 4D. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for the object) for each participant in the self-performed/self-performed condition. Participants self-performed the actions in the study phase and in the retrieval practice phase. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. Each item type also had two levels of memorability: memorable items (M) and non-memorable items (NM). For each object there were two memorable actions and two non-memorable actions.

Raw Data for Each Participant in the Observation/Observation Condition. The Data Represents Accuracy for Each Item Type.

Rp+		Rp-		Nrp	
M	NM	M	NM	M	NM
1	1	1	0.75	1	0.5
1	1	1	0.75	1	0.875
1	1	1	0.75	1	0.625
0.5	0.75	1	0.75	0.625	0.75
1	0.75	1	1	0.875	0.875
1	1	1	1	1	1
1	1	0.75	0.5	0.75	0.75
0.75	0.75	1	0.75	0.625	0.625
1	1	1	0.5	0.75	1
1	0.5	1	0.5	0.625	0.625
1	0.25	0.75	0.75	0.75	0.5
1	1	0.75	1	0.875	0.625
0.75	0.75	0.75	0.5	0.75	0.75
1	0.75	1	0.75	0.75	0.75
1	1	1	1	0.875	0.5
1	0.75	0.75	0.75	0.625	0.625
1	0.75	0.25	0.5	1	0.75
0.75	0.75	1	1	0.75	0.625
0.75	0.75	0.75	0.5	0.625	0.375
1	1	1	1	1	1

Appendix N. Raw data from experiment 4D. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for the object) for each participant in the observation/observation condition. Participants observed the actions being performed in the study phase and in the retrieval practice phase. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. Each item type also had two levels of memorability: memorable items (M) and non-memorable items (NM). For each object there were two memorable actions and two non-memorable actions.

Raw Data for Each Participant in the Self-Performed/Observation Condition. The Data Represents Accuracy for Each Item Type.

Rp+		Rp-		Nrp	
M	NM	M	NM	M	NM
1	1	1	1	1	0.5
1	1	0.75	0.5	1	0.5
1	1	0.75	1	0.875	0.75
1	1	0.75	0.25	0.75	0.875
1	1	0.75	0.5	1	0.625
1	1	1	1	1	1
1	1	1	1	1	1
1	0.75	1	1	0.875	0.75
0.75	0.25	0	0.75	0.5	0.625
0.75	1	1	1	1	1
1	1	0.5	1	1	0.75
1	1	0.75	0.5	0.875	0.375
1	1	0.75	0.75	0.875	0.875
1	0.75	1	1	0.875	0.625
1	0.75	0.75	0.25	0.875	0.875
0.75	1	0.75	0.75	0.875	0.5
1	0.75	1	0.25	0.875	0.625
1	1	1	1	1	1
1	1	1	0.75	1	0.5
1	1	0.5	0.75	0.5	0.75

Appendix N. Raw data from experiment 4D. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for the object) for each participant in the self-performed/observation condition. Participants self-performed the actions in the study phase and observed the actions being performed in the retrieval practice phase. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. Each item type also had two levels of memorability: memorable items (M) and non-memorable items (NM). For each object there were two memorable actions and two non-memorable actions.

Raw Data for Each Participant in the Self-Performed/Observation Condition. The Data Represents Accuracy for Each Item Type.

Rp+		Rp-		Nrp	
M	NM	M	NM	M	NM
1	1	0.75	1	1	1
1	0.75	1	1	1	0.375
1	1	0.5	0.5	1	0.875
1	1	1	0.75	1	0.875
1	1	0.75	0.5	1	1
1	1	0.5	1	1	0.625
1	1	0.5	0.75	0.625	0.75
1	0.75	0.25	0.75	0.375	0.875
0.75	1	0.5	0.75	0.5	0.625
0.75	1	0.75	0.5	1	0.5
1	1	1	1	1	0.25
0.75	0.25	1	0.75	1	1
1	0.5	0.5	0.75	0.875	0.75
1	0.75	0.75	1	0.75	0.625
1	0.75	0.75	0	1	1
1	1	1	0.75	0.625	0.75
1	0.75	1	0.5	1	0.625
1	1	0.25	0.25	0.5	0.25
1	1	1	0.75	1	0.375
1	1	1	0.75	0.875	0.5

Appendix N. Raw data from experiment 4D. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for the object) for each participant in the observation/self-performed condition. Participants observed the actions being performed in the study phase and self-performed the actions in the retrieval practice phase. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. Each item type also had two levels of memorability: memorable items (M) and non-memorable items (NM). For each object there were two memorable actions and two non-memorable actions.

Appendix O: Raw Data (Experiment 4E) for Each Participant in the Self-Performed/Observation Condition.

Rp+		Rp-		Nrp	
M	NM	M	NM	M	NM
1	1	1	0.75	0.875	0.875
1	1	1	0.75	0.875	0.875
1	1	1	1	0.875	0.625
1	1	1	1	0.75	0.625
1	1	1	0.75	0.875	0.75
1	1	0.75	1	0.75	0.75
1	0.75	0.75	0.25	0.625	0.625
1	1	0.75	0.75	0.875	0.75
1	1	1	0.75	0.75	0.5
1	0.75	1	0.25	0.625	0.375
0.75	1	0.75	0.5	0.875	0.375
1	0.75	0.75	1	1	0.625
1	1	1	0.5	1	1
0.75	0.75	0.75	0.25	0.875	0.5
0.75	0.75	0.75	0.75	0.875	0.875
1	0.5	0.75	1	0.5	0.125
1	1	1	1	0.875	0.5
1	1	1	0.5	1	0.75
1	1	0.5	0.75	0.875	0.75
1	0.5	0.75	0.75	1	0.375

Appendix O. Raw data from experiment 4E. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for the object) for each participant in the observation/self-performed condition. Participants self-performed the actions being performed in the study phase and observed the actions in the retrieval practice phase. The retrieval practice and test phases took place 24 hours after the study phase. There were three item types of interest: Rp+ items, Rp-items, and Nrp items. Each item type also had two levels of memorability: memorable items (M) and non-memorable items (NM). For each object there were two memorable actions and two non-memorable actions.

Appendix P: List of Items Used in Experiments 5A, 5B, and 5C

Object
Map
Torch
Knife
Screwdriver
Plasters
Aspirin
Vitamins
Allergy
Tablets
Box
Plastic Bag
Glasses
Case
Bottle
Hat
Wallet
Belt
Gloves
Book
Post-It
Pen
Ruler

Appendix P. The above table shows the objects used in experiments 5A, 5B, and 5C.

Appendix Q: Raw Data for Experiment 5A. The Raw Data Represents Participants Accuracy for Each Condition.

Raw Data for Participants in the Self-Performed Condition. The Data Represents Accuracy for Each Item Type.

Rp+	Rp-	Nrp
1	1	0.8
1	0.7	1
1	1	0.95
1	0.9	0.9
1	1	0.65
1	1	1
1	1	0.9
0.9	0.9	0.8
1	0.8	0.95
1	0.9	0.95
1	1	1
1	0.9	0.95
0.9	1	0.95
1	1	0.85
1	1	1
1	0.9	0.9
1	1	0.95
1	1	0.95
1	1	1
1	0.8	0.95

Appendix Q. Raw data from experiment 5A. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. The above data represents accuracy of the participants response (i.e. whether the participant correctly recalled the action for the object) for participants in the self-performed condition. Participants self-performed the actions being performed in the study phase and in the retrieval practice phase.

Raw Data for Participants in the Observation Condition. The Data Represents Accuracy for Each Item Type.

Rp+	Rp-	Nrp
1	0.8	1
1	1	0.85
1	0.9	1
1	1	0.9
1	1	0.85
1	1	0.95
1	1	1
1	0.9	0.75
1	1	0.9
1	1	0.9
1	1	1
1	0.9	0.85
1	1	0.85
1	1	0.9
0.9	0.8	1
1	1	1
1	1	0.95
1	0.8	0.95
0.9	0.9	1
1	1	0.9

Appendix Q. Raw data from experiment 5A. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. The above data represents accuracy of the participants response (i.e. whether participants correctly recalled the action for the object) for participants in the observation condition. Participants observed the actions being performed in the study phase and in the retrieval practice phase.

Appendix R: Raw Data for Experiment 5B. The Raw Data Demonstrates Recall Accuracy for Participants in Each Condition.

Raw Data for Each Participant in the Self-Performed Condition. The Data Represents Accuracy for Each Item Type.

Rp+	Rp-	Nrp
1	0.5	0.6
1	0.8	0.7
1	0.8	0.85
1	0.8	0.5
0.9	0.6	0.75
1	0.6	0.7
1	0.9	0.6
1	0.7	0.75
1	0.7	1
1	0.8	0.75
1	0.6	0.75
1	0.5	0.65
1	0.9	0.9
0.8	0.7	0.7
1	1	0.6
1	0.8	0.35
1	0.5	0.75
1	0.9	0.7
1	0.8	0.55
1	0.7	0.8

Appendix R. Raw data from experiment 5B. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. The above data represents accuracy of the participants response (i.e. whether participants correctly recalled the action for the object) for participants in the self-performed condition. Participants self-performed the actions being performed in the study phase and in the retrieval practice phase.

Raw Data for Each Participant in the Observation Condition. The Data Represents Accuracy for Each Item Type.

Rp+	Rp-	Nrp
1	0.5	0.7
1	0.6	0.85
1	0.5	0.7
1	0.8	0.8
0.9	0.5	0.55
1	0.7	0.65
1	0.6	0.6
1	0.9	0.7
1	0.8	0.45
1	0.7	0.8
1	0.5	0.65
1	1	0.9
0.9	0.8	0.75
0.9	0.8	0.6
0.8	0.6	0.55
1	0.7	0.65
1	0.7	0.7
1	0.4	0.6
1	1	0.9
1	0.9	0.5

Appendix R. Raw data from experiment 5B. There were three item types of interest: Rp+ items, Rp- items, and Nrp items. The above data represents accuracy of the participants response (i.e. whether the participants correctly recalled the action for the object) for participants in the observation condition. Participants observed the actions being performed in the study phase and in the retrieval practice phase.

Appendix S: Raw Data for Participants in Experiment 5C.

Rp+	Rp-	Nrp
0.8	0.4	0.7
0.9	0.6	0.75
0.8	0.5	0.75
1	0.4	0.65
1	0.4	0.7
0.9	0.8	0.75
0.6	0.4	0.6
0.9	0.6	0.45
0.7	0.5	0.65
0.9	0.5	0.65
1	0.6	0.7
1	0.4	0.8
0.9	0.7	0.75
1	0.6	0.75
0.9	0.5	0.5
0.9	0.6	0.8
0.9	0.6	0.4
1	0.5	0.5
1	0.3	0.5
1	0.6	0.65

Appendix S. Raw data from experiment 5C. There were three item types of interest: Rp+ items, Rp- items, and Nrp items.

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