Emergent slot machine gambling: A relational frame theory approach.

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Emergent slot machine gambling: A relational frame theory approach

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Abstract

It has been suggested that gambling behaviour may not be solely controlled by schedules of reinforcement, but may be under the control of verbal behaviour. Relational frame theory is a contemporary account of verbal behaviour which may be able to account for aspects of gambling behaviour that cannot be explained by a pure schedule of reinforcement account. Chapter 2 demonstrated that contextual cues may influence preferences for concurrently available slot-machines, thus overriding the contingencies of reinforcement in place. Chapter 3 demonstrated that the presence of accurate or inaccurate rules may influence slot-machine choice and affect gambling persistence. Participants that received inaccurate rules regarding the payout probability of a slot machine, gambled for longer than those given accurate rules. Chapter 4 reported that the discriminative functions of slot-machines could be transformed in accordance with derived same and opposite relations, such that participants showed preferences for slot-machines that had never been experienced before. Chapter 5 demonstrated that not only could preferences for concurrently available slot machines be transformed in accordance with derived comparative relations, but found that preferences for slot machines increased relative to the relational network that had been trained. In Chapter 6, ratings of wins, near-misses and losses on a computer simulated slot-machine could be altered in accordance with derived same and opposite relations, and could even override the non-arbitrary properties of a slot-machine. It was concluded that gambling is verbal behaviour and can be accounted for by derived relations and the transformation of function. These findings may explain instances of gambling behaviour which cannot be accounted for by the direct acting contingencies.

Declaration and Statements

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Conference Presentations

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List of Abbreviations

DRL: Differential reinforcement of low rate behaviour (schedule of reinforcement)

fMRI: Functional Magnetic Resonance Imaging

FR: Fixed ratio schedule of reinforcement

RFT: Relational frame theory

RR: Random ratio schedule of reinforcement

SOGS: South Oaks Gambling Screen

VR: Variable ratio schedule of reinforcement

Chapter 1

Gambling, Gambling Research, and Behaviour Analysis

Gambling has been defined as "playing a game of chance for money" or "risking much in the hope of great gain" (Oxford Dictionary, 2000, p.358). It is an activity that has been part of society for thousands of years with the first lottery offering monetary prizes apparently taking place in Florence in 1530 (Brenner & Brenner, 1990; Everitt, 2009). Queen Elizabeth I established a lottery in 1569 as a means of raising money. Prizes included money, goods and even seven days free from arrest, unless a serious crime was committed (Brenner & Brenner, 1990).

Until the twentieth century, those who gambled were considered criminals or sinners. These perceptions did not change until Gamblers Anonymous was founded, which resulted in increased interest in psychoanalytic explanations of gambling behaviour (Lesieur & Custer, 1984). This led to gambling being seen as an 'illness' to be treated, as opposed to criminality and resulted in social acceptance of gambling as an acceptable leisure activity (Lesieur & Custer, 1984). Today, gambling remains a popular social pastime with a wide range of gambling games available such as card games, gaming machines and sports betting.

For the majority of the population, gambling is a form of recreation to be enjoyed responsibly, but for a minority it can develop into a problem leading to debt, jeopardised relationships, and even suicide. This poses the challenging question: why can some individuals gamble regularly without developing a problem, whereas others will go on to suffer severe hardship as the result of a gambling problem. For clinicians, this also means that they must be able to distinguish between the recreational and the problem or pathological gambler. Several instruments have been developed to identify such individuals, with two of the most commonly used being the Diagnostic and Statistical Manual and the *South Oaks Gambling Screen* (SOGS; Lesieur & Blume, 1987).

Measures of problem and pathological gambling

The release of the DSM-V (Diagnostic and Statistical Manual, Fifth Edition) is expected to bring about changes to the way in which pathological gambling is classified (Mitzner, Whelan, & Meyers, 2011). Previously, in the DSM-IV, pathological gambling was considered an impulse control disorder. The DSM-V however is expected to class it in the Addiction and Related Disorders section. Additionally, only four items from the diagnostic criterion are required to meet classification for pathological gambling according to DSM-V, whereas the DSM-IV required five. According to the DSM-IV, pathological gambling can be defined by "persistent and recurrent maladaptive gambling behavior that disrupts personal, family, or vocational pursuits." (DSM IV-TR, p. 615). In order to be diagnosed with pathological gambling, an individual must display a minimum of four out of ten diagnostic items (see Table 1.1)

Table 1.1. Criteria for a diagnosis of pathological gambling as measured by the DSM-V.

Criteria* for Pathological Gambling from the DSM-V
1) Preoccupied with gambling.
2) Gambles with increasingly larger amounts of money.
3) Repeated unsuccessful efforts to reduce or cease gambling.
4) Restless or irritable when trying to decrease gambling.
5) Gambles to escape problems or relieve negative mood.
6) Attempts to win back lost money.
7) Lies to others to conceal extent of gambling.
8) Risks losing or loses important relationships or jobs due to gambling.
9) Relies on others to relieve financial problems caused by gambling.

Note: *Criteria have been paraphrased for the purposes of the present literature review.

One measure that has been used frequently in gambling research is the SOGS (Lesieur & Blume, 1987). The SOGS is a widely used 16-item inventory for identifying potential problem and potential pathological gambling. The SOGS is a gambling screen, therefore not strictly a diagnostic tool, however it can be used in research as a means of assessing a participant's gambling history, as well as indicating potential gambling problems (Petry, 2005). Items on the SOGS include questions involving deception when gambling, such as claiming to be winning when in fact they were losing money, hiding betting slips, and borrowing money. A score of 3-4 indicates that there is the potential for problem gambling whereas a score of 5 and above indicates potential pathological gambling. According to Lesieur and Blume (1987) the instrument has good reliability and validity in clinical samples.

Stinchfield (2002) found that the SOGS could correctly distinguish between a general population sample and a gambling sample which consisted of individuals receiving treatment for gambling problems. However, it overestimates gambling severity in the general population by producing a 50% false positive rate (Stinchfield, 2002). It must be emphasised, however, that the SOGS was specifically developed as a diagnostic tool for problem gamblers within a clinical setting and not for use with the general public (Stinchfield, 2002).

Whilst most assessment tools measure the extent to which an individual may have a problem with the gambling, the Gambling Functional Assessment (GFA), developed by Dixon and Johnson (2007), identifies the *functions* that may be maintaining a gambler's behaviour, therefore ascertains the extent to which the consequences of gambling may be sustaining behaviour. The GFA is a 20 item instrument which identifies the extent to which four key functions of behaviour may be maintaining gambling behaviour. These functions consist of; a sensory function (for example, lights, sounds of the machine), an escape function (avoiding a stressful home life), a tangible function (to win money), or an attention function (attention or social reinforcement from peers, spouse). For example, an individual that visits the casino because he enjoys meeting friends may score highly on the measures that assess an attention function (Dixon & Johnson, 2007). Miller, Meier, and Weatherly (2009) reported that the GFA had good internal consistency and acceptable reliability. However, one limitation of this study was that participants were undergraduate students and not a clinical population.

Prevalence of problem and pathological gambling

For many, gambling is a social activity and a form of entertainment. Others may see gambling as a chance to win money for little effort (Wagenaar, 1988). For the vast majority of the population, gambling is a relatively harmless pursuit although international estimates of recreational gambling and problem gambling differ. China reports high levels of pathological gambling with 2.5% to 4% of the population falling within this category (Loo, Raylu, & Oei, 2008). European estimates suggest that Norway has few problem and pathological gamblers. A phone survey of 2014 respondents revealed that 0.45% and 0.15% of the Norwegian population surveyed met the diagnosis for problem and pathological gambling, respectively (Gotestam & Johnson, 2003). Switzerland shows a higher incidence of problem gambling with estimates of 2.2% (Bondolfi et al., 2000) whereas pathological gambling is approximated at 0.8%.

Reports indicate that a large population in the UK partake in recreational gambling with an estimated 73% of the population gambling in 2010 (Wardle et al., 2010). This figure includes those who play the National Lottery. When the National Lottery is excluded, this figure drops to 56%. The next most common forms of gambling consist of other lotteries (25%), followed by scratch cards (24%), betting on horse races (16%), slot-machine gambling (13%), and finally private betting (11%). Seventy-five per cent of men gambled in 2010 compared to 71% of women, with those aged between 44 and 64 being most likely to gamble.

Although over two thirds of the UK population gamble annually, the prevalence of problem gambling according to DSM-IV is thought to be approximately 0.9%. This figure suggests that problem gambling has risen by 0.3% since 2007 (Wardle et al., 2010). Measures of 'at risk' gambling estimate that 5.5% of the UK population are at low risk, whereas 1.8% are at moderate risk of developing a problem with gambling (Wardle et al., 2010).

Research on Gambling:
Biomedical, Neuroscience, Social, and Cognitive Approaches

Various explanations have been offered regarding the factors that may cause and maintain problem gambling. With such a large proportion of the population participating in recreational gambling yet only a minority presenting with a problem, the difficult task for researchers is to account for why some seem to develop a problem whereas others do not. The present literature review will firstly consider how various approaches within psychology have sought to explain and undertake research on gambling behaviour. Then, the development of the gambling literature within behaviour analysis, from initial research on schedules of reinforcement to current theories of verbal behaviour and its integral role in explanations of gambling behaviour, will be outlined.

Biomedical. The biomedical approach assumes that there is an "organic condition that exists within the body that contributes to the onset and continuation of pathological gambling" (Porter & Ghezzi, 2006, p. 24). Serotonergic dysfunction has been implicated as a factor in the development of pathological gambling (De Caria et al., 1996) and numerous studies have found that selective serotonin reuptake inhibitors (SSRIs) such as fluvoxamine and clomipramine are able to reduce gambling severity in pathological gamblers (Hollander et al., 1998, 2000). The neurotransmitter dopamine has been suggested as a factor in many reward-seeking behaviours including gambling behaviour. Bergh, Eklund, Södersten, and Nordin (1997) revealed that the pathological gamblers had significantly smaller concentration of dopamine in the cerebrospinal fluid (CSF) and an increased level of noradrenalin compared to non-gambling controls. Nordin and Sjödin (2006) found that pathological gamblers showed decreased levels of dopamine in the CSF compared to healthy control whereas levels of noradrenalin were equal in the gambling sample and the control sample. The somewhat contradictory findings of Bergh et al. (1997) and Nordin and Sjödin (2006) suggest that there is still much work to be done in order to understand the role of neurotransmitters in gambling behaviour.

With regard to a genetic cause for problem gambling, Walters (2001) conducted a meta-analysis of the behaviour-genetic literature involving family and twin studies and estimated that heritability could account for approximately 16% of problem gambling. However, family studies are likely confounded by the fact that all participants generally share the same environment therefore it is difficult to discern between environmental influences and the genetic influences (Walters, 2001). Monozygotic twin studies are a possible solution to the difficulties in researching phenomena that have both an environmental and genetic influence. Eisen et al. (2001) studied 3356 male twins with regard to gambling behaviour and concluded that genetic factors accounted for 62% of the variance in symptoms of gambling.

Genetic explanations have been criticised, as they cannot account for all problem gamblers. Comings et al. (1996) suggested that approximately 40-60% of pathological gamblers possessed the D2A1 allele. If as many as 60% of gamblers posses the D2A1 allele, this means that the remaining 40% of gamblers do not posses such an allele, therefore their gambling cannot be accounted for by this particular gene.

Neuroscience. Research that examines the differences in brain activation between pathological gamblers and non-problem gamblers is steadily increasing (Potenza, 2008). Potenza et al. (2003) reported functional magnetic resonance imaging (fMRI) data, in which changes in blood flow in the brain and spinal cords are measured, and found that pathological gamblers showed decreased activity in the frontal and orbitofrontal cortex, basal ganglia and thalamus compared to the recreational gamblers, when viewing a video of a gambling scene (Potenza et al., 2003). These areas of the brain are thought to be involved in impulse regulation (Potenza et al., 2003). Reuter et al. (2005) reported that pathological gamblers showed significantly lower right ventral striatal activation than non-gambling controls, and a negative correlation was reported between gambling severity and activation. This lower activation is also observed in individuals who are substance dependent (Reuter et al., 2005).

Recent fMRI studies have tended to focus on the neural underpinnings of the near-miss. A near-miss occurs when two out of three matching symbols appear on the payout line of a slot-machine. Clark, Lawrence, Astley-Jones, and Gray (2009) undertook fMRI with non-gambling participants whilst they played a simplified computer simulated slot-machine. Participants were asked to rate their chances of winning following every trial. It was found that near-misses were associated with increased blood oxygen level demand (BOLD) signal in the ventral striatum and the anterior insula which were also the areas that were associated with winning trials (Clark et al., 2009). Near-misses were also rated as being more unpleasant than a full miss, although a near-miss lead to greater motivation to continue to play. These self-report ratings correlated with insula activity (Clark et al., 2009). Chase and Clark (2010) replicated the experiment with regular gamblers and pathological gamblers. In support of their previous experiment, near-misses were associated with increased ventral striatal activity. It was also found that gambling severity was an accurate predictor of increased dopaminergic activity in the midbrain when presented with a near-miss. These findings provided much insight into the neural underpinnings of the phenomenon of the near-miss. Given that a near-miss elicits similar activity to that of a win, this demonstrates how powerful a near-miss may be for persistence in gambling (Chase & Clark, 2010).

Neuroscientific approaches to gambling behaviour are a welcome and valuable contribution to the literature and have demonstrated that differences are seen in brain activation of gamblers in comparison to non-gamblers; however, such an account is limited. First, it is not able to explain how or why certain individuals may develop a problem with gambling whereas other do not, and secondly, as fMRI is a measure of behaviour it may only measure differences in brain activation therefore does not necessarily add to our understanding of the causes of gambling behaviour.

Socio-cultural research. There is evidence that individual differences may exist across cultures which suggests that gambling may be socially reinforced. Ellenbogen, Gupta, and Derevensky (2006) reported higher incidences in problem gambling in adolescents who did not have English or French as their first language, and suggested that this may be due to differences in parental attitudes. Zitzow (1996) reported that 9.6% of Native American youths obtained scores on the SOGS indicative of pathological gambling compared to 5.4% in the non-Native population. The first casinos appeared on Native American reserves in the 1970s as part of a solution to the high rates of unemployment within Native Americans (Dixon & Moore, 2006). This increased availability to gamble is a possible factor in the high incidences of Native American pathological gambling.

The Chinese community also has high incidences of pathological gambling. In China, gambling is a widespread activity with the game *majiang* being played by so many people and being such an integral part of Chinese culture that it is barely considered a form of gambling (Papineau, 2005). Treatment seeking is very low for gambling problems in China (GAMECS Project, 1999; VCGA, 1999) which may in part be due to the Chinese Classification of Mental Health Disorders (CCMD-2-R, 1995) which does not recognise problem gambling as a mental health problem (Blaszczynski et al., 1998). In China, excessive gambling is viewed as "the product of a sick, dysfunctional, individualistic society" (Papineau, 2005, p.163) therefore those with a gambling problem may be stigmatised. While prevalence studies can demonstrate that differences exist, they do not supplement our understanding as to *why* they exist.

Personality. Personality has been implicated as an explanation for why some may develop a problem with gambling whereas others may not. There are data to suggest that co-morbidity exists between personality disorders and pathological gambling. Dell, Ruzicka, and Palisi (1981) found that pathological gamblers seeking treatment from Gamblers Anonymous scored significantly higher on scales of gregariousness, narcissism, and aggression on the Millon Multiaxial Clinical Inventory (MMCI; Millon, 1978) compared to the normative sample (Dell et al., 1981). Black and Moyer (1998) reported that 87% of pathological gamblers met criteria for a personality disorder, especially avoidant, schizotypal, obsessive-compulsive, and paranoid personality disorders.

Until the publication of DSM-V, pathological gambling had been classified as an impulse control disorder, which generated research examining whether levels of impulsivity differed in problem and pathological gamblers compared to non-gamblers. Impulsivity is defined as “actions that are poorly conceived, prematurely expressed, unduly risky, or inappropriate to the situation and that often result in undesirable outcomes” (Evenden, 1999, p.348). It has been suggested that showing impulsive behaviour in childhood may correlate with gambling problems later in life (Vitaro, Arseneault, & Tremblay, 1999). Vitaro et al. (1999) reported that 12-14 year old boys that scored highly on measures of impulsivity were more likely to develop a gambling problem by age 17. Similarly, it has been found that adults with gambling problems measured significantly higher on self report measures of impulsivity and adult ADHD symptoms compared to healthy controls (Lawrence, Luty, Nadine, Bogdan, Sahakian, & Clark, 2009).

Cognitive explanations.

The cognitive literature has sought to explain problem gambling in terms of cognitive distortions in beliefs, termed cognitive bias. Some of the irrational thought patterns that have been implicated include inaccurate estimation of probability, believing certain variables co-vary, and an individual believing they have control over the outcome of a game (Wagernaar, 1988). Slot-machine players for example, have reported using skill when gambling on such machines even though the design of a slot-machine makes it impossible for any skilful behaviour to take place (Griffiths, 1990). Griffiths (1994) conducted an experiment in which the vocalisations of 30 non-gamblers and 30 regular slot-machine gamblers were analysed while playing slot-machines. It was found that the regular gamblers were more likely to emit irrational vocalisations regarding their play and were more likely to report that their skill was important in determining the outcome of the machine, than non-gamblers (Griffiths, 1994). Furthermore, the regular gamblers played for significantly longer than the non-gamblers. Given these results, Griffiths concluded that the difference between regular gamblers and non-gamblers was cognitive stating that “regular gamblers process information differently and think there is more skill than there actually is” (Griffiths 1994, p. 367). The cognitive distortions that will be discussed in more detail are the illusion of control and representativeness.

Illusion of control. The 'illusion of control' was first described by Langer (1975). This is the belief that an individual has control over the outcome of a game of chance. To examine the theory of the illusion of control Ladouceur and Sevigny (2005) conducted an experiment with recreational gamblers in which a stopping device was installed on a video lottery terminal. In the first phase of the experiment, participants played the game without the use of the stopping device, before being presented with a questionnaire that measured illusion of control. In the second phase, participants were able to use the stopping device during play followed by a second questionnaire. It was found that when this device was made available, participants reported that the device could affect how the reels stopped, thus affecting their chance of winning. Ladouceur and Sevigny (2005) also reported that the device increased gambling persistence. These findings demonstrated that the manipulation of a structural characteristic such as the presence of a stopping device may interact with an individual's evaluation of a slot-machine such that they believe their chances of winning are increased. This may result in greater persistence of slot-machine play with machines containing similar devices.

Taking a more qualitative approach, Toneatto, Blitz-Miller, Calderwood, Dragonetti, and Tsanos (1997) conducted open-ended interviews with regular and heavy gamblers in which they were asked about their strategies, techniques and rituals when gambling. According to Toneatto et al. (1997) the most frequently reported cognitive distortion amongst problem gamblers is what is known as active illusory control with 32 of the 38 participants reporting a distortion from this category. The active illusory control category included self-efficacy, cognitive control and behavioural control, for example, the reliance on lucky numbers, lucky objects, 'winning' systems and other superstitious behaviours. Probability control was the second highest distortion recorded. This included chasing losses, belief in false contingencies and probability errors (believing the probability of a win is better than it is). The authors noted that only 8% of the sample did not report any form of cognitive distortion which was interpreted as support for the theory that such distortions are implied in problem gambling.

Representativeness. According to Kahnemann and Tversky (1972), representativeness refers to instances in which individuals judge "a sample to be likely or not on the basis of similarity and random appearances" (Petry, 2005, p.214). According to Griffiths (1994), representativeness can explain Wagenaar's (1988) 'gambler's fallacy'. The gambler's fallacy maintains that gamblers believe that as the number of successive losses increases, the probability that a win will follow soon also increases. Corney and Cummings (1985) reported that participants were more likely to predict that tails would follow next, if there had been a string of coin tosses in which heads had been the outcome, despite each coin toss being completely independent from the previous one.

However, Delfabbro and Winefield (1999) were unable to provide evidence for the gamblers fallacy. Eighteen regular poker machine gamblers and 21 occasional poker machine gamblers were video recorded whilst playing a poker machine in a casino. Participants were required to rate how confident they were that the machine would pay out a large amount over the next 1-10 trials as well as saying aloud a number between 1 and 10 to indicate how confident they were. Given the gambler's fallacy, it was predicted that following a string of losses participants would become more confident that the machine would pay out, whereas following a win, confidence of a payout would decrease. The results revealed little evidence that participants behaved in accordance with the gambler's fallacy as the participants that only gambled occasionally were more likely to alter their expectancies than the regular gamblers (Delfabbro & Winefield, 1999). This questioned the idea that the gambler's fallacy is complicit in the development of gambling problems.

Aside from the gambler's fallacy, the heuristic of representativeness has been used to account for why gamblers may believe that a lottery ticket containing the numbers 1, 2,3,4,5 is less likely to win that a ticket with the numbers 7, 16, 22, 39, 45 despite the probability of winning for both these tickets being identical (Petry, 2005). Hardoon, Baboushkin, Derevensky, and Gupta (2001) reported that participants showed an increased preference for lottery tickets containing numbers that appeared random. However, no significant differences were found between non-problem or pathological gamblers in cognitive distortions, which suggest that such distortions were present across all groups. These findings challenge the view that individuals develop problems with gambling due to such distortions (Petry, 2005). If non-gamblers show the same cognitive distortions as those with extreme problems with gambling, then how can this explain why some individuals develop a problem whereas others do not?

Blaszczynski and Silove (1995) have criticised accounts that explain problem gambling in terms of false irrational belief, as they claim that there is no direct evidence that such beliefs are causal in developing a problem with gambling. If a large number of heavy gamblers exhibited irrational beliefs then it would be expected that many regular gamblers would become problem gamblers (Ladouceur, Paquet, & Dube, 1996), yet the vast majority of regular gamblers do not become pathological gamblers. Additionally, these explanations cannot inform *how* such faulty cognitions develop. Clearly, such explanations cannot fully account for the development of problem gambling.

Structural Characteristics of Electronic Gaming Machines

Structural characteristics of Electronic Gaming Machines (EGMs) may have an effect on the development and persistence of problem gambling (Griffiths, 1990; Parke & Griffiths, 2006). Much of the research so far has been conducted using computer-simulated slot-machines. There are some significant benefits to using computer-simulated slot-machines as in the UK, slot-machines are legally controlled to ensure a certain payout probability (Parke & Griffiths, 2007), and in some states in America it is illegal to own casino equipment (Weatherly & Phelps, 2006). Therefore, using computer-simulated slot-machines in a laboratory environment can overcome some of these legalistic obstacles.

Charles Le Fey developed the first gaming machine in the United States in 1895 (Dickerson, 1996). This primitive machine contained reels with fruit symbols. Over the past century, gaming machines have developed considerably and presently, many types of electronic gaming machine (EGMs) exist. As mentioned earlier, slot-machines are the fourth most common form of gambling after the national lottery, scratch cards and betting on horses (Wardle et al., 2010), and account for 60% of a casino's revenue (Ghezzi et al., 2006). Clearly these machines have proven popular, however it has been suggested that such machines may be a particularly detrimental form of gambling with some researchers going as far as claiming that EGMs are the 'crack-cocaine' of gambling due to the severity of addiction and the speed at which this addiction may be acquired (see Dowling, Smith, & Thomas, 2005). There is data suggesting that EGMs are the most popular form of gambling amongst problem gamblers (Griffiths et al., 1999; Lund, 2006) and in Norway EGMs were considered so harmful that they were banned in 2007 (Lund, 2009).

In a review of the literature regarding EGMs, Dowling et al. (2005) concluded that whilst EGMs are strongly implicated in problem gambling, the analogy that such machines are considered the crack-cocaine of gambling should be disputed. Dowling et al. (2005) argue that although there is evidence that EGMs are harmful, it remains to be seen whether problem gambling progresses more rapidly in EGM players compared to other forms of gambling. However, the authors do maintain that there appear to be differences in the so-called 'addictive potential' of the numerous types of gambling activity and warned against upholding the traditional view that all types of gambling are comparable. Dowling et al. (2005) state that vast differences exist between the different forms of gambling activity such as the way in which they are played, bet size, probability of a win, the environment in which the gambling takes place and so on, therefore gambling is not only one type of activity. Many gamblers persist with a specific type of gambling activity and the populations that seem to engage in each activity are not a homogenous group (Dowling et al., 2005). This highlights the need for research to be specifically designed towards a specific game and cautions against generalising findings across all forms of gambling. One of the most widely researched structural characteristics in the cognitive literature is that of the near-miss.

Near-miss. A near-miss is said to have occurred when two out of three matching symbols appear on the payoff line of a slot-machine (Langer, 1975). Although Skinner (1953) has been credited as one of the first to describe the phenomenon commonly known as the near-miss (Habib & Dixon, 2010) it has attracted much research from scientists within all domains of psychology. Skinner (1953) described the near-miss as "almost hitting the jackpot", therefore acting as a conditioned reinforcer. It is believed that a near-miss may encourage play even though the probabilities across trials remained constant (Reid, 1986). A survey on regular slot-machine gamblers found that many respondents reported increased heart rate and excitement not just when they were winning but also when they were nearly winning (Griffiths, 1993).

Kassinove and Schare (2001) suggested that there may be an optimal percentage of near-misses for greatest persistence in slot-machine play. Participants were required to play a slot-machine across 50 trials in which the percentage of near-misses was either presented on 15, 30, or 45% of trials. In the final phase, participants played a slot-machine under conditions of extinction, therefore no wins, losses or near-misses were presented. The participants that had been presented with a near-miss on 30% trials played for longer in the extinction phase. Least persistence in gambling was seen in participants who had experienced a near-miss on 15% of trials or 45% of trials. It was suggested that when a near-miss occurred on only 15% of trials, the near-miss was not followed frequently enough by a winning trial therefore was not reinforcing, whereas for those who had encountered a near-miss on 45% of trials, the effect was lost due to extinction.

Côté, Caron, Aubert, Desrochers, and Ladouceur (2003) also demonstrated that near-misses may increase persistence in slot-machine play. An experimental group and a control were exposed to 48 slot-machine trials, during which 9 wins and

12 near-misses occurred. During the second part of the experiment, further slot-machine trials were presented except no wins occurred therefore every trial was a losing trial. For the experimental group approximately 25% of the losses were near-misses, whereas for the control group no near-misses occurred. Participants could play the slot-machines for a maximum of 240 trials. It was found that the experimental group which had continued to be presented with near-misses played significantly more slot-machine trials than the control group (Côté et al., 2003).

Taking a different approach to the near-miss research, Wohl and Enzle (2003) investigated how nearly winning a large amount (near big win) and the nearly losing a large amount (near big loss) can affect an individual's perception of luck. In Experiment 1, participants played a computer-simulated wheel of fortune. In the near big loss condition, the wheel stopped just next to the bankrupt outcome. In the near big win condition, the wheel stopped just next to the jackpot outcome. Participants were given the Belief in Good Luck questionnaire (Darke & Freedman, 1997). It was found that those in the near big loss condition perceived themselves to be more lucky than those in the near big win condition (Wohl & Enzle, 2003). Wohl and Enzle explained their findings in terms of counterfactual thinking. Upward counterfactual thinking consists of perceiving an event that is better than the potential outcome, whereas downward counterfactual thinking consists of an event being worse than the potential outcome. In the case of the participants who nearly hit bankrupt, they may have thoughts such as "I nearly lost everything" (downward counterfactual) and see themselves as more lucky because they avoided losing money.

Although research from cognitive psychologists has supplemented the gambling literature greatly, it is not without its criticisms. Delfabbro (2004) questioned the emphasis and integrity of the illusion of control. Whilst there seems to be much support for this heuristic being involved in gambling, Delfabbro (2004) has argued that this distortion may not be as reliable as or integral to gambling as believed. Langer and Roth (1975) found that early wins in a simple coin toss experiment lead to a greater illusion of control. However, this effect was not replicated in subsequent studies by Coventry and Norman (1998) or Ladouceur and Mayrand (1984). Anderson and Brown (1984) suggested that the reason these studies failed to replicate the effect was partly due to the nature of the task being unrepresentative of a genuine gambling task and partly due to the use of non-gamblers or infrequent gamblers as participants. However, given the findings of

Hardoon et al. (2001) it seems that cognitive distortions are present in non-gamblers as much as they are in gamblers therefore findings of the illusion of control should not differ between these populations.

The notion that irrational beliefs and faulty cognitions may *cause* behaviour is a mechanistic or meditational account of gambling characteristic of much of cognitive psychology. In cognitive science, causation is often attributed to internal systems (Chiesa, 1992). However, given the findings of Hardoon et al. (2001) and the criticisms of Blaszczynski and Silove (1995) that cognitive distortions are not causal in the development of gambling, it seems that cognitive explanations of gambling behaviour appear lacking. Behavioural accounts however, look to environmental causes of behaviour and identifying functional relations between the environment and behaviour. Perhaps a behaviour analytic account of gambling may be able to provide a more comprehensive explanation of gambling behaviour.

Behaviour Analysis, Schedules of Reinforcement & Gambling

Early behavioural accounts explained gambling behaviour in terms of the direct contingencies of reinforcement. According to Skinner "the variable ratio is at the heart of all gambling" (1971, p.35). Skinner (1953, 1971) maintained that the variable-ratio (VR) schedule of reinforcement made gambling behaviour resistant to extinction. In a VR schedule of reinforcement, a variable number of responses are required in order for that response to be reinforced. For example, a VR-5 schedule would mean that a response is reinforced after an average of every five responses, but reinforcement could occur after only one response or after ten responses, as long as the average number of responses is equal to five. Behaviour that has been reinforced on a VR schedule of reinforcement is more resistant to extinction than those responses reinforced on fixed ratio (FR) schedules. In an FR-5 schedule, reinforcement is delivered consistently after every five responses. With fixed schedules, if reinforcement is no longer delivered after the *n*th response, the organism will quickly stop emitting the response. However, in the case of the VR schedule, on some occasions responses may have been reinforced after only one response and other times it may have been after twenty responses. The organism may, therefore, show persistence in responding.

For many years Skinner's account of gambling in terms of a VR schedule was widely accepted without challenge until Crossman (1983) pointed out that many slot-machines in the USA are programmed on random-ratio (RR) schedules of reinforcement. In an RR schedule, every spin is independent of the last; the criterion for reinforcement does not, therefore, depend on the number of responses from one reinforce to the next. Research into the effects of schedules of reinforcement surrounding gambling behaviour has revealed many complexities regarding participant's behaviour (Weatherly & Phelps, 2006) as will be discussed later.

Nonhuman research.

Research supporting the influence that schedules of reinforcement have on gambling was provided by Fantino (1967) who presented pigeons with a concurrent choice between a FR-50 schedule and a mixed-ratio schedule said to represent a gambling schedule. In the first phase, pecking on one key led to the mixed ratio schedule becoming available which resulted in one of three FR schedules becoming available (therefore reinforcement occurred on alternating fixed ratio schedules), whereas pecking a second key lead to an FR-50 schedule becoming available. The FR schedule that became available on the mixed-ratio schedule was of equal probability; however, the different schedules were programmed such that overall the arithmetic mean of the mixed-schedules was the same as the FR-50. In the second phase, choosing the mixed schedule resulted in either an FR-1 or FR-99 becoming available, whereas for the fixed schedule was now varied. It was found that pigeons showed most response allocation to the mixed-ratio 'gambling like' schedule (Fantino, 1967).

Kendall (1987) provided further support for Fantino using pigeons. Pigeons were given the choice between an FR-30 and a second gambling-like schedule which sometimes led to the presentation of an FR-10 schedule. If the FR-10 was not presented, a 60 second timeout occurred in which neither schedule was available. If the pigeon chose the FR-30 they had to expend more time and effort responding to receive reinforcement, however reinforcement was guaranteed. Selecting the gambling schedule resulted in the possibility of an FR-10 which led to more reinforcement being delivered and for less key pressing. However, if the FR-10 did not become available the pigeon would be unable to obtain any food. Kendall (1987) reported that pigeons showed most response allocation to the gambling-like schedule.

In an additional study, Kendall (1989) replicated and extended the previous experiment with two additional changes. First, a *closed economy* was implemented so that the only food available to the pigeons was the food given as reinforcement during the experiment. Secondly, the timeout following a loss varied between 1 and 30 minutes. On the gambling like schedule there was a 10% probability of being presented with the FR-10 low response schedule and a 90% chance of a lengthy time out. The non-gambling schedule consisted of an FR-30. Kendall (1989) found that the pigeons still showed increased preference for the gambling like schedule, even though the long timeout sessions meant that the subjects lost out on food overall.

Weatherly and Derenne (2007) designed an experiment that simulated human gambling more closely than previous non-human experiments by using flashing lights to indicate whether reinforcement would be delivered. Weatherly and Derenne (2007) measured whether rats would show a post-reinforcement pause following wins and losses. Human research has shown that following a win a pause is observed before the individual initiates the next gamble, termed a post-reinforcement pause. Following a loss, the latency between the loss and the initiation of the next gamble is much smaller. It has also been shown that larger wins lead to increased latencies (Delfabbro & Winefield, 1999; Schreiber & Dixon, 2001).

In an experiment by Weatherly and Derenne (2007), rats were required to press a lever for food reinforcement, which was delivered on an FR-5 schedule. A Cue condition was implemented which was designed to represent a human slot-machine whereas in the No-Cue condition no such lights were used. In the Cue condition, upon completing the FR-5, a grid of lights began to flash. The grid consisted of three rows of three lights (therefore nine lights in total). Once the flashing lights had stopped, only three of the lights remained which signalled whether reinforcement would be delivered, and if so, the quantity of reinforcer that was about to be delivered. If three diagonal lights were illuminated then reinforcement was delivered, therefore signalling a losing trial. If the first, second or third columns were illuminated, then a small, medium or large amount of food reinforcement was delivered, respectively. In the No-Cue condition, the flashing lights board was not used. It was found that the smallest duration of post-reinforcement pauses were seen following a loss, with duration steadily increasing as size of reinforcer increased. These findings are akin to human studies. However, no differences in duration of post-reinforcement latencies were seen between the Cue and No-Cue conditions which the authors claimed would have been expected in a human study.

In an attempt to address some of the limitations of the Weatherly and Derenne (2007) study, Peters, Hunt, and Harper (2010) designed an experiment in which the near-miss was incorporated. Rats responded by a lever press on an FR-10 schedule which led to a light display being presented. The light display consisted of five lights in a single row. A win was signalled by four lights (small win) or five lights (big win) becoming highlighted. To indicate a losing trial, one, two or three lights became highlighted and no subsequent reinforcement was delivered. Lights were illuminated sequentially to represent casino slot-machines as this sequential presentation is thought to be an important structural characteristic (Ladouceur & Sevigny, 2002). On winning trials, an additional lever was then pressed to collect food reinforcement. Pressing this lever on losing trials did not produce reinforcement. Peters et al. (2010) incorporated this extra contingency to ensure that the rats attended to the lights. An extinction condition in which no reinforcers were delivered was also administered.

It was found that rats showed the smallest post-reinforcement pauses following only one light being presented and these latencies increased as the number of lights increased, so that when five lights were illuminated, greatest post-reinforcement pauses were observed. Peters et al. (2010) concluded that rats exhibit the same patterns of post-reinforcement pauses as humans. Furthermore, due to the methodology implemented they claimed that these pauses were a result of the light stimuli and not merely due to the time required to consume the reinforcer. Evidence for this was provided by the extinction condition in which rats continued to display the same response latencies depending on the number of lights illuminated, even though food reinforcement was not delivered.

Zentall and Stagner (2010) presented pigeons with a non-human gambling analogue and found that pigeons do not always make the optimal choice in terms of the quantity of reinforcement available. Pigeons were presented with two schedules. One schedule always resulted in three food pellets (fixed-ratio). The other schedule was a VR schedule that mimicked a gambling like schedule. On 20% of trials, selecting this schedule produced a red coloured stimulus followed by ten food pellets, whereas on 80% of trials a green stimulus was made available which lead to no food pellets, therefore on the gambling like schedule, an average of two food pellets could be earned. It was found that pigeons showed increased preference for the gambling like schedules even though this only resulted in an average of two pellets. However, it is possible that these findings are due to a preference for a VR schedule over an FR schedule (Zentall & Stagner, 2010), therefore a second experiment was designed in which one schedule resulted in either of the colour stimuli resulting in 10 pellets on 20% of trials, therefore neither colour was discriminative for the delivery of 10 pellets. An average of two pellets could be won on this schedule. The alternative schedule always guaranteed three food pellets. It was found that pigeons showed increased response allocation to the three-pellet schedule. The authors concluded that preference for the two-pellet schedule in Experiment 1 was due to the signalling value of the colour stimulus that indicated that 10 pellets would be delivered. In Experiment 2, this discriminative function was eliminated and pigeons showed increased response allocation to the optimum schedule in terms of the quantity of food pellet reinforcement. According to Zentall and Stagner (2010) these findings have potential implications for human gambling. In terms of slot-machines, the winning display acted as a conditioned reinforcer signalling that reinforcement is about to be delivered. Zentall and Stagner (2010) question whether gamblers would continue to wager if no signals, such as lights and sounds, were presented when a win occurs. These findings suggest that such conditioned reinforcers may be implicated in gambling persistence.

Non-human research suggests that rats and pigeons show preferences for gambling-like schedules of reinforcement. Although some may contest the validity of non-human gambling research, such research has some distinct advantages. When investigating gambling in humans in a laboratory setting, ethical considerations mean that it is not possible for that individual to gamble their own money or go into debt. With non-human research, the experimenter can starve a pigeon before the experiment, which is considered an analogy of 'debt', and consequently makes food more reinforcing. It remains to be seen whether food starvation in non-humans is functionally equivalent to a gamblers financial debt (Weatherly & Phelps, 2006). Despite the advantages of conducting gambling research with non-human subjects, for a better understanding of the factors that influence human gambling behaviour and for behaviour analytic research to impact upon the wider gambling literature, it is critical that such research be conducted with human participants.

Human research.

Behaviour-analytic researchers have analysed the extent to which individuals are sensitive to the schedules of reinforcement of a slot-machine and how this may influence slot-machine choice. Dixon, Maclin, and Daugherty (2006) used computer-simulated slot-machines to investigate the relationship between schedule and magnitude of reinforcement and slot-machine choice. Participants were presented with two slot-machines, one which paid out on a VR-10 (little and often) and the other slot-machine paid out on a VR-50 (larger sums but less often), therefore if equal bets were placed on each slot-machine overall payout would be the same. It was found that 86% of participants allocated most responding to the VR-10 slot-machine as it resulted in more instances of reinforcement (Dixon et al., 2006).

In an extension of the experiment by Dixon and colleagues, Haw (2008) investigated the effect of rate of reinforcement on concurrent slot-machine choice. Dixon et al. analysed the effect of frequency of wins on slot-machine choice, however Haw (2008) examined the effect of payback rate. Payback rate was defined as the monetary value of wins expressed as a percentage of wins and expenditure. For example, if a gambler bets £1.00 and wins 70 pence, the payback rate would be 70%. As well as measuring payback rate, Haw (2008) analysed the point at which participants switched machines. Participants completed an initial practise phase in which they were exposed to both slot-machines and could gamble between one and eight dollars. Once participants had built up a history with both machines, they played each slot-machine a further 40 times. Finally participants were given $500 credits to bet on either slot-machine. In this phase, participants could freely switch between both slot-machines, with every win size and frequency being recorded by the experimenter.

It was found that only 61% of participants most frequently chose the slot-machine that had paid out the most in the practise phase. A chi-square revealed that this was not a statistically significant effect, therefore it was concluded that there was no significant relationship between reinforcement and slot-machine choice (Haw, 2008). These findings did not support those of Dixon et al. (2006). When accounting for the differences in the findings between the two studies, Haw (2008) suggested that preferences for a particular slot-machine may only occur when the differences between the machines are enlarged, for example when there are large differences in payout probabilities. Haw (2008) suggested that this may explain why these findings were not in accordance with Dixon et al. (2006) as the payback percentages in Haw's study did not differ as greatly.

It is possible that the participants in Haw's study were not sensitive to the schedules of reinforcement in place as there is evidence that human participants do not always show a preference for the slot-machine with the highest percentage payout. This is consistent with the literature on schedules of reinforcement that has reported that human participants do not always maximise responding on schedule of reinforcement (Hayes, Zettle, & Rosenfarb, 1989; Madden & Perone, 1999). Weatherly, Thompson, Hodny, and Meier (2009) presented six non-pathological gamblers with concurrently available slot-machines that paid out at different rates. Participants were given $5 worth of tokens and instructed which two slot-machines they could play. All of the payout percentages programmed corresponded to actual casino payout probabilities with the overall percentage payouts experienced by each of the participants being 97.9%, 90.3%, 78.4%, 91.8%, 75.2%, and 139.9%, respectively. Participants were able to switch freely between two slot-machines and played until either the participant quit or 20 minutes had passed. The frequency of plays on each slot-machine and amount bet were recorded. Once participants had shown stable responding towards one particular slot-machine, the schedule of reinforcement was altered by the researcher for one or both of the slot-machines.

It was found that the payout percentage of each slot-machine had very little effect on slot-machine choice with participants not necessarily preferring the slot-machine that paid out the most (Weatherly et al., 2009). Three of the participants played almost exclusively on the slot-machine that paid out at the highest rate; however Weatherly et al. could not conclude that this was as a result of the contingencies of that slot-machine, as these participants rarely played the other slot-machines therefore did not experience the contingencies of the other machines. The participants who allocated responding to both slot-machines only went on to show preference for the slot-machine with the highest payout contingencies in five out of 25 conditions. Weatherly et al. (2009) concluded that factors other than payout contingencies, influence slot-machine choice, and that participants' behaviour was perhaps partly rule-governed and not solely determined by the schedule of reinforcement of the slot-machines.

Behaviour Analytic Research on Gambling

Illusion of control. Behaviour analytic gambling research has evolved over recent years such that research aims to go beyond an explanation based purely upon direct contingencies of reinforcement. Dixon, Hayes, and Ebbs (1998) and Dixon (2000) looked at the cognitive phenomenon of the illusion of control and demonstrated that it can in fact be brought under experimental control. It was found that given the choice between the experimenter selecting numbers in a game of roulette compared to the participant being able to select their own numbers, participants preferred to select their own numbers even though they would have to lose an extra chip in order to do so and the probability of winning remains the same (Dixon et al., 1998). In a later experiment, Dixon (2000) gave participants accurate and inaccurate rules informing the participants of their chance of winning in a game of roulette. Dixon (2000) found that when given accurate rules participants wagered fewer chips than when given inaccurate rules. This finding is important as it demonstrates that external rules given to an individual can influence their gambling behaviour, and is not indicative of an internal belief or cognitive distortion.

Extending research on the illusion of control to video poker Dixon, Jackson, Delaney, Holton, and Crothers (2007) concurrently presented participants with two computer simulated poker machines to play. One of the poker machines allowed participants to choose which cards they wanted to hold or discard whereas the computer selected the optimal cards on the other slot-machine. Participants could freely switch between each poker machine. Prior to playing the poker machines, participants were either given accurate rules in which they were told that the computer-selected option was the optimal choice, or inaccurate rules stating that self-selecting cards would increase their chance of winning. No significant differences were found between the effects of the accurate or inaccurate rule on the number of hands played; however, participants played more hands on the machine which allowed them to self select their cards, although this was not a statistically significant difference. This finding suggests that individuals prefer to believe that they have control over a game, even when it means forfeiting the optimum.

In the second experiment, participants were presented with a non-rule baseline followed by an inaccurate rule and later, an accurate rule. It was found that 12 out of 13 participants preferred the self-select game and once given the inaccurate rule that this option was a better option, participants increased their allocation to the self-selecting game even more. Once given the accurate rule that the computer-selected option was the optimal option, only half of participants adhered to that rule by switching from the self-select game. As the authors had employed a protocol analysis element to the experiment they were able to examine the subtle differences between those who followed the rule and those who did not. Dixon et al. (2007) reported that participants that followed the accurate rules seemed to pay more attention to reinforcement and how much they had won or lost, and were less attentive to performance. Those who ignored the accurate rule seemed to evaluate their play on a trial by trial basis and were less aware of their winnings. Perhaps then, illusion of control relates to a lack of attention to wins and losses (Dixon et al., 2007).

Near miss. Behaviour analytic accounts of the near-miss propose that it is a verbal event which has reinforcing properties that are similar to that of a win, with an individual believing that a win may happen soon (Dixon & Schreiber, 2004). Human behaviour can be considered a verbal event if it involves responding to arbitrary relations between stimuli and in the absence of a direct history of reinforcement (see later for a more detailed discussion). For example, a near-miss may have considerable reinforcing properties by an individual merely reflecting on how they would have spent any winnings if a win had occurred (Dixon & Delaney, 2006). This is in itself is a reinforcing event even though there is no direct contingency of reinforcement for this event, that is, a win has not occurred. Dixon and Delaney (2006) suggested that the near-miss has a discriminative function so that a person may view a near-miss as a win. Dixon and Schreiber (2004) reported that when individuals are asked to rate how close they are to a win or a loss following a spin on a slot-machine, participants' rated a near-miss as closer to a win compared to trials in which no matching symbols occur.

Maclin, Dixon, Daugherty, and Small (2007) concurrently presented participants with three computer simulated slot-machines in which near-misses were presented on 15, 30, or 45% trials. It was found that participants showed a greater preference for the slot-machine with the highest number of near-misses. These data are interesting as Kassinove and Schare (2001) found that 30% near misses lead to greatest persistence in play. The differences in findings may be related to the measures that were taken in the two experiments as Maclin et al. (2007) were measuring preference by means of response allocation to each machine whereas

Kassinove and Schare (2001) measured persistence. Maclin et al. (2007) concluded that having encountered a string of losses, the slot-machine with the most near-misses is most preferred. This is interesting because the payout probabilities for the three slot-machines in the first part of the experiment were identical, therefore participants did not win any more money on these machines. Furthermore, a near-miss is still in fact a losing trial therefore a higher incidence of near-misses will not mean that an individual wins any more money.

Structural characteristics. Research has been conducted into the effects of structural characteristics of slot-machines, such as colour, on gambling behaviour. Zlomke and Dixon (2006) demonstrated that preferences for concurrently presented computer simulated slot-machines that were identical in payout probability, but differed in colour (yellow or blue) could be altered. Initially, participants did not show any significant preference for either slot-machine. However, following a non-arbitrary relational training task in which colour yellow was trained as a contextual cue for more-than and colour blue was trained as a contextual cue for less-than, participants showed an increased preference for the yellow (more-than slot-machine).

These findings were replicated and extended by Hoon, Dymond, Jackson, and Dixon (2007, 2008) by employing a modified non-arbitrary relational training and testing procedure. The results supported those of Zlomke and Dixon (2006) in that participants also showed an increased preference for the more-than slot-machine at post-test. The findings of these experiments were significant as the payout probability and schedule and magnitude of reinforcement for the two slot-machines were identical and all participants were exposed to the direct contingencies of the machines, yet participants shifted their preference towards one of the slot-machines. These findings cannot be explained by contingencies alone, but suggest that additional factors such as structural characteristics may be implicated in gambling behaviour.

A further modification of Zlomke and Dixon (2006) and Hoon et al. (2007, 2008) was conducted with children using a computer-simulated board game. Using a pre-test post-test design, participants played the board game using either a red or a blue coloured die (Johnson & Dixon, 2009). A non-arbitrary relational training and testing phase established colour blue as a contextual cue for less-than and colour red as contextual cue for more-than. Following this intervention, six out of seven participants showed increased preference for red dice (more-than) when playing the board game.

The slot-machines seen in 21st century casinos are complex machines that not only vary in colour, but contain many complex structural features. Many machines now feature stopping devices that enable gamblers to stop the reels before they have finished spinning. Nastally, Dixon, and Jackson (2009) presented participants with two different slot-machines – one with a stopping device and one without. Participants were divided into one of three experimental conditions; Button Slot Winner, No Button Slot Winner or Equal Win Rate. In the Button Slot Winner condition the slot-machine with the stopping device paid out 80% of the time. In the No Button Slot Winner condition the slot-machine without the stopping device paid out 80% of the time, whereas in the Equal Win Rate condition both machines paid out at a rate of 30%. In the Button Slot Winner condition nine of ten participants allocated most responding to slot-machine with the stopping device. In the Non-Button Slot Winner nine out of ten participants showed the most preference for the slot-machine without the stopping device. In the Equal Win Rate condition half of participants showed increased response allocation to the slot-machine with the stopping device, whereas the other half showed most preference for the machine without the stopping device. The findings of Nastally et al. (2009) contradict previous research that has reported that a stopping device leads to increased play on a slot-machine (Ladouceur & Sevigny, 2005), as Nastally et al. found no preferences for the slot-machine with the stopping device when the payout contingencies were equal. The authors concluded that although such devices may promote the illusion of control, the payout contingencies of the slot-machines are a stronger indicator of slot-machine preference (Nastally et al., 2009).

From the research described above, it is clear that factors affecting the persistence and maintenance of gambling are highly complex. Non-human work has demonstrated that pigeons will show an increased preference for a gambling like schedule even when this leads to less reinforcement resulting in a 'debt' of food supply (Kendall, 1989). Research into the near-miss has found that gamblers rate a near-miss trial as closer to win despite no reinforcement being delivered for a near-miss (Dixon & Schreiber, 2004). Furthermore, following a string of losses, participants show increased preference for the slot-machine that delivers the highest frequency of near-misses, even though a near-miss is also a losing trial therefore does not result in any more credit being awarded (Maclin et al., 2007). Researchers have also shown that participants will show increased preference for a slot-machine that is the same colour as a cue for more-than, even though the other slot-machine available is of equal payout probability (Zlomke & Dixon, 2006; Hoon et al., 2007, 2008).

Clearly the research reported cannot be explained by considering just the payout probability. Although contingencies of reinforcement may be fundamental in explaining the patterns of responding a gambler may exhibit when playing slot-machines and other such games of chance, this alone cannot explain why some people will develop a problem with gambling whereas the majority may regularly engage in gambling but will not develop a problem as such. Skinner highlighted the distinction between contingency-shaped and rule-governed behaviour, yet he did not discuss this with regard to gambling behaviour (Porter & Ghezzi, 2006). In a casino environment, individuals are exposed to many verbal stimuli such as signs informing them of the jackpot available or statements about their play made by those around them (Dixon & Delaney, 2006). If contingencies of reinforcement alone cannot account for problem gambling, then perhaps by accounting for the influence of verbal behaviour, a fuller understanding of gambling may be reached.

An integrative approach to gambling behaviour.

Recently, conceptual accounts have been proposed as to why certain individuals may develop a problem with the gambling whereas others do not. Weatherly and Dixon (2007) proposed an integrative account to gambling behaviour incorporating contingencies of reinforcement, verbal rules, and establishing operations/setting events as being integral. Establishing operations or setting events refer to events that alter the reinforcing value of a stimulus (Cooper, Heron, & Heward, 2007; Michael, 1993). In the context of gambling, lower social economic status (SES) may make money a more effective reinforcer (Weatherly & Dixon, 2007). Other relevant setting events may include age, gender, and ethnicity (Weatherly & Dixon, 2007). In the example of lower SES as a setting event, if money is the primary reinforcer this may increase the likelihood of developing a severe gambling problem, whereas the gambler who enjoys the excitement of gambling may never develop a pathological problem (Weatherly & Dixon, 2007).

Verbal rules may also be implicated in pathological gambling (see later for a more detailed discussion). If an individual is given false verbal rules overestimating the probability of achieving a win, then it is likely that they will wager increased amounts of money and increased persistence in play (see Dixon 2000). Self-rules such as "red is my lucky colour" may lead a gambler to play the red slot-machine. Weatherly and Dixon emphasise the importance of such rules stating that:

> "if these [verbal] rules are fallacious, then they may not only promote gambling, but also alter the consequence(s) maintaining the gambling behavior. If these rules lead to losses, and thus an increase in the efficacy of winning money, then they will serve to promote pathological gambling." (2007, p.15).

Weatherly and Dixon argue that much of the behaviour-analytic gambling data conducted so far seem to support the proposed integrative model. One significant advantage of this model is that by incorporating mechanisms of contingencies of reinforcement, verbal rules, and establishing operations, the model may be able to account for how the exact same contingencies of a gaming machine have different effects on different individuals, resulting in one individual developing a serious problem whereas another is able to stop gambling at will (Weatherly & Dixon, 2007). The authors also claim that this model allows for testable predictions as well as an independent measure of pathology. Furthermore, it may have significant treatment implications through identifying causes of pathological gambling, thus enabling the identification of effective treatment that is specific to the cause of the specific individual's gambling problem (Weatherly & Dixon, 2007).

The Present Thesis: Towards a Verbal Account of Gambling

It has been suggested that verbal behaviour may be strongly implicated in gambling behaviour (Dymond & Roche, 2010). In order to discuss a verbal account of gambling, one must begin with Skinner's account of verbal behaviour published in 1957. Skinner's book *Verbal Behavior* was an attempt at providing a functional definition of verbal behaviour. Skinner claimed that verbal behaviour occurs when a speaker's behaviour is "reinforced through the mediation of other persons" (1957, p.2) and that such behaviour is "shaped and maintained by mediated consequences" (1957, p.2). It is important to note that by this definition the behaviour of a listener is not verbal behaviour as the listener is merely mediating the reinforcement of the speaker. According to Skinner (1957), this is no different to mediating reinforcement for any other behaviour.

Skinner proposed that combinations of sounds by a speaker can be reinforced by another individual, termed the listener, by the way that listener acts as a consequence of the sounds uttered. For example, asking for a drink is reinforced by the speaker receiving a drink. This behaviour then becomes very important for social interaction. In the book *Verbal Behavior*, Skinner (1957) made a distinction between the formal and functional properties of language, asserting that language is a learned behaviour that is acquired and influenced by the same environmental variables as any other behaviour. Skinner proposed that verbal behaviour could be studied through a unit of analysis known as verbal operants. Altogether, six verbal operants were identified, termed tacts, mands, echoics, intraverbals, and autoclitics. A tact is determined by an antecedent stimulus which is then named or tacted whereas mands are controlled by reinforcers, such as saying the word "drink" when thirsty, and receiving a drink accordingly. Echoic behaviour occurs when an utterance is repeated or echoed. An intraverbal consists of a verbal response in which the antecedent is also verbal behaviour but the physical properties of the correspondence between the antecedent and the response is arbitrary. Finally, an autoclitic is verbal behaviour which alters or modifies the behaviour of the listener, for example, words such as "maybe", "I think", or "not". A complete account of Skinner's *Verbal Behaviour* is beyond the scope of the present thesis; however, the defining features of Skinner's taxonomy aimed to provide functional definitions of verbal behaviour which were predicated on the principles of respondent and operant conditioning, and reinforced through the verbal community (Hayes, Blackledge, & Barnes-Holmes, 2001).

Hayes et al. (2001) argue that Skinner's definition is not functional and is too broad thus preventing further empirical investigation. One fundamental principle that Skinner has claimed to be key to the explanation of verbal behaviour is that of history of reinforcement. One major problem with this however, is that it cannot account for the generativity of language. This would mean that, for example, when learning new words, every single word would require a direct history of reinforcement in order for that word to be learned, therefore cannot explain how humans can produce many novel utterances in the absence of such reinforcement (Wulfert & Hayes, 1988). It seems that language can develop without a direct history of reinforcement (Hayes, Barnes-Holmes, & Roche, 2001) as will be discussed later.

Returning again to the relevance of this on gambling behaviour; accounts of human behaviour that attempt to explain all instances of gambling behaviour through the direct contingencies of reinforcement, may encounter conceptual limitations. Dixon and Delaney (2006, p.174) encapsulate this issue in the following analogy:

> "Specifically, if two people who have never gambled before play the same slot-machine for the same initial amount of spins, and contact the same programmed contingencies, and one player continues playing while the other one quits, we are left without a meaningful account of the different behaviours."

If these two individuals have contacted exactly the same contingencies of reinforcement, then a pure schedule of reinforcement account falls short of an explanation as to why one persists whilst the other walks away. The studies by Zlomke and Dixon (2006), Hoon et al. (2007, 2008) and Weatherly et al. (2009) highlight that preferences for slot-machines cannot solely be explained by the payout probability of a slot-machine. So what, then, is exerting control over a gambler's behaviour? A more complete explanation of such responding may be accounted for by contemporary behavior-analytic accounts of verbal behaviour.

Rule-governed behaviour

One area of verbal research that developed after the publication of *Verbal Behavior* was that of rule-governed behaviour. According to Skinner, rules are stimuli that specify a contingency (Skinner, 1969) and are followed due to the reinforcement of previous behaviour for rule following (Skinner, 1966). In the 1980s much research was conducted into the effects of rule following on behaviour (Hayes et al., 2001). One area of research into rule-governed behaviour found that externally delivered rules may even override the control exerted by schedules of reinforcement (Hayes, Brownstein, Haas, & Greenaway, 1986). Hayes et al. (1986) studied the effects of externally delivered instructions on preference to concurrent schedules. Participants were presented with multiple schedules, consisting of an FR-18 and a differential-reinforcement-of low-rate (DRL) 6 s schedule, and required to press a button for a chance to win monetary reinforcement. Participants were assigned to one of four conditions; minimal instructions, instructed to press the button slowly, instructed to press the button fast or given an accurate rule informing them when to press slowly and when to press quickly. The schedule altered between the FR schedule and the DRL schedule at two-minute intervals. When given inaccurate instructions (Minimal, Go Slow, and Go Fast conditions), it was found that participants' responding varied greatly and few points were won. Participants in the accurate rule condition, however, earned more points and showed schedule sensitive responding.

With regard to gambling, there is evidence to suggest that gambling may also be influenced by rule-governed behaviour (Dixon, 2000; Dixon et al., 2007; Weatherly & Meier, 2008). The effects of rules on a gambler's behaviour are of great importance to understanding why an individual may gamble in a particular way, as in a casino environment there are many other verbally able individuals who may encourage a gambler to continue playing by emitting statements regarding how close he was to winning, or implying that the tactics he is employing are not working (Dixon & Delaney, 2006). As well as human interaction, a casino contains many signs such as "mega jackpots" or "you have to play to win" (Dixon & Delaney, 2006) or images of pots of gold and lucky symbols. All of these stimuli are examples of environmental variables or external rules, that may mediate a gambler's behaviour and influence which games that individual plays and at what point he will cease gambling.

There is empirical evidence that externally delivered rules can influence gambling behaviour. As discussed earlier, Dixon (2000) demonstrated that delivering accurate rules that specify the probability of winning may reduce the number of chips wagered in a game of roulette. Dixon et al. (2007) reported that participants preferred to play a computer simulated poker machine in which they could select their own cards over a computer controlled machine which selected the optimal cards. However, once told that the computer-selected machine was the optimal option, half of the participants then switched to the computer selected machine.

Whilst Dixon (2000) demonstrated that accurate rules may reduce wagering in roulette, Weatherly and Meier (2008) demonstrated that accurate rules may also reduce persistence in slot-machine gambling. Following initial exposure to a slot-machine, participants were either instructed about the random ratio schedule of reinforcement on slot-machine, warned against playing slot-machines for long periods of time, or given both sets of instructions. Weatherly and Meier (2008) reported a significant decrease in the number of slot-machine trials played across all groups compared to the first phase of the experiment. It was concluded that gambling may be partly rule-governed and that presenting gamblers with accurate information about the schedules involved in gambling, may reduce gambling persistence (Weatherly & Meier, 2008).

The rule-governed behaviour literature demonstrated that rules may override contingencies of reinforcement, even though the rule stated may inaccurately describe the contingency in place (Dixon, 2000; Hayes et al., 1986). These findings were important conceptually as rule following is a uniquely human capacity; therefore, it implied that the human ability for language may account for some of the behavioural differences between humans and non-humans. Whilst this was a significant progression for the behavioural literature, there was a limit to the extent to which rule-governed behaviour could be applied to human responding. Empirical investigations into rule-governed behaviour typically involved presenting an instruction, and then measuring the relative effects on schedule responding. This method had limitations as "instructions were treated as an object, not a term that referred to a functional relation between environmental stimulation and the action of the organism" (Hayes et al., 1989, p. 193). It also implies that verbal behaviour may have a causal role in performance on concurrent schedule, however, Dymond and Barnes (1994) argued that the two can influence each other in a non-linear fashion (Dymond & Barnes, 1994).

In behaviour analysis, emphasis is placed on providing *functional relations* between stimuli and the behaviour it occasions (Hayes & Hayes, 1992). That is, behaviour analysis seeks to predict and control behaviour by identifying the variables that *maintain* a behaviour (Skinner, 1953), thus identifying the function of a particular behaviour. In the rule-governed behaviour literature however, the way in which rules came to exert control over behaviour could not be determined. Such an account assumed that if instructional stimuli are discriminative for a particular behaviour then this insinuates that every instruction requires a direct history of reinforcement for the rule being followed (Hayes & Hayes, 1992). If instructions require a history of reinforcement, then this infers that rules will only be followed when they are accurate (Galizio, 1979). It is likely that much of human behaviour can be occasioned without a direct history of reinforcement with a particular stimulus (Hayes et al., 2001), yet this could not be accounted for by rule-governed behaviour. Additionally, the language hypothesis claimed that the behaviour of the listener was verbal which was contrary to Skinner's claims (Hayes et al., 2001). Finally, although

Skinner claimed that rules specified a contingency of behaviour, he did not define what it meant to *specify* a contingency, and this definition was integral to the definition of rule-governed behaviour (Parrott, 1987; Hayes & Hayes, 1989). Hayes et al. (2001) argued that if 'to specify' meant that a discriminative stimulus occasions behaviour, then this is no different to contingency shaped behaviour and therefore according to Skinner's definition, is not considered verbal behaviour as it involves a direct contingency of reinforcement.

The questions that arose from these limitations together with discoveries in the domain of research on equivalence relations that human subjects could emit responding to stimuli in the laboratory that had not been directly trained, but were indirectly related, paved the way for research into derived relational responding and the development of a contemporary account of human language and cognition.

Derived Relational Responding

Stimulus Equivalence. Given the limitations of both Skinner's account and the limited scope of the rule-governed behaviour literature, a new concept was required that would be able to answer some of the questions raised by Skinner's definition of verbal behaviour. Research into stimulus equivalence has demonstrated that participants could respond to relations that were not directly trained or based on purely physical properties. It is possible that such responding may be able to explain the generativity of behaviour, particularly verbal behaviour. The fundamental principle of stimulus equivalence is that having being trained certain relations, humans can then derive many more untrained relations (Sidman 1971; Wulfert & Hayes, 1988). For example, having being trained that stimulus A is the same as stimulus B, and B is the same as stimulus C, humans will then derive that C is the same as A, in the absence of direct training. Stimulus equivalence has generated a great deal of research and as Barnes (1994, p.91) pointed out, "One of the main reasons for this attention to equivalence lies in the fact that it is not readily accounted for by the concept of conditional discrimination." It is significant as it accounts for how a child having being taught to say "cat" in the presence of an actual cat, when shown a cartoon picture of a cat the child will be able to respond "cat" despite never being directly taught this in the presence of the cartoon.

The three defining features of stimulus equivalence are reflexivity, symmetry and transitivity. Reflexivity refers to correctly selecting A in the presence of A.

Symmetry is seen when having been trained that A is the same as B, the untaught relation of B is the same as A emerges. After having learnt to select B in the presence of A, and C in the presence of B, transitivity occurs when selecting A in the presence of C (Sidman, Kirk, & Willson-Morris, 1985).

Much research has been conducted investigating equivalence relations. Sidman, et al. (1985) trained children and adults three sets of arbitrary stimuli in which each set of stimuli contained three stimuli (that is, A1, A2, A3; B1, B2, B3; and C1, C2, C3) through a conditional discrimination task. In the presence of A1, participants learned to select B1 and C1; in the presence of A2, participants learned to correctly select B2 and C2, and so on. Following this training, participants were trained three more stimulus sets of three (D1, D2, D3; E1, E2, E3; and F1, F2, F3). This meant that participants were presented with 12 different conditional discriminations in total across the six sets of stimuli. Three of the participants were then given further training in which they were trained C1 and E1, C2 and E2 and C3 and E3 relation. These participants were presented with a total of 15 different conditional discriminations. From these 15 trained relations, a further 60 conditional relations emerged that had not been trained.

A further defining feature of stimulus equivalence is that of transfer or transformation of stimulus functions. This occurs when the stimulus functions that have been trained to one member of an equivalence relation, transfer to other members of the equivalence relation without direct training (Dymond & Barnes, 1994). For instance, Barnes and Keenan (1993) demonstrated transfer of discriminative stimulus functions. In Experiment 1, participants were trained two three-member equivalence classes consisting of A1-B1-C1 and A2-B2-C2. Participants then learned to emit a low rate of responding when presented with B1 and to emit a high rate of responding when presented with B2. In the next experiment the authors were able to show a transformation of these discriminative functions to novel stimuli that were physically similar to the stimuli in the previous experiment. Functions that have been shown to transform through equivalence relations include consequential functions (Hayes et al., 1987; Hayes, Kohlenberg, & Hayes, 1991), respondent eliciting functions (Dougher, Augustson, Markham, Greenway, & Wulfert, 1994), and avoidance functions (Augustson & Dougher, 1997).

Relational Frame Theory

Equivalence was a key move forwards in the explanation of novel verbal behaviour. One criticism of the equivalence research however, was that it can't account for all the relations that are part of a verbal repertoire, as equivalence research only examined 'same' relations, that is, behaviour in which a relation of sameness (equivalence) existed between the stimuli. For example, an individual could learn through arbitrary training the English word "house" is the same as the French word "maison", and the word "maison" is the same as the Spanish word "casa". This individual could then derive that the Spanish word for house is casa. It has been suggested however, that a great number of relations exist between stimuli other than just same relations, for example comparative relations such as better, worse, more, and less; temporal relations such as before, after, now, and then; and spatial relations such as above, below, left, and right (Hayes, Fox, Gifford, Wilson, Barnes-Holmes, & Healy, 2001). Principles of stimulus equivalence are unable to account for these relations.

The research on stimulus equivalence however allowed for the development of relational frame theory (RFT) in which complex behaviour such as human language and cognition can be further explored. In a similar way to equivalence, RFT is able to explain behaviour in the absence of a direct history of reinforcement through derived relations, therefore addressing some of the key limitations of Skinner's definition of verbal behaviour, yet it extends the study of derived relational responding to all types of relations other than just relations of sameness (Hayes & Wilson, 1993).

RFT defines human language and cognition as a form of operant behaviour in which an organism responds to a stimulus in relation to another stimulus (Hayes et al., 2001). This is termed relational responding. Steele and Hayes (1991) define relational responding as being arbitrarily applicable with an "extensive history, largely in the context of language training, that can be brought into the experimental situation by virtue of contextual cues" (1991, p. 520). Contextual cues that specify a relation, often referred to as a C_{rel}, have been defined as cues which symbolise "a context in which a history of a particular kind or relational responding is brought to bear on the current situation" (Hayes et al., 2001, p. 30). Contextual cues that specify a function or a C_{func} are defined as cues that symbolise "the stimuli that select particular psychologically relevant, non-relational stimulus functions in any given situation" (Hayes et al., 2001, p. 33).

Relational responding occurs when, for example, an organism learns through reinforcement, that A is greater in relation to B, and B is greater in relation to C. Given this, the organism can deduce through mutual entailment that B must be less than A, and C must be less than B, despite such rules never being directly trained. Furthermore, combinatorial entailment will allow an individual to derive that C must be less than A and A must be greater than C. Derived relations have been found to emerge developmentally in human infants (Lipkens, Hayes, & Hayes, 1993).

Relational responding consists of mutual entailment, combinatorial entailment and the transformation of stimulus function. These concepts are the defining features of RFT. A relational frame is:

> "the term used to specify a particular pattern of contextually controlled, arbitrarily applicable relational responding involving mutual entailment, combinatorial entailment, and the transformation of stimulus functions, that is based upon a general history of relational learning rather than on a history of direct nonrelational training with respect to the stimuli involved or solely on the formal properties of the related events." (Hayes & Wilson, 1993, p. 286).

The second key component of RFT is the transformation of stimulus function. This occurs "when a given stimulus in a relational network has certain psychological functions, the functions of other events in that network may be modified in accordance with the underlying derived relation" (Hayes et al., 2001, p 31). In other words, the function of a stimulus is transformed based on its relation to other stimuli that have not been directly trained. For example, say that participants were trained that arbitrary stimulus A1 was the same as B1 and C1, and A2 was the same as B2 and C2. If an electric shock was then delivered in the presence of stimulus B1, but not in the presence of B2, then B1 may acquire conditioned fear eliciting properties. Next, to test for transformation of functions, C1 may be presented, in the absence of shock. If fear is elicited, then transformation of (Pavlovian eliciting) functions in accordance with same relational frames may be said to have occurred (see Dougher et al., 1994; Roche & Barnes, 1997; Roche et al., 2000). In this example, the trained fear response acquired for B1 was transformed in accordance with C1 due to the same relation between B1 and C1.

In the literature on stimulus equivalence and RFT the terms 'transfer' and 'transformation' of functions are used interchangeably (Dougher, Hamilton, Fink, & Harrington, 2007). Transfer of functions was initially used in the equivalence literature to describe the untrained emergence of stimulus functions where the untrained functions are the same (Dougher et al., 2007). However, RFT research tends to use the term transformation as relations other than equivalence or sameness are studied therefore the trained and untrained functions may be different (Dymond & Barnes, 1995; Roche et al., 2000). Where the trained and untrained functions are different, those functions of the stimulus cannot *transfer* to another stimulus, rather those functions *transform* in accordance with the derived relations (Dougher et al., 2007). For example, given more-than and less-than relations, stimuli in the network do not simply acquire the same functions of the trained stimulus function; rather, the functions of the stimuli are transformed in *accordance* with the relations of more-than and less-than.

Dymond and Barnes (1995) demonstrated that a transformation of self-discriminative functions extends beyond just equivalence relations, and can be transformed through relations of same, more-than, and less-than. Participants first completed a non-arbitrary relational training task to establish contextual cues for the relations (that is, same, opposite, more-than, less-than). Following this, participants completed arbitrary relational training which established a relational network of same relations between A1-B1-C1, A1 less-than B2, and A1 more-than C2. From these trained relations, participants were able to respond accurately to seven derived stimulus relations. Participants were then trained a self-discriminative function which required participants to make a response on three schedules of reinforcement. If a response was not made, participants were trained to select novel stimulus X1, if one response was made then participants were required to select B1, and finally if two responses were made, participants were required to select novel stimulus X2. In a test for transformation of function, it was found that when participants made no response, they selected B2, if they emitted one response they selected C1 and when they made two responses, they selected C2. These findings could only be accounted for through the transformation of the self-discriminative functions through same, more-than and less-than relations.

Whelan and Barnes-Holmes (2004) were the first to demonstrate a transformation of consequential functions in non-equivalence relations, namely same and opposite relations. Whelan and Barnes-Holmes (2004) trained arbitrary stimulus A1 as a conditioned punisher. Secondly, contextual cues for the relations same and opposite were established through non-arbitrary relational training. Once these cues had been acquired, participants were trained the network A1 is the same as B1 and C1, and opposite to B2 and C2. When presented with the stimuli from the network under extinction conditions it was found that the C2 stimulus functioned as a reinforcer due to the relation of 'opposite' to A1, even though a reinforcing function had never been directly trained. These findings demonstrated that functions that are 'opposite' to any given function may be acquired through the transformation of function. Whelan and Barnes-Holmes (2004) were then able to reverse this effect by training B2 as a conditioned punisher, and showing that the reinforcing functions transformed to C2.

Whelan, Barnes-Holmes, and Dymond (2006) provided further support for the transformation of consequential functions by training a seven member relational network. In this experiment, participants were trained a network of nonsense words A<B, B<C, C<D, E>D, F>E and G>F. In the next phase stimulus D was paired with the delivery of points, thus establishing D as a reinforcer. When participants were later presented with the stimuli from the network, participants showed an increased preference for the stimuli that appeared higher in the network.

Features of derived relations and transformation of function are integral to RFT, as the theory argues that in order for an event to be considered a verbal event, some form of arbitrarily applicable relational responding and a transformation of function must take place (Dymond & Rehfeldt, 2000). It has been shown that non-humans can respond correctly when presented with non-arbitrary relational training tasks or tasks in which discriminative stimuli are differentially reinforced, therefore the ability to respond accurately in such a way does not constitute a verbal event (Hayes, Gifford, & Wilson, 1996). To illustrate the concept of arbitrary responding, consider the example given by Dymond and Rehfeldt (2000) of a child who has a direct history of stopping at stop signs. Given the child's learning history, the stop sign is acting as a discriminative stimulus and this is event is non-verbal. However, if the child has derived an equivalence relation between the stop sign, the spoken word "stop", and the signal of the school crossing patrol to stop, when the child's teacher later gives the instruction "stop" when crossing a road, the child will behave in the same way as when presented with the stop sign, as the functions of the sign will transform to the command "stop" (Dymond & Rehfeldt, 2000). The spoken word "stop" and the written word stop share no similar physical properties. Therefore this would be considered a verbal event as derived arbitrary relations and transformation of stimulus function were occasioned.

The human capacity for responding to arbitrary stimuli when it is not possible to respond based on the physical properties of a stimulus, is possible due to responding being brought under contextual control. When relational responding is arbitrarily applied, this gives rises to relational frames which are determined by an organism's individual history of responding to a particular cue. Hayes et al. (2001) assert that many different features of an event can function as a contextual cue, although these cues often consist of written words or spoken phrases. Dymond and Rehfeldt (2000) suggest that RFT may be able to provide an explanation for many different complex behaviours where a traditional behaviour analytic account has typically been unable, for example, terrorism (Dixon et al., 2003) sexual arousal (Roche, Barnes-Holmes, Smeets, Barnes-Holmes, & McGeady, 2000), gambling behaviour (Dixon & Delaney, 2006) and psychopathology (Wilson et al., 2001), to name but a few.

With regard to gambling behaviour, RFT may be able to account for instances of gambling behaviour in which an individual shows a preference for a particular slot-machine despite never having experienced a win on that particular slot-machine, or why two individuals may experience the exact same contingencies of reinforcement on a slot-machine, yet one can walk away whilst the other persists (Dixon & Delaney, 2006). Dixon and Delaney (2006) give the hypothetical example of a lady named Joyce who queues for the same slot-machine, named Lucky 7s, every time she gambles, despite their being hundreds of other slot-machines of similar perhaps even better, payout probabilities being available. To Joyce, Lucky 7s is the best slot-machine to play. When we delve into Joyce's history, it transpires that Joyce had a dog named Lucky as a child, whom Joyce remembers with much affection. In this example, the psychological functions of the dog named Lucky have transformed through arbitrary relations such that the slot-machine has now acquired some of the positive functions, despite there being no common formal properties which would otherwise relate Joyce's dog with a slot-machine. Perhaps then, gambling may be, at least in part, a verbal event which participates in derived relations and transformation of functions.

The impact of derived relational responding on gambling behaviour: Illustrative research

Currently, only a handful of studies on the role of derived relational responding in gambling behaviour have been conducted. One such study using equivalence relations and a children's pre-gambling game was conducted by Dymond, Bateman, and Dixon (2010). Ethical and legal restrictions mean that children cannot be exposed to gambling, however, games of chance such as those involving dice, are often played by children and may represent a form of pre-gambling. Dymond et al. (2010) first trained and tested children for the formation of two, three-member equivalence relations (A1-B2-C1- and A2-B2-C2). Upon reaching mastery criterion, children were then exposed to a computer simulated gambling game. To play the dice, children had to select one of two concurrently presented dice. The dice were labelled B1 and B2. The game was programmed such that the die labelled B1 always rolled 4, 5, or 6 (high roll) and the die labelled B2 always rolled 1, 2, or 3 (low roll). Once participants had completed the game they were exposed to a further game, in which the dice were labelled C1 and C2. This phase was under extinction, therefore, participants selected a die as before but could not see what number they rolled. All participants except for one showed increased preference for the die labelled C1 due to its participation in an equivalence relation with B1 (the high roll die). In terms of gambling, these findings were significant as they demonstrated how an individual may transform the functions of a particular stimulus in a game, such as an image on a slot-machine, despite there being no history of reinforcement of that image on that slot-machine paying out.

Dixon, Nastally, Jackson, and Habib (2009) used an equivalence paradigm to alter the effect of the near-miss. In the first phase of the experiment, participants were presented with images containing outcomes of a slot-machine, that is, a win (C1), a near-miss (C2), or a total loss (C3), and asked to rate how close each outcome was to a win. In the next part of the experiment, participants were trained three, three member equivalence classes (A1-B1-C1, A2-B2-C2, A3-B3-C3). Stimuli A1, A2, and A3 were abstract images, stimuli B1, B2, and B3 consisted of the words "win", "loss", and "almost" respectively. Stimuli C1, C2, and C3 were the win, near-miss and loss images from the first phase. Finally, participants were presented with the slot-machine rating phase again.

It was predicted that due to the stimuli participating in equivalence relations that the word "almost" (B3) would take on some of the functions of the total loss (C3) and that and the word "loss" (B2) would take on some functions of the near-miss slot image (C2). A1 was expected to remain unchanged given the equivalence relation with the winning slot-machine (C1). It was found that 10 out of 16 participants rated the total loss closer to win than the near miss stimuli. Dixon et al. (2009) suggest that this study demonstrates that the near-miss is a not a personality trait or a faulty cognition, but it is a verbal event that can be manipulated and altered.

The first experiment to demonstrate a transformation of discriminative functions of a slot-machine in accordance with equivalence relations was conducted by Dymond, McCann, Griffiths, Cox, and Crocker (in press). Participants were trained and tested on two equivalence relations represented by A1-B1-C1 and A2-B2-C2. On completion of this training and testing, participants were then simultaneously presented with a slot-machine labelled B1 which paid out on 20% of trials, and a slot-machine labelled B2, which paid out on 80% of trials. Finally, participants were concurrently presented with slot-machines C1 and C2. In Experiment 1, slot-machines C1 and C2 were under extinction, in Experiment 2 slot-machines C1 and C2 were under conditions of non-reinforcement (participants could not see whether they had won or lost), whereas in Experiment 3 slot-machines C1 and C2 both paid out at a rate of 0.5 (matched probability). It was found that in all three experiments, participants showed a statistically significant higher preference for slot-machine C2 over slot-machine C1, due to C2 participating in an equivalence relation with B2 (the high payout slot). These findings demonstrated that derived equivalence relations and transformation of discriminative functions may influence responding on slot-machines such that gamblers can show preferences for slot-machines despite having never played them before or experiencing a win on that particular slot-machine. Given these findings, it is possible that a relational frame theory account of gambling may be able to explain real world gambling. It is critical therefore, that empirical analyses are undertaken which further investigate the transformation of gambling relevant stimulus functions in accordance with derived relations.

Summary.

Behaviour-analytic research has suggested that whilst schedules of reinforcement are integral to gambling behaviour (Dixon et al., 2006), participants do not always show a preference for the slot-machine with the highest payback percentage (e.g., Weatherly et al., 2009), and the structural characteristics may override these schedules of reinforcement (Hoon et al., 2007, 2008; Zlomke & Dixon, 2006). These findings suggest that an account of gambling behaviour based solely on the schedules of reinforcement of a slot-machine may be incomplete (Weatherly & Dixon, 2007). This lead to the suggestion that verbal behaviour may be able to account for instances of gambling behaviour that are not readily explained by contingencies of reinforcement (Dixon & Delaney, 2006), therefore research is required which involves investigating the role that verbal behaviour has to play in the development and maintenance of problem gambling.

Chapter 2

Altering Preferences for Concurrently Available Slot-Machines: Non-Arbitrary Contextual Control in Gambling Choice

The structural characteristics of slot-machines or electronic gaming machines have been implicated in the persistence and maintenance of problem gambling (Griffiths, 1990). The term "structural characteristic" encompasses many features including lights, colours, sounds, and bill payment options. Adding or removing some of these features has been shown to be associated with the level of enjoyment in slot-machine play (Loba, Stewart, Klein, & Blackburn, 2001; Sharpe et al., 2005). Loba et al. (2001) reported that video lottery terminals that had fast reels and produced sounds were played for longer periods of time than those that had slower reels and no sound.

Behaviour-analytic gambling research has conducted preliminary analyses into the effects of structural characteristics of electronic gambling machines, specifically how colour may influence slot-machine choice. Zlomke and Dixon (2006) and Hoon et al. (2007, 2008) conducted studies in which participants were presented with two concurrently available slot-machines that were identical in schedule and magnitude of reinforcement and differing only in colour (one slot-machine was yellow and the other was blue). The slot-machines paid out according to a random ratio 0.5 schedule. Magnitude of reinforcement was held constant such that one credit was required to play a slot-machine, therefore one credit lost on a losing spin, and one credit was won for a winning spin. It was found that participants showed no particular preference for either slot-machine, allocating approximately equal responding to both machines. Participants were then given a non-arbitrary relational training task in which the colour yellow was established as a contextual cue for more-than and the colour blue was established as a contextual cue for less-than. Following this training, participants were given a further 50 slot-machine trials to play, under identical conditions as before. It was found that participants allocated increased responding to the yellow slot-machine, despite both slot-machines being identical in payout probability (Hoon et al., 2007, 2008; Zlomke & Dixon, 2006).

Researchers have attempted to replicate the findings of Zlomke and Dixon (see Fredheim, Otterson, & Arntzen, 2008; Hoon et al., 2007, 2008; Johnson & Dixon, 2009; Nastally, Dixon, & Jackson, 2010). Fredheim et al. (2008) used an identical procedure to Zlomke and Dixon (2006) in non-problem gamblers yet found that unlike Zlomke and Dixon study only four out of twelve participants showed an increased preference for the more-than slot-machine at post-test. In a second experiment, the authors altered the way in which instructions were used so that individuals who had not reached criterion responding for non-arbitrary training and testing within one hour had the instructions repeated to them. Secondly, a brief interview was conducted following the experiment to identify whether participants had attended to the contextual cue (the Colour Group) or simply responded to the comparison stimuli independent of the contextual cue (the Number Group). When analysing the results, participants were then assigned to either the Colour Group or the Number Group depending on the findings of the interview. It was found that in the Colour Group, eight out of twelve participants showed increased preference for the more-than (yellow) slot-machine at post-test whereas in the Number Group only two participants out of six showed increased preference towards the more-than slot-machine at post-test (Fredheim et al., 2008).

The original non-arbitrary relational training procedure used by the Zlomke and Dixon (2006) has potential limitations, which may explain the finding of Fredheim et al. (2008). Specifically, during relational training, participants were presented with the contextual cue (a yellow or blue coloured screen) followed by three comparison stimuli. For example, the screen appeared yellow and then $1, $5, and $10 notes are presented. In this case, there are in fact two correct responses as both $5 and $10 are more than $1. This method has been criticised as, firstly, it presents an ambiguous situation due to there being two correct answers, and secondly, it may lead to the more-than cue being established as a cue for 'opposite' (Hoon et al., 2007, 2008). It is possible that these factors may explain why Fredheim et al. (2008) only saw the effect in a minority of participants in their first experiment because if the training task is ambiguous then the contextual cues will not be clearly established and, hence, may influence post-test performance.

In order to resolve the problems created by presenting three comparison stimuli, Hoon et al. (2007, 2008) employed a training task in which only two comparison stimuli were presented ensuring only one correct response per trial. During baseline, participants did not show a particular preference for either slot-machine, however, following the non-arbitrary relational training and testing phase, participants showed an increased preference for the yellow 'more-than' slot-machine. The results of the aforementioned studies are important as they demonstrate that a preference for structural characteristic such as colour, may override the direct payout contingencies of a slot-machine. The slot-machines in these studies were programmed to pay out on a schedule of 0.5, yet following non-arbitrary training the majority of participants made choices regarding which slot-machine they wanted to play based on the structural characteristic of the slot-machine despite the fact that each machine paid out on an identical schedule.

While there are merits to the research already conducted on the influence of contextual cues in slot-machine gambling, there are some methodological limitations with the research designs that have been used. First, most notably, the pre-test/post-test design, which has been used in all of the previous research on this topic, does not remove all threats to internal validity because it may be subject to test/re-test sensitivity. Second, in previous experiments, all participants received an identical number of baseline exposures (50 trials) to the slot-machine pre-test phase. Any resulting changes in slot-machine preferences may not have appeared stable because of the spontaneous change following a certain number of trials. Within single case research, there are a number of alternatives to the pre-test/post-test designs used by Hoon et al. (2007, 2008) and Zlomke and Dixon (2006) that may overcome some of the limitations just described.

The non-concurrent multiple baseline design offers an alternative to this design and aims to provide a robust demonstration of functional control (Harvey, May, & Kennedy, 2004; Kennedy, 2005; Watson & Workman, 1981). In a multiple baseline design, participants receive differing lengths of baseline trials before the intervention is implemented. In this case, functional control is demonstrated when changes in behaviour are seen only once the intervention is applied and not for any other reason. Consider this example; one participant is given ten baseline trials, another participant is given twenty baseline trials and a third participant is given thirty baseline trials before an intervention is implemented. If, following intervention, a change in the target behaviour is seen in the direction that was predicted, then assuming this change is consistent and stable, the data will have verified the prediction. If the same effect in behaviour change is seen in all three participants, then this exemplifies replication. Therefore, if a change in behaviour has been observed in accordance with the prediction, and this prediction has been verified and replicated, then it can be said that the experimenter has functional control over the behaviour, as the intervention is the cause of any changes in behaviour.

Another form of single case design is a reversal design. In a simple reversal design baseline levels of responding are recorded and once stability is achieved, treatment is implemented. These baseline data can then act as a comparison condition to the treatment condition (Chambless & Hollon, 1998) to see if the behaviour has changed as predicted. Once treatment has been employed and the level and trend of behaviour during this condition has been recorded, visual analysis of the graphed data should reveal that patterns of behaviour during the treatment phase were different to the patterns of behaviour seen during baseline. Then, once stability has been achieved in the treatment condition, treatment is withdrawn (or reversed) and behaviour should return to a similar pattern as seen during baseline. Finally, treatment is implemented once more, and assuming treatment is effective, behaviour will be recorded in this final phase will be similar to that of the first treatment phase, thus replicating the effects of treatment. If this occurs then a demonstration of functional control can be said to have taken place as a change in behaviour was seen once the intervention was in place, whereas removal of the treatment intervention resulted in behaviour returning to baseline responding. Therefore, the behaviour changes as a function of the treatment intervention. Whilst the reversal design can be a very effective method of assessing the effectiveness of an intervention, some interventions do not lend themselves to such a design as they result in irreversible behaviour changes. In such instances, a non-concurrent multiple baseline design would be more appropriate.

To date, only one published experiment has used a (non-concurrent) multiple baseline design (Dixon & Holton, 2009) and only one experiment has used a reversal procedure as part of a pre-test/post-test design (Nastally et al., 2010). In their study on delay discounting, Dixon and Holton (2009) presented participants with hypothetical choices involving differing amounts of money with differing lengths of delay before receiving the money. On each trial the contextual cues, colour pink or colour purple, were simultaneously presented. Participants then completed a non-arbitrary training procedure that was similar to that of Zlomke and Dixon (2006) except that the two contextual cues (colour pink and colour purple) were trained as 'better than' and 'worse than'. In the final phase, participants were re-presented with the delay discounting task only this time the contextual cues had acquired functions of 'better than' or 'worse than', such that participants showed less frequent discounting (Dixon & Holton, 2009).

Nastally et al. (2010) adopted the same procedure as described in Hoon et al. (2008) using problem gamblers, except that a second non-arbitrary training phase was presented in which the contextual cue that had initially been trained as the more-then cue, became the contextual cue for less-than. It was found that participants' preferences for the slot-machines reversed following the second non-arbitrary phase such that preference was now shown for the slot-machine the same colour as the cue trained as more-than in the second phase.

To overcome the limitations of the pre-test/post-test design used in previous studies, the present experiments sought to replicate and extend the findings of Hoon et al., (2007, 2008) using a non-concurrent multiple baseline design. In Experiment 1, the contextual cues were counterbalanced across subjects. In Experiment 2, the non-arbitrary training task was only implemented once responding became stable. In Experiment 3, a reversal design was incorporated to examine whether preferences could be shifted and reversed.

Experiment 1

Method

Participants

Three participants (2 males, 1 female), aged 20 to 22 years ($M = 21$; $SD = 1$), attending Swansea University were recruited through personal contacts. Participants completed the *South Oaks Gambling Screen* (SOGS; Lesieur & Blume, 1987), the most widely used instrument to assess gambling experience. A score on the SOGS of 3-4 indicates potential problem gambling, and a score of five or above indicates probable pathological gambling (Lesieur & Blume, 1987). P2 scored zero on the SOGS, while P1 and P3 both scored three ($M = 2$, $SD = 1.41$).

Apparatus

The experiment took place in a small room containing a desk, a desktop computer with 16-inch display, full sized keyboard and a two-button click mouse. Stimulus presentation and the recording of responses were controlled by the computer and were programmed in Visual Basic®.

Design

A non-concurrent multiple baseline across participants design was used and the contextual cues were counterbalanced so that two participants were trained that yellow was the more-than cue and blue the less-than cue, and one participant was trained that blue was the more-than cue and yellow the less-than cue.

Procedure

There were three phases to the experiment; slot-machine baseline trials, the non-arbitrary relational training intervention and slot-machine trials post-intervention.

Slot-machine Task: Baseline

The slot-machine task was employed to obtain data on participants' baseline choices towards two concurrently available slot-machines that were identical in schedule and magnitude of reinforcement and differed only in background colour, one being predominantly yellow and the other being predominantly blue. Participants were presented with the following on-screen instructions:

On the following screen you will see a button in the middle of the screen. When you click on the button with your mouse two slot-machines will be revealed. Click your mouse on the slot-machine you would like to play and earn as many points as possible.

On clicking the button on the screen, participants were presented with a grey screen which revealed a red button in the centre of the screen containing the instructions *Click here*. Clicking the red button presented participants with a screen containing a blue rectangular box named Slot-machine 1, and a yellow rectangular box named Slot-machine 2. These boxes were randomly positioned on opposite sides of the screen throughout trials to control for position bias. To play a slot-machine, participants clicked the *Spin* button on the left hand side of the screen. All participants started with 100 credits and only one credit could be bet at a time. On clicking the spin button the reels spun for three seconds and sound effects were heard which were similar to those of actual casino slot-machines. A winning spin consisted of three identical symbols on the pay off line, and resulted in one credit being awarded in the *Total Credits* box at the top left of the screen. A losing spin consisted of two matching symbols or no matching symbols and one credit was subtracted from the *Total Credits* box. After playing a slot-machine, participants were taken back to the initial grey screen with '*Click here*' button and a new phase began.

Each participant was presented with a different number of baseline trials, pre-determined by the experimenter: P1 received 40 baseline slot-machine trials, P2 received 80 baseline trials and P3 received 120 baseline trials.

Non-Arbitrary Relational Training

This phase trained the background colour yellow as a contextual cue for more-than and established background colour blue as a contextual cue fore less-than. For P1 and P2 the colour yellow was trained as the contextual cue for more-than and blue was the cue for less-than. This was counterbalanced for P3 so that blue was trained as the more-than cue and yellow was trained as the less-than cue.

During non-arbitrary training the background screen would appear either yellow or blue, then after approximately three seconds, two stimuli would appear on screen, one stimulus on the left and the other on the right (see Figure 2.1). The stimuli presented differed along a physical dimension. Participants were required to select an image by clicking on the image with a mouse. On selecting the correct stimulus, the word '*Correct*' was displayed on the screen for one second and a chime sound effect was heard, whereas following an incorrect respond the word '*Wrong*' was presented and a buzzer sound effect was heard. One point was awarded for each correct response, which was displayed at the top centre of the screen. The computer programme automatically proceeded to the next trial. There were 48 trials in the training phase and participants had to respond correctly across 43 trials in order to progress to the test phase. If criterion was not met, they were exposed to the training phase again.

Participants were trained with four different sets of stimuli in the relational training phase. These were pound notes (£5, £20, £50), dice (1, 4, 6), poker chips ($5, $25, $500), and letter grades (A+, C+, D-). Participants were tested with the four sets of stimuli from training and four additional sets which included coins (1p, 20p, £1), playing cards (4 of spades, 9 of spades, king), jackpots (5 million, 10 million, 20 million) and positions (1^{st}, 8^{th} 10^{th}). It should be noted however that although this phase was a non-arbitrary training task, due to the nature of the stimuli (bank notes, playing cards etc) this phase was partly reliant upon the participant having a history of arbitrary relational responding to the stimuli.

P1 and P2 learned to select the image that represented 'more-than' when the background colour was yellow and the image that represented 'less-than' when the background colour was blue. The reverse was true for P3 in the counterbalanced condition.

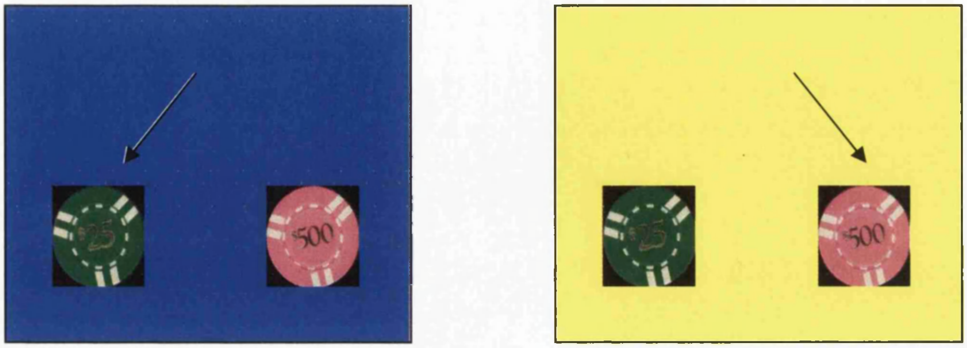


Figure 2.1. An example of a less-than (left panel) and a more-than trial (right panel) where blue is trained as the less-than cue and yellow is trained as the more-than cue. In the presence of the less-than contextual cue, the image portraying the lesser quantity is reinforced (indicated with an arrow). In the presence of the more-than contextual cue, the image portraying the greater quantity is reinforced (indicated with an arrow).

Non-Arbitrary Relational Testing

The purpose of this phase was to test whether the more-than and less-than relations established during training would be applied to four novel sets of stimuli. The novel stimulus sets consisted of coins (1p, 20p, £1), playing cards (4 of spades, 9 of spades, king of spades), jackpots (5 million, 10 million, 20 million) and positions (1^{st}, 8^{th} 10^{th}). Participants were required to respond correctly across all 48 trials. If a participant failed the test phase, they were re-exposed to the training phase. The format of the test phase was identical to the training phase except that no feedback was given.

Slot-machine Task: Post-Intervention

This phase was to investigate whether the non-arbitrary relational training task would increase responding to a particular slot-machine. P1 received 120 post-intervention slot-machine trials, P2 received 80 slot-machine trials and P3 received 40 slot-machine trials. This ensured that all participants completed a total of 160 slot-machine trials throughout the whole experiment.

Results and Discussion

All participants completed the non-arbitrary relational training and testing. Criterion for the training phase required that participants obtain a score of at least 43 in order to progress to the test phase. Participants were required to get all 48 trials correct in the test phase to complete the task.

Table 2.1.
Number of correct trials during non-arbitrary relational training and testing in Experiment 1.

Participant	Non-arbitrary Relational Training (/48)	Non-arbitrary Relational Testing (/48)
1	23	-
	27	-
	27	-
	23	-
	26	-
	24	-
	42	-
	48	48
2	26	-
	38	-
	48	48
3	36	-
	39	-
	48	48
Mean	33.93 (9.86)	48 (0)

Standard deviation given in parentheses.

Table 2.1 shows that P1 required the highest number of training phases in order to progress to the test phase, whereas P2 and P3 only required three exposures to training. All participants passed the relational test after only one exposure.

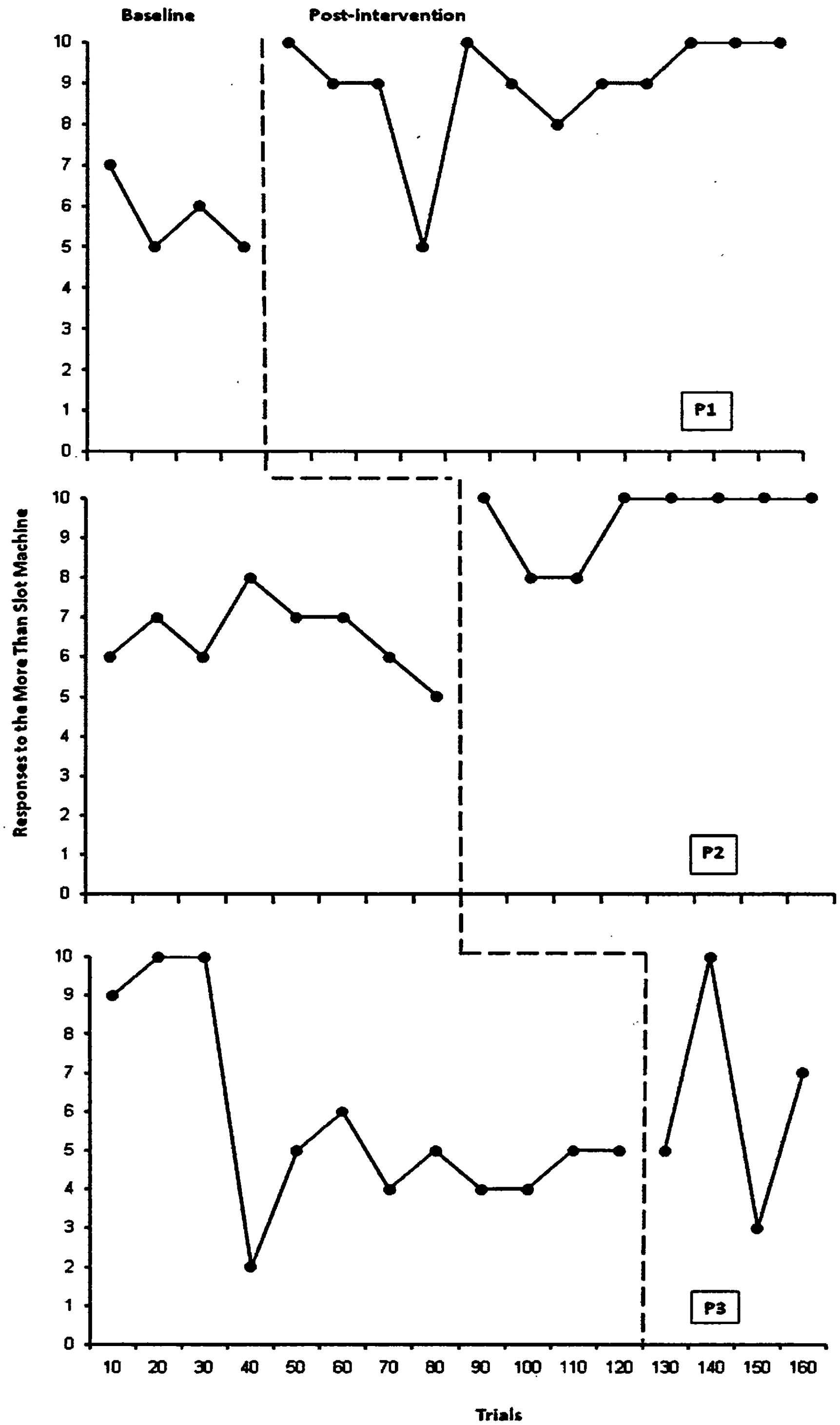


Figure 2.2. Participants' response allocation to the more-than slot-machine in Experiment 1.

Figure 2.2 depicts the number of responses allocated towards the more-than slot-machine (that is, the slot-machine that was the same colour as the more-than contextual cue) during baseline and post-intervention. All participants showed stable levels of responding during baseline, suggesting no particular preference for either coloured slot-machine. Following the relational training and testing intervention, two of the three participants (P1 & P2) showed an increase in the number of responses allocated to the more-than slot-machine. This increase remained stable for the remainder of the post-intervention phase. The participant (P3), who received the shortest post-intervention phase, showed a smaller increase in response allocation to the more than slot-machine. Overall, the percentage difference in responding allocated towards the more-than slot-machine from baseline to post-intervention was 32.5% for P1, 30% for P2, and 5% for P3. The findings of Experiment 1 support those of Hoon et al. (2007, 2008) and Zlomke and Dixon (2006) that preferences for concurrently available slot-machines may be altered in accordance with contextual cues.

Although there was a clear shift in slot-machine preferences for P1 and P2, this effect was less evident for P3, who had received the lowest number of post-intervention trials. Thus, a limitation of Experiment 1 was that the participant who received the shortest exposure to the post-intervention trials also produced unstable responding. Accordingly, this made it difficult to assess the effects of the relational training intervention on slot-machine preferences. If more trials had been given following the intervention then this may have resulted in stable responding towards one slot-machine allowing any slot-machine preference to be assessed. In order to overcome this limitation, the number of baseline trials should be determined on the basis of visual analysis (level and trend) and the intervention should be employed only once responding is stable. The same stability criteria could then be adopted during the post-intervention phase.

Experiment 2 was conducted to explore this issue in participants who met a SOGS classification of problem gambler. Problem gamblers were recruited in an attempt to increase the validity of the study and to test the extent to which contextual factors may influence actual gamblers. Additionally, in Experiment 2, the colour of the least preferred slot-machine during baseline was targeted as the contextual cue for more-than in the non-arbitrary training task in order to rule out any resulting shift in preferences towards the more-than slot-machine occurring on the basis of pre-existing colour preferences. Nastally et al. (2010) used a similar procedure to train the colour of the least preferred slot-machine during baseline as the more-than contextual cue.

Experiment 2

Method

Participants

Three male participants aged 20 to 24 years (*M* = 22.67; *SD* = 2.31) were recruited through a campus-wide e-mail advertising the study. Only participants with a minimum SOGS score of 3 were recruited. Participants SOGS scores were 7, 6 and 3 (*M* = 5.33, SD = 1.70).

Procedure

The procedure of Experiment 2 was identical to that of Experiment 1 with the following exceptions. Firstly, participants were not given a pre-determined number of baseline trials. Instead, baseline slot preferences were monitored every 30 trials and once responding appeared stable the non-arbitrary relational training task was given. Responding was said to be stable when there was no indication of an upward or downward trend, and data points fell within a small range of values (Cooper et al., 2007). Secondly, whereas in Experiment 1 the contextual cues had been counterbalanced across participants, in Experiment 2, the colour of the least preferred slot-machine during baseline was targeted as the more-than contextual cue in the relational training intervention. Following the relational training intervention, participants were re-presented with the concurrent slot-machine task. In the same way as the baseline task, responses were monitored every 30 trials and the experiment only ended once responses appeared stable. Finally, only individuals with a minimum SOGS score of 3, indicating a potential problem gambler, were recruited.

Results and Discussion

All participants completed the non-arbitrary relational training and testing phase (see Table 2.2). P5 required the fewest number of exposures to the training task before progressing to the test phase. P4 required eight exposures before reaching criterion responding. All participants passed the non-arbitrary test after only one exposure to the task.

Table 2.2
Number of correct trials during non-arbitrary relational training and testing in Experiment 2.

Participant	Non-arbitrary Relational Training (/48)	Non-arbitrary Relational Test (/48)
4	42	-
	48	48
5	26	-
	44	47
6	37	-
	48	46
	48	48
Mean	41.86 (8.09)	47.25 (0.96)

Standard deviation given in parentheses.

Figure 2.3 shows that participants' preferences for concurrently available slot-machines were altered, such that participants allocated most responding to the slot-machine that was the same colour as the more-than contextual cue. The extent of this increase in preference varied across participants, with responding by P6 showing the greatest post-intervention increase. Post-intervention responses from P4 were initially variable but increased in level and trend by the fifth block of trials where an increase in preference is seen towards the more-than slot-machine. Responses then stabilised whilst showing a fairly clear preference for the more-than slot-machine. The results for P5 are perhaps not as clear. For two of P5's post-intervention blocks of trials, he made an increased number of responses to the more-than slot-machine, and for one block of trials P5 shows equal responding to each slot-machine. Unfortunately, P5 terminated his participation before additional post-intervention trials could be administered. P6 required the highest number of baseline trials before the intervention was implemented, and then showed the most marked increase towards the more-than slot-machine during the final phase. Overall, the findings of Experiment 2 demonstrated that problem gamblers' preferences for one of two concurrently available slot-machines can be altered in accordance with a relational training intervention that targets the colour of the least preferred slot-machine, and rules out competing explanations in terms of pre-existing colour preferences.

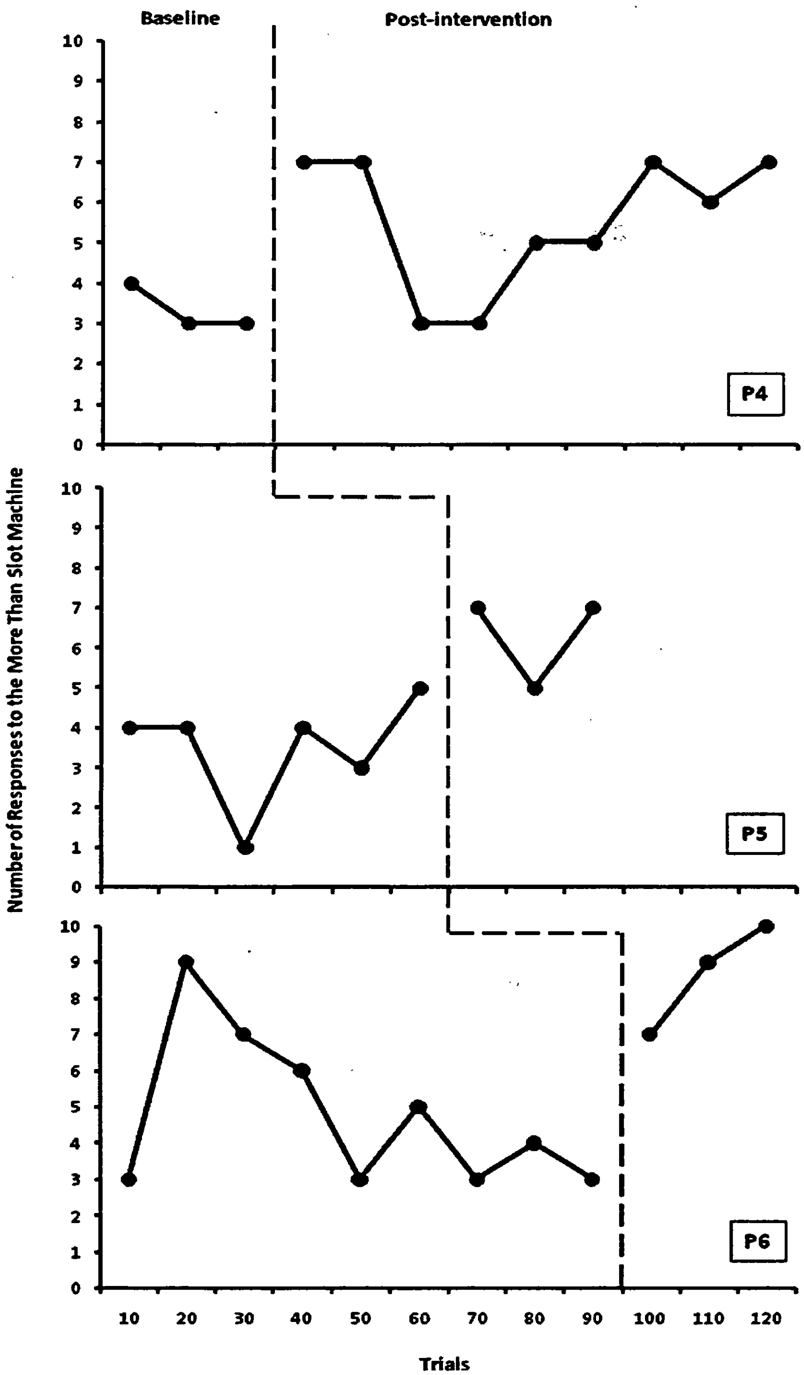


Figure 2.3. Participants' response allocation to the more-than slot-machine in Experiment 2.

In Experiment 3, an additional measure was incorporated: given that the presence of a non-arbitrary relational training task can alter participants' preferences for concurrently available slot-machines, if the original task were then reversed and the contextual cue originally established as the more-than cue was now trained as the less-than cue, it would be expected that preferences for the slot-machines would shift accordingly. Therefore, Experiment 3 was a further modification of Experiment 2 with the addition of a reversal design.

Experiment 3

Experiment 3 employed a reversal design in which, following initial baseline, intervention and post-intervention trials, the colour previously established as the more-than cue was trained as the less-than cue and vice versa in a second training intervention.

Method

Participants

In Experiment 3, there were two male participants aged 25 and 27 (M = 26; SD = 1). Only individuals with a minimum SOGS score of 3 were recruited. One participant scored 6 on the SOGS (P7) and the other scored 5 (P8) indicating that both participants were potential pathological gamblers ($M = 5.5$, $SD = 0.5$).

Procedure

The procedure for Experiment 3 was identical for that of Experiment 2 with the exception of additional non-arbitrary training tasks that reversed the contextual cues. P7 was given 2 reversals (therefore, 3 training tasks in total) whereas P8 was only given one reversal. As in Experiment 2, the least preferred slot-machine was targeted as the more-than contextual cue for the first non-arbitrary training intervention, and this was only implemented once responding appeared stable. The second (and third, in the case of P7) training intervention was also only implemented once stability had been achieved.

Results and Discussion

Both participants completed the non-arbitrary relational training and testing phase (see Table 2.3). In the first non-arbitrary training task P7 completed the training phase after just one exposure to the task (i.e., 48 trials). P8 required 2 exposures to the training task to the first non-arbitrary training task.

Table 2.3
Number of correct trials during the non-arbitrary relational training and testing in Experiment 3.

Participant	Non-arbitrary training (/48)	Non-arbitrary testing (/48)	*Reversal 1* Non-arbitrary training (/48)	*Reversal 1* Non-arbitrary testing (/48)	*Reversal 2* Non-arbitrary training (/48)	*Reversal 2* Non-arbitrary testing (/48)
7	45	47	43	47	43	48
8	35	-	43	48	-	-
	48	47	43	48	n/a	n/a
Mean	42.67	47	43	47.5	-	-
	(6.81)	(0)	(0)	(0.71)	-	-

Standard deviation in parentheses.

Figure 2.4 shows participants' preferences towards the more-than slot-machine. During baseline, both participants showed no clear preferences for either slot-machine and responding stabilized after 60 trials. Following the first relational training intervention, both participants' preferences for the more-than slot-machine increased as predicted. Following the second relational training intervention, P7 showed equal response allocation to the more-than slot-machine, whilst responding by P8 approximated to that of the earlier post-intervention phase. P7 then received a third relational training intervention and subsequently showed a decreased preference for the more-than slot-machine. This is perhaps due to the interaction of the direct contingencies of the slot-machines. From the data of P7 it appears that as more trials are undertaken, the effect of the contextual cue weakens and the payout probability exerts more control. In a similar way, P8 initially shows a slight increase for the more-than slot-machine following the first intervention, then following the second intervention shows a fairly equal preference for more than and the less than slot-machine.

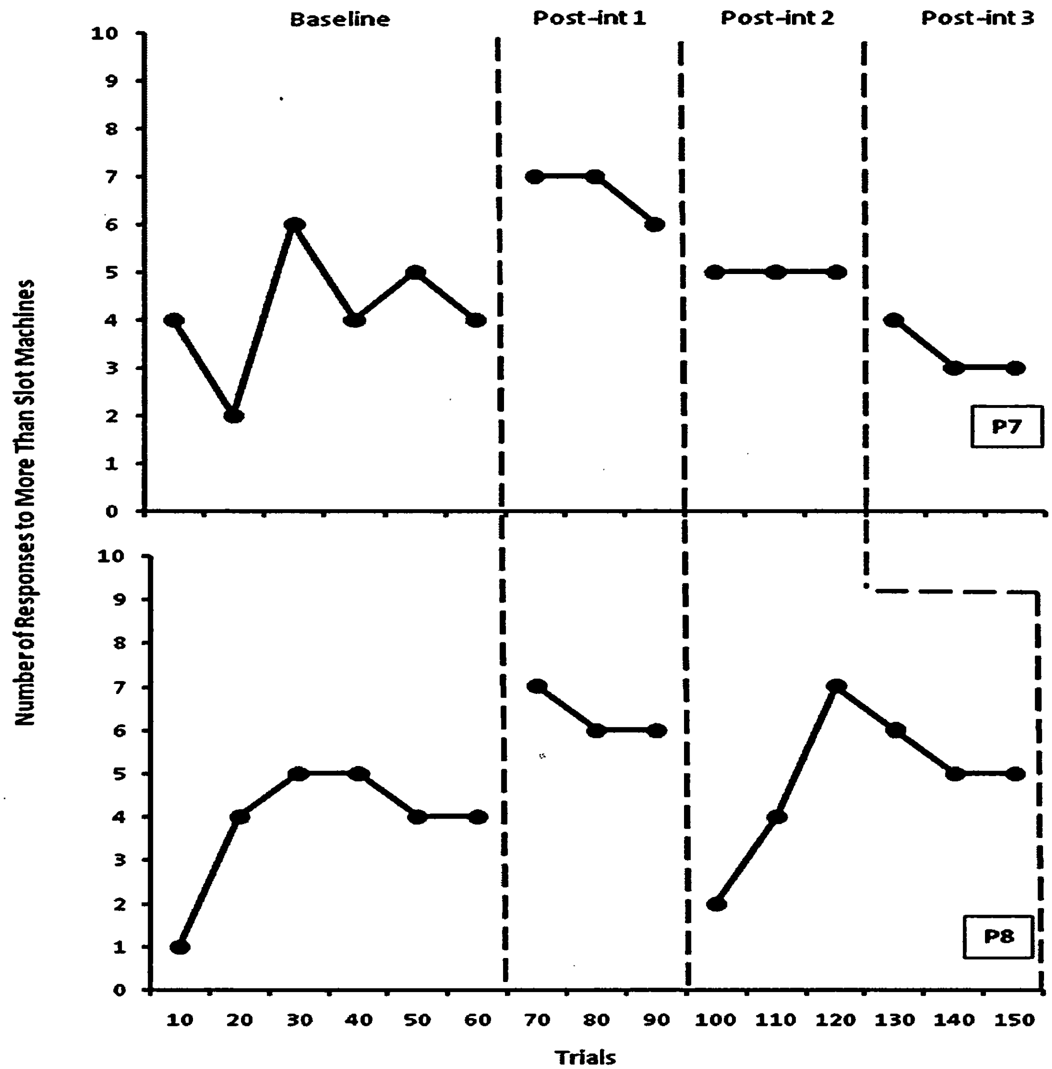


Figure 2.4. Participants' response allocation to the more than slot-machine in Experiment 3.

Overall, the findings of Experiment 3 demonstrated that problem gamblers' preferences for one or two concurrently available slot-machines may be repeatedly altered in accordance with a relational training intervention when that intervention was evaluated using a reversal design. The findings from both participants, however, illustrate that the level of altered preferences decreases as the intervention is repeated. This suggests that the effects of the intervention targeting the background colours interacted with the concurrent, matched schedule of programmed reinforcement, leading to diminished control by the background colours.

General Discussion

The current experiments aimed to replicate the findings of Hoon et al. (2007, 2008) and extend them by using a design that allowed for a better demonstration of experimental control. In Experiment 1, a clear shift was seen in P1 and P2 who allocated the majority of trials to the more-than slot-machine following the non-arbitrary intervention. The effect was less clear in P3. Unfortunately, as P3 was given the shortest number of post-intervention trials, this did not allow for his responding to become stable and, therefore, preference cannot clearly be determined from his data. This participant also received the highest number of baseline trials and had therefore most experience of the direct contingencies of the slot-machines prior to non-arbitrary training. For this reason, it is possible that the payout probabilities may have exerted more control than the contextual cue. In Experiment 2, the number of baseline and post-intervention trials given to each participant were not predetermined, but instead responses were monitored until responding appeared stable. All three participants showed an increase in response allocation towards the more-than slot-machine following the intervention. Experiment 3 incorporated a reversal design and the results were particularly interesting as the data seem to show that with extended exposure to the contingencies of reinforcement and additional non-arbitrary training tasks, the control exerted by the non-arbitrary training intervention begins to diminish and the schedules of reinforcement appear to influence responding.

Across Experiments 1-3, every participant, except P3, showed an increase in preferences towards the more-than slot-machine in the first ten trials following the first intervention. This increased response allocation was not, however, always maintained during all post-intervention trials. The findings of the present experiments, particularly Experiment 3 are perhaps not quite as clear as the initial studies by Zlomke and Dixon (2006) and Hoon et al. (2007, 2008). The finding that participants do not always show a consistent preference for the more-than slot-machine following relational training is likely due to the payout probability of each slot-machine: With the probability of the slot-machines being 0.5, it is highly plausible that a participant may experience a string of losses on what has been trained as the 'more-than' slot-machine resulting in switching over to the slot-machine that was the same colour as the less-than cue. A contextual cue can be trained to represent 'more-than', however when that cue is paired with a random ratio schedule such as that of a slot-machine, the direct contingencies of the schedule of reinforcement of that machine are also going to influence responding and may conflict with the individual's understanding of the properties of the contextual cue. Whilst it has long been understood that contingency-shaped behaviour and the schedules of reinforcement are an important factor in gambling behaviour (Skinner, 1974) the extent to which contextual cues may interact with or override direct contingencies of reinforcement are not clearly understood.

The interaction between the contextual cues and the contingencies of the slot-machine highlight the need for this sort of research to present slot-machine tasks following intervention under extinction (or, more accurately, non-reinforcement). Had participants only been able to play the slot-machines but not actually experience any wins or losses, then the contextual cue may have continued to control behaviour. Although presenting trials under extinction may overcome some of the limitations of the present experiment, the reality is that in a casino environment it is always possible that an individual will experience winning trials of varying size on an electronic gaming machine, therefore presenting solely extinction trials will not completely imitate gambling.

One alternative to presenting slot-machines under extinction would be to alter the payout probability of the slot-machine. The payout probability of the slot-machines in the present experiments was 0.5 and five credits were awarded for a winning spin, which is fairly generous compared to those of casino slot-machines (Parke & Griffiths, 2006). It would be interesting to see to what extent the contextual cues exert control when the payout probability was set to 0.3 as wins would occur less frequently therefore the contextual cue may function as a more salient rule and continue to exert control over behaviour.

Perhaps the findings of current experiments give rise to the question; is this is as far as non-arbitrary research on gambling can take us? Electronic gaming machines are rarely, if ever, controlled solely by the formal properties of the stimuli and the nature of stimulus functions are beyond such formal characteristics. The present findings indicate that factors other than just schedules of reinforcement may govern preferences for slot machines. Whilst this is an important contribution to our understanding of slot machine gambling behaviour, explanations of non-arbitrary contextual control of gambling may fall short as they are unable to explain how an individual with no prior history with a particular contextual cue can show preferences for a particular slot machine. Future research requires a verbal account of gambling behaviour and the role of transformation of functions in the acquisition and persistence of problems with gambling.

Chapter 3

Transformation of Discriminative Slot-Machine Functions via Equivalence Relations: The Role of Accurate and Inaccurate Instructions

There are many situations in which an individual is presented with a choice between concurrent schedules. The generalised matching law was proposed to analyse how organisms respond given such a choice. According to Rachlin (1971) the generalised version of the matching law states "organisms divide their time between alternatives in proportion to the value of the reinforcement consequent on the choice" (Rachlin, 1971, p. 249).

The casino environment is a situation in which a gambler is presented with concurrent schedules of reinforcement as choosing to play one slot-machine results in not being able to respond to the other slot-machines available (Dixon et al., 2006). Dixon et al. (2006) applied the matching law to evaluate participants' preferences for concurrently available computer simulated slot-machines. One slot-machine paid out on a VR-10 and the other paid out on a VR-50. It was found that 83% of participants allocated greatest responding to the VR-10 slot-machine, therefore the matching law could account for the 83% of participants' responding. These findings were broadly consistent with Savastino and Fantino (1994) who found that humans were able to maximise reinforcement on concurrent schedules. However, Haw (2008) failed to replicate these findings reporting that reinforcement did not affect slot-machine selection, but did affect when an individual changed machines. This suggests that humans are not always able to maximise reinforcement.

Although the matching law can account for non-human responding to concurrent schedules in which reinforcement is maximised, there is research to suggest that humans do not always emit responding that maximises reinforcement on concurrent schedules (Hayes et al., 1989; Madden & Perone, 1999). This lead to the proposal that language may be a key factor in human schedule performance and resulted in research being conducted into the effects of instructions on concurrent schedules. Hayes et al. (1986) investigated the effects of instructions on responding to concurrent schedules. Participants were required to respond to multiple schedules, a FR-18 and a DRL-6 sec schedule, by pressing a button for a chance to win monetary reinforcement. It was reported that when given inaccurate instructions, participants' responding varied greatly and few points were won. In the accurate rule condition, however, participants earned more points and showed schedule sensitive responding.

Findings such as these (see Hayes, 1989, for a book length review), have suggested that rule-governed behaviour may override direct contingencies of reinforcement such that humans respond in accordance with externally stated rules or self-stated rules and not the schedule in place (Hayes et al., 1989). The term "rule-governed behaviour" was first coined by Skinner (1966) and described how rules or instructions may influence behaviour without being shaped by contingencies of reinforcement (Törneke, Luciano, & Valdivia, 2008). The literature on rule-governed behaviour has demonstrated that instructions may even override contingencies of reinforcement (Galizio, 1979) and these instructions continue to exert control despite being at odds with the schedules in operation.

Gambling and rule-governed behaviour

An experiment by Weatherly and Meier (2008) investigated the effects of the presence or absence of accurate rules on gambling persistence. Participants were given 100 tokens to play a slot-machine and told to try and win as many tokens as possible. This phase of the experiment ended if either the participant ran out of tokens, the participant quit or if 15 minutes elapsed. In a later session participants were allocated to one of three groups. The first group were given instructions regarding the random ratio (RR) nature of slot-machines in which every spin is independent of the last, the second group were given information about the payback percentages of slot-machines and advised against playing slot-machines for a long period of time, whereas group three were given both sets of instructions. Significant decreases in the number of gambling trials played and the number of credits bet were seen across all groups. However the presentation of these rules did not eradicate gambling (Weatherly & Meier, 2008). It was concluded that gambling is partly rule-governed and that providing accurate information about gambling may help to reduce gambling behaviour (Weatherly & Meier, 2008).

Dixon, Hayes, and Aban (2000) conducted an experiment into the effects of accurate and inaccurate rules on persistence when playing roulette. In the first phase, participants were exposed to a game of roulette in which the outcomes were determined randomly and were not given any instructions regarding the contingencies of the game. In the second phase, participants played another roulette game that paid out on 20% of trials, 80% of trials, or the random schedule as before, and presented with accurate, inaccurate or no additional rules. The accurate rules consisted of statements such as "roulette is a losing game, you should quit as soon as possible" (Dixon et al., 2000, p. 693) and instructions to bet only a few chips.

Inaccurate rules consisted of being told that roulette is a winning game and to bet large numbers. Finally, participants were presented with a further roulette game in which the payback probability was 0.2. There was an option to end play at any time. It was found that participants who received inaccurate rules placed larger bets and gambled for longer than those who received accurate rules. Furthermore, participants' gambling was determined by the rule given, whether accurate or inaccurate, despite the contingencies of reinforcement being contrary to the rule (Dixon et al., 2000).

The studies by Weatherly and Meier (2008) and Dixon et al. (2000) suggested that the presence of accurate and inaccurate rules can influence gambling behaviour. These findings support the assertion of Porter and Ghezzi (2006) that merely analysing the contingencies of reinforcement is not enough to explain gambling behaviour, they state; "what is needed is a rigorous analysis of how verbal behaviour is affected by the prevailing contingencies, this in the context of examining the various rules that pathological gamblers routinely bring to and/or derived from the contingencies and then follow as gaming strategies" (Porter & Ghezzi, 2006, p.26).

The aforementioned studies suggest that contingencies of reinforcement alone may not wholly account for gambling behaviour, as humans do not always show schedule sensitive responding when gambling (Weatherly et al., 2009), and rules may interact with these schedules or even override the contingencies (Dixon, 2000; Weatherly & Meier, 2008). The studies described each involved presenting different types of instructions, some accurate and some inaccurate, and then determining the relative effects on slot-machine choice and persistence in gambling. For the analysis of gambling behaviour to continue to proceed, what is now needed is a functional analysis of role of instructions and rules in overriding and otherwise counteracting the direct contingency control exerted by underlying schedules of reinforcement. To this extent, the literature on rule-governed behaviour and gambling may be incomplete. As Hayes et al. (1989) have suggested, in work of this kind "instructions were treated as an object, not a term that referred to a functional relation between environmental stimulation and the action of the organism" (Hayes et al., 1989, p. 193). This is problematic as behaviour analytic explanations of different categories of stimuli have always been explained in terms of the functional relation between the stimuli and the behaviour it occasions (Hayes & Hayes, 1992), yet instructional control was not specified in this way. *In other words, exactly how these instructions* *came to exert control were not addressed.* Furthermore, if instructions are treated as an object in the same way as any other stimulus that becomes discriminative for a certain behaviour, then this implies that all instructions must be directly learned (Hayes & Hayes, 1992) and that instructions will only be followed when they are accurate and will not be followed when they are inaccurate (Galizio, 1979). In terms of gambling behaviour, it is likely that the gambler will not have been presented with any rules, whether accurate or inaccurate, about the chances of a win on a particular game. In the absence of a functional analysis of the role played by externally-delivered rules in the analysis of gambling behaviour, researchers are left clutching for explanations of how, for instance, a gambler can play a slot-machine for the first time in the absence of any externally delivered rules or instructions, yet may hold certain beliefs or self-rules about how 'lucky' that slot-machine is. Therefore a traditional account of rule-governed behaviour may be unable to account for an individual's gambling in a *novel* environment.

From self-rules to derived relational responding

Gamblers may form their own self-rules that influence the way they gamble on slot-machines. According to Zlomke and Dixon (2006), self-rules may form when novel stimuli acquire certain functions through differential reinforcement, and these functions are then applied to other objects within the environment. In studies by Zlomke and Dixon (2006) and Hoon et al. (2007, 2008) participants showed a preference for one particular slot-machine based on the structural property, namely colour, of that slot-machine despite a second slot-machine being concurrently available that was identical in payout probability.

Whilst these findings are a valuable addition to the gambling literature, there are instances of gambling behaviour that cannot be accounted for by instructional control, structural characteristics, and schedules of reinforcement. Consider, for instance, the gambler who insists on always playing the same slot-machine even though that individual has never experienced a win of that particular machine, and despite there being many other slot-machines available to play (Dixon & Delaney, 2006). It is possible that derived relational responding and the transformation of functions may account for such behaviour. For example, if a gambler was told "the lucky sevens slot-machine always pays out", it is likely that this individual will choose to play the lucky sevens slot-machine, assuming the rule-giver is considered a credible source in the eyes of the gambler. Suppose now, that in the gambler's learning history "lucky sevens" participated in a derived same or similar relation with "magic charms". Given the choice between a magic charms slot-machine and another slot-machine, the gambler may choose to play the magic charms slot-machine due to the functions of the rule delivered about the lucky sevens slot-machine, as they both participate in a derived relation.

To date, only a handful of empirical gambling studies have sought to demonstrate a transformation of discriminative functions in gambling scenarios. The first study to demonstrate transformation of function in slot-machine gambling was conducted by Dymond et al. (in press) who demonstrated that gambling relevant functions may be transformed in accordance with derived relations and influence responding on slot-machines that have never been played before. This finding provided empirical support to the suggestion that gambling behaviour is not controlled purely by schedules of reinforcement and suggests that it is not just the presence or absence of inaccurate rules that influence gambling behaviour. It has already been discussed that the matching law may not be able to account for the way in which people gamble (e.g. Dixon et al., 2006; Weatherly et al., 2009) and that accurate or inaccurate instructions may also be influential (Dixon, 2000; Weatherly & Meier, 2008). However, research of this kind is limited because it does not allow for a functional account of the way in which instructions control behaviour (Hayes et al., 1989).

Experiment 4

Research is needed, and functional explanations proffered, of the ways in which verbal rules may influence gambling behaviour. It is possible that paradigms involved in research on equivalence relations may be useful in this regard, particularly due to the way in which they have defined verbal rules. In effect, rule following may be dependent on derived stimulus relations (Hayes & Hayes, 1992). Derived relations, such as equivalence relations, may be crucial to the understanding of verbal events such as rules, as verbal events are considered as members of relational classes which participate in a network of arbitrary relations with other events in the environment (Hayes et al., 1989). In other words "verbal stimuli are those that participate in derived stimulus relations and that have their functions based, in part, on the transfer of functions" (Dymond & Rehfeldt, 2000, p.240).

Dymond et al. (2011) showed that the discriminative functions of a slot-machine can transform in accordance with equivalence relations, but given that rules also participate in derived relations, this opens up the question as to whether the transformation of discriminative slot-machine functions may be influenced by accurate and inaccurate rules.

Only one published study has demonstrated a transformation of discriminative function through equivalence relations in computer simulated slot-machines (Dymond et al., in press). Investigating whether transformation of function occurs in gambling scenarios may help explain why individuals develop preferences for one slot-machine over another, despite having never experienced a win on that slot-machine (Dixon & Delaney, 2006). Experiment 4 was designed to examine the effects of accurate and inaccurate rules and the role of transformation of function on slot-machine choice.

In Experiment 4, participants were trained on two, three member equivalence classes of nonsense words represented by A1-B1-C1 and A2-B2-C2 through arbitrary relational training and testing. Following this, two slot-machines labelled B1 and B2 were presented sequentially. These slot-machines were identical in schedule and magnitude of reinforcement. Finally, participants were presented with slot-machines C1 and C2 under extinction. There were three conditions in this phase in which participants were given different instructions regarding how to play the slot-machines. Participants in the Minimal condition were given minimal instructions in which they were told to try and win as many points as possible, participants in the Specified condition were told that slot-machine C1 paid out more, and participants in the Unspecified condition were told that one slot-machine paid out more than the other but were not told which one. It was predicted that participants in the Minimal condition would show equal responding to slot-machines C1 and C2 due to a transformation of the discriminative equal payout functions of B1 and B2, where C1 and C2 participate in an equivalence relation with B1 and B2, respectively. It was predicted that in the Specified condition the verbal rule would exert control over behaviour; therefore participants would show an increased preference for slot-machine C1. Finally, in the Unspecified condition it was predicted that participants would show a preference for one slot-machine over the other, but which slot-machine this was, would vary between participants. In summary, it was expected that a transformation of discriminative function in accordance with the equivalence relations would occur in the Minimal condition, but that where additional verbal rules were given, the verbal rule would control responding.

Method

Participants

Thirteen participants, six males and seven females, aged between 18 and 34 (*M*=23, SD=4.63) were recruited from Swansea University. Participants were administered the *South Oaks Gambling Screen* (SOGS; Lesieur & Blume, 1987). Participants were not excluded on the basis of SOGS score as in Chapter 2, due to ethical and practical implications of recruiting only problem gamblers. The mean SOGS score was 0 (*SD* = 0). Participants were awarded £7 on completion of the experiment.

Apparatus

The experiment took place in a small room containing a desk, a desktop computer with 16-inch display, full sized keyboard and a two-button click mouse. Stimulus presentation and the recording of responses were controlled by the computer, which was programmed in Visual Basic®. Six nonsense words were used during equivalence training and testing. These were MEL, PAF, LEK, HUV, JOM, and ZID. They will be referred to using alphanumerics.

Procedure

Phase 1: Equivalence training

The purpose of this phase was to train conditional discriminations for six nonsense words. At the start of training participants received the following instructions:

> *In a moment some words will appear on the screen. Look at the words at the top of the screen then look at the two words at the bottom of the screen on the left and the right. Choose one of the two words at the bottom of the screen by clicking on it. Sometimes the computer will give you feedback, and at other times it will not. However, you can get all of the tasks without feedback correct by carefully attending to the tasks with feedback.*

Clicking a box at the bottom of the screen started the task.

Participants were presented with a grey screen in which a nonsense word appeared at the top centre of the screen and remained for approximately three seconds. This nonsense word then disappeared and two additional nonsense words appeared onscreen with one in the bottom left hand corner and the other in the bottom right hand corner. These words remained onscreen until participants made a response. To select a nonsense word, the participant was required to click on the word with the mouse. Making a correct selection resulted in the word 'Correct' being displayed onscreen for three seconds, whereas an incorrect selection resulted in the word 'Wrong' being displayed for three seconds. After this, a new trial began. Nonsense words A1 or A2 were always presented at the top of the screen during training followed by the B1 and B2 stimuli, or C1 and C2 stimuli, which were presented at the bottom of the screen. For example, given the sample stimulus A1, and the comparison stimuli B1 and B2, selecting B1 was reinforced. When presented with A1-B1-B2 the correct response was B2; given A2-B1-B2 the correct response was B2; given A1-C1-C2, the correct response was C2; given A2-B2-C2 the correct response was C2. Trials were presented in a pseudorandom order throughout training. Participants were required to respond across eight consecutive correct trials in order to progress to equivalence testing.

Phase 2: Equivalence testing

The purpose of the test phase was to test for equivalence relations in the absence of feedback. Participants were tested for symmetry and equivalence trials. The symmetry trials consisted of B-A trials and C-A trials, whereas equivalence trials consisted of B-C trials and C-B trials. In a B-C trial, the B stimulus would appear at the top of the screen as the sample with the C stimuli at the bottom of the screen as comparisons, whereas in a C-B trial, the C stimulus would appear at the top of the screen as the sample stimulus with the B stimuli as comparisons. The trials in this phase consisted of B1-C1, B2-C2, C1-B1, and C2-B2. It was predicted that given B1 as the sample stimulus with C1 and C2 as comparisons, C1 would be selected; given B2 with C1 and C2, C2 would be selected; given C1 with B1 and B2, B2 would be selected; and finally where C2 was the sample with B1 and B2, B2 would be selected. Each task was presented 4 times generating a total of 16 trials. Participants were required to respond correctly to all 16 trials. If a participant responded incorrectly to at least one trial, they were re-exposed to Phase 1. The program ran until participants met criterion for both Phase 1 and Phase 2.

Phase 3: Training of discriminative slot-machine functions.

The purpose of Phase 3 was to train discriminative functions for two slot-machines labelled with two of the nonsense words, nonsense word B1 and nonsense word B2. Both slot-machines paid out at a rate of 0.5 (i.e., 50% of trials) and each slot-machine was presented 25 times, generating 50 trials. Participants were presented with the following instructions:

> *In the first part of the experiment you will be given two slot-machines to play. One slot-machine is called ZID [B1] and the other is called MEL [B2]. The computer will present the slot-machines one at a time for you to play. To play the machine, click the 'Bet 1' button and then click the 'Spin' button. Your aim is to win as many points as possible. Good luck!*

The slot-machines were identical in appearance, predominantly grey containing three reels. Each slot-machine appeared on screen sequentially until each had been played 20 times. To play a slot-machine, participants were required to click on the 'Bet 1' button, which automatically deducted one credit from the 'Total Credits' box and made the 'Spin' button available. Clicking Spin called the three reels to spin for approximately five seconds before stopping. If three matching symbols appeared on the payoff line then the participant was awarded five credits in the Total Credits box. If less than three symbols were matching then participant lost a credit therefore one credit was removed from the "Total Credits" box. All participants started with 100 credits and it programmed so that all ended with 200 credits.

At the end of this phase, participants were presented with a Likert scale and instructed to rate how likely they thought it was that a win could occur on each slot-machine. The scale ranged from 1 (*very unlikely*) to 5 (*very likely*). Participants rated each slot-machine by clicking on the number on the scale with the right button of the mouse on the scale that corresponded to each slot-machine.

In an attempt to more closely simulate actual gambling, participants were told they could win money to take home with them depending on how much they won on the slot-machines. In fact, all outcomes were fixed and participants received the same amount (£7) at the end of the study.

Phase 4: Test for transformation of discriminative function.

The purpose of Phase 4 was to test whether the delivery of minimal or inaccurate rules would influence slot-machine preference. There were three conditions: Minimal instructions, Specified instructions, and Unspecified instructions. In the Minimal condition, participants were given minimal instructions that merely asked them to "try and win as many points as possible". In the Specified condition, participants were also asked to win as many points as possible but were told that "slot-machine [C1] paid out most often". In the Unspecified condition, participants were told that one machine "paid out more than the other", but were not told which one. The instructions for each condition were as follows:

Minimal condition:

You will now be presented with two slot-machines to play. Your task is to win as many points as possible. You won't always be able to see how many points you win or lose, but the computer is recording your score.

Specified condition:

You will now be presented with two slot-machines to play. Please try and win as many points as possible. You won't always be able to see how many points you win or lose, but the computer is recording your score. Most people work out that slot-machine C2 pays out the most. Your task is to earn as many points as possible.

Unspecified condition:

You will now be presented with two slot-machines to play. Please try and win as many points as possible. You won't always be able to see how many points you win or lose, but the computer is recording your score. Most people work out quickly which slot-machine pays out the most. Your task is to earn as many points as possible.

Following these instructions, participants were concurrently presented with slot-machines labelled with nonsense words C1 and C2. This phase was conducted in the absence of feedback. Participants could not actually play the slot-machine; only select which slot-machine they wanted to play. To select a slot-machine required clicking on the chosen slot-machine. Having selected a slot-machine, the next trial was initiated with two more slot-machines being concurrently presented. This phase was in the absence of feedback. Tests for transformation of function are generally conducted under such conditions (Dymond et al., in press) as providing reinforcement for this phase would make it difficult to accurately assess participants' preferences. For example, if this phase had not been conducted in the absence of reinforcement, and a participant had experienced a win for selecting slot-machine C1, this participant would now be more likely to select slot-machine C1 on their next trial given that selecting this slot-machine has just been reinforced. In this instance, the reinforcement contingencies may have interfered with the participant's preferences making it difficult to assess whether Phase 3 had influenced slot-machine choice or not. Preference for a particular slot-machine was defined as allocating at least 75% of responses to a particular machine.

As in Phase 3, participants were presented with a Likert scale and instructed to rate how likely they thought it was that a win could occur on each slot-machine. The scale ranged from 1 (very unlikely) to 5 (very likely). Participants rated each slot-machine by clicking on the number on the scale with the right button of the mouse on the scale that corresponded to each slot-machine.

Results

Table 3.1 shows that all participants except for P5 passed equivalence training and testing, therefore the data from P5 was not presented as they did not progress to the slot-machine phases of the experiment. P1, P2, P3, P7, and P9 met criterion for training and testing after only one exposure to the task. The mean number of trials required to meet criterion for equivalence training was 14.83, whereas the mean number of cycles to complete equivalence training and testing was 2.17.

Table 3.1.
Number of trials required to meet criterion responding during equivalence training and testing (Phase 1 & 2) in Experiment 4.

Condition	Participant	Equivalence training	Equivalence testing
Minimal	P1	25	16/16
	P2	13	16/16
	P3	8	16/16
	P4	13	8/16
		8	5/16
		8	15/16
		8	16/16
Specified	P6	60	5/16
		23	15/16
		8	16/16
	P7	16	16/16
	P8	27	14/16
		8	16/16
	P9	14	16/16
Unspecified	P10	20	15/16
		8	16/16
	P11	32	9/16
		8	15/16
		8	16/16
	P12	22	11/16
		10	15/16
		8	15/16
		8	15/16
		8	16/16
	P13	20	6/16
		34	15/16
	Mean	14.83 (11.04)	11.06 (4.15)

Standard deviation given in parentheses.

Minimal condition

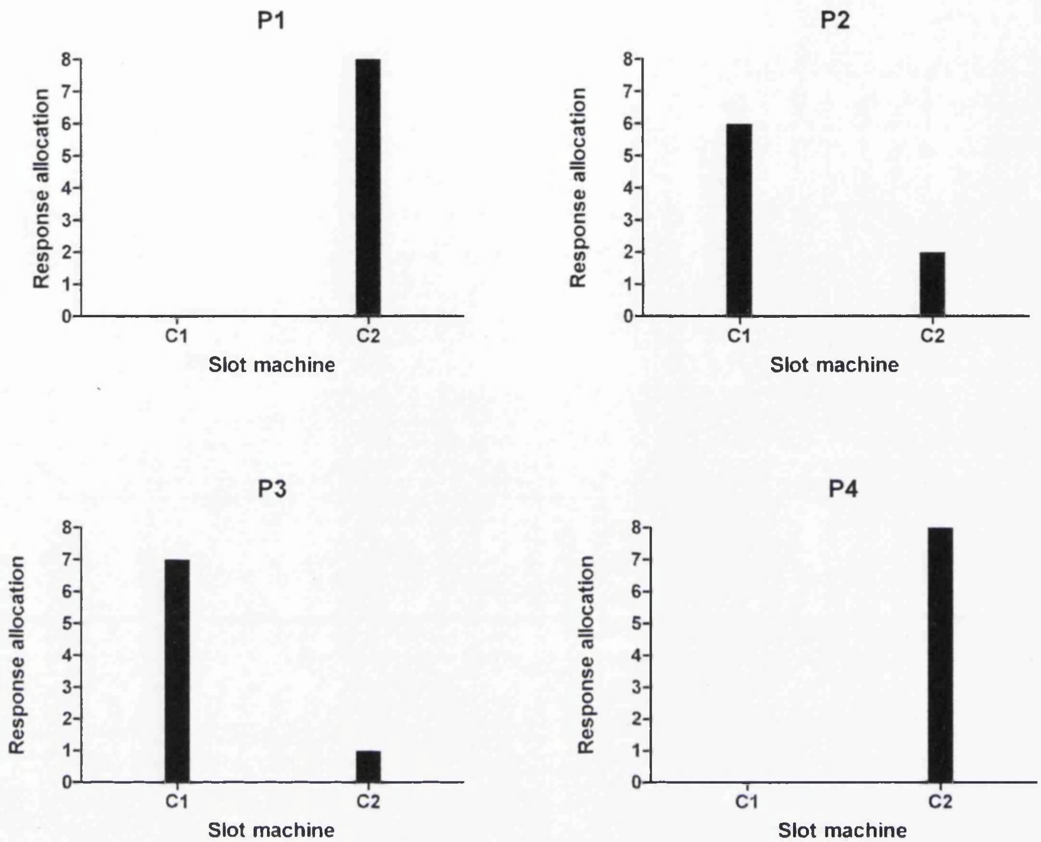


Figure 3.1. Participants' response allocation (choices of either C1 or C2) during Phase 4 of the Minimal condition in Experiment 4.

Figure 3.1 shows that all participants showed a preference for one particular slot-machine by allocating at least 75% of responses to one slot-machine, however the slot-machine that was the most preferred varied across participants. It had been predicted that participants' preferences would transform in accordance with the matched probabilities of slot-machine B1 and B2 which both paid out on 50% of trials and show approximately equal responding to slot-machines C1 and C2. It is important to note however, that participants' responding is generally quite consistent. Harrison and Green (1990) reported that when participants were presented with matching to sample tasks but not given any feedback, participant responding tended to be fairly consistent, that is, they consistently selected the same comparison stimulus in the presence of a particular sample stimulus. It seems that such consistent patterns on behaviour were in control of responding in the present experiment.

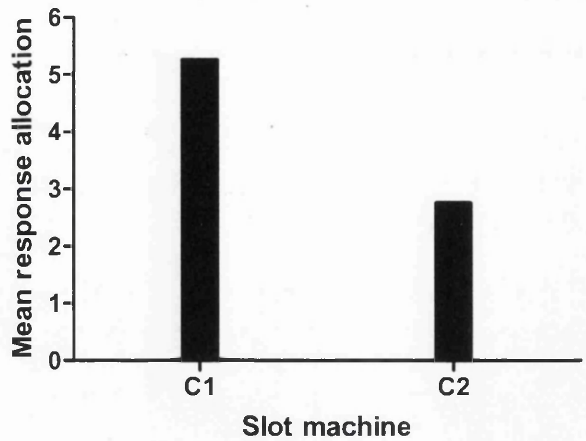


Figure 3.2. Participants' mean response allocation (choices of either C1 or C2) during Phase 4 of the Minimal condition.

Figure 3.2 shows the mean choice across all participants in the Minimal condition. There was a preference for slot-machine C1 with a mean of 5.25, whereas the mean for slot-machine C2 was 2.75.

Table 3.2.
Participants' slot-machine ratings to slot-machines B1 and B2 following Phase 3, and C1 and C2 following Phase 4 of the Minimal Condition.

	Slot-machine			
Participant	Slot-machine B1	Slot-machine B2	Slot-machine C1	Slot-machine C2
P1	2	4	2	4
P2	3	3	4	4
P3	4	3	4	3
P4	2	3	4	3
Mean	2.75	3.25	3.5	3.5
SD	0.96	0.50	1.00	0.58

1 = very unlikely, 2 = unlikely, 3 = neutral, 4 = likely, 5 = very likely

When examining the ratings data in Table 3.2 it is apparent that participants' preferences in Phase 4 were generally consistent with the ratings given to slot-machine B1 and B2 following Phase 3. For example, P1 rated slot-machine B1 as unlikely to pay out and slot-machine B2 as likely to pay out. Then, during Phase 4, P1 allocated all responding to slot-machine C2. P3 rated slot-machine B1 as likely to payout and B2 as neutral, and then went on to select slot-machine C1 on seven out of eight trials.

Specified condition

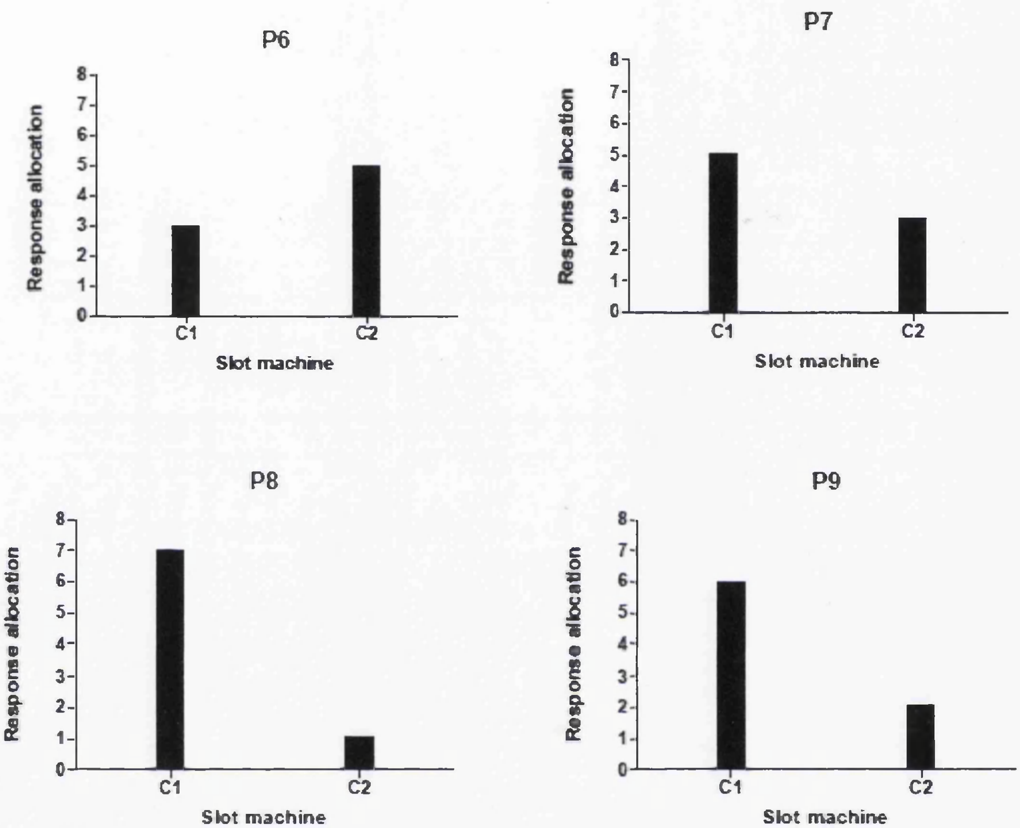


Figure 3.3. Participants' response allocation (choices of either C1 or C2) during Phase 4 of the Specified Condition where slot-machine C1 was specified as the high payout slot-machine.

In the Specified condition, participants were instructed that slot-machine C1 paid out more than slot-machine C2. Figure 3.3 shows that three out of four participants allocated more responses to slot-machine C1 over slot-machine C2, however only P8 and P9 met the 75% criterion for preference. The difference in preference between slot-machine C1 and C2 for P7 was only very small. P6 showed a slight increase in preference to slot-machine C2. This is interesting as P6 had rated slot-machine B1 as likely to pay out and slot-machine B2 as unlikely (see Table 3.3 for ratings data), and was then instructed that slot-machine C1 paid out more, therefore it would be expected that a preference would be shown for slot-machine

C1. Although P7 had rated slot-machine B2 as likely to pay out and B1 as unlikely, when instructed that C1 paid out more, they then allocated more responses to slot-machine C1.

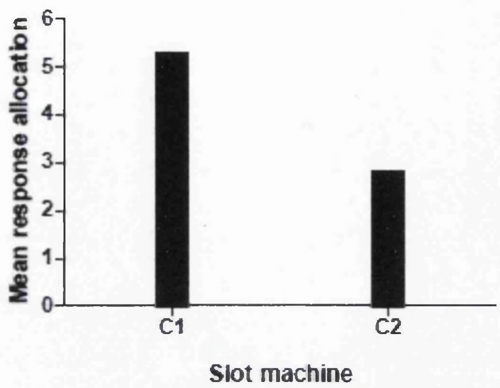


Figure 3.4. Participants' mean response allocation (choices of either C1 or C2) during Phase 4 of the Specified condition where slot-machine C1 was specified as the high payout slot-machine.

Figure 3.4 shows that on average, participants showed a preference for slot-machine C1 over slot-machine C2. The mean response allocation for slot-machine C1 was 5.25 whereas the mean response allocation for slot-machine C2 was 2.75.

Table 3.3.
Participants' slot-machine ratings to slot-machines B1 and B2 following Phase 3, and C1 and C2 following Phase 4 of the Specified condition.

	Slot-machine			
Participant	Slot-machine B1	Slot-machine B2	Slot-machine C1	Slot-machine C2
P6	4	2	4	4
P7	3	4	3	4
P8	5	4	4	3
P9	4	4	4	4
Mean	4 (0.82)	3.5 (1.00)	3.75(0.50)	3.75 (0.50)

1 = very unlikely, 2 = unlikely, 3 = neutral, 4 = likely, 5 = very likely

Standard deviation given in parentheses.

Unspecified condition

In the unspecified condition, participants were informed at the start of Phase 4 that one slot-machine paid out more than the other, therefore it was predicted that participants would show increased preference for one slot-machine over the other but it could not be specified which slot-machine each participant would prefer. Figure 3.5 shows that all participants allocated at least 75% of responding to one slot-machine over the other. P11 and P13 selected slot-machine C2 across every trial.

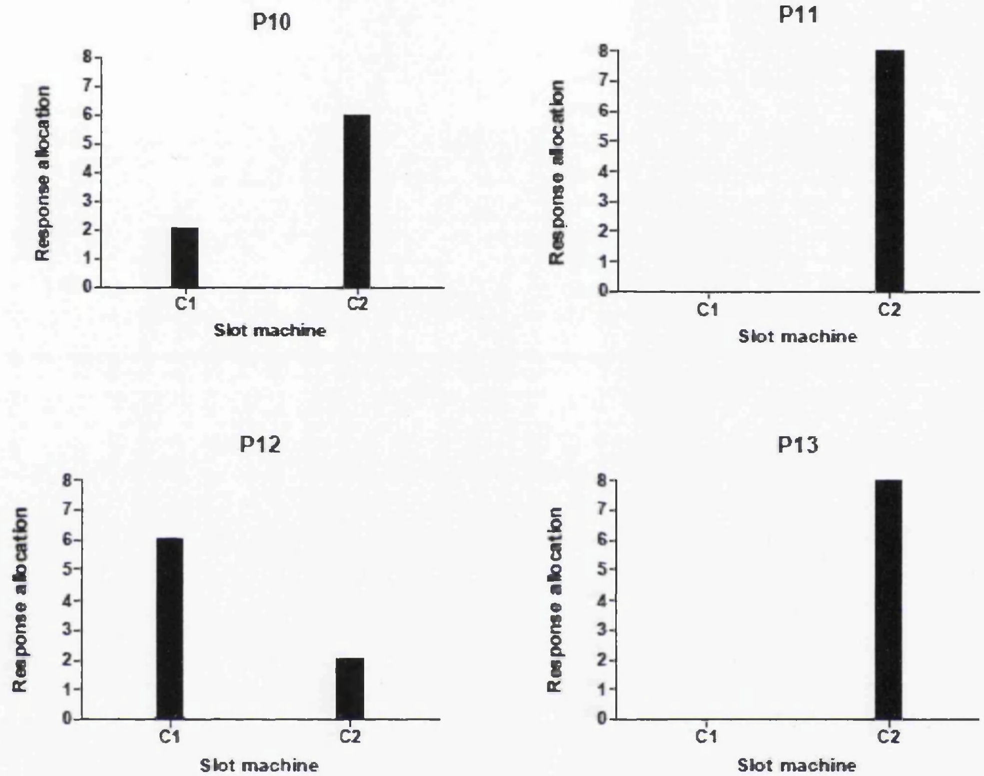


Figure 3.5. Participants' response allocation (choices of either C1 or C2) during Phase 4 of the Unspecified condition where one slot-machine was instructed as paying out more.

Regarding the slot-machine ratings data in Table 3.4, P11 and P13 rated slot-machine B2 as very likely and likely to pay out, respectively. This was consistent with their strong preference for slot-machine C2 in Phase 4. P12 rated all slot-machines as neutral although allocated more responding to slot-machine C1. The ratings of P10 were not consistent with slot-machine choice in that slot-machine B2 was rated as unlikely to pay out, yet slot-machine C2 was the most preferred during Phase 4.

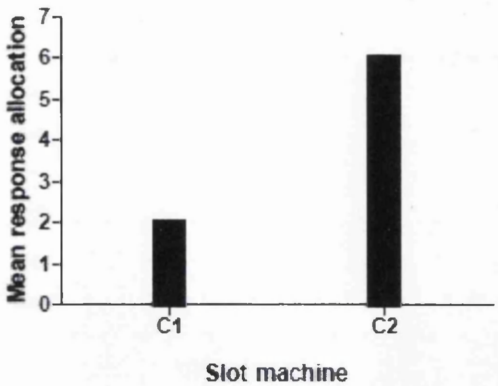


Figure 3.6. Participants' mean response allocation (choices of either C1 or C2) during Phase 4 of the Unspecified condition, where participants were instructed that one slot-machine paid out more often.

Figure 3.6 shows that more responding was allocated to slot-machine C2 across participants, with a mean response of six for slot-machine C2 and a mean response of two to slot-machine C1.

Table 3.4.
Participants' ratings to slot-machines B1 and B2 following Phase 3, and C1 and C2 following Phase 4 of the Unspecified condition.

	Slot-machine			
Participant	Slot-machine B1	Slot-machine B2	Slot-machine C1	Slot-machine C2
P10	4	2	2	2
P11	4	5	0	5
P12	3	3	3	3
P13	3	4	0	5
Mean	3.5 (0.57)	3.5 (1.29)	1.25 (1.50)	3.75 (1.50)

1 = very unlikely, 2 = unlikely, 3 = neutral, 4 = likely, 5 = very likely
Standard deviation given in parentheses.

Table 3.5 shows the sequence of responses made by participants in all conditions. It is interesting that in the Specified condition, all participants initially selected slot-machine C1 which had been instructed as the high payout slot-machine. The participants in the Minimal condition tended to allocate all responding to one slot-machine as did participants in the Specified condition.

Table 3.5.
Sequence of responding to slot-machines C1 and C2 during Phase 4 for each participant across all conditions. Bold type indicates selection of the 'high payout' slot-machine.

		Trial							
Condition	**Participant**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Minimal	P1	C2	C2	C2	C2	C2	C2	C2	C2
	P2	C2	C1	C1	C1	C2	C1	C1	C1
	P3	C2	C1	C1	C1	C1	C1	C1	C1
	P4	C2	C2	C2	C2	C2	C2	C2	C2
Specified	P6	**C1**	C2	C2	C2	**C1**	C2	C2	**C1**
	P7	**C1**	**C1**	**C1**	C2	C2	C2	**C1**	**C1**
	P8	**C1**	**C1**	**C1**	**C1**	C2	**C1**	**C1**	**C1**
	P9	**C1**	**C1**	**C1**	C2	**C1**	C2	**C1**	**C1**
Unspecified	P10	C2	C2	C2	C1	C2	C2	C1	C2
	P11	C2	C2	C2	C2	C2	C2	C2	C2
	P12	C1	C1	C1	C1	C1	C2	C1	C2
	P13	C2	C2	C2	C2	C2	C2	C2	C2

Figure 3.7 shows the mean ratings for each slot-machine in each condition. There is little variation in the mean ratings across the three conditions, with the exception of the rating for C1 and C2 in the unspecified condition.

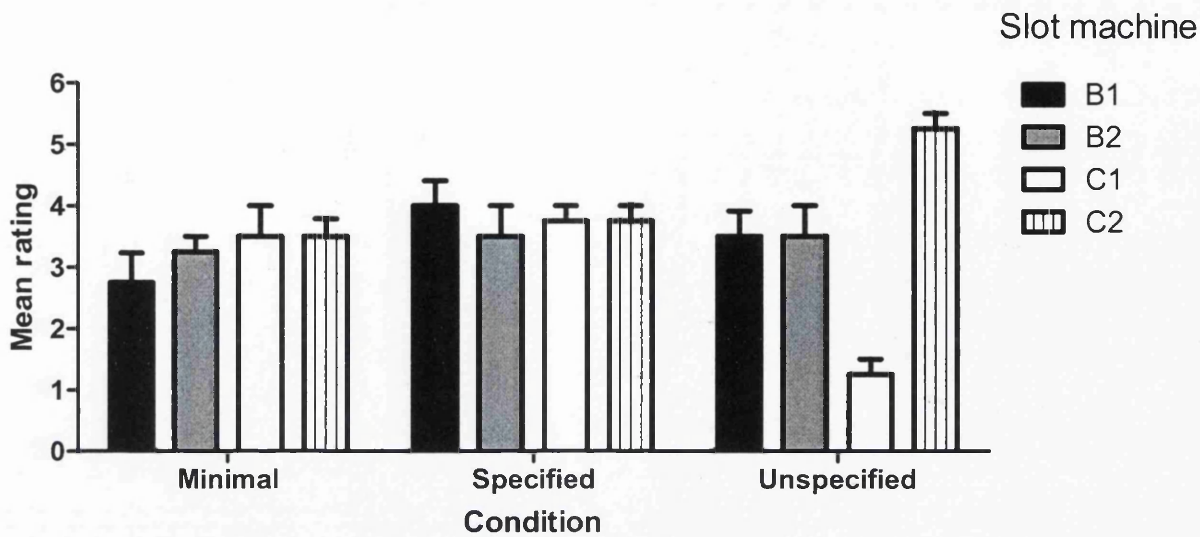


Figure 3.7. Mean ratings for slot-machines in all three conditions. Error bars indicate the standard mean error.

Discussion

Experiment 4 demonstrated that instructions may influence preferences for concurrently available slot-machines. It had been expected that participants in the Minimal condition would show equal responding to either slot-machine as participants had experienced the equal payouts of slot-machines B1 and B1 which participated in derived relations with C1 and C2. However, participants' responding indicated a clear preference for one slot-machine. The generalised matching law predicts that organisms will divide their responses equally given equal reinforcement, and therefore these findings were not as predicted. It must be highlighted, however, that the preferred slot-machine did in fact differ between participants. In the Specified condition, the experimenter delivered rule exerted control over participants' responding, with participants showing a preference for the slot-machine that had been specified as paying out the most. In the Unspecified condition, all participants showed a preference to one slot-machine over another, although which slot-machine was preferred varied.

For two out of four participants, preference for slot-machines C1 and C2 was consistent with ratings of slot-machines B1 and B2. This suggests a transformation of function in accordance with the equivalence relations between participants' perception of which slot-machine paid out more during Phase 3, and slot-machine choice in Phase 4. Here transformation was defined as participants showing response allocation to a slot-machine in Phase 4, that was consistent with the rating that had been given to the slot-machine that participated in a indirect relation in Phase 3. The findings of the present study are consistent with studies by Weatherly and Meier (2008) and Dixon et al. (2000) that experimenter delivered rules can influence gambling behaviour. The ratings data of the present experiment are consistent the findings of Weatherly et al. (2008) that humans are not always sensitive to the contingencies of a slot-machine, as many participants did not rate the slot-machines as paying out equally.

A limitation of Experiment 4 was that participants were only presented with eight slot-machine trials in the final phase of the experiment. It may have been that the extended exposure to slot-machines B1 and B2, followed by only eight trials of slot-machines C1 and C2, contributed to the unexpected results in the Control condition. Furthermore, in a real-life casino environment, gamblers may play slot-machines for extended periods of time until they choose to quit or run out of money. An additional limitation is that casino slot-machines are not under conditions of extinction therefore any rules that may have been derived by the gambler will also be interacting with the direct schedules of reinforcement of that particular slot-machine. Finally, there was no accurate rule condition in Experiment 4, as participants in the Minimal condition were merely instructed to try to win as many points as possible, but they were not informed about the payout probabilities of the slot-machines.

In Phase 4 of Experiment 5, participants were given either accurate or inaccurate rules about how to play the slot-machines in order to win as many points as possible.

Experiment 5

Method

Participants

Fourteen participants, two males and twelve females, aged between 22 and 36 (M=27.07, SD=5.37) were recruited from Swansea University. The mean SOGS score was 0.21 (SD = 0.58). Participants were awarded £7 on completion of the experiment.

Procedure

Experiment 5 was identical to Experiment 4 except for the following important differences. First, in Phase 4, participants were presented with slot-machines C1 and C2 concurrently on screen and were able to play the slot-machines. The slot-machines were identical to those presented in Phase 3, except they were labelled C1 and C2, respectively. Second, having chosen to play one of the slot-machines (by clicking 'Bet 1' and 'Spin') both slot-machine C1 and C2 remained on the screen. Both machines were of identical 0.5 payout probability. Third, there were four conditions in Experiment 5 made from a combination of accurate and inaccurate rules and the presence or absence of instructions to quit: Accurate rule (no instruction to quit), Inaccurate rule (no instruction to quit), Accurate rule (and instruction to quit), and Inaccurate rule (and instruction to quit). The instructions were as follows:

Accurate condition:

You will now choose between playing slot-machine C1 and slot-machine C2. These slot-machines have the same payout probability. Your aim is to win as many points as possible.

Inaccurate condition:

You will now choose between playing slot-machine C1 and slot-machine C2. Slot-machine C1 pays out more than slot-machine C2. Your aim is to win as many points as possible.

Control condition:

You will now choose between playing slot-machine C1 and slot-machine C2. Your aim is to win as many points as possible.

Half of the participants in the accurate and inaccurate condition also received the additional instruction stating, "You may quit at any time". Participants could end the experiment by pressing the 'Quit' button that that was situated at the bottom right of the screen. The 'Quit' button was present onscreen throughout this phase for all participants, whether or not they had been instructed that they could quit. There was a maximum of 150 slot-machine trials during this phase.

Results and Discussion

Table 3.6 shows that all participants in Experiment 5 completed equivalence training and testing. The mean number of equivalence training trials required was 21.7 trials. P14, P16, P17, P18, P20, and P23 only required one exposure to training and testing, whereas P26 required five exposures. The mean number of cycles required to meet criterion for equivalence training and testing was 2.23.

Table 3.6.
Number of trials required to meet criterion responding during equivalence training and testing in Experiment 5.

Condition	Participant	Equivalence Training	Equivalence Testing
Accurate	P14	11	16/16
	P15	21	1/16
		63	7/16
		9	0/16
		55	15/16
		8	16/16
	P16	11	16/16
Inaccurate	P17	10	16/16
	P18	55	16/16
	P19	11	9/16
		17	7/16
		8	8/16
		18	10/16
		8	16/16
Accurate (+ quit)	P20	13	16/16
	P21	8	2/16
		28	16/16
	P22	16	14/16
		8	16/16
	P23	16	16/16
Inaccurate (+ quit)	P24	28	12/16
		8	16/16

Condition (*cont.d*)	Participant	Equivalence Training	Equivalence Testing
Inaccurate (+ quit)	P25	47	8/16
		24	16/16
	P26	8	9/16
		68	10/16
		8	12/16
		21	14/16
		8	16/16
	Mean	21.17 (17.67)	11.42 (5.75)

Standard deviation given in parentheses.

Figure 3.8 shows that all three participants allocated their responses completely equally (50% to each slot-machine); however the sequence of responding varies greatly. P14 and P16 show unstable responding with the number of responses made to each slot-machine varying in each block of trials, whereas P15 shows fairly stable responding. Although participants were not instructed that they could quit at any time, P15 and P16 quit after 10 and 25 trials, respectively.

Accurate rule condition

Panel A **Panel B**

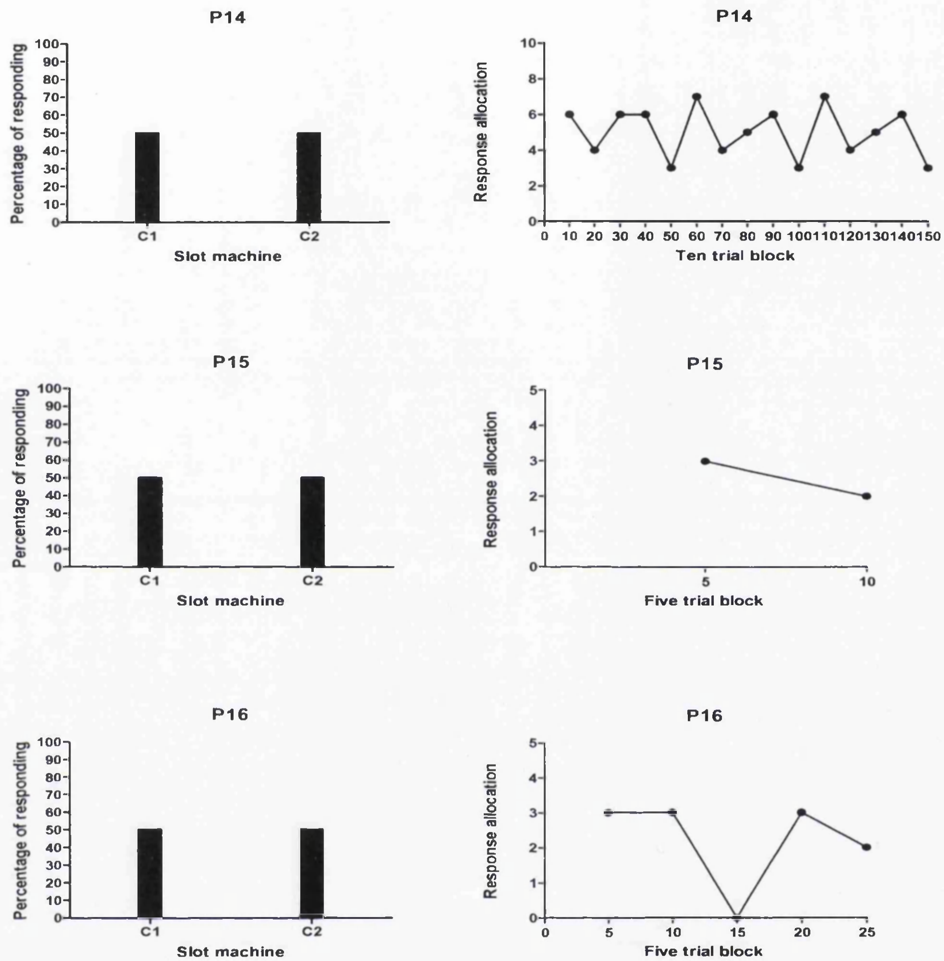


Figure 3.8. Participants' slot-machine choices to slot-machines C1 and C2 during Phase 4 of the Accurate Condition under matched probability. Figures in Panel A show the overall percentage of allocation to each slot-machine, whereas figures in Panel B show the sequence of responding given by the number of choices made to slot-machine C1. Figures in Panel B are shown in five or ten trial blocks, depending on how many trials were completed.

Inaccurate rule condition (C1 pays out more)

Panel A **Panel B**

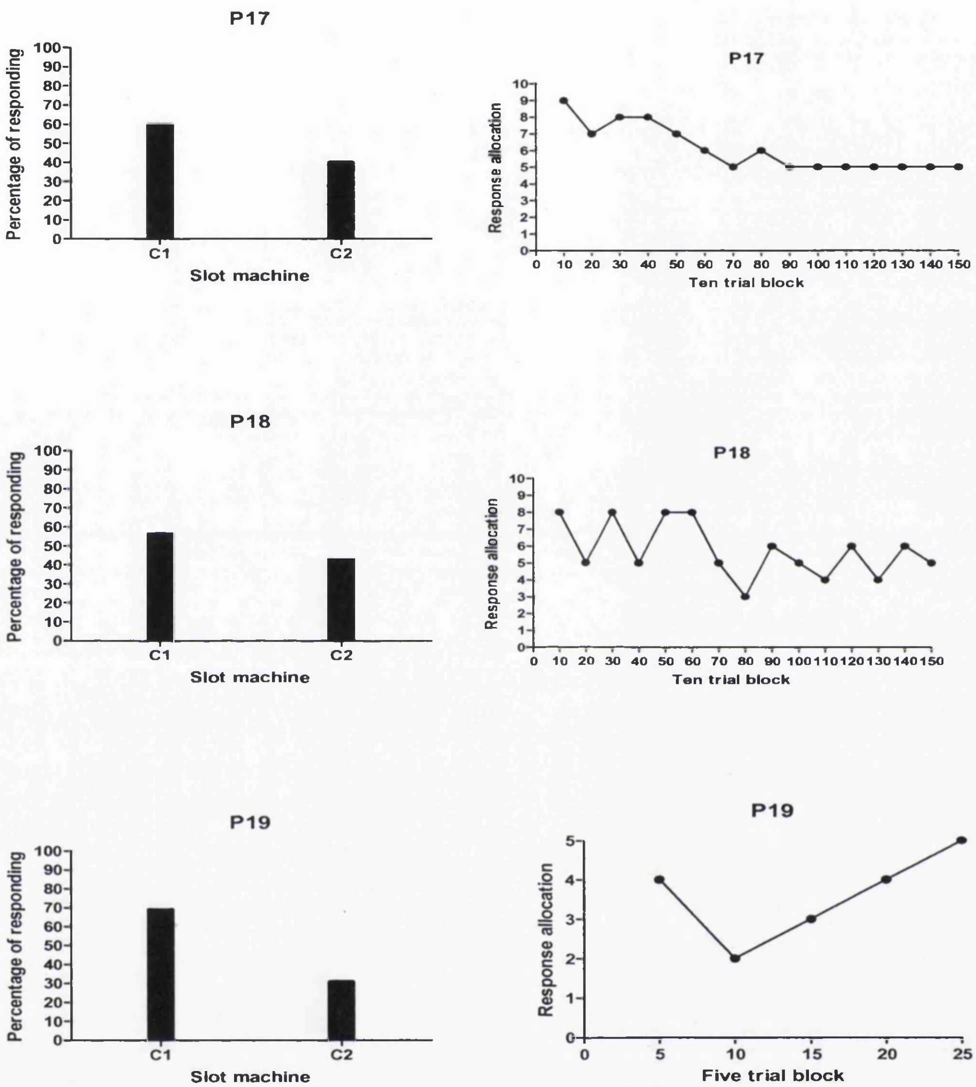


Figure 3.9. Participants' overall slot-machine choices during Phase 4 of the Inaccurate Condition are shown in Panel A, and the sequence of slot-machine choice to slot-machine C1 are shown in Panel B.

Figure 3.9 shows that all participants showed a preference for slot-machine C1 which was the slot-machine that they had been instructed as being of higher payout, however the preference shown in P17 and P18 is only very slight. From Panel B, it is clear that P17 initially showed a preference for slot-machine C1, however this decreased with extended exposure suggesting that the control exerted by the inaccurate rule diminished with responding becoming sensitive to the schedule. A similar effect was seen in P18 although responding was fairly unstable.

P19 initally showed a preference for slot-machine C1, then seemed to allocate more responses to C2, and in the final ten trials switched back to C1.

Accurate condition (+quit)

Panel A **Panel B**

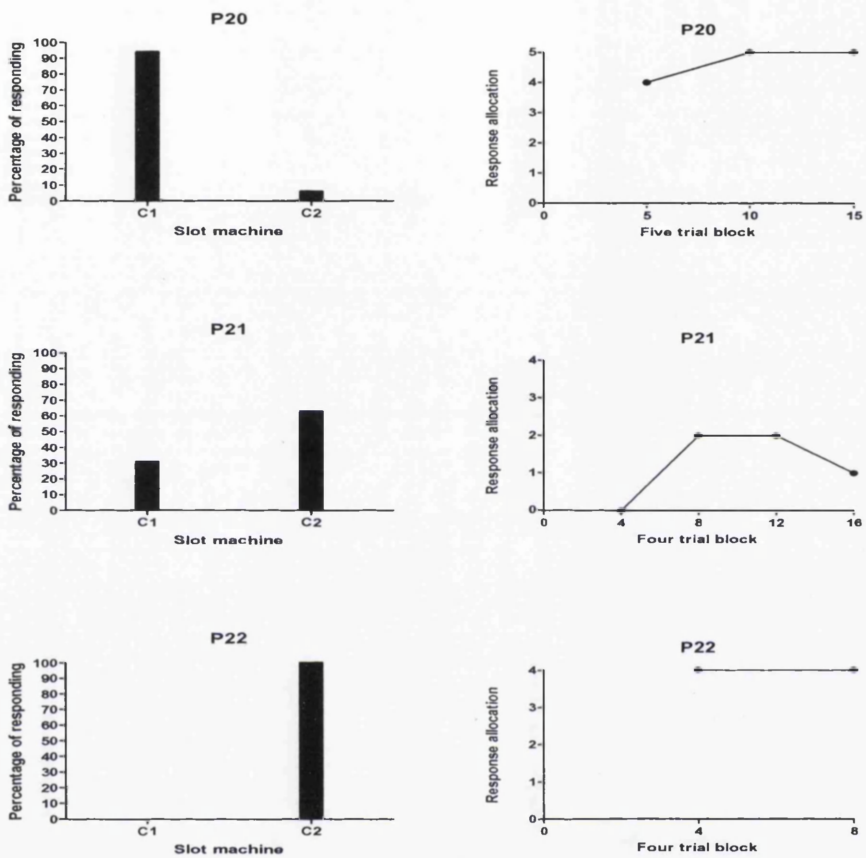


Figure 3.10. Participants' overall slot-machine choices during Phase 4 of the Accurate Condition shown in Panel A, and sequence of slot-machine choice to the most preferred slot-machine are shown in Panel B.

Figure 3.10 shows that all three participants showed a strong preference for one slot-machine over another, although there is no consistency between participants as to which slot-machine was the most preferred. All participants terminated responding within 16 trials.

Inaccurate condition (+quit)

Panel A **Panel B**

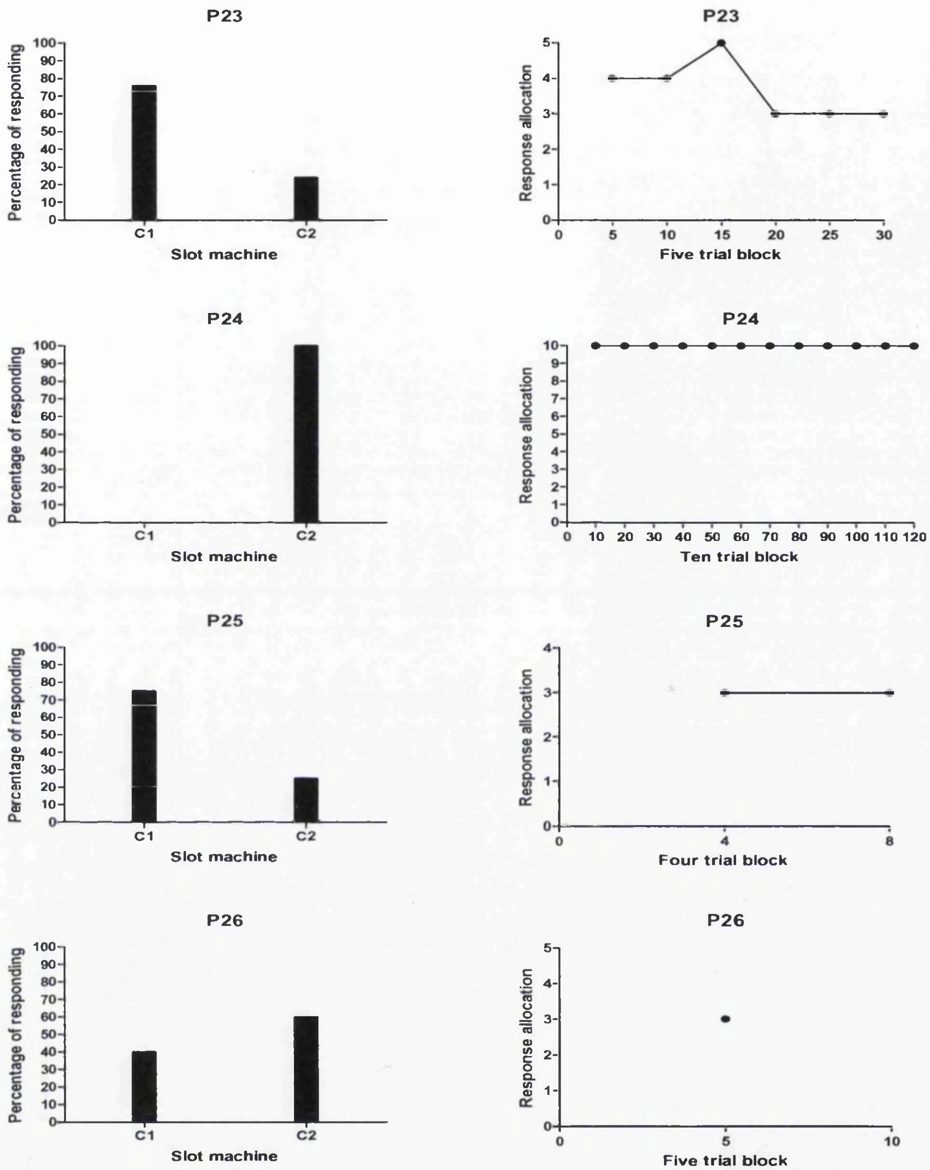


Figure 3.11. Participants' overall slot-machine choices during Phase 4 of the Inaccurate Condition are shown in Panel A, and sequence of choice to the most preferred slot-machine are shown in Panel B.

Participants in this condition were told that one of the slot-machines paid out more than the other. P23, P24,and P25 were told C1 paid out more, whereas P26 was told that C2 paid out more. Figure 3.11 shows that all participants, with the exception of P24 showed preference for the slot-machine that had been instructed as the high payout machine, although the choices made by P26 did not meet the 70% criterion. P26 however, terminated after only 5 trials so there is little data for this participant.

The sequence of responding in Panel B for P23 shows that preference for the high payout slot-machine decreased slightly across trials. P24 showed very stable responding, allocating all responses to slot-machine C2. P25 also showed very stable responding.

Control condition (no equivalence training)

Panel A **Panel B**

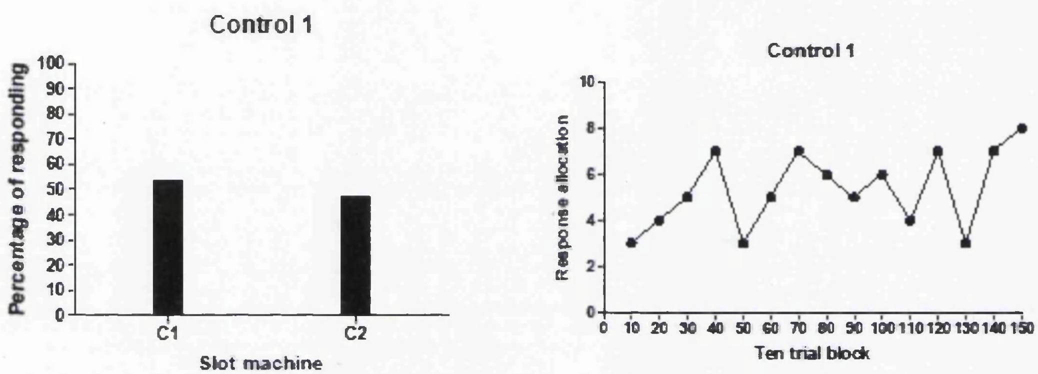


Figure 3.12. Participants' overall slot-machine choices during Phase 4 of the Control Condition, and sequence of choice to the most preferred slot-machine.

Figure 3.12 shows that participants in the control condition showed relatively equal responding to each slot-machine, suggesting that participants were emitting schedule sensitive behaviour.

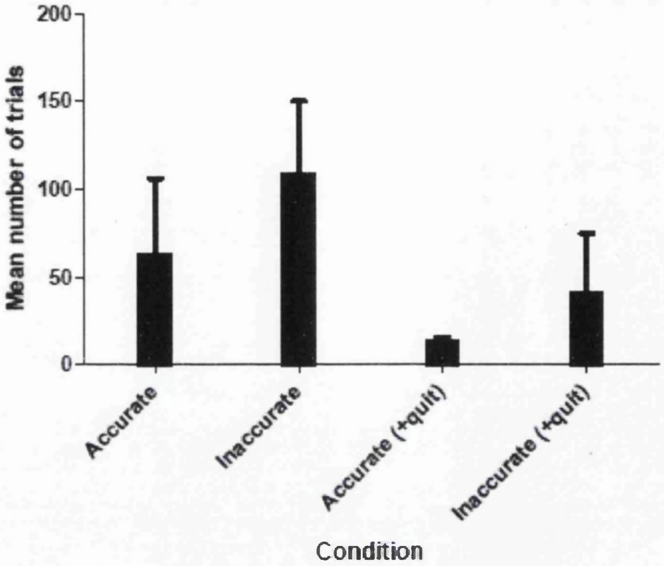


Figure 3.13. Mean number of trials undertaken in Phase 4 before terminating by participants in each of the four conditions in Experiment 5. Error bars indicate standard mean error.

Figure 3.13 shows that participants who were not told that they could quit at any time, gambled for longer than those that did receive this instruction. Participants in the Accurate (+quit) condition completed the fewest number of trials before ending the experiment, whereas those who received inaccurate instructions and were not told that they could stop at any time were the most persistent gamblers.

Experiment 5 found that when participants are presented with accurate rules about the equal payout probability of concurrently available slot-machines, participants will show approximately equal responding to each slot-machine. However, when inaccurate rules are presented, participants will initially allocate more responding to the slot-machine that has been instructed as paying out more. Additionally, as participants continue to gamble, thus experiencing the payout probabilities of the slot-machines, responding becomes more equal. This suggests that although the experimenter-delivered rule initially controls behaviour, the instructional control gradually diminishes. It was also found that participants who were not instructed that they could quit at any time gambled for longer than those who could quit when they wanted.

General Discussion

In Experiment 4, all of the participants in the Minimal instruction condition showed a preference for one slot-machine over the other. However, the preferred slot-machine differed across participants: in the Specified condition, three out of four participants preferred slot-machine C1, which had been instructed as paying out more often, (suggesting that the experimenter-delivered rule exerted control over responding), whilst in the Unspecified condition, participants' preferences were distributed equally across both slot-machines. In Experiment 5, participants in the Accurate (no quit) condition all showed equal responding. However, in the Accurate (+quit) condition in which participants were instructed they could quit at any time, a clear preference was observed for one slot-machine over the other. In the Inaccurate (no quit) condition, all three participants showed an increased preference for slot-machine C1 (instructed as being of high payout). Although the overall difference in preference was small, participants initially allocated greater responding to slot-machine C1. This effect decreased as test trials continued, suggesting that the control of the rule diminished whilst the matched schedules of reinforcement began to exert control over responding. In the Inaccurate (+quit) condition, all participants except for one, showed a preference for the slot-machine that had been instructed as paying out more often.

It is interesting to note that participants in the Minimal condition of Experiment 4 did not allocate responding equally between the two slot-machines as would be expected given the concurrent choice of identical schedules (cf. Weatherly et al., 2009). It is difficult to say why this may have occurred. However, a possible factor may have been the extensive exposure to slot-machines B1 and B2 during Phase 3 (50 trials), followed by a short exposure (8 trials) to slot-machines C1 and C2, combined with the absence of feedback. It is also noteworthy that participants' preferences for slot-machines C1 and C2 were consistent with their ratings of slot-machines B1 and B2. For example, P1 rated slot-machine B1 as unlikely to pay out and slot-machine B2 as likely to pay out, and then went on to select slot-machine C2 across all trials. This suggests that the discriminative payout functions of slot-machines B1 and B2 (as measured by ratings to each slot-machine), transformed in accordance with equivalence relations to C1 and C2, with participants showing preference for the slot-machine that participated in an equivalence relation with the instructed high payout machine.

In the Specified condition of Experiment 4, three out of four participants showed preference for the slot-machine that had been instructed as paying out the most, which suggests that the experimenter-delivered rule exerted a degree of control. In the Unspecified condition, it was predicted that participants would show a preference for one slot-machine over the other, but exactly which slot-machine was preferred differed between participants. While all participants did in fact show a preference for a particular slot-machine, it is difficult to say with certainty whether this was a result of the rule delivered, as the participants in the Minimal group also emitted similar responding. The ratings data for P11 and P13 may help shed light on this as these participants rated slot-machines B1 and B2 as very likely and likely to pay out, respectively, and then went on to allocate all responses to slot-machine C2. As in the control condition of Experiment 5, this suggests that a transformation of discriminative functions in accordance with equivalence had occurred, despite there being no actual differences in the payout probabilities of the slot-machines. P10, however, rated slot-machine B1 as likely to payout, and all other slot-machines as unlikely to pay out, but then showed most preference for C2, whereas P12 rated all slot-machines as neutral but allocated greater responding to slot-machine C1.

In Experiment 5, participants in the Accurate (no quit) condition showed equal responding to each slot-machine as was predicted, yet in the Accurate (+quit) condition all three participants seemed to prefer one slot-machine over another. One possible explanation for participants allocating responding to one slot-machine more than the other is that given accurate rules detailing that the concurrent slot-machines were of equal payout probability, responding on just one slot-machine should, in theory, result in the same amount of reinforcement as the responding to the other slot-machine, therefore, it doesn't matter which slot-machine a participant chooses to play. This finding is not consistent with predictions of the generalised matching law and is perhaps related to the type of schedule of reinforcement that was in place. Typically, interval schedules are employed in matching law research. This is because concurrent interval schedules are independent; therefore whilst an organism is responding on one of the interval schedules, the other schedule may elapse at any moment (Pierce & Epling, 1983). Given a ratio schedule however, where reinforcement can only be received for the schedule that is being responded to, preference will merely be seen for the schedule that results in the most reinforcement (Herrnstein & Loveland, 1975). In the present experiments, it was possible that a participant would receive the same amount of reinforcement by responding to just one slot-machine. There was, therefore, no great benefit to switching between the two slot-machines and nor was this possibility manipulated by the addition of variables known to influence matching or non-matching (e.g., changeover delays).

With regards to the generalised matching law, the present experiment found much variation in participants' responding. In the Accurate (no quit) condition of Experiment 5, all participants responding to the slot-machines were equally distributed as predicted by the generalised matching law, however in the accurate (+quit) condition responding did not conform to the generalised matching law. Given that the only difference between these two conditions was whether participants were instructed that they could quit or not, there are no clear reasons as to why one group would show matching and the other would not. Participants in the Inaccurate conditions did not respond in accordance with the generalised matching law, which was likely due to the rule that had been delivered. The participants in the Control condition of Experiment 5 allocated relatively equal responding to either slot-machine. It is not possible to claim whether or not participants in Experiment 4 were responding in accordance with the matching law as the final slot-machine phase in which slot-machine choice was measured was under extinction, therefore participants were not contacting any reinforcement.

The findings that some participants did not respond in accordance with the schedule in place and sometimes rated a slot-machine as being more likely to payout despite the payout probabilities being identical, are in line with those of Weatherly et al. (2009). Weatherly and colleagues reported that participants were not sensitive to the payout contingencies of a slot-machine, even when one slot-machine paid out more than another. However, as Weatherly et al. (2009) report, it is difficult to claim with confidence that allocating exclusive responding to one slot-machine can be considered a preference, as that individual hasn't experienced the contingencies of the other slot-machines. An additional problem with the present study was that all participants in the Accurate (+quit) condition terminated responding within 16 trials. It can only be speculated as to whether participants would have begun to show equal responding if extended exposure to the slot-machines had been implemented.

There is a large body of literature that suggests human behaviour is not always sensitive to schedules of reinforcement. Numerous studies have reported that in comparison to non-humans, humans do not always maximise reinforcement on schedules (e.g., Savastano & Fantino, 1994; Silberberg, Thomas, & Berendzen, 1991). Explanations for this difference in behaviour have looked to the procedural differences in experiments on non-humans and humans (Matthews, Shimoff, Catania, & Sagvolden, 1977). For example in a non-human experiment, reinforcement is often delivered in the form of a highly visual stimulus and a consumable, whereas the human participant may merely be delivered a point and no consumable is delivered (Matthews et al., 1997). A second key difference is the way in which responding is trained. A non-human's behaviour will be shaped until the organism learns to respond in the appropriate way, whereas the human subject is often given verbal instructions. It has been reported that when humans are given minimal instructions regarding how to respond, increased sensitivity has been shown (Matthews et al., 1977). In the case of the present study however, the ratings and slot-machine choice data of participants given minimal instructions in Experiment 4 suggest that participants could not accurately report the contingencies of the slot-machines.

Whilst there may be some merit to the above explanations in terms of explaining the lack of sensitivity shown by participants in the present study, when we turn again to consider actual gambling behaviour, these explanations still seem to fall short. Whilst the delivery of points in an experimental task may not be the optimum situation for inducing schedule sensitive behaviour, in a real-life gambling scenario, the reinforcement is in the form of a generalized conditioned reinforcer, money. Therefore, showing insensitive responding to the schedule of a slot-machine could result in losing large amounts of money. Assuming that money acts as a reinforcer for a gambler, the explanation that the type of reinforcer affects the degree of schedule sensitive behaviour does not seem to account for a gambler showing insensitive responding. A way of ensuring that a gambling experiment more closely resembles real-life gambling would be to require participants to gamble their own money, however ethical restrictions prevent this. First, there is the issue that the participant may lose his or her own money, but perhaps of greater concern is that those participants who have obtained high scores on gambling measures (for example, the SOGS) indicating pathological gambling, are being encouraged to engage in their pathology by gambling their own money (Weatherly & Phelps, 2006).

Considering now the effects of rules on participants' responding on the slot-machines during Phase 4, some variability was found in Experiments 4 and 5 in the extent to which the experimenter-delivered rules were followed. It can only be speculated as to why this occurs as a thorough understanding of each participant's behaviour would involve a complete account of their learning history with rule following (Törneke et al., 2008). According to Törneke et al. (2008, p.144) "RFT holds that rules alter behaviour through the appropriate transformation of functions that result from the contact with the elements included in the rule". This assumes that the individual has to be able to respond in accordance with derived relations in order to understand the rule. Hayes et al. (1989) gives the example of presenting a rule in which someone is told that when they hear the bell ring they must get the cake out of the oven. In this example, the words *bell, cake, get* and *oven* participate in same relations with the sound of an actual bell, actual cakes, going to get something and an actual oven. The present study assumed that giving the instruction "*slot-machine C1 pays out the most*" would participate in a same relation with the actual computer simulated slot-machine and winning more points.

In conclusion, the present chapter supported previous suggestions that gambling behaviour may be influenced by accurate and inaccurate externally delivered rules by influencing slot machine choice and persistence in play. However, it was also found that with extended exposure to the contingencies of a slot machine, the control exerted by inaccurate rules sometimes seemed to diminish and responding that was in accordance with the schedule of reinforcement in place began to emerge. This suggests that in a casino environment, if a fellow patron delivers an inaccurate rule to a gambler which overstates the payout probability of a slot machine, although the gambler may initially showed increased responding to that particular slot machine even if it is to his detriment, with prolonged exposure to the schedule of reinforcement in place, the individual may then begin to show schedule sensitive responding such that the rule that had been delivered no longer exerts control over behaviour.

Chapter 4

Emergent Slot-Machine Choice: A Transformation of Discriminative Functions in Accordance with Same and Opposite Relational Frames

Behaviour-analytic research on the effects of structural characteristics of slot-machines on gambling behaviour has found that participants' preferences for a particular machine can be altered with a non-arbitrary relational training intervention (Hoon et al., 2007, 2008; Zlomke & Dixon, 2006). The simulated slot-machine studies by Zlomke and Dixon (2006) and Hoon et al. (2007, 2008) demonstrated that gambling behaviour may not be controlled solely by directly experienced contingencies of reinforcement. If participants' behaviour had been governed purely by the schedule of reinforcement, then an equal preference for both slot-machines would have been observed at post-test because both paid out on 50% of trials.

Although the studies by Zlomke and Dixon (2006) and Hoon et al. (2008) provided preliminary insight into how gambling may not be controlled solely by schedules of reinforcement alone, these experiments do not supplement a strictly verbal account of gambling as defined by RFT (Hayes et al., 2001), for the following two reasons. First, for an event to be considered a verbal event in terms of RFT, responding must be arbitrarily applicable. The training tasks in both of these experiments consisted of non-arbitrary relational responding, which refers to responding to stimuli that differ along a physical dimension, for example, the size or physical quantity of an object. Non-humans should, in principle, be able to complete such tasks (see Reese, 1968) as the organism receives reinforcement for selecting the larger or smaller stimulus, therefore becoming a learned operant (Hayes et al., 2001). From this, the organism is then able to respond to the relation between the stimuli as Hayes et al. (2001) elaborate:

> "If selecting only the larger of two stimulus objects is reinforced over a series of trials with varying objects, there is no reason to be surprised if an organism begins to respond to the relation between the stimuli rather than their absolute characteristics." (p. 25)

Whilst the organism may now be responding to a relation, this is still specified by the physical properties of the stimuli (Hayes et al., 2001). However, a verbal event in accordance with RFT consists of responding to relations between stimuli that are not specified by the physical characteristics of those stimuli. This is termed arbitrary relational responding and is controlled by the context in which responding occurs so that the contextual cue determines the relation between stimuli or the function of a stimulus, and not physical characteristics of the stimuli (Hayes et al., 2001). Berens and Hayes (2004) argue that if humans are more advanced in symbolic language than non-humans then it should be very difficult, if not impossible, to train non-humans to respond accurately to arbitrary relational tasks. A few studies have claimed, equivocally, to establish symmetry and arbitrary relational responding in non-humans (see Jitsumori et al., 2002; Schusterman & Kastak, 1993), but the evidence base suggests that non-humans cannot respond to relational stimuli other than non-arbitrary stimuli as the training procedures used in these studies were generally those used for establishing relational operants (Berens & Hayes, 2004; Hayes, 1989). For these reasons, a non-arbitrary model of gambling cannot be considered a verbal account of gambling and experiments that aim to provide such an account must include the arbitrarily applicable nature of verbal behaviour.

The second reason why the Zlomke and Dixon (2006) and Hoon et al. (2008) studies are not true *verbal* experiments is that an integral component of the RFT account of verbal behaviour is that of *derived* relational responding. In the aforementioned studies, participants were directly trained that the colour yellow was a contextual cue for more-than and colour blue was a contextual cue for less-than. This training intervention is not dissimilar to non-human literature on identity matching to sample and oddity from sample, in which animals are trained to select the comparison stimulus that is the same (identity) in the presence of one sample stimulus, or the stimulus that is different (oddity) in the presence of another stimulus, through differential reinforcement (Cumming & Berryman, 1965). Eckerman (1970) trained pigeons using differential reinforcement to select the correct line (horizontal or vertical) depending on which colour stimulus was presented. No component of the tasks presented by Eckerman (1970) required the subject to derive relations between the stimuli. Subjects were merely responding, in the absence of feedback, with the more-than/less-than relations that had been directly trained. This was also true of the Zlomke and Dixon (2008) and Hoon et al. (2008) papers. Thus, for a more complete account of gambling behaviour, the fundamental components of RFT must be incorporated into empirical studies.

There are currently a few empirical studies in the behaviour-analytic literature which have incorporated the defining features of RFT and demonstrated transformation of discriminative functions in simulated gambling tasks. The transformation of discriminative functions in accordance with equivalence relations has also been demonstrated in the gambling literature. Dixon et al. (2009) employed an equivalence paradigm to alter the effect of the near-miss in slot-machine gamblers. Following a task in which an image of a near-miss on a slot-machine participated in a derived same relation with the word "loss", participants rated the near-miss as being closer to loss. Similarly, where an image of a loss on a slot-machine participated in a derived same relation as the word "almost" participants rated the loss image as closer to a win. Dixon et al. (2009) concluded that the near-miss is a verbal event that can be manipulated and altered (Dixon et al., 2009).

Dymond et al. (in press) demonstrated that the discriminative functions of a slot-machine may transform in accordance with equivalence relations in computer simulated slot-machines. Participants were first trained two, three-member equivalence relations (A1-B2-C1- and A2-B2-C2). Next, participants were simultaneously presented with slot-machine B1 which paid out on 20% of trials and slot-machine B2 which paid out on 80% of trials. Participants were then concurrently presented with slot-machines C1 and C2 and required to select which slot-machine they wanted to play. It was found that participants selected slot-machine C2 significantly more than slot-machine C1. This experiment demonstrated that gamblers may show preferences for particular slot-machines having never experienced the payout probability of that slot-machine.

The aforementioned gambling studies were conducted using equivalence relations. In RFT, relations other than sameness or equivalence can be studied, for example, opposite (Dymond & Barnes, 1996), more-than and less-than (Whelan et al., 2006), and before/after relations (Barnes-Holmes, Hayes, Dymond, & O'Hora, 2001). Furthermore, the RFT literature has demonstrated that transformation of function in accordance with relations other than sameness or equivalence can occur such as self-discriminative response functions through relations of more-than and less-than (Dymond & Barnes, 1995), eliciting functions through relations of more-than and less-than (Dougher et al., 2007), and consequential functions in accordance with same and opposite relations (Whelan & Barnes-Holmes, 2004). For instance, Dymond, Whelan, and Smeets (2005) showed contextual control over the transformation of discriminative functions in accordance with same and opposite relations. Participants were first trained to hand wave in the presence of B1 and clap in the presence of B2. They were then trained that A1 was the same as B1 and C1, whereas A1 was opposite B2 and C2. These trained relations led to the following, tested relations: Same B1-C1, Same B2-C2, Opposite B2-C1, and Opposite C2-B1.When later presented with C1, participants hand waved (the response trained for B1) in the presence of the Same contextual cue, and clapped (the response trained for B2) in the presence of the Opposite contextual cue. When presented with C2 and the Same cue, participants clapped (the response trained for B2), whereas they waved when C2 was presented with the Opposite cue.

Transformation of discriminative function and slot-machine choice.

Currently, there are no gambling studies that have investigated relations other than sameness (equivalence). Given that relations other than same can be studied, a verbal account of gambling must examine these other relations and how functions of stimuli may transform in accordance with these different arbitrary relations. It is possible that relations such as same, opposite, more-than and less-than that have become indirectly related to stimuli within the casino environment, may be influencing a gamblers gaming choices, persistence in play and expenditure. In Chinese culture, for example, the colour red is considered lucky as it symbolises happiness, whereas the colour white represents death and bad omens (He, 2009). As a result of this red may then participate in a relation of opposition to white. For the Chinese gambler, any other stimuli that participate in a relation of same with the colour red or the colour white, may be considered lucky or unlucky respectively, despite the fact that these colours and related symbols have never been related to a big win or big loss in a casino.

Experiment 5 was designed to investigate the transformation of discriminative functions of slot-machine choice in accordance with the relational frames of same and opposite. The present study used a new procedure called the Relation Completion Procedure (RCP; Dymond & Whelan, 2010) to train same and opposite relations. The RCP has been shown to be marginally more effective than traditional matching to sample procedures as participants are more likely to pass arbitrary training and complete the tasks within fewer trials (Dymond & Whelan, 2010). Given that the focus of the present study was to test for transformation of discriminative functions of a slot-machine, any procedure that facilitates successfully completing arbitrary training and testing was of great advantage.

Participants were trained and tested with a relational network of nonsense words which established same and opposite relations between the nonsense words.

Next, two computer simulated slot-machines were simultaneously presented which were labelled with stimuli B1 and B2 from the network. Slot-machine B1 never paid out whilst slot-machine B2 paid out on 80% of trials. Participants were then concurrently presented with slot-machines C1 and C2 under extinction. It was predicted that participants would show greatest preference for slot-machine C2 due to stimulus C2 participating in a derived same relation with B2, where B2 had been trained as the high payout slot-machine.

Experiment 6

Method

Participants

Eight participants, two males and four females, aged between 18 and 21 (*M* = 19.37, *SD* 1.19), were recruited from Swansea University. Participants were administered the SOGS. The mean SOGS score was 0.5 (*SD* = 0.53). Participants were awarded course credit for their involvement in the study.

Apparatus

The experiment took place in a small room containing a desk, a desktop computer with 16-inch display, full sized keyboard and a two-button click mouse. Stimulus presentation and the recording of responses were controlled by the computer, which was programmed in Visual Basic. The two stimuli that were trained as contextual cues for Same (♓) and Opposite (♑) were taken from the Wingdings font. Fourteen nonsense syllables were used during the arbitrary relational training and testing phases (CUG. ZID, MEL, JOM, PAF, LEP, LER, DAX, ROG, BEH, QAD, FIH, VIR, YEM); they will be referred to using alphanumerics.

Procedure

The procedure for Phases 1 and 2 were identical to those developed and reported by Dymond and Whelan (2010). Before starting the experiment, all participants were given a standardised information sheet and gave their written consent. Participants were then given the following instructions:

Thank you for agreeing to participate in this study. You will be presented with a series of images or nonsense words on the top half of the screen from left to right. Then you will be presented with 5 images or nonsense words on the bottom of the screen. Your task is to observe the images or words that appear from left to right and drag one of these images or words from the bottom to the *blank, yellow square. Click and hold the mouse over the image or word to drag it to the blank square. To confirm your choice, click 'Finish Trial'. If you wish to make another choice, then click 'Start Again'. Sometimes you will receive feedback on your choices, but at other times you will not. Your aim is to get as many tasks correct as possible. It is always possible to get a task correct, even if you are not given feedback.*

Participants were then required to click a box at the bottom of the screen that began the first task.

Phase 1: Non-arbitrary relational training and testing.

The purpose of the first phase was to train the contextual cues for same and opposite. Participants were presented with a screen which consisted of a grey section at the bottom third of the screen whereas the top two thirds of the screen appeared blue. The sample stimulus appeared at the left of the blue section of the screen; followed one second later by the contextual cue to the right (therefore appeared central) and after a further one second, a third blank square appeared towards the right of the screen. One second later the three comparison stimuli appeared in the grey section of the screen below (see Figure 4.1). The positioning of the comparison stimuli were randomised on all trials.

To make a response, participants were required to select one of the comparison stimuli, then drag and drop it in the blank square in the blue section of the screen. This made two new buttons appear below the comparison stimuli, with the options 'Finish Trial' or 'Start Again'. By clicking 'Start Again" the stimuli were reset. Clicking the Finish Trial button ended the trial, therefore clearing the screen and presenting feedback. A correct response produced the word 'Correct' whereas an incorrect response produced the word 'Incorrect'. Once feedback had been presented a new trial commenced.

The sample and comparison stimuli in Phase 1 consisted of shapes or objects that differed along a physical dimension. A total of six stimulus sets were used during training. Once a participant responded correctly across eight consecutive trials, they progressed to testing. The non-arbitrary relational test was identical in format to training except that no feedback was given following trials and six novel stimulus sets were employed. Eight consecutive correct responses were required to complete Phase 1 and progress to Phase 2. If this criterion was not met, participants were re-exposed to non-arbitrary training.

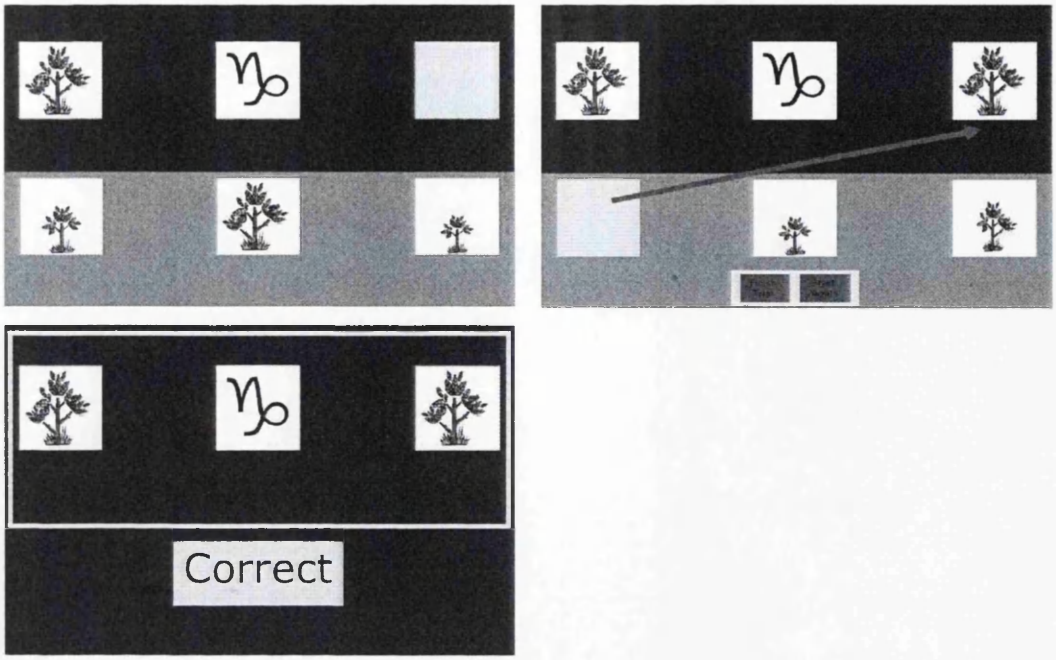


Figure 4.1. Screen shots from a 'same' non-arbitrary training trial. The red arrow is for illustrative purposes only and indicates that a comparison stimulus has been selected from the bottom left of the screen then moved and dropped in the blank square at the top right of the screen.

Phase 2: Arbitrary relational training and testing.

The purpose of Phase 2 was to train and test a relational network of nonsense words (see Figure 4.2) using the contextual cues of same and opposite that had been trained during Phase 1. The format of arbitrary relational training was identical to that of the non-arbitrary training trials, except that the stimuli were arbitrary, that is, did not differ along a physical dimension. Therefore, an arbitrary sample stimulus would be presented, followed by the contextual cue for same or opposite, and then the blank square. Following this the three arbitrary comparison stimuli would be displayed at the bottom of the screen. Participants were required to select one of the comparison stimuli, drag and drop it in the blank square. On confirming their choice, feedback was given. For example, if presented with the contextual cue for SAME with sample stimulus A1, and the comparison stimuli C1, C2 and N2, selecting comparison stimulus B1 was reinforced. There were eight training trials in total, with correct response shown in italics: SAME/A1 [*B1*-B2-N1], SAME/A1 [*C1*-C2-N2], OPPOSITE/A1 [B1-*B2*-N1], OPPOSITE/A1 [C1-*C2*-N2], SAME/X1 [*Y1*-B1-N3], SAME/X1[*Y2*-C1-N3], OPPOSITE/X1 [*Y3*-B2-N3], OPPOSITE/X1 [*Y4*-C2-

N3]. During a block of training each trial was presented twice. A criterion of eight consecutive correct trials was required before a participant could progress to testing.

The purpose of the test phase was to identify whether participants could respond correctly to derived relations. The format of this part of the experiment was identical to that of arbitrary training except that no feedback was given. The following eight novel stimulus sets were presented during the test: SAME/B1 [*C1*-C2-N1], SAME/C1 [*B1*-B2-N1], SAME /B2 [C1-*C2*-N1], SAME/C2 [B1-*B2*-N1], OPPOSITE/B1 [C1-*C2*-N1], OPPOSITE/C2 [*B1*-B2-N1], OPPOSITE/B2 [*C1*-C2-N1], and OPPOSITE/C1 [B1-*B2*-N1]. Each trial was presented twice during one block of testing, generating 16 trials. A criterion of 14/16 correct was required in order to pass the test and complete this phase of the experiment. If criterion was not met, the participant was re-exposed to Phase1. Participants were required to reach criterion within four cycles of Phase 1 and Phase 2 in order to pass. If a participant did not pass within 4 cycles, the experiment terminated. If a participant did pass Phase 1 and 2, they progressed to Phase 3.

Given the arbitrary relations that had been trained, it was predicted that the following relations would be derived: (a) choose C1 given B1 in the presence of SAME; (b) choose B1 given C1 in the presence of SAME (C1 and B1 are both the same as A1 and therefore the same as each other); (c) choose C2 given B2 in the presence of SAME; (d) choose B2 given C2 in the presence of SAME (C2 and B2 are both opposite to A1 and therefore the same as each other); (e) choose C2 given B1 in the presence of OPPOSITE; (f) choose B1 given C2 in the presence of OPPOSITE (C2 is opposite to A1, and B1 is the same as A1, and therefore C2 is opposite of B1); (g) choose C1 given B2 in the presence of OPPOSITE; and choose B2 given C1 in the presence of OPPOSITE (C1 is the same as A1, and B2 is opposite to A1, and therefore C1 is opposite to B2).

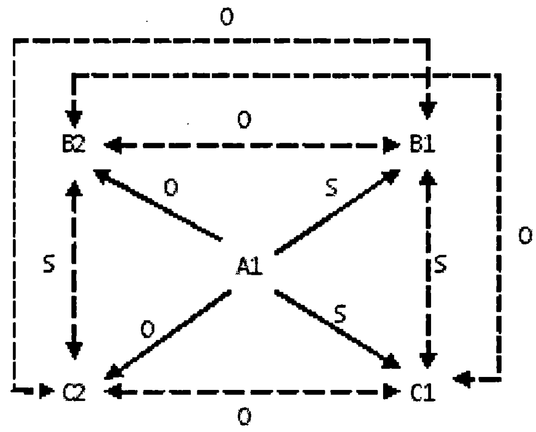


Figure 4.2. The relational network of nonsense words trained through non-arbitrary and arbitrary relational testing. The nonsense words are represented by alphanumerics (A1, B1, B2, C1, C2). A solid line indicates a trained relation, whereas a dashed line indicates a derived relation. 'S' and 'O' represent Same and Opposite, respectively.

Phase 3: Training of discriminative slot-machine functions.

The purpose of this phase was train two slot-machines labelled with a nonsense word from the relational network as a low or a high payout slot-machine respectively. Slot-machine B1 never paid out whereas slot-machine B2 paid out on 80% of spins. The slot-machines were identical in appearance, predominantly grey containing three reels. Each slot-machine appeared on screen sequentially until each had been played 40 times. To play a slot-machine, participants were required to click on the 'Bet 1' button, which automatically deducted one credit from the 'Total Credits' box and made the 'Spin' button available. Clicking spin called the three reels to spin for approximately five seconds before stopping. If three matching symbols appeared on the payoff line then the participant was awarded five credits in the Total Credits box. If less than three symbols were matching then the participant lost a credit, therefore one credit was removed from the "Total Credits" box. All participants started with 100 credits and it programmed so that all ended with 144 credits. Before the task participants were presented with the following instructions:

> *In the first part of the experiment you will be given two slot-machines to play. One slot-machine is called ZID and the other is called MEL. The computer will present the slot-machines one at a time for you to play. To play the machine, click the 'Bet 1' button and then click the 'Spin' button. Your aim is to win as many points as possible. Good luck!*

At the end of this phase, participants were presented with a Likert scale and instructed to rate how likely they thought it was that a win could occur on each slot-machine. The scale ranged from 1 (very unlikely) to 5 (very likely). Participants rated each slot-machine by clicking on the number on the scale with the right button of the mouse on the scale that corresponded to each slot-machine.

Phase 4: Transformation of discriminative slot-machine functions.

The purpose of this phase was to test for transformation of discriminative slot-machine functions in accordance with same and opposite when participants were presented with pairs of slot-machines labelled with indirectly related members of the relational network. At the start of this task, participants were presented with the following onscreen instructions:

You will now be presented with some more slot-machines named after the nonsense words you saw in the previous task. Please select which slot-machine you would like to play by clicking the 'Spin' button on your chosen slot-machine. You will not be able to see how many points you win on each machine, but the computer is still recording your score. Your aim is to try to earn as many points as possible.

Participants were presented with two slot-machines onscreen at a time and selected the machine that they wanted to play by clicking on the "Click to spin" button on the chosen slot-machine with a mouse. However, the reels did not actually spin and credit was not awarded or lost. The slot-machines were identical in appearance except for the nonsense word of each slot-machine that was situated just above the reels. Each trial either consisted of slot-machines B1 and B2 being presented as well as slot-machines C1 and C2.

Due to a programming error, P1-P4 received 8 extinction trials, with B1, B2 C1 and C2 each presented twice. P5-P8 received 16 extinction trials, with B1, B2, C1 and C2 each presented four times. At the end of this phase, participants were again presented with a five-point likert scale (1 = very unlikely, 5 = very likely).

It was predicted that when presented with slot-machines B1 and B2, slot-machine B2 would be the selected to be played more often than slot-machine B1, as B2 was trained as a high payout probability slot-machine during Phase 3. When presented with C1 and C2 it was predicted that C2 would be chosen more often than slot-machine C1. These predictions were made based on the relations that had been trained during the arbitrary training tasks: A1 is the same as B1, A1 is opposite to

B2, A1 is the same as C1, A1 is opposite to C2, therefore giving rise to the derived relations that B1 is the same as C1, B1 is opposite to C2, and B2 is the same as C2. As Phase 3 trained B1 as a low payout slot-machine and B2 as a high payout slot-machine, therefore it was predicted that these functions would transform in accordance with the relational network such that slot-machine C1 would be least preferred and slot-machine C2 would be most preferred.

Results and Discussion

Table 4.1.
Number of trials required to meet criterion for non-arbitrary and arbitrary training and testing in Phases 1 and 2 of Experiment 6.

Participant	Non-arbitrary training (trials to criterion)	Non-arbitrary testing (trials to criterion)	Arbitrary training (trials to criterion)	Arbitrary testing (trials to criterion)
P1*	24	8/8	73	8/16
	8	8/8	20	8/16
	8	8/8	24	8/16
	8	8/8	24	-
P2*	9	8/8	247	4/16
	8	7/8	-	-
	10	7/8	-	-
	8	8/8	9	13/16
P3*	10	8/8	98	7/16
	8	8/8	66	12/16
	9	8	30	9/16
	8	8/8	-	-
P4	21	6/8	-	-
	8	8/8	147	13/16
	8	8/8	18	15/16
P5	15	8/8	145	7/16
	13	8/8	73	9/16
	15	8/8	20	6/16
	9	8/8	8	8/16

Participant (*cont.d*)	Non-arbitrary training	Non-arbitrary testing	Arbitrary training	Arbitrary testing
P6	15	8/8	81	3/1
	8	8/8	8	6/16
	8	8/8	8	8/16
P6	8	8/8	8	3/16
P7	27	8/8	83	8/16
	8	8/8	37	7/16
	8	8/8	59	6/16
	8	7/8	-	-
	8	7/8	-	-
	8	8/8	9	8/16
P8	11	8/8	106	7/16
	8	8/8	16	11/16
	8	8/8	8	14/16
Mean	10.63	7.81	54.81	8.20
SD	4.94	0.47	57.83	3.24

*denotes participant that terminated

Of the eight participants, only two (P4 and P8) successfully completed both the non-arbitrary and the arbitrary relational training tasks. P5, P6 and P7 failed at the arbitrary phase of the experiment, whereas the remaining participants withdrew before all four exposures had been presented.

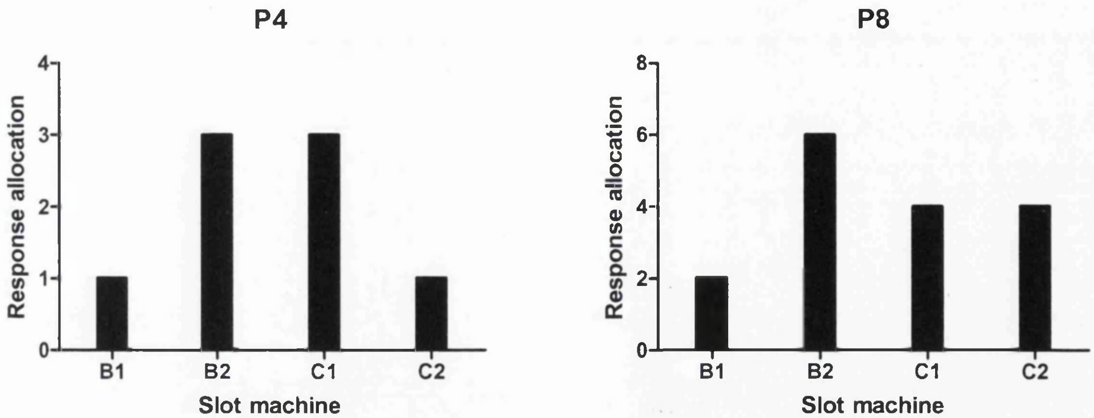


Figure 4.3. P4 and P8's slot-machine choices during the test for transformation of functions in Phase 4 of Experiment 6.

Figure 4.3 shows the slot-machine choices for P4 and P8 under extinction, where B1 had been trained as the slot-machine under extinction (payout of zero) and B2 is trained as a high payout slot-machine (0.8). The results of P4 do not indicate that a transformation of function had occurred with equal preference being shown for B1 and C2, and B2 and C1. As slot-machine C2 participated in a same relation with B2, it would be expected that slot-machine C2 would be more preferred than C1. P8 showed the most preference for B2 and least preference for slot-machine B1, which would be as expected due to the payout contigencies of slot-machine B2 that were experienced in Phase 3 of the experiment. Equal preference was seen for slot-machines C1 and C2 which was not in line with predictions.

Table 4.2.
Participants' slot-machine ratings during Phase 3 and Phase 4 of Experiment 6 where 1 = very unlikely, 2 = unlikely, 3 = neutral, 4 = likely, 5 = very likely.

	Phase 3		**Phase 4**			
	B1	**B2**	**B1**	**B2**	**C1**	**C2**
P4	2	5	2	3	4	2
P8	1	5	3	4	2	4
Mean	1.5	5.0	2.5	3.5	3.0	3.0
SD	0.71	0.00	0.71	0.71	1.41	1.41

Table 4.2 shows the ratings data made by participants towards each slot-machine. The slot-machine ratings when under extinction are most noteworthy, as consistency with actual slot-machine choice was expected. The ratings from P4 are consistent with slot-machine choice as slot-machines B1 and C2 were rated as

unlikely to payout and were also the least preferred slot-machines. Ratings for P8 are generally consistent except that slot-machine C2 was rated as likely to pay out, yet P8 only selected this slot-machine on four trials.

The findings of Experiment 6 were ambiguous in terms of a demonstration of transformation of discriminative function. Two further experiments were designed to try and overcome some of the shortcomings of Experiment 6. In the previous experiment, participants were presented with slot-machines B1, B2, C1 and C2, in the absence of feedback, during the test for transformation of functions. In the present experiment, only slot-machines C1 and C2 were presented. Presenting only the derived stimuli, C1 and C2, is consistent with previous tests for transformation of function (see Dymond et al., 2007).

Experiment 7

Method

Participants

Seven participants, 3 males and 4 females, aged between 20 and 25 (*M* =21.74, *SD* = 1.98), answered an e-mail requesting volunteers for a psychology study. All participants were students at Swansea University. The mean SOGS score was 0.43 (*SD* =0.53).

Procedure

The procedure for Experiment 7 was identical to that of Experiment 6 except that during the extinction phase, only slot-machines C1 and C2 were presented. This concurrent choice was presented a total of eight times. It was predicted that participants would show increased preference for slot-machine C2 when presented under extinction due to the stimulus C2 participating in a relation of same to B2, when stimulus B2 had been trained as a high probability slot-machine.

Results and Discussion

Table 4.3.
Number of trials required to meet criterion for non-arbitrary and arbitrary training and testing in Phases 1 and 2 of Experiment 7.

Participant	Non-arbitrary training (trials to criterion)	Non-arbitrary testing (trials to criterion)	Arbitrary training (trials to criterion)	Arbitrary testing (trials to criterion)
9	12	7/8	-	-
	24	7/8	-	-
	8	8/8	75	5/16
	8	8/8	19	14/16
10	12	8/8	19	14/16
11	13	8/8	120	5/16
	8	8/8	46	9/16
	8	8/8	8	5/16
	8	8/8	8	8/16
12*	15	7/8	-	-
	15	8/8	42	9/16
	8	8/8	123	9/16
	18	8	8	11/16
	8	-	-	-
13	10	7/8	-	-
	8	8/8	53	14/16
14	9	8/8	55	9/16
	8	8/8	18	2/16
	9	8/8	21	3/16
	8	8/8	8	8/16
15	28	8/8	100	16/16
Mean	11.67	7.80	48.50	8.81
SD	5.63	0.41	39.83	4.18

* denotes participant that terminated

All participants passed the non-arbitrary relational training and testing. P11 and P14 did not meet criterion responding for the arbitrary relational test therefore did not proceed to the slot-machine phases of the experiment. Participants required a mean number of 48.5 arbitrary training trials to meet criterion responding and progress to the test phase. P12 terminated his participation after three exposures to the arbitrary training and testing task.

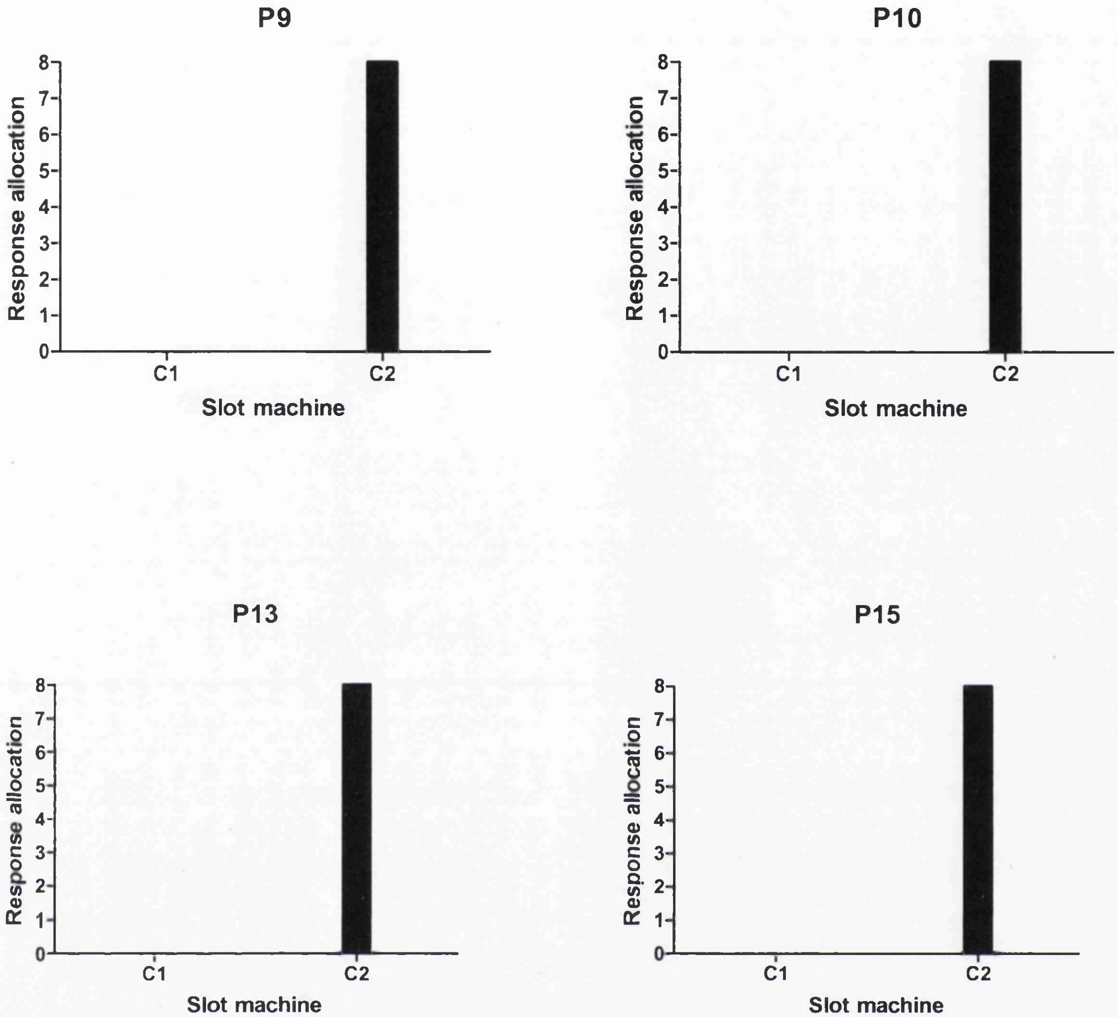


Figure 4.4. Participants' slot-machine choices during the test for transformation of functions in Phase 4 of Experiment 7.

All participants who passed Phase 1 and 2 and progressed to the slot-machine phases of the experiment showed most preference for slot-machine C2 when concurrently presented with slot-machines C1 and C2 under extinction. All four participants chose to play slot-machine C2 on every trial, and did not select slot-machine C1 at all. This suggests that participants' preferences had transformed in accordance with the network trained during arbitrary relational training and testing. Slot-machine C1 was not selected on a single trial by any of the participants due to stimulus C1 participating in derived relation of same with stimuls B1, where B1 had been paired with a low probability slot-machine.

Table 4.4.
Participants' slot-machine ratings during Phase 3 and Phase 4 of Experiment 7, where 1 = very unlikely, 2 = unlikely, 3 = neutral, 4 = likely, 5 = very likely.

	Phase 3		Phase 4	
	B1	B2	C1	C2
P9	1	4	2	3
P10	1	4	1	4
P13	1	4	1	4
P15	2	4	2	2
Mean	1.25	4	1.5	3.25
SD	0.5	0.0	0.58	0.96

The ratings data for P10 and P13 as shown in Table 4.4 are highly consistent with those participants' slot-machine choices. P9 rated slot-machine C2 as neutral even though they selected slot-machine C2 across all trials and never selected slot-machine C1. The ratings for P15 are inconsistent with their slot-machine choices as both slot-machines were rated as unlikely to pay out despite a clear preference being shown for slot-machine C2 over slot-machine C1 when playing the slot-machines.

It has been shown that transformation of consequential functions in accordance with the relations of same and opposite can be varied. Dymond, Roche, Forsyth, Whelan, and Rhoden (2008) trained an avoidance response in the presence stimulus B1, which resulted in derived avoidance in the presence of C1 (via two combinatorially entailed same relations). Then, in a second experiment, this response was attached to stimulus B2, resulting in derived avoidance in the presence of C2 (via two combinatorially entailed opposite relations). Experiment 7 of the present thesis demonstrated transformation of discriminative function via two combinatorially entailed opposite relations. Experiment 8 was designed to show that transformation of function can occur via two combinatorially entailed same relations by training slot-machine B1 as the high probability slot-machine and slot-machine B2 as the slot-machine under non reinforcement. This change should result in a shift in slot-machine preference so that slot-machine C1 becomes the most preferred slot-machine when concurrently presented with slot-machine C2 under extinction conditions.

Experiment 8

Method

Participants

Seven female participants aged between 21 and 35 (*M* =27.57, *SD* = *4.83*) answered an e-mail requesting volunteers for a psychology study. All participants were students at Swansea University. All participants had a SOGS score of 0.

Procedure

The procedure for Experiment 8 was identical to that of Experiment 7 except that during Phase 3 in which the slot-machine functions are trained, B1 was trained as the high probability slot-machine and B2 was trained as the slot-machine under extinction. This was to see whether increased preference would be shown for slot-machine C1 during transformation of function test, due to the derived same relation between B1 and C1.

Results and Discussion

Table 4.5.
Number of trials required to meet criterion for non-arbitrary and arbitrary training and testing for Phases 1 and 2 of Experiment 8.

Participant	Non-arbitrary training (trials to criterion)	Non-arbitrary testing (trials to criterion)	Arbitrary training (trials to criterion)	Arbitrary testing (trials to criterion)
16	31	8/8	127	2/16
	8	8/8	16	5/16
	8	8/8	18	9/16
	8	7/8	-	-
	8	7/8	-	-
	8	8/8	10	12/16
17	10	8/8	26	16/16
18	9	8/8	36	12/16
	12	8/8	9	14/16
19	8	8/8	42	9/16
	8	8/8	23	5/16
	8	8/8	19	2/16
	8	8/8	8	5/16
20*	14	8/8	39	8/16
	8	8/8	12	3/16
	8	8/8	12	4/16
	8	8/8	-	-
21	11	8/8	6	9/16
	8	8/8	10	10/16
	8	8/8	8	16/16
22	13	8/8	92	3/16
	8	8/8	57	3/16
	8	8/8	14	16/16
Mean	10.00	7.91	29.20	8.15
SD	5.03	0.29	31.16	4.90

*denotes participant who terminated his/her participation.

In Experiment 8, all participants successfully passed the non-arbitrary relational training and testing and progressed to the arbitrary relational tasks. P16 and P19 failed to meet criterion for the arbitrary test and did not proceed to the slot-machine tasks, and P20 terminated the experiment early. P17 required only one exposure to arbitrary training and testing, P18 required two exposures and P21 and P22 both required three exposures. Four participants progressed to the slot-machine tasks.

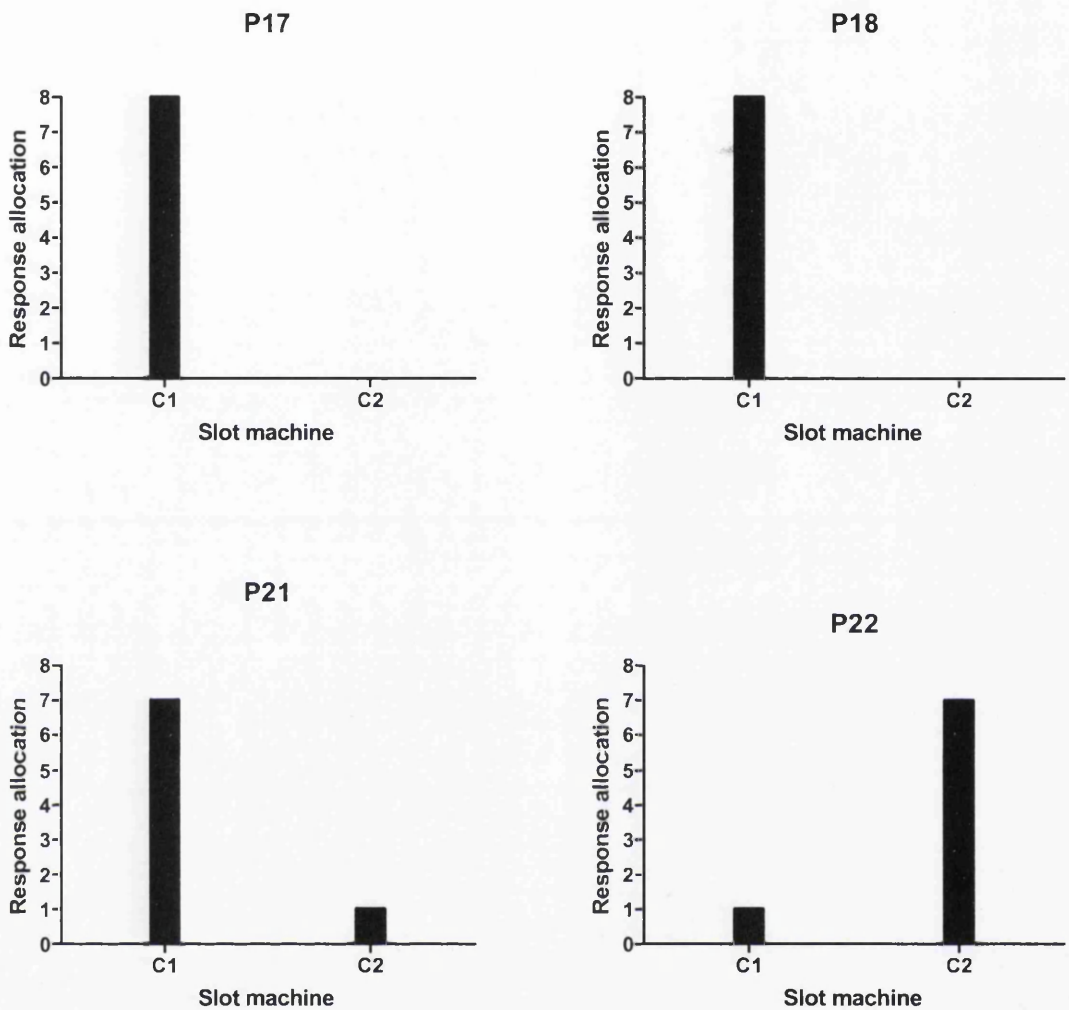


Figure 4.5. Participants' slot-machine choices during the test for transformation of functions in Phase 4 of Experiment 8.

Figure 4.5 shows that three out of four participants showed a strong preference for slot-machine C1 over slot-machine C2 when presented under extinction due to the same relation between B1 and C1, where stimulus B1 was trained as a high payout slot-machine. P17 and P18 never selected slot-machine C2 and P21 selected slot-machine C2 only once. It is interesting that P22 showed a high preference for slot-machine C2 given that stimulus C2 participates in a derived relation of same as B2 which had been subsequently trained as a low payout slot-machine.

Table 4.6.
Participants' slot-machine ratings during Phase 3 and Phase 4 of Experiment 8, where 1 = very unlikely, 2 = unlikely, 3 = neutral, 4 = likely, 5 = very likely.

	Phase 3		Phase 4	
	B1	B2	C1	C2
P17	5	1	5	1
P18	5	1	5	1
P21	5	1	5	1
P22	2	2	2	5
Mean	4.25	1.25	4.25	2.0
SD	1.5	0.5	1.5	2.0

The ratings of the slot-machines for Experiment 8 are highly consistent with actual slot-machine choices during the extinction phase with P17, P18 and P21 rating slot-machine C1 as very likely to pay out and slot-machine C2 as unlikely to pay out. P22 rated slot-machine C2 as very likely to pay out which was consistent with their high preference for slot-machine C2 under extinction.

General Discussion

The findings of Experiment 6 were unclear as only two participants passed the arbitrary relational test phase and progressed to the slot-machine phases. They showed relatively equal distribution of responding during the test for transformation of functions. Thus, no clear preference was demonstrated. The findings of Experiments 7 and 8 demonstrated that participants' preferences for concurrently available slot-machines may transform in accordance with same and opposite relational frames. In Experiment 7, participants showed a preference for slot-machine C2, which participated in a relational frame of sameness with B2 (via two combinatorially entailed opposite relations) that had been directly trained high payout discriminative functions during slot-machine training. In Experiment 8, participants showed a preference for slot-machine C1, which participated in a relational frame of sameness with B1, which had been trained with high payout discriminative functions during slot-machine training.

As noted, only two participants in Experiment 6, P4 and P8, completed arbitrary training and testing and progressed to the slot-machine phases. Their slot-machine choice data do not suggest that transformation of function occurred. A possible explanation for the differences in predicted patterns of transformation in Experiments 6, 7 and 8 may be changes made to the test for transformation of function. In Experiments 7 and 8, one exposure to concurrent presentations of slot-machines C1 and C2 were given, which was consistent with the procedures of Dymond et al. (2007), and all but one of the participants (P22) showed the predicted performance. In Experiment 6 however, participants were presented with slot-machines B1 and B2 concurrently, as well as slot-machines C1 and C2 during Phase 4. Specifically P4 was presented with four trials of slot-machine B1 and B2, and four trials of slot-machine C1 and C2, whereas P8 received eight trials of each combination of slot-machines. It seems that presenting a short block of only slot-machines C1 and C2 during Experiments 7 and 8, lead to more reliable results. During Phase 4, participants are required to select a slot-machine, but they do not actually get to play the slot-machine, i.e. the reels don't spins and money cannot be won or lost. Perhaps this brief, simple exposure to only those two slot-machines was just enough to prevent extinction. It is not necessary to present slot-machines labelled B1 and B2 during Phase 4, as this only tests whether the discriminative functions of the slot-machines had been acquired and were maintained (in the presence of feedback). Any preferences seen for these slot-machines would not be due to a transformation of discriminative function as the function was directly trained with these slot-machines. The relative advantages and disadvantages of presenting the slot-machines used during discriminative function training can only be fully addressed through further empirical investigation.

Perhaps a 'cleaner' demonstration of transformation of function would have been seen in Experiment 6 with additional exposure to the arbitrary training tasks. Previous research has re-exposed participants to the arbitrary training and testing phases if criterion was not met during the test for transformation of functions. Usually, pre-determined mastery and exposure criteria are adopted, such that additional transformation test exposures, where necessary, are given until either the predicted performance emerges or the exposure criterion is met, whichever comes first (Barnes & Keenan, 1993; Dymond & Rehfeldt, 2000). It is possible, then, that a similar re-exposure criterion would have facilitated the predicted shift in preference for P22 in Experiment 8, as well as for the participants in Experiment 5. This issue warrants empirical attention.

The present experiments provide further empirical support for the use of the RCP (Dymond & Whelan, 2010) to train relational networks of same and opposite. Dymond and Whelan (2010) reported that participants required nominally fewer arbitrary training and testing trials when participants were presented with RCP in comparison with the equivalent matching-to-sample task. In Experiment 7, four out of six participants passed arbitrary training and testing with one participant terminating before their final exposure, and one participant failing. In Experiment 8, four out of seven participants met criterion for arbitrary training and testing with two failing and one terminating.

In Experiment 6, however, only two participants passed the arbitrary training and testing tasks. Three participants terminated their participation and the remaining three participants failed. It is difficult to understand why only two participants were successful given that this was not seen in the subsequent experiments and was also not found in Dymond and Whelan (2010). A possible explanation comes from the manner in which participants were recruited (i.e., via the psychology undergraduate subject pool credit system). This system requires all psychology students to participate in departmental research to obtain "course credit". Tasks in which complex arbitrary relations are trained and tested require concentration and meeting stringent criteria, yet a participant will receive credit regardless of how well they do on the task. Perhaps the low pass rate of Experiment 6 was as a result of such low motivation, as the participants that failed or terminated the experiment still received subject pool credit. It is noteworthy that the participants in Experiments 7 and 8 had responded to a campus advert requiring volunteers to help with a psychology study, and were not given any monetary reimbursement. Although it has been suggested that the non-contingent nature of course credit systems may result in low motivation to complete the task required (Critchfield, Schlund, & Ecott, 2000), it should be noted that Dymond and Whelan (2010) also awarded course credit or monetary reinforcement yet reported a higher pass rate.

One possible criticism of the present study is that an account based solely on equivalence relations is able to explain the data (e.g., Sidman, 1994, 2000; Tonneau, 2004). This seems unlikely, firstly, due to the way in which non-arbitrary training established the contextual cues for same and opposite. In the non-arbitrary training, a sample stimulus was presented, followed by the contextual cue and finally the comparison stimuli. If the sample was a small tree, and the contextual cue presented was same, then the correct response would be to select the comparison stimulus that also depicted the small tree. Given a small tree and the contextual cue for opposite, the correct response would be to select the image depicting the largest tree. Therefore, the same sample stimulus (small tree) participates in a same relation with the small tree and an opposite relation with the large tree. An equivalence relation cannot have been formed as the correct response to the sample stimulus differs depending on which relation is specified by the contextual cue.

The second reason why equivalence relations *solely* are unlikely to explain the current data is due to the combinations of stimuli that were presented during arbitrary training and testing. During arbitrary training, participants are essentially trained an equivalence, or same, relation between A1, B1, and C1. However, this is not the case for A1, B2, and C2, as stimulus A1 is trained as opposite to B2 and C2. Then during arbitrary testing, stimuli B1, B2, C1, and C2 are all presented as sample stimuli with both contextual cues for same and opposite. For example, given B2 as the sample stimulus, followed by the contextual cue for same, and finally the comparison stimuli of B1, C1, and C2, selecting stimulus C2 would be the correct response. Now consider a trial in which B2 is the sample but the contextual cue for opposite is presented. In this case selecting B1 would be the correct response and C2 would now be incorrect. An equivalence paradigm cannot account for this response, because in an equivalence relation, selecting B2 in the presence of C2 would always be the correct response, regardless of contextual cue. In the case of the present study, however, the correct response can only be occasioned due to the relation defined by the contextual cue. It is unlikely, therefore, that participants would pass both non-arbitrary relational testing and arbitrary training and testing without responding to the contextually controlled relations of same and opposite (Dymond et al., 2007; Dymond & Barnes, 1996).

In terms of gambling research, the present study supplements the growing body of literature showing that gambling relevant stimuli may transform in accordance with derived relations (Dixon et al., 2009; Dymond et al., 2010, 2011). Dymond et al. (2011) found that participants showed a greater preference for a slot-machine that participated in a derived equivalence (same) relation with a slot-machine that had been trained as discriminative for a high payout slot-machine. The current findings extend those of Dymond et al. (2011) by demonstrating that discriminative slot-machine functions may transform in accordance with derived relations of opposite as well as sameness.

The data from the present chapter also provide empirical support to recent suggestions from within the broader behaviour analytic literature that verbal behaviour is a vital component for explaining gambling behaviour (Dixon & Delaney, 2006; Dymond & Roche, 2010; Weatherly & Dixon, 2007), and extends beyond a traditional behavioural account based solely on schedules of reinforcement. The data from this chapter suggest that preferences for concurrently available slot-machines may be influenced by characteristics or features of a slot-machine that are indirectly related to directly experienced payout probabilities. Participants did not experience the contingencies of the slot-machines labelled C1 or C2 yet showed a preference for one over the other. The structural characteristics of the slot-machines perhaps acquired 'positive' or 'lucky' functions due to that characteristic being indirectly related to another characteristic that had previously been established as having a high payout, therefore being perceived as 'lucky'. If a symbol is considered lucky, then another symbol that participates in an opposite relation with that symbol may be considered unlucky and vice versa. Additionally, these findings provide empirical evidence to the suggestion that structural characteristics of slot-machines are influential in gambling (Griffiths, 1990).

In conclusion, the present experiments suggest that preferences for concurrently available slot-machines may transform in accordance with same and opposite relations, and provide empirical support for a contemporary approach to the role of verbal behaviour in gambling.

Chapter 5

"This Slot-machine is Better Than that One": Transformation of Discriminative Functions in Accordance with Derived Comparative Relations

Behaviour analysts interested in derived stimulus relations have utilised procedures from the transitive inference (TI) literature as a means of explaining human reasoning. Transitive inference is an important characteristic of human deductive reasoning (Vasconcelos, 2008), and explains how individuals can deduce one piece of information from other, related information. For example, if told that A is bigger than B, and B is bigger than C, an individual may deduce that A is bigger than C. Transitive inference procedures are comparable to the behaviour-analytic literature on derived stimulus relations in which participants are trained hierarchical relations such as A < B < C < D < E (see Munnelly, Dymond, & Hinton, 2010). These hierarchical relations are often termed comparative relations in the behaviour analytic literature. Comparative relations consist of those that differ in size, such as a stimulus being greater-than another stimulus. These comparative relations may initially be non-arbitrary, that is, differ along a physical dimension, but comparative relations can also be trained for stimuli that do not differ in their physical properties. For example, given the choice between a nickel and a dime, a small child may prefer the nickel due to the physical size of the coin (Berens & Hayes, 2007). However, as the child learns the monetary value of nickels and dimes, the child may then show a preference for the dime (Berens & Hayes, 2007). The literature on derived stimulus relations has found that comparative relations can be derived (Dymond & Barnes, 1995).

Derived comparative relations are relevant to gambling behaviour as they may explain how a gambler comes to behave in accordance with self-statements such as "this slot-machine pays out more" than another, in the absence of a direct history with either slot-machine (Dymond & Roche, 2010). Furthermore, as it has been suggested that the structural characteristics of slot-machines may influence how an individual gambles on a particular machine (Griffiths, 1990), it is possible that the characteristics of that slot-machine may participate in derived comparative relations with other stimuli in an individual's learning history, which may in turn influence slot-machine choice. The present chapter sought to undertake the first such investigation of the transformation of discriminative slot-machine functions in accordance with derived comparative relations.

A recent study by Munnelly et al. (2010) trained participants with a relational network of comparative relations, represented here by the letters A-B-C-D-E. Stimulus A was trained as the least-ranking member of the network and stimulus E the highest-ranking member of the network. Participants were first trained and tested to establish two nonsense syllables as contextual cues for more-than and less-than. In the next phase, participants were trained with the relational network of nonsense words using these contextual cues. The first group of participants received arbitrary relational training using the more-than cue to train the network E > D > C > B > A. This was achieved by simultaneously presenting the more-than cue onscreen followed by two of the nonsense words. For example, given the more-than cue followed by A and B, selecting B was reinforced (B > A). Participants were presented with four training trials, E > D, D > C, C > B, and B > A. From this training, it was predicted that participants would derive that if B is greater than A, then A must be less than B (mutual entailment). During a test phase, participants were presented with the more-than and less-than cues and tested on mutually entailed and combinatorially entailed trials. The mutually entailed trials that were tested consisted of A < B, B < C, C < D, and D < E. Furthermore, if B is more than A, and C is more than B, then A must be less than C (combinatorial entailment). The combinatorially entailed trials consisted of A < C, B < D, C < E, C > A, D > B, E > C, A < D, B < E, D > A, E > B. A second group of participants received training using the less-than contextual cue (A < B < C < D < E). Findings showed a high degree of accuracy across both groups in deriving comparative relations in a manner similar to that seen in TI studies (Munnelly et al., 2010).

Reilly, Whelan, and Barnes-Holmes (2005) used a similar procedure to train a five term relational network (A < B < C < D < E). One group of participants were trained using the more-than cue with the following tasks: B > A, C > B, D > C, and E > D. A second group were trained using the less-than cue with the following tasks: A < B, B < C, C < D, and D < E. A third group were trained with both the more-than and the less-than cue: A < B, B < C, and D > C, E > D. To test for differences between the groups as a function of the type of training structure used, Reilly et al. (2005) measured response latencies on all trials (trained, mutually entailed, and combinatorially entailed). It was found that response latencies were significantly lower for the group that received training with the more-than cue, and were also faster for trained and mutually entailed trials compared to combinatorially entailed trials (Reilly et al., 2005).

The studies by Reilly et al. (2005) and Munnelly et al. (2010) demonstrate that complex relational networks can be trained using contextual cues for more-than and less-than through non-arbitrary and arbitrary relational training. The findings of differences in response latencies by Reilly et al. (2005) suggest that when training such networks, participants may find training with the more-than cue both easier to acquire and subsequently derive.

Whelan, Barnes-Holmes, and Dymond (2006) provided empirical evidence that when a function is attached to one member of a relational network, the functions of other members of the network may be transformed in accordance with the derived relation. Whelan et al. (2006) first trained and tested a seven-member network of nonsense words. Contextual cues for more-than and less-than were first established through non-arbitrary relational training and testing. These contextual cues were then employed in an arbitrary relational training and testing task in which participants were trained in the following discriminations: A < B, B < C, C < D, E > D, F > E, and G > F. All possible mutual and combinatorial entailment relations were then tested. On passing the derived relations test, in the next phase, participants were required to select a circle containing stimulus D that resulted in the delivery of points whereas selecting a circle containing novel stimulus X resulted in a loss of points. This training established consequential functions for D and X. Finally, transformation of functions was tested by means of a simultaneous discrimination task or a free operant task. During these tasks, participants were presented with circles containing the stimuli from the relational network, that is A, B, C, D, E, F and G. However, whereas in the previous phase selecting a circle resulted in presentation or loss of points, selecting a circle during the transformation of functions test resulted in that member of the network being presented. For example, given circle A and circle B, selecting circle B resulted in stimulus B being presented.

It was predicted that when presented with circles containing stimuli from the relational network, the circle containing the higher-ranking member of the network would be selected over the lower ranking members. Specifically (predicted preference marked in italics): A - *B*, A - *C*, A - *D*, A - *E*, A - *F*, A - *G*, B - *C*, B - *D*, B - *E*, B - *F*, B - *G*, C - *D*, C - *E*, C - *F*, C - *G*, D - *E*, D - *F*, D - *G*, E - *F*, E - *G*, F - *G*. It was found that participants' preferences for the arbitrary stimuli were transformed in accordance with the relational network, such that preference was shown for the highest-ranking stimulus in the network. These findings are significant as they demonstrate how the consequential functions of a stimulus or an event may be transformed due to the relation of that stimulus with another event, in the absence of a direct contingency of reinforcement (Whelan et al., 2006).

Dougher et al. (2007) demonstrated a transformation of function in accordance with more-than and less-than relations. In a non-arbitrary training task, participants were presented with sample A, B, or C, and learned to select the smallest, middle sized or largest comparison, respectively, from three comparison stimuli. This training established sample A as a contextual cue for smallest, B as a contextual cue for middle sized and C as a cue for greatest. Sample A was then used in an arbitrary training task to establish four different coloured circles green (G), purple (P), blue, (Bl), and red (R), in the hierarchy G < P < Bl < R. For example, in the presence of sample stimulus A and the comparison stimuli G and P, selecting P would be the reinforced correct response. Participants were later trained a steady rate of keyboard pressing in the presence of Circle P. When presented with circles G and Bl in a test phase, participants pressed more slowly in the presence of circle G and more rapidly in the presence of circle P. This rate at which participants pressed the keyboard was transformed in accordance with the arbitrary relations of G < P < Bl < R (Dougher et al., 2007).

With regards to gambling, the transformation of discriminative functions may shed light on why an individual shows a preference for a particular slot-machine due to the particular physical characteristics of that machine, despite never having experienced winning on that machine. Weatherly and Dixon (2007) give the example of a gambler who says, "I have my lucky Red Sox shirt on". The process by which this shirt becomes "lucky" can be explained by transformation of stimulus function, as Weatherly and Dixon (2007) describe:

> "Upon entering the casino a novice gambler finds an empty chair at a slot-machine. The machine is of the variety 'Red, White, and Blue', in which large payoffs are made when three sets of bars line the payoff window. Over the course of one hour of play, this individual comes close to winning a number of times, and then, with one more spin of the reel, wins a large jackpot when three sets of red bars land on the win line. Obviously excited, this player informs his friend of what has occurred, who proclaims 'Red must be your lucky colour'. The next day, recalling the phrase from the prior day, the gambler selects a red shirt to wear the next morning. Even upon seeing the shirt in the closet, an increased tendency to gamble is reported. Despite

attempts to draw this person out of the casino, he repeatedly states 'I will win. I am wearing my lucky shirt.' While the red shirt has never been paired with winning, or perhaps even gambling, certain psychological functions have emerged between the red bars of the slot-machine, money won, the friend's comment, and a shirt with the word Red Sox written on it." (Weatherly & Dixon, 2007, p.14.)

There are only a few demonstrations of transformation of function in the gambling literature, such as Dymond et al. (in press) who reported that the discriminative functions of slot-machines may transform in accordance with derived relations.

The present experiment was designed using similar training procedures as those of Munnelly et al. (2010) in which an arbitrary relational network of nonsense words A < B < C < D < E was trained and tested. Following arbitrary training and testing, discriminative functions of high or low payout percentages were established for two slot-machines labelled with a member of the relational network. One of the slot-machines was named with nonsense word C from the network and trained as a low payout slot-machine (paying out on 20% of trials). A second slot-machine was labelled with a novel stimulus X and paid out at a high rate of 80%. To test for a transformation of discriminative functions, pairs of slot-machines labelled A, B, C, D, E, and X were presented concurrently (for example, slot-machine A and slot-machine B, slot-machine C and slot-machine E). The slot-machines were under conditions of non-reinforcement, as participants could not see how many points they had won or lost. It was predicted that participants would choose to play the slot-machines labelled with nonsense words that were ranked more highly in the network compared to the slot-machines labelled with members lower in the network.

Experiment 9A

Method

Participants

Four participants, 2 males and 2 females, aged between 19 and 38 (M = 25.25, SD = 8.62), were recruited from across Swansea University. The mean SOGS score was 4.5 (SD = 3.11). Participants were compensated with £5 at completion of the study.

Apparatus

The experiment took place in a small room containing a desk, a desktop computer with 16-inch display, full sized keyboard and a two-button click mouse. Stimulus presentation and the recording of responses were controlled by the computer, which was programmed in Presentation (NeuroBehavioral Systems, CA) and Visual Basic.Net, respectively. During the experiment, participants were presented with five nonsense words in Phase 2 (VEK, JOM, BIH, CUG, and PAF), and an additional, novel nonsense word in Phase 3 (YUT).

Procedure

The experiment was divided into two main sequences: relational training and testing and slot-machine discriminative function training and testing, each consisting of two phases. See Figure 5.1 for a schematic overview.

Phase 1: Non-arbitrary relational training and testing. The purpose of this phase was to train and test non-arbitrary relational responding with stimuli differing in physical quantities. In non-arbitrary training, participants were first presented with the following onscreen instructions:

> *During this phase you will be presented with one cue in the middle of the screen and two images beneath it in the centre of the screen, one on the right and one on the left. Your task is to choose one of the images. To select the image on the right, press the marked key on the right of the keyboard. To select the image on the left, press the marked key on the left of the keyboard. Please try to do so as quickly and as accurately as possible. Sometimes the computer will give you feedback, and at other times it will not. However, you can get all of the tasks without feedback correct by carefully attending to the tasks with feedback. Remember, there is always a correct answer. The computer will tell you when this phase is finished. Please press the space bar to begin.*

On each trial, either the more-than or less-than contextual cue appeared in the top middle of the screen followed by two images of differing physical quantities at the left and right bottom of the screen. The images used were (quantities of each object are in parentheses) beakers (1, 3, 6), tractors (1, 2, 3), ladybirds (2, 4, 8) and basketballs (1, 2, 8). For example, if presented with the more-than contextual cue followed by 1 basketball and 8 basketballs, selecting the 8 basketball image would result in the word 'Correct' being displayed on the screen for 3 s. Given the less-than contextual cue with 1 basketball and 8 basketballs, selecting 1 basketball would be the correct response. An incorrect response resulted in the word "Wrong" being displayed for 3 s. Responses were made by clicking on the 'z' key to select the image on the left or the '?' to select the image on the right. These keys were marked with a sticker on the keyboard for ease of responding.

As each set of stimuli contained three images representing few, intermediate and most, this generated 3 trials when presented with both the less-than cue and the more-than cue (Few/Intermediate, Few/Most, Intermediate/Most). Given that there were four sets of stimuli and two contextual cues, this generated 24 trial types. Participants were required to make 10 consecutive correct responses in order to reach criterion responding and progress to the test phase.

The test phase was identical in appearance to the training phase, except that new stimuli sets were used and no feedback was presented. The images used were boats (1, 2, 3), apples (1, 4, 7), traffic lights (1, 3, 4) and turtles (2, 3, 4). Participants were required to make 10 consecutive correct responses in order to progress to the next phase. If a participant failed to do so, they were re-exposed to training.

Phase 2: Arbitrary relational training and testing. The purpose of this phase was to train a relational network of nonsense words (E > D > C > B > A) using the contextual cues that had been established in Phase 1. Participants were presented with the contextual cue for more-than at the top of the screen and two comparisons. Participants learned to select the word that represented more-than by pressing the 'z' or '?' key as before. Participants were required to respond within 3 seconds. If a response was not made within this time, the words "Too Slow" were presented onscreen. A correct choice resulted in the word "Correct" being displayed in the centre screen for approximately 3 seconds and an incorrect response resulted in the word "Wrong" being displayed onscreen for 3 seconds. Participants were presented with the following trials, B > A, C > B, D > C, E > D. All images were counterbalanced across trials and presented in a quasi-random order. Participants were required to make 12 consecutive correct responses to meet the training criterion.

On completing arbitrary relational training, participants were exposed to arbitrary relational testing to test for the emergence of mutually entailed and combinatorially entailed relations. The format was identical to the training phase except for two major differences. First, participants were not given feedback after any responses. Second, participants were also presented with mutually and combinatorially entailed trials when presented with the less-than contextual cue. The relations that had been trained consisted of B > A, C > B, D > C, E > D, therefore it was expected that this would give rise to the following mutually entailed relations A < B, B < C, C < D, D < E. Additionally, it would also be expected that ten further combinatorially entailed relations would be derived. These relations were A > C, B < D, C < E, C > A, D > B, E > C, A < D, B < E, D > A, E > B.

In this phase, there were 4 trained relations, 4 mutually entailed relations, and 12 combinatorially entailed relations presented. During the arbitrary relational test, each of these 18 trials was presented once. Participants were required to meet a criterion of a minimum of 16 correct responses out of 18 during this phase. If participants failed to reach this criterion after one block, they were re-exposed to *Phase 1 (Non-arbitrary training and testing)* and *Phase 2 (Arbitrary relational training and testing)* a maximum of three further times.

Phase 3: Training discriminative slot-machine functions. The purpose of this phase was to establish discriminative functions for two different slot-machines labelled with members of the relational network. Participants were presented with the following onscreen instructions:

> *You will be given two slot-machines to play. One slot-machine is called BIH and the other is called YUT. The computer will present the slot-machines one at a time for you to play. To play the machine, click the 'Bet 1' button and then click the 'Spin' button. Your aim is to win as many points as possible. Good luck!*

In this phase, participants were exposed to two slot-machines of differing probabilities, slot-machine labelled C from the relational network and slot-machine labelled X (a novel nonsense word). The slot-machines were grey with three reels. To play a slot-machine, participants were required to click on the 'Bet 1' button, which automatically deducted one credit from the 'Total Credits' box situated above the reels, and made the 'Spin' button available. Clicking 'Spin' caused the three reels to spin for approximately five seconds before stopping. If three matching symbols appeared on the payoff line then the participant was awarded five credits in the 'Total Credits' box at the top of the screen. If less than three symbols matched, then no further credits were deducted as one credit had already been lost in order to play the slot-machine. Participants started with 100 credits and the slot-machines were programmed such that all participants experienced wins or losses on exactly the same trials and ended with 155 credits. Participants were presented with each slot-machine on screen one at a time until they had played each machine 40 times. The slot-machines were identical in appearance except that slot-machine C was labelled with the nonsense word BIH and had a payout probability of 0.2 (i.e., it 'paid out' on 8 out of 40 trials). Slot-machine X was labelled with a novel nonsense word and had a payout probability of 0.8 (i.e., it paid out on 34 out 40 trials).

Phase 4: Transformation of discriminative slot-machine functions. The purpose of this phase was test for transformation of discriminative slot-machine functions when participants were presented with pairs of slot-machines labelled with members of the relational network. At the start of this task, participants were presented with the following onscreen instructions:

> *You will now be presented with some more slot-machines named after the nonsense words you saw in the previous task. Please select which slot-machine you would like to play by clicking the 'Spin' button on your chosen slot-machine. You will not be able to see how many points you win on each machine, but the computer is still recording your score. Your aim is to try to earn as many points as possible.*

Participants were presented with two slot-machines onscreen at a time and selected the machine that they wanted to play by clicking on the on the chosen slot-machine with a mouse. However, the reels did not actually spin and credit was not awarded or lost. The slot-machines were identical in appearance except for the nonsense word of each slot-machine that was situated just above the reels. The nonsense words were from the relational training procedures (A = VEK, B = JOM, C = BIH, D = CUG, E = PAF), with the addition of nonsense word YUT (stimulus X) from the previous slot-machine phase.

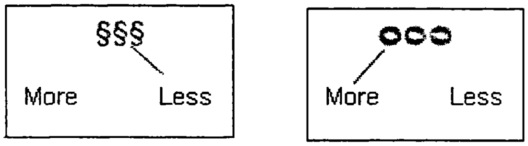
Participants were presented with all possible combinations of slot-machine and each combination was presented four times. There were 60 trials in this phase. The side on which the slot-machines were presented was counterbalanced.

At the end of this phase, participants were presented with a Likert scale and instructed to rate how likely they thought it was that a win could occur on each slot-machine. The scale ranged from 1 (*very unlikely*) to 5 (*very likely*). Participants rated each slot-machine by clicking on the number on the scale with the right button of the mouse on the scale that corresponded to each slot-machine.

Phase 3 trained the discriminative function of low probability/payout percentage for slot-machine C. Phase 4 was designed to see if this function would transform in accordance with the relational network from Phase 2, such that participants would show greater preferences for slot-machines D and E, as D and E had been trained in the previous task as 'more-than' C, compared to slot-machines A and B, which participated in a derived relation of 'less-than' C. Given the network E > D > C > B > A, where stimulus C was trained as a low probability slot-machine, the following preferences were predicted (preference marked in italics): A – *B*, A – *C*, A - *D*, A – *E*, A – *X*, B – *C*, B – *D*, B – *E*, B – *X*, C – *D*, C – *E*, C – *X*, D – *E*, D – *X*, and E – *X*.

It was predicted that given when slot-machine X was an option, this slot-machine would always be selected as participants had experienced the high contingencies of this slot-machine. It was predicted that with the exception of concurrent presentations of slot-machines E and X, slot-machine E would be the preferred selection over any other slot-machine as stimulus E was trained as the greatest stimulus in the relational network during arbitrary relational training. It was predicted that when presented with slot-machine D and C, slot-machine D and B, or slot-machine D and A, slot-machine D would be the preferred choice as stimulus D was trained as a more-than C, B, and A. When presented with slot-machines C and B, or C and A, it was predicted that slot-machine C would be selected as C is greater than B and A. Finally, when presented with slot-machine B and slot-machine A it was predicted that slot-machine B would be selected as stimulus B was greater than A.

Phase 1: Non-arbitrary relational training.



Phase 2: Arbitrary relational training.

E > D > C > B > A

Trained	More B / A	More C / B	More D / C	More E / D
Tested	Less A / B	Less B / C	Less C / D	Less D / E
	Less A / C	Less B / D	Less C / E	More C / A
	More D / B	More E / C	Less A / D	Less B / E
	More D / A	More E / B		

Phase 3: Training of discriminative slot machine functions.

E > D > C > B > A
↑
Trained as low payout slot machine
0.2 probability

Novel stimulus X
↑
Trained as high payout slot machine
0.8 probability

Phase 4: Test for transformation of function – all combination of slot machines under extinction (predicted preference marked in bold) and graphical presentation of predicted slot machine choice.

A **B**	B **C**	C **D**	D **E**	E **X**
A **C**	B **D**	C **E**	D **X**	
A **D**	B **E**	C **X**		
A **E**	B **X**			
A **X**				

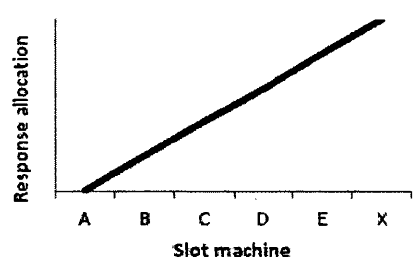


Figure 5.1. Schematic experimental overview. In Phase 1 participants receive reinforcement for selecting the correct comparison stimulus, the words ‘more’ and ‘less’ are used for clarity. In Phase 2, the arbitrary symbols from Phase 1 are employed as contextual cue for more and less to train the relational network of nonsense words. In Phase 3 stimulus C is paired with a low payout slot-machine and novel stimulus X is paired as a high payout slot-machine. In Phase 4, the table represents all possible combinations of slot-machines that were presented, and the graphical figure displays predicted preference for each slot-machine.

Results and Discussion

Table 5.1.
Number of trials required for participants to reach criterion during the non-arbitrary and arbitrary training and testing in Experiment 9A.

Participant	Non-arbitrary relational training	Non-arbitrary relational testing	Arbitrary relational training	Arbitrary relational testing
P1	15	10	84	7/18
	10	10	25	11/18
	10	55	49	11/18
	10	10	41	11/18
P2	12	22	47	9/18
	10	13	20	16/18
P3	57	10	114	16/18
P4	25	10	115	16/18
Mean	18.63	17.5	61.88	12.13
SD	16.33	15.71	37.73	3.48

Table 5.1 above shows that all participants completed the non-arbitrary relational training and testing. Only P1 failed to complete the arbitrary relational training tasks within four exposures to the task, therefore did not proceed to Phase 3 of the experiment. P3 and P4 completed the experiment after only one exposure to each task. Figure 5.2 below shows each participant's individual slot-machine choices during Phase 4 of the experiment. The slot-machine choices for P2 and P3 are in accordance with the relational network of nonsense words that was trained in the arbitrary relational training task with slot-machine A having never been selected and slot-machine E being the most preferred slot-machine regarding slot-machines from the relational network. Both P2 and P3 selected slot-machine E on 16 out of 20 trials. This means that the only occasions in which slot-machine E was not selected was when concurrently presented with slot-machine X. Given that participants had been exposed to the high payout contingencies of slot-machine X during Phase 3, it had been predicted that slot-machine X would be the most preferred slot-machine. P4 however did not select slot-machine X at all during phase 4. The slot-machine choices for P4 show that slot-machine A was the least preferred of the slot-machines

from the network. Slot-machines C, D and E were each selected 16 times during Phase 4 suggesting equal preference.

Figure 5.2 displays the mean response allocation across all participants. The general trend is that slot-machine A is the least preferred slot-machine and slot-machine E is the most preferred slot-machine, with a clear pattern of preference which increases in accordance with the trained relational network demonstrating a transformation of the discriminative slot-machine functions.

E > D > C > B > A

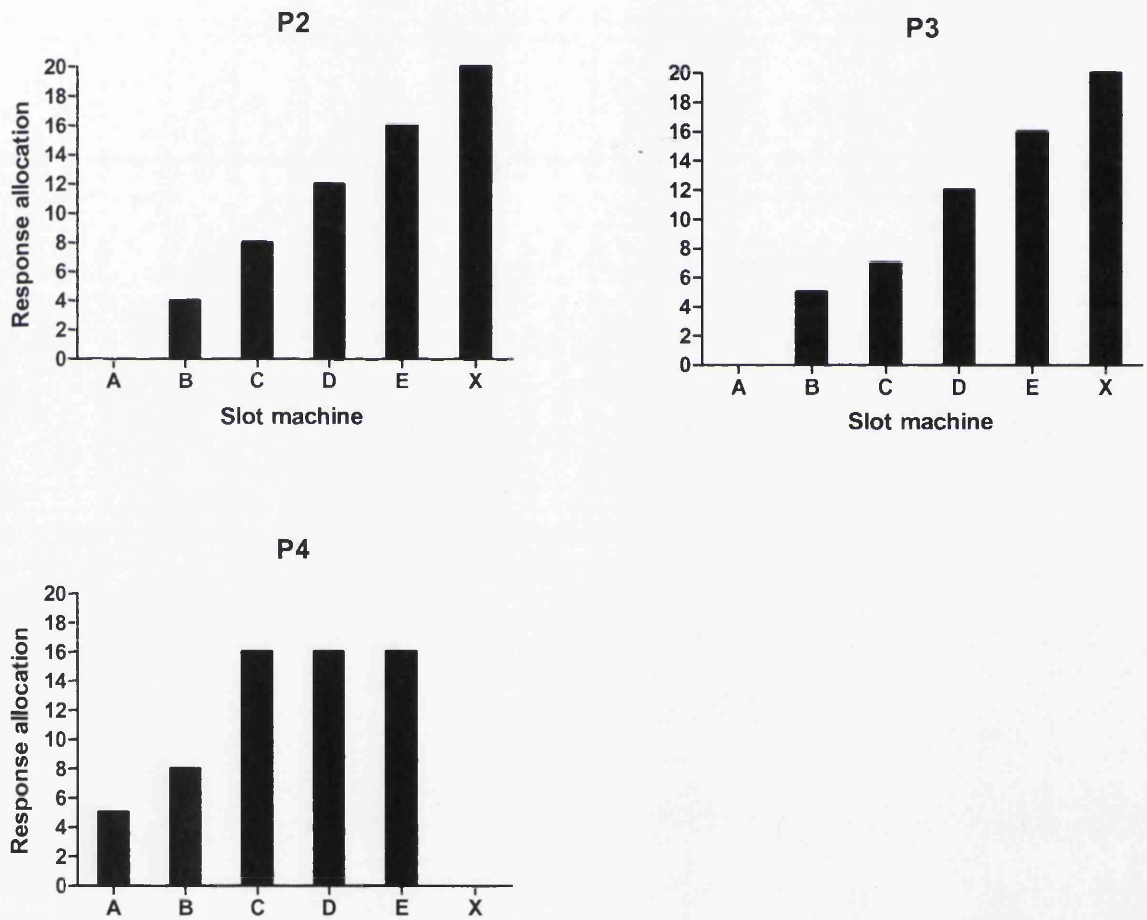


Figure 5.2 . Participants' response allocation to each slot-machine under extinction during Phase 4 of Experiment 9A.

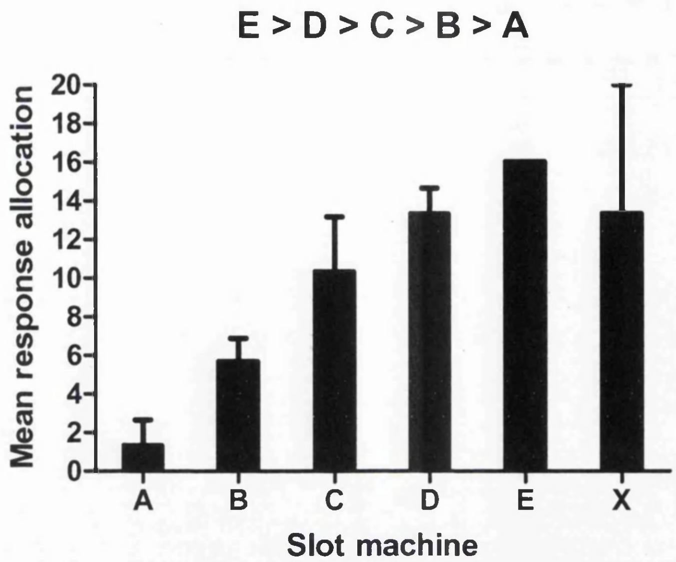


Figure 5.3. Mean response allocation during Phase 4 of Experiment 9A.

Experiment 9A demonstrated that preferences for concurrently available slot-machines can be determined by a transformation of discriminative functions in accordance with an arbitrary relational network. However, during arbitrary relational testing participants were only presented with each trial once. Given that the criterion for the arbitrary test was 16/18, participants could still meet criterion even though they had not learned to respond correctly to two of the relations. Additionally, if the participant had responded to one or two correctly by chance, then potentially only 14 of the 18 relations had been learned yet the participant may have passed the test without having fully mastered the task. To eradicate this problem, a modification was made to the programme for Experiment 9B so that so that each trial was presented twice.

Experiment 9B

Method

Participants

Six participants, 4 males and 2 females, aged between 20 and 26 (*M* =22.83, *SD* = 2.23), were recruited from across Swansea University. The mean SOGS score was 2.33 (*SD* = 1.51). Participants were compensated with £5 at completion of the study.

Procedure

The procedure for Experiment 9B was identical to Experiment 9A, except for the following two important differences. Firstly, in the arbitrary training task, the three second period within which participants had to respond was removed. Now, the next trial commenced after the participant responded. Secondly, in the test phase of the arbitrary training task, participants had previously only been presented with 18 trials in each test phase. This meant that each combination of test trial was only presented once. To overcome this issue, participants were presented with 36 test trials in Experiment 7B so that each trial was presented twice. During the arbitrary relational test, each of these 18 trials was presented twice in a block of 36 trials in a quasi-random order. Participants were required to meet a criterion of a minimum of 30 correct responses out of 36 during this phase. If participants failed to reach this criterion after one block, they were re-exposed to *Phase 1 (Non-arbitrary training and testing)* and *Phase 2 (Arbitrary relational training and testing)* a maximum of three further times.

Results and Discussion

Table 5.2 shows the number of trials that each participant required in order to complete non-arbitrary and arbitrary relational training. In Experiment 9B, all participants except for P7 completed the non-arbitrary training task and progressed to the arbitrary training task. P5, P8 and P9 only required one exposure to each task to meet criterion. P6 and P10 completed all training and testing tasks within 2 exposures.

Table 5.2.
Number of trials required for participants to reach criterion during the non-arbitrary and arbitrary training and testing in Experiment 9B.

Participant	Non-arbitrary training	Non-arbitrary testing	Arbitrary training	Arbitrary testing
P5	27	10	96	35/36
P6	670	10	168	19/36
	35	10	72	32/36
P7*	40	10	-	-
P8	15	10	132	32/36
P9	64	10	24	36/36
P10	26	10	24	19/36
	21	10	24	33/36
Mean	11.25	10	77.14	29.86
SD	225.86	0	57.91	7.60

*denotes that participant who terminated the experiment

Figure 5.4 shows each participants' individual preferences for all the slot-machines when presented under extincion. It shows participants preferences for the slot-machines increase in accordance with the relational network. This effect is particularly apparent in P8 and P9, with slot-machine A being the least preferred and slot-machine E being the most preferred slot-machine from the network. P5, P8 and P9 never selected slot-machine A when presented under extinction, whereas P10 only chose to play slot-machine A three times. P8 was the only participant whose slot-machine choices were in accordance with prediction on 100% of trials. Responding for P5 and P9 were as predicted on 93% and 95% of trials, respectively. The data from P6 and P10 show greatest deviation from the prediction, with correct responses seen across 80% and 84% of trials, respectively.

All participants showed greatest preference for slot-machine X. This was originally predicted, as particpants had direct experience playing slot-machine X 40 times with a payout percentage of 0.8 (Phase 3). The data from P6 show that (excluding X which did not feature in the network) slot-machine C was the most preferred. During slot-machine function training, slot-machine C was trained as the low probability slot-machine; therefore, it is surprising that a preference would be seen for this particular slot-machine

E > D > C > B > A

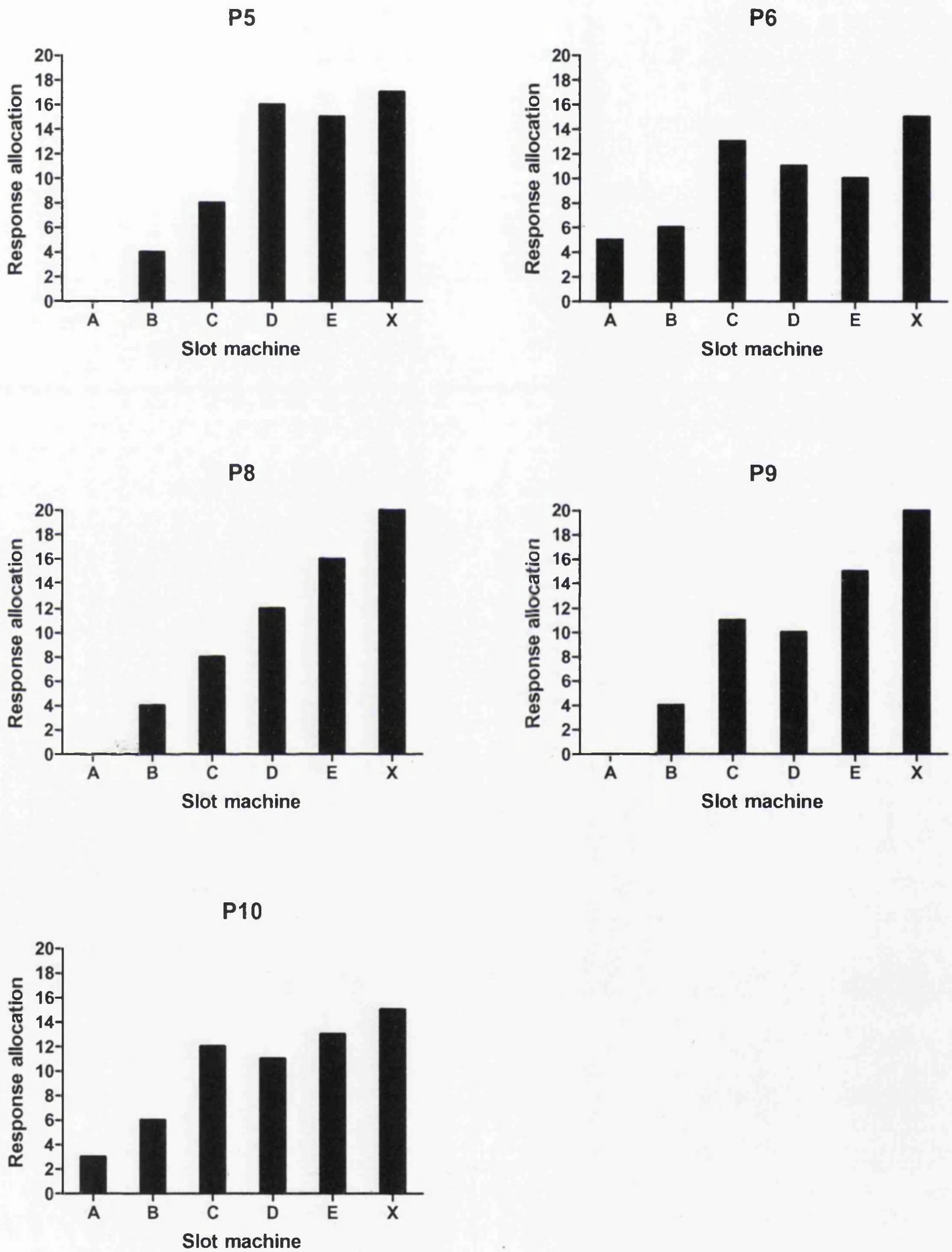


Figure 5.4. Participants' response allocation to each slot-machine under extinction during Phase 4 of Experiment 9B.

The general trend of Figure 5.4 is that slot-machine A was the least preferred slot-machine and slot-machine E the most preferred slot-machine (when only taking into account the slot-machine containing stimuli from the relational network). Figure 5.5 shows the mean response allocation for all participants during the final slot-machine phase in Experiment 9B. The results are particularly interesting as there is a very clear pattern of preferences which increase in accordance with the trained relational network, clearly demonstrating a transformation of the discriminative slot-machine functions. Participants only had a direct history of playing slot-machine C and slot-machine X, yet when presented with slot-machines E and D under extinction, a preference was seen for slot-machine E despite never actually playing that slot-machine.

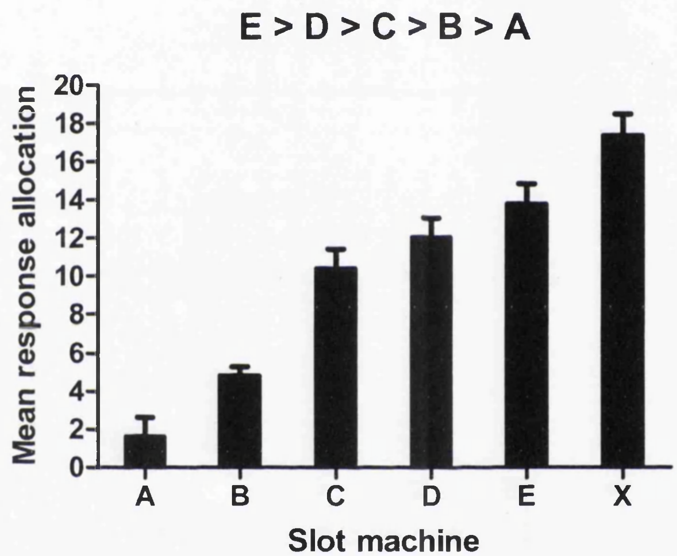


Figure 5.5. Mean response allocation during Phase 4 of Experiment 9B.

A further experiment was designed in which participants were trained in the same network of nonsense words except that during arbitrary training the less-than contextual cue is used instead of the more-than cue. This results in the network A < B < C < D < E, where stimulus A is still trained as the least in the network and stimulus E is trained as the greatest. The purpose of this was to test whether the same pattern of a derived transformation of discriminative functions would occur when trained using the less-than network.

Experiment 10

Method

Participants

Six participants, 4 males and 2 females, aged between 20 and 21 (*M* = 20.2, *SD* = 0.45), were recruited from across Swansea University. The mean SOGS score was 0.5 (*SD* = 0.84). Participants were compensated with £5 at completion of the study.

Procedure

The procedure for Experiment 10 was identical to that of Experiment 9B except that during arbitrary relational training the less-than contextual cue was presented instead of the more-than contextual cue. For example, in the previous experiments, given the more-than cue and stimulus A and stimulus B, the correct response that was reinforced would be selecting stimulus B. In the present experiment, given stimulus A and stimulus B and the less-than contextual cue, the correct response would be to select stimulus A. The network that was trained was A < B < C < D < E.

Given the network A < B < C < D < E, where stimulus C was trained as a low probability slot-machine, the following preferences were predicted (preference marked in italics): A – *B*, A – *C*, A - *D*, A – *E*, A – *X*, B – *C*, B – *D*, B – *E*, B – *X*, C – *D*, C – *E*, C – *X*, D – *E*, D – *X*, and E – *X*.

Results and Discussion

Table 5.3.
Number of trials required for participants to reach criterion during the non-arbitrary and arbitrary training and testing in Experiment 10.

Participant	Non-arbitrary relational training	Non-arbitrary relational testing	Arbitrary relational training	Arbitrary relational testing
P11	18	18	84	18/36
	26	10	24	20/36
	14	10	12	17/36
	10	10	12	36/36
P12	24	10	108	26/36
	10	10	36	35/36
P13*	105	10	48	23/36
	10	10	72	19/36
	10	11	-	-
P14	18	10	72	22/36
	10	10	36	35/36
P15	20	10	84	35/36
P16	16	10	168	17/36
	10	15	48	8/36
	10	10	12	30/36
P17	245	48	-	-
	32	48	-	-
	10	48	-	-
	10	48	-	-
	10	36	-	-
P18	25	10	72	32/36
Mean	30.62	19.14	59.2	24.93
SD	53.27	15.47	42.42	8.54

*denotes that participant terminated the experiment

Table 5.3 above shows that all participants except for P17 passed the non-arbitrary relational training and testing. For this reason, P17 did not progress to the arbitrary training phase. P13 voluntarily terminated the experiment prior to her third exposure to the arbitrary training task. The remaining 6 participants successfully met criterion responding for Phase 2 within four exposures to the task and proceeded to the slot-machine phases of the experiment.

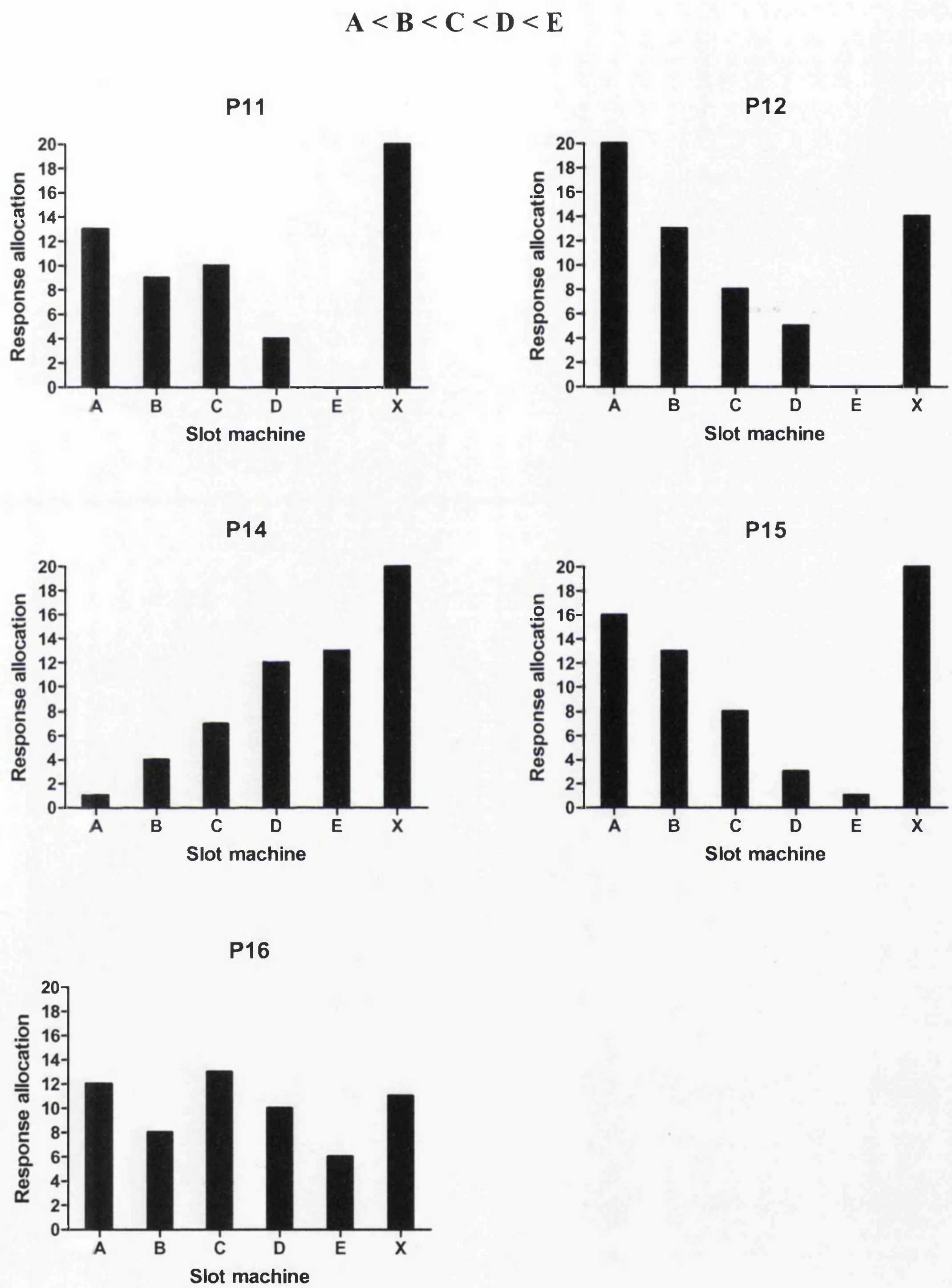


Figure 5.6. Participants' response allocations to each slot-machine under extinction during Phase 4 of Experiment 10.

The figure above shows participants' slot-machine choices during test for transformation of discriminative function. Only P15 responded correctly in accordance with the relational network with slot-machine A being the least preferred slot-machine and slot-machine E being the most preferred slot-machine from the relational network. It is interesting that P11, P12, and P14 showed preferences for the slot-machines that were the opposite of the relational network. It is difficult to explain such responding, however, it may relate to the way in which the network was trained. For example, when presented with the less-than contextual cue followed by stimulus A and stimulus B, the response that is reinforced is selection of stimulus A, as A is less-than B. Therefore, when concurrently presented with slot-machine A and slot-machine B, the participant has a history of positive reinforcement for selecting stimulus A (resulting in the word 'Correct' being presented having selected stimulus A over stimulus B), making it more likely that slot-machine A will be selected. If this is the case, this may have implications as to whether the less-than cue was functioning as a contextual cue for less-than.

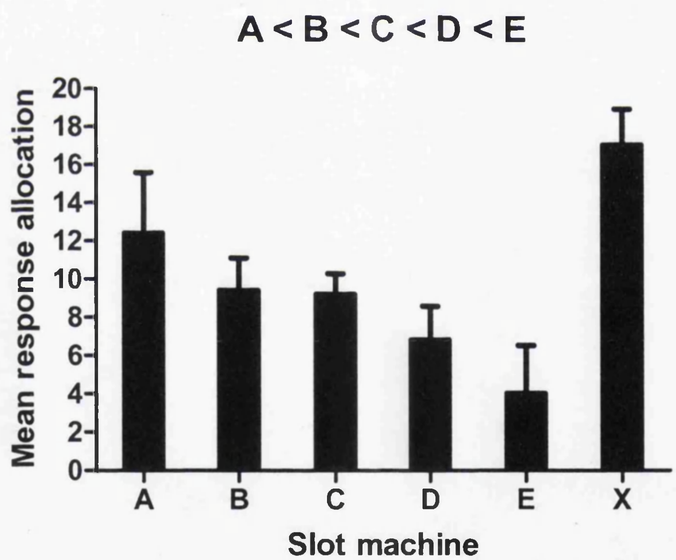


Figure 5.7. Mean response allocation to each slot-machine across all participants during Phase 4 of Experiment 10.

Figure 5.7 shows that all participants showed increased preferences for slot-machine A with a gradual decrease for the slot-machines in the middle of the network, with slot-machine E being the least preferred slot-machine. These findings are the opposite of what was predicted and transformation of discriminative functions cannot be said to have occurred.

A key limitation of Experiments 9A, 9B and 10 was the design of Phase 4 in which emergence of transformation of functions is tested. In the RFT literature, tests for transformation of function are typically subject to a mastery criterion, so that if the criterion is not met during the first exposure to the transformation task, further exposures to the arbitrary training tasks are presented. This often has the effect of making the demonstration of predicted transformations of functions more likely (Dymond & Rehfeldt, 2000). Experiment 11 was designed to replicate and extend Experiments 9A and 9B by including a mastery criterion for the transformation of functions phase.

Experiment 11

Method

Participants

Seven participants, 2 males and 5 females, aged between 19 and 21 (M = 19.57, SD = 0.79), were recruited from across Swansea University. The mean SOGS score was 1.71 (SD = 1.25). Participants were awarded course credit on completion of the study.

Procedure

The procedure for Experiment 11 was identical to that of Experiment 9B except that during Phase 4, if participants did not respond in accordance with predictions to at least 18 out of 20 trials, they were re-exposed to the entire task starting with non-arbitrary relational training and testing (Phase 1), followed by arbitrary training and testing (Phase 2), the discriminative slot machine function training (Phase 3) and finally re-tested for transformation of function (Phase 4). Furthermore, if participants' slot-machine choices were as predicted on 18 out of 20 trials, the two incorrect could not be the same trial type; otherwise participants were returned to the start of the experiment. Participants were only exposed to the entire experiment (that is, Phases 1 to 4) a maximum of three times. An additional change to Phase 4 was that each combination of slot-machines was only presented twice, instead of four times as in the previous experiments.

Results and Discussion

Table 5.4.
Number of trials required for participants to reach criterion during non-arbitrary and arbitrary training and testing of Experiment 11.

Participant	Non-arbitrary relational training	Non-arbitrary relational testing	Arbitrary relational training	Arbitrary relational testing
19	14	10	84	31/36
	11	10	36	28/36
	10	10	12	28/36
	10	10	24	36/36
20	14	10	144	25/36
	10	10	24	30/36
	10	10	12	33/36
21	115	48	-	-
	12	23	48	20/36
	30	10	12	25/36
	14	10	72	31/36
22	24	17	36	19/36
	10	10	36	30/36
23	24	17	36	19/36
	10	10	36	30/36
24	80	10	36	20/36
	10	10	24	18/36
	10	20	12	34/36
	10	10	12	36/36
	10	10	12	35/36
25	10	19	204	21/36
	10	20	24	17/36
	10	10	36	18/36
	10	10	12	31/36
	10	11	12	35/36
	10	10	12	35/36
Mean	23.94	15.44	56.6	24.67
SD	29.96	9.90	54.21	5.98

Table 5.4 shows that all participants successfully passed the non-arbitrary and arbitrary relational training and testing. Although P21 passed arbitrary training, they terminated after one exposure to slot-machine tasks. The table shows the number of trials required to complete non-arbitrary and arbitrary relational training and testing, including any additional exposures to these tasks following participants failing the test for transformation of function. However, the mean number of trials required to meet criterion were calculated using only the data from the participants initial exposure to the task, as during any further exposures to these tasks mastery criterion has already been achieved previously.

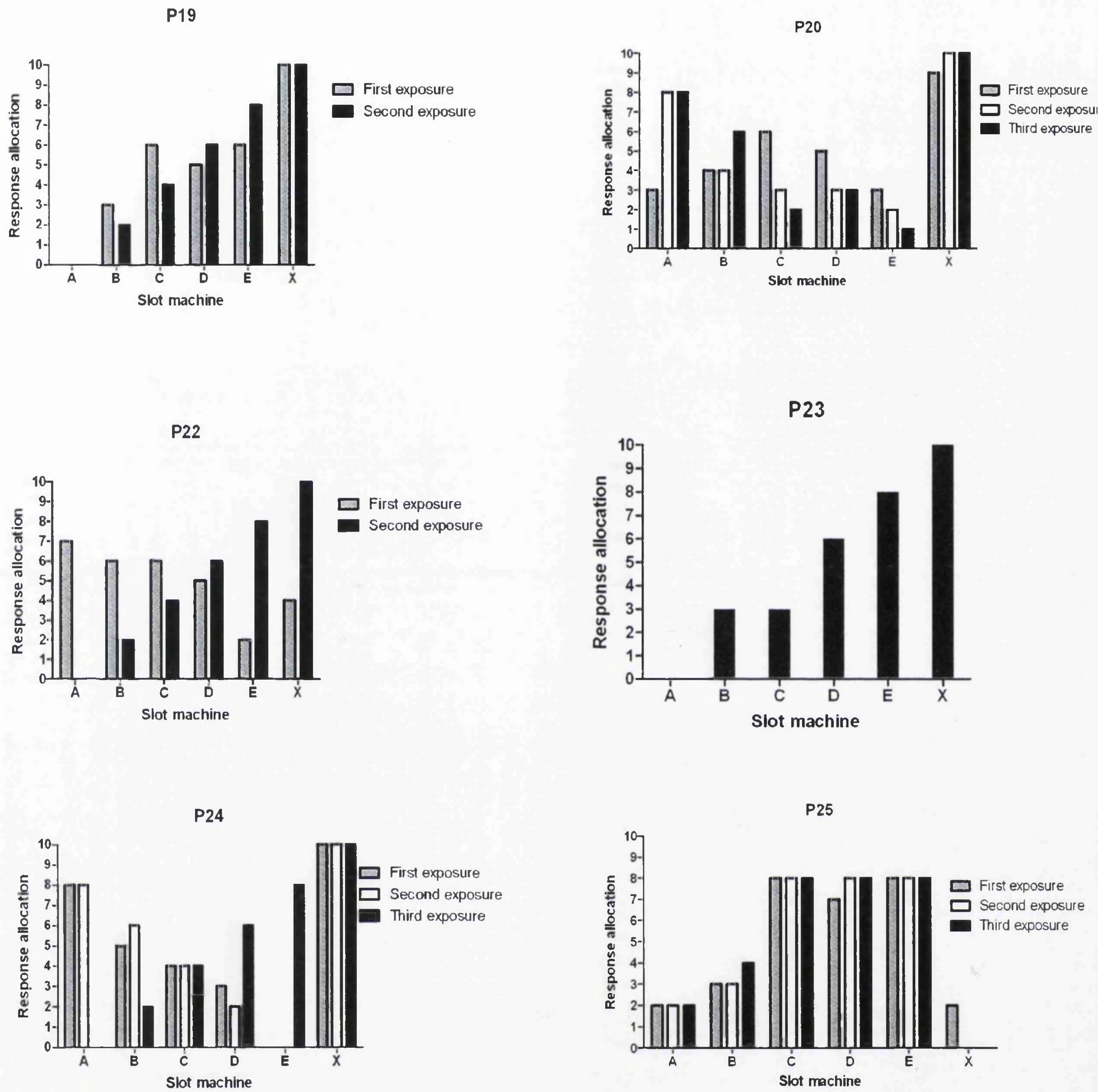


Figure 5.8. Participants' individual slot-machine response allocation during Phase 4 of Experiment 11. Participants requiring more than one exposure to Phase 4 are shown where necessary.

Figure 5.8 shows that P20, P22, P23 and P24 all showed slot-machine preferences in accordance with the relational network therefore demonstrating a transformation of function. Whilst P25 did not meet criterion for a transformation of function, slot-machine choices were close to that of the relational network in that slot-machine A was the least preferred, with slot-machine C, D, and E being the most preferred. P25 selected slot-machine X very rarely which is unusual compared to other participants, who often select this slot-machine the most due to the high payout contingencies of this slot-machine that are presented in Phase 3.

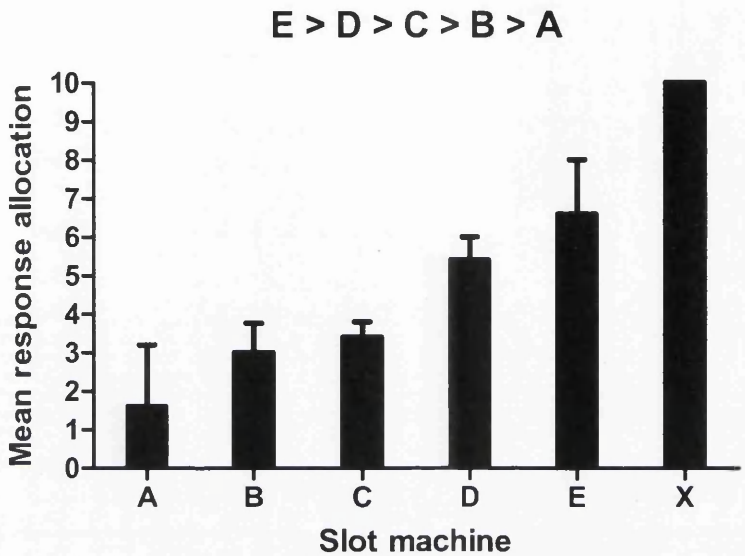


Figure 5.9. Mean response allocation during Phase 4 of Experiment 11.

Four out of six participants met criterion for transformation of function, that is, four participants emitted responses in accordance with predictions. In Experiments 9A and 9B where no criterion was set, only one participant in each experiment responded in accordance with predictions. Perhaps if a criterion had been set for Experiment 10 then more participants would have responded in accordance with prediction.

Experiment 12 was designed to test whether participants would respond in accordance with prediction having been trained using the less-than cue, when a criterion during test for transformation of function was included. Additionally, participants were trained the opposite network to Experiments 9A, 9B, and 10 so that stimulus A was now trained as the greatest member of the network and slot-machine E was trained as the smallest member of the network. As Whelan et al. (2006, p.325) state "[if] relational frames are instances of operant behavior, it follows that altering the baseline relational training contingencies will lead, in appropriate contexts, to the derivation of newly entailed relations and the transformation of functions in accordance with these relations." Therefore, whichever stimulus from the derived relation is established as having the highest payout probability in the network, it is predicted that transformation of function will occur in accordance with that particular network. Whelan et al. (2006) were able to reverse the pattern of transformation of function that occurred via the relational network that was originally trained so that the stimulus that was previously trained as the highest-ranking member of the stimulus became the lowest ranking member of the network.

Experiment 12

Method

Participants

Fourteen participants, 3 males and 11 females, aged between 18 and 23 (*M* = 19.8, *SD* = 1.52), were recruited from across Swansea University. The mean SOGS score was 0.75 (*SD* = 1.06). Participants were awarded course credit on completion of the study.

Procedure

The procedure for Experiment 12 was identical to that of Experiment 11 except for minor differences during arbitrary relational training. Firstly, participants were given training with a reversed relational network to that employed previously such that stimulus A was now the highest ranked member of the network and stimulus E was the lowest ranked member of the network. This was achieved by conducting arbitrary relational training using the less-than contextual cue: E < D < C < B < A. During arbitrary relational training, participants were presented with the less than cue and the following four relations: E < D, D < C, C < B, B < A, generating the network E < D < C < B < A. Given this network, where stimulus C was trained as a low probability slot-machine, the following preferences were predicted (preference marked in italics): *A* – B, *A* – C, *A* - D, *A* – E, A – *X*, *B* – C, *B* – D, *B* – E, B – *X*, *C* – D, *C* – E, C – *X*, *D* – E, D – *X*, and E – *X*.

Results and Discussion

Table 5.5.
Number of trials required for participants to reach criterion during the non-arbitrary and arbitrary training and testing in Experiment 12.

Participant	Non-arbitrary training	Non-arbitrary testing	Arbitrary training	Arbitrary testing
P26	19	10	120	21/36
	11	16	36	15/36
	16	10	24	24/36
	10	10	60	34/36
P27	14	38	96	17/36
	14	10	12	18/36
	10	10	12	26/36
	10	10	23	19/36
P28	19	10	60	30/36
	10	10	12	32/36
	10	10	12	32/36
P29	41	48	-	-
	333	10	48	15/36
	13	13	36	18/36
	10	39	36	22/36
	14	48	-	-
	10	48	-	-
	10	39	12	26/36
P30	12	10	71	26/36
	10	10	13	26/36
	10	10	24	21/36
	10	10	12	21/36
P31	26	10	60	20/36
	10	12	24	19/36
	20	13	72	26/36
	16	10	12	19/36
P32	27	12	36	26/36
	11	10	12	27/36
	10	10	12	26/36

Participant *(cont.d)*	Non-arbitrary training	Non-arbitrary testing	Arbitrary training	Arbitrary testing
P32 *(cont.d)*	10	17	24	18/36
P33	10	10	84	17/36
	10	13	12	16/36
	10	10	36	17/36
	10	10	12	18/36
P34	134	48	-	-
	16	21	72	19/36
	49	10	24	24/36
	11	10	24	33/36
	10	24	24	36/36
	10	10	24	33/36
P35	87	10	96	19/36
	44	10	24	20/36
P36	10	10	144	19/36
	24	15	552	22/36
	11	10	48	19/36
P37	10	10	51	17/36
	10	10	54	17/36
	22	10	120	28/36
	20	26	36	31/36
P38	10	10	12	32/36
	10	10	24	31/36
	39	10	60	19/36
	10	10	48	17/36
P39	10	10	30	32/36
	10	10	36	30/36
	10	10	48	31/36
Mean	24.16	15.54	51.27	23.54
SD	46.77	11.48	77.43	6.01

Table 5.5 above shows that only five participants, namely P26, P28, P34, P38, and P39, passed the non-arbitrary and arbitrary relational tasks. All of these

participants, except for P28, required four exposures to the task in order to meet criterion responding. P28 completed these tasks within three exposures. The remaining eight participants failed to meet criterion responding with four exposures to the task therefore were not given the slot-machine tasks.

E < D < C < B < A

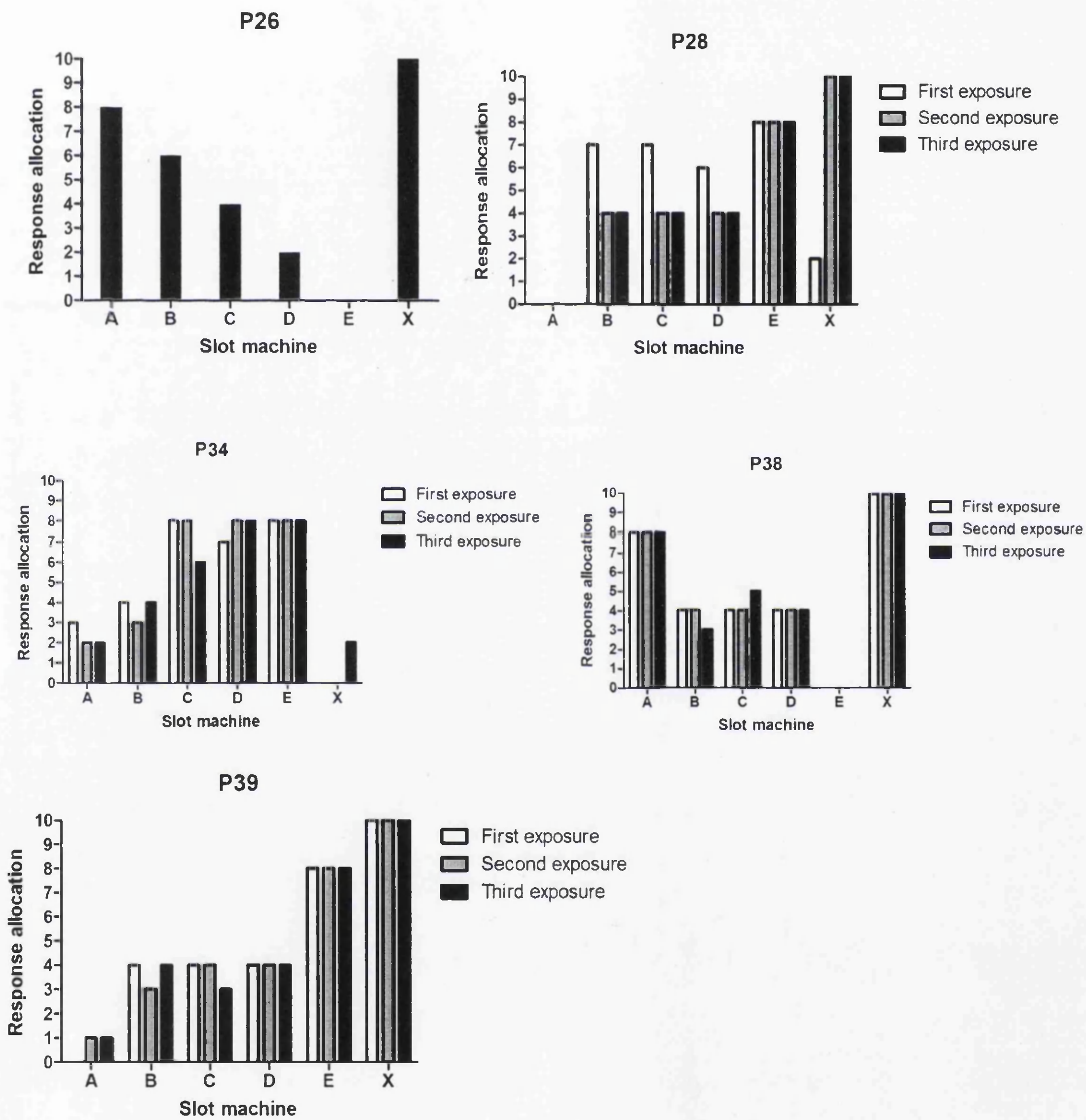


Figure 5.10. Participants' response allocation to each slot-machine under extinction during Phase 4 of Experiment 12. Participants who required more than one exposure to Phase 4 are shown where appropriate.

Figure 5.10 above shows between-participant variability in slot-machine choices during the test for transformation of discriminative functions. Only P26 demonstrated a transformation of discriminative function in accordance with predictions. Although P37 did not meet criterion for Phase 4, greatest preference was seen for slot-machine A (excluding slot-machine X), which was in line with predictions. P28, P34, P38 showed increased preference to slot-machine E (excluding slot-machine X), despite the fact that stimulus E was trained as 'least' in the relational network. P28 never selected the highest ranked stimulus, represented by slot-machine A, during any of their three exposures to this phase. These findings are consistent with the findings from Experiment 10 which also trained the relational network using the less-than contextual cue and found that participants' preferences for slot-machines were the inverse of the trained relational network.

From Figure 5.11, which shows the mean responses across all participants in Phase 4, it is clear that no clear preferences were seen for any of the slot-machines containing stimuli from the relational network. As expected, slot-machine X, labelled with the novel stimulus, was the most preferred slot-machine of all the slot-machines.

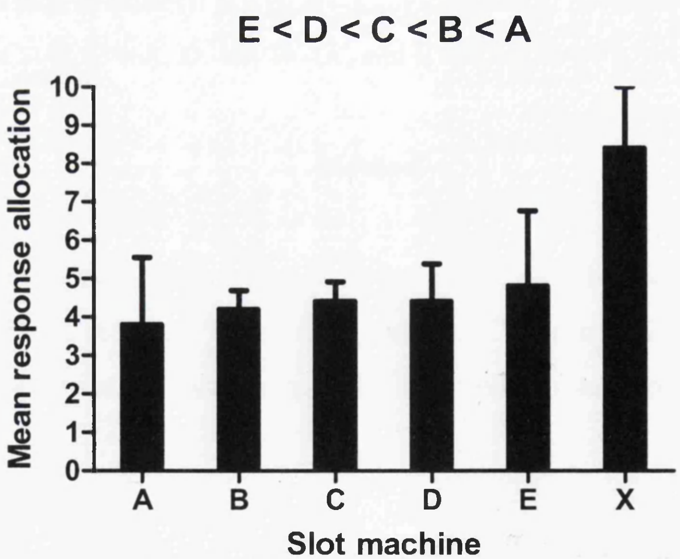


Figure 5.11. Mean response allocation during Phase 4 of Experiment 12.

Despite the addition of a criterion during Phase 4, Experiment 12 did not demonstrate a transformation of discriminative functions when the relational network was trained using the less-than cue. Experiment 13 was designed to see if transformation of function is more readily demonstrated when participants are trained using the more-than cue as the experiments in which the more-than network had resulted in a clear transformation of function, whereas when trained with the less-than cue this had not occurred. Reilly et al. (2005) reported higher levels of accuracy when participants were trained with the more-than cue compared to the less-than cue, so perhaps this accuracy extends to tests of transformation. Participants in Experiment 11 were trained with the same network as Experiment 10, with stimulus A and stimulus E the greatest and smallest members of the network, respectively.

Experiment 13

Given the unexpected findings of Experiments 10 and 12, Experiment 13 employed the same network as Experiment 12 using the more-than cue in arbitrary relational training. Through non-arbitrary and arbitrary relational training, participants were trained the network A > B > C > D > E, using the more-than contextual cue. Given the network A > B > C > D > E, where stimulus C was trained as a low probability slot-machine, the following preferences were predicted (preference marked in italics): *A* – B, *A* – C, *A* - D, *A* – E, A – *X*, *B* – C, *B* – D, *B* – E, B – *X*, *C* – D, *C* – E, C – *X*, *D* – E, D – *X*, and E – *X*.

Method

Participants

Four participants, three males and one female, aged between 21 and 36 (*M* =, 31 *SD* = 7.26), were recruited from across Swansea University. The mean SOGS score was 0.25 (*SD* = 0.5). Participants were awarded course credit on completion of the study.

Procedure

The procedure for Experiment 13 was identical to that of Experiment 11 in which nonsense word A was trained as the greatest stimulus in the network and nonsense word E was trained as the smallest member. However, participants were trained using the more-than cue thus generating the relational network A > B > C > D > E. It was predicted that when all combinations of slot-machines were presented under extinction, slot-machine A would be the most preferred slot-machine from the network, and slot-machine E would be the least preferred. Specifically, the following preferences were predicted (preference marked in italics): *A* – B, *A* – C, *A* – D, *A* – E, A – *X*, *B* – C, *B* – D, *B* – E, B – *X*, *C* – D, *C* – E, C – *X*, *D* – E, D – *X*, and E – *X*.

Results and Discussion

Table 5.6.
Number of trials required for participants to reach criterion during the non-arbitrary and arbitrary training and testing in Experiment 13.

Participant	Non-arbitrary relational training	Non-arbitrary relational testing	Arbitrary relational training	Arbitrary relational testing
P40	63	10	252	18/36
	10	16	24	21/36
	10	10	24	32/36
	10	10	47	26/36
	25	10	48	31/36
	10	10	12	22/36
	10	10	36	30/36
P41	15	10	36	34/36
P42	10	10	60	36/36
P43	46	10	60	24/36
	10	10	36	27/36
	10	10	18	29/36
	14	10	12	18/36
Mean	20.89	10.67	58.00	26.56
SD	19.62	2.00	74.70	6.75

All four participants passed the non-arbitrary relational training and progressed to arbitrary training and testing. Only P43 failed to meet criterion responding for the arbitrary relational test therefore did not proceed to the slot-machine phases of the experiment (Phase 3 and 4).

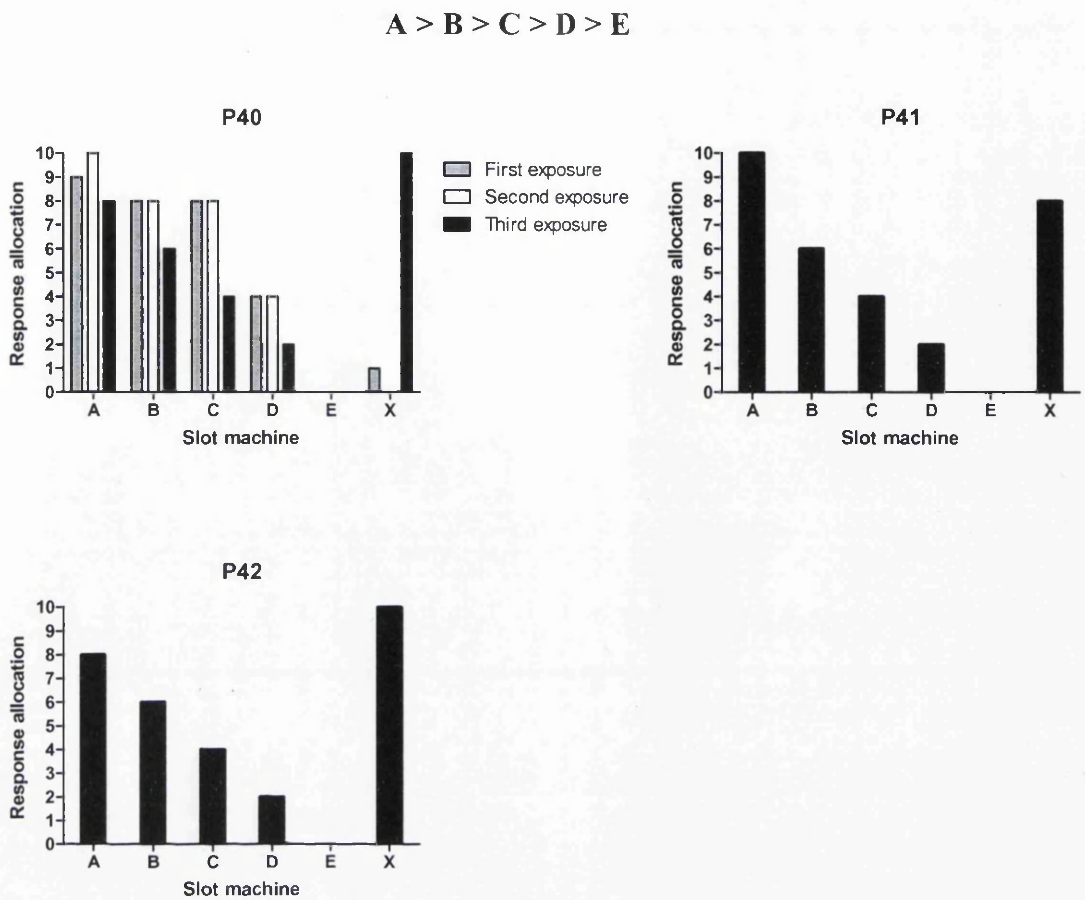


Figure 5.12. Participants' response allocations during Phase 4 of Experiment 13. Participants requiring more than one exposure to Phase 4 are shown where necessary.

Figure 5.12 shows that all participants slot-machine choices transformed in accordance with relational network where A > B > C > D > E. Regarding slot-machines containing stimuli from the relational network, all participants chose to play slot-machine A most frequently than any other slot-machine. Slot-machine E was not selected by any participants. P40 required three exposures to the non-arbitrary and arbitrary training and testing before meeting criterion for transformation of discriminative function, whereas P41 and P42 only required one exposure. These results are consistent with Experiment 9A and 9B and Experiment 10 in which arbitrary relational training took place using the more-than cue and slot-machine choices transformed in accordance with the relational network.

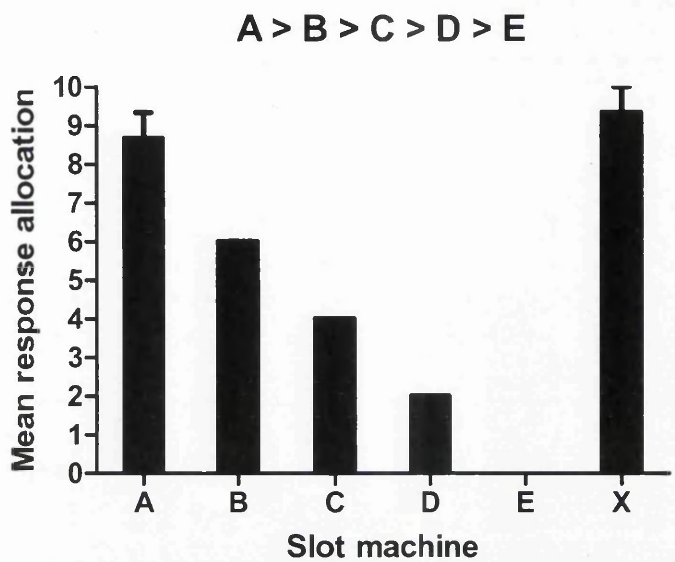


Figure 5.13. Mean response allocation to each slot-machine across all participants during Phase 4 of Experiment 13.

General Discussion

The present chapter demonstrated that discriminative functions of slot-machines may transform in accordance with derived comparative (more-than and less-than) relations. Experiments 9A, 9B, 11, and 13 demonstrated a clear increase in preferences for the slot-machines labelled with the highest ranking stimuli from the relational network. The slot-machine preferences of participants in Experiments 10 and 12 did not, however, demonstrate transformation of function, and the possible reasons for this will be discussed below.

Experiments 9A, 9B, 11, and 13, are consistent with the existing literature on the transformation of functions through derived relations of more-than and less-than (e.g., Dougher et al., 2007; Whelan et al. 2006). The present study is consistent with Dougher et al.'s (2007) findings on operant discrimination transformation (schedule performance) and adds to it the demonstration of transformation involving selections of, and preferences for, concurrently presented slot-machines labelled with members of the relational network. As such, the findings are the first to show a transformation of gambling-relevant stimulus functions in accordance with derived comparative relations and thus support and extend RFT studies on gambling (e.g., Dymond et al., 2011).

The findings may explain why individuals show preferences for slot-machines without having ever experienced a win on that machine (Dixon & Delaney, 2006). Participants in the present experiments never actually experienced the payout contingencies of the slot-machines from the network, with the exception of slot-machine C, yet demonstrated particular preferences for these machines. These preferences can only be explained in terms of a transformation of discriminative function in accordance with derived relations.

The present study adds much needed empirical support to the proposal that verbal behaviour is integral to explaining gambling behaviour (Dixon & Delaney, 2006; Dymond & Roche, 2010). Dymond et al. (2011) explain that the slot-machine preferences emitted by participants are "a derived outcome in much the same way as playing an unfamiliar slot-machine that is described as "hotter" than another: the behavioral processes that mediate this behavior are, according to contemporary behavior analytic accounts, identical" (Dymond et al., p.9). Furthermore, these findings highlight that accounts of gambling behaviour which do not extend beyond schedules of reinforcement, can only partially explain gambling behaviour (Dymond & Roche, 2010; Dymond et al., 2011), as structural characteristics of a slot may machine may participate in derived relations and influence gambling behaviour accordingly.

The present findings may question the cognitive accounts of gambling that individuals who gamble do so due to an inherent gambler's fallacy or a cognitive distortion (Dixon et al., 2009). A cognitive explanation of the present experiment may suggest that it was a cognitive distortion which resulted in participants showing preferences for the slot-machines containing the higher-ranking stimuli (e.g. Joukhador, Blaszczynski, & Maccallum, 2004; Tonneatto et al., 1997), despite having never actually experiencing the contingencies of these slot-machines. However, what is most likely is that participants' slot-machine choices in Experiments 9A, 9B, 11, and 13 came to be controlled by the contingencies arranged by the experimenter and were not due to unpredicted variables such as repeated exposure to the pairs of slot-machines. Experimental control was demonstrated in that participants who were trained on the network A > B > C > D > E, showed greatest preference for slot-machine A, whereas the participants who were trained on the network E > D > C > B > A showed greatest preference for slot-machine E. In each case, there were no particularly salient or enticing features of stimuli A or E and, thus, the ranked preferences can only be accounted for in terms of a transformation of function in accordance with the relational network. If it is possible to bring such preferences under experimental control as was demonstrated in the current study, then it is feasible that other aspects of gambling behaviour may not be the result of cognitive distortions intrinsic to the gambler, but rather are a verbal event which can be manipulated (Dixon et al., 2009).

There are limitations to the present studies, as transformation of discriminative function in accordance with prediction was not seen in Experiments 10 and 12. It is noteworthy that the experiments in which a transformation of function was not seen were the experiments in which participants received less-than training. Although no published findings have reported differences in transformation of functions in accordance with more-than and less-than relations, differences have been found in the training of these relations. Reilly et al. (2005) found higher levels of accuracy in participants who were given the more-than training compared to the less-than training. It is possible that this may have been a contributing factor to the transformation results in the less-than experiments. The mean number of exposures to complete non-arbitrary and arbitrary relational training and testing were slightly lower when trained with the more-than cue (2 and 1.33 for Experiments 9A and 9B, respectively) than when trained using the less-than cue (2.17 and 3.2 for Experiments 10 and 12, respectively).

Future directions for research may include a replication of the present experiment in which the arbitrary test in which mutual and combinatorial entailed trials were presented is removed, and instead the slot-machine trials are presented immediately following the completion of the arbitrary training. This would help determine whether the arbitrary test is necessary to obtain a transformation of function. Another issue that warrants further empirical attention would be to implement a reversal design in which participants are initially trained on the network A > B > C > D > E, then following exposure to the slot-machines, participants are trained on the network E > D > C > B > A. Participants should initially show a preference for slot-machines A and B, however following the second arbitrary training preference should now be shown for slot-machines E and D. Such an extension would allow for a more robust demonstration of experimental control (Whelan & Barnes-Holmes, 2004).

In conclusion, preferences for concurrently available slot-machines may be transformed in accordance with derived comparative relations, indicating that verbal behaviour may influence the way in which individuals gamble. This suggests that an individual may choose to play a particular slot machine due to the presence of a particular structural characteristic, such as a familiar symbol or image, regardless of the contingencies of reinforcement of that slot machine. Given that structural characteristics of slot machines also encompass features such as sounds, bill payment options and the use of the near-miss, it is possible that properties of these characteristics may also participate in derived relations and the transformation of function and influence the way in which people play slot machines. This would require further empirical investigation.

Chapter 6

Transformation of Discriminative Slot-Machine Functions: Altering Win, Loss and "Near-Miss" Outcome Ratings

The phenomenon of the 'near-miss' was first described by Langer (1975) and describes when two out of three matching symbols occur on the payout line of a slot-machine. Skinner (1953) proposed that near-misses may act as conditioned reinforcers, stating that "almost hitting the jackpot increases the probability that the individual will play the machine, although this reinforcement costs the owner of the device nothing" (Skinner, 1953, p. 397). This conditioned reinforcement effect is said to increase gambling persistence. In a game of skill, near-misses may be useful for a player by giving important feedback about the individual's technique which enables improvement, and increases their chance of winning (Ghezzi, Wilson, & Porter, 2006; Griffiths, 1999). However, playing slot-machines involve no skill; therefore, a near-miss may give misleading information regarding the gambler's chances of winning in future (Ghezzi et al., 2006).

Because near-misses consist of two out of three matching symbols, visually they appear closer to a win than no matching symbols. Indeed, gamblers do not always accurately attribute near-miss trials as losses (Griffiths, 1991). Dixon and Schreiber (2004) presented undergraduate participants with an actual casino slot-machine and analysed the verbalisations they emitted while gambling. It was found that all participants produced verbal statements indicating that they believed a near-miss was closer to a win, suggesting that participants viewed near-misses and total losses as distinct. Dixon and Schreiber (2004) reported that individuals perceived near-misses as 'almost winning'. A limitation of their study's findings was the reliance on self-report measures. There is, however, evidence that a difference in physiological responding occurs when gamblers are presented with a near-miss outcome compared to a total loss outcome. Griffiths (1993) reported that participants' heart rate increased for both wins and near-misses when playing slot-machines, suggesting that the physiological effects of a near-miss more closely resembled those of a winning trial, and not of a losing trial. Clark, Crooks, Clarke, Aitken and Dunn (2011) provided further support for these findings by measuring both heart rate and electrodermal activity (EDA) as participants played simulated slot-machines. It was found that although near-misses were rated as being more unpleasant than a total loss trial, a near-miss was associated with increased heart rate and EDA, which was comparable to a winning trial (Clarke et al., 2011).

Qi, Ding, Song, and Yang (2011) compared ratings of wins, near-misses and losses, with electrophysiological activity by measuring event-related-potentials, specifically feedback related negativity (FRN) and the P300. Measures of the FRN are thought to reflect good/bad evaluations whereas the P300 is associated with motivation and assessing probability (Qi et al., 2011). It was found that although participants reported that near-misses motivated them to gamble more whereas total losses did not, measures of FRN did not find any electrophysiological differences between near-miss and total loss trials. However, measures of the P300 amplitude indicated that near-misses were more similar to the amplitude observed following wins, with the amplitude on near-miss trials exceeding those of wins. A functional magnetic resonance imaging (fMRI) study by Habib and Dixon (2010) revealed that when pathological gamblers were presented with near-misses, activation near the substantia nigra and ventral tegmental areas was the same as during presentations of winning trials. However, when non-pathological gamblers were presented with a near-miss, activation was similar to that observed in losing trials. Additionally, Chase and Clark (2010) reported greater dopaminergic activity in the midbrain on near-miss trials in gamblers.

When near-misses are programmed, individuals will gamble for longer periods of time, compared to those who are not presented with near-misses (Côté, Caron, Aubert, Desrochers, & Ladouceur, 2003; Reid, 1986). Côté et al. (2003) found that participants who were presented with a mixture of near-miss and loss trials gambled for longer than those who were just presented with losses. In the first phase of the experiment an experimental and a control group played a three reel video lottery terminal for 48 trials. Nine of these trials were wins, 12 were near-misses, and 27 were total losses. In the second phase, participants were presented with up to 240 additional trials and instructed that they could terminate whenever they wanted. In the control group all trials in this phase were total losses, whereas in the experimental group, near-misses had been randomly distributed across 25% of trials. It was found that even though neither group experienced a single winning trial in the second phase, the experimental group played for a mean of 72 trials whereas the control group played for a mean of 54 trials (Cote et al., 2003).

There may be an optimum number of near-misses for persistence in slot-machine play. Kassinove and Schare (2001) conducted an experiment in which the percentage of near-misses varied across groups. Participants were first required to play a slot-machine for at least 50 trials in which a near-miss was presented on 15%, 30%, or 45% of trials depending on the experimental group. Next, participants played the slot-machine under extinction conditions in which no wins or near-misses were presented. It was found that the group which had contacted 30% near-misses during the previous phase played significantly more trials in the extinction condition than the participants in the 15% or 45% condition. Kassinove and Schare (2001) suggested that for the participants in the 15% group, the near-miss was not followed by a win frequently enough for the near-miss to be reinforcing, whereas for those in the 45% trial, the effect of the near-miss was effectively lost as a result of extinction.

Ghezzi et al., (2006) however, reported findings that challenged those of Kassinove and Schare (2001). In an initial forced exposure phase, participants were required to play a slot-machine in which winning spins were presented on 40% of trials, with the remaining 60% of trials resulting in a losing spin consisting of a combination of near-misses and losses. The number of forced exposure trials was varied such that participants played 25, 50, 75, or 100 trials. At the end of this phase, participants were presented with a choice phase in which they could continue playing the slot-machines for as long as they wished. The number of near-misses presented were then varied, so that a near-miss occurred on 0%, 33%, 66%, or 100% of trials. It was found that participants who were presented with 66% near-miss trials showed most persistence, that is, played the most trials during the choice phase. However, when the number of choice trials played was analysed in accordance with the number of forced exposure trials given, the group that had been presented with 66% near-miss trials were not always the group which showed most persistence. For example, those participants who had been presented with 100 forced exposure trials and 33% near-misses in the choice phase played for longer than those who had been presented with 66% near-misses. Ghezzi et al. (2006) concluded that more research was needed on the conditions under which the near-miss prolongs gambling.

Maclin et al. (2007) manipulated the percentage of near-misses and measured participants' preferences for different slot-machines rather than persistence at gambling. Participants were concurrently presented onscreen with three computer-simulated slot-machines which were of identical payout probability with every fifth trial resulting in a win. Near-misses were either presented on 15%, 30% or 45% of trials. Participants could freely switch between the three slot-machines across 100 trials. In a second, optional phase, participants were re-presented with the slot-machines but under extinction conditions, therefore every trial was a total loss trial. It was found that in the first phase participants on average, showed most preference for the slot-machine that resulted in 45% near-misses, with least preference being shown for the 30% slot-machine. The difference in preferences was fairly small (Maclin et al., 2007).

It has been suggested that the near-miss may, in fact, be a verbal event (Dixon & Schreiber, 2004) which can be manipulated and altered (Dixon et al, 2009). If the effects of the near-miss on gambling persistence and the other measures described function as verbal events, then it follows that the stimuli that make up a near-miss display may themselves participate in derived relations. Dixon et al. (2009) demonstrated that the stimuli associated with the near-miss may be altered in accordance with equivalence relations. Specifically, when an image depicting a near-miss on a slot-machine participated in a derived same relation with the word "loss", participants subsequent ratings for the near-miss decreased (Dixon et al., 2009).

Experiment 14

The study by Dixon et al. (2009) indicated that it is possible to alter the ratings of how close the near-miss is to a win. This suggests that the effect of the near-miss is not due to an inherent or permanent trait within the gambler, but is a phenomenon that can be altered and even weakened (Dixon et al., 2009). If it can be shown that the near-miss participates in derived relations, then the discriminative functions of wins, near-misses and losses may come to be transformed in accordance with the specified derived relations. The present experiments were designed to extend the findings of Dixon et al. (2009) by examining whether the discriminative functions of different slot-machine outcomes can be transformed in accordance with the derived relations of same and opposite.

In Experiment 14, participants were trained and tested in same and opposite arbitrary relations (A1 is same as B1, A1 is same as C1, A1 is opposite B2, A1 is opposite C2). Next, participants played a simulated slot-machine in which the wins, total losses, and near-misses were made up of combinations of the B1 stimulus from arbitrary training and testing. In the final phase, participants were presented with images depicting slot-machine outcomes of wins, near-misses and losses that consisted of the C1 and C2 stimuli, and asked to rate how close each image was to a win. It was predicted that participants would rate the C1 near-miss image as being closer to a win than the C2 near-miss image.

Method

Participants

Fifteen participants, six males and nine females, aged between 22 and 36 (*M* = 29, *SD*=4), were recruited from Swansea University. Participants were administered the SOGS (Lesieur & Blume, 1987), which provides a measure of gambling history with scores between 3 and 5 indicative of potential problem gambling and scores of 6 and above indicative of potential pathological gambling. The mean SOGS score was 0.2 (*SD* = 0.63).

Apparatus

The experiment took place in a small room containing a desk, a desktop computer with 24-inch display, full-sized keyboard and a two-button click mouse. Stimulus presentation and the recording of responses were controlled by the computer, which was programmed in Visual Basic. Two stimuli were trained as contextual cues for Same (♓) and Opposite (❄). One nonsense syllable and six images similar to images that appear on slot-machine reels were employed as the stimuli for arbitrary relational training and testing (CUG, cherry, plum, lemon, watermelon, bell, and the number seven). From here on they will be referred to using alphanumerics.

Procedure

There were two conditions in Experiment 14; an Experimental condition and a Control condition. Participants in the Experimental condition were presented all phases (phases 1 to 4). The Control condition was only presented with Phases 3 and 4 (therefore not given non-arbitrary or arbitrary relational training). Phases 1 and 2 used a modified version of the Relational Completion Procedure (RCP) as reported by Dymond and Whelan (2010) and were similar to Phases 1 and 2 of Chapter 4. Participants were given a standardised information sheet and written consent was obtained. To begin the task, participants were presented with the following instructions;

> *Thank you for agreeing to participate in this study. You will be presented with a series of images or nonsense words on the top half of the screen from left to right. Then you will be presented with 3 images at the bottom of the screen. Your task is to observe the images or words that appear from left to right and drag one of these images or words from the bottom to the blank, yellow square.*

Click and hold the mouse over the image or word to drag it to the blank square. To confirm your choice, click 'Finish Trial'. If you wish to make another choice, then click 'Start Again'. Sometimes you will receive feedback on your choices, but at other times you will not. Your aim is to get as many tasks correct as possible. It is always possible to get a task correct, even if you are not given feedback.

To begin the first task, participants clicked a button at the bottom of the instructions page.

Phase 1: Non-arbitrary relational training and testing.

The first phase trained the contextual cues for same and opposite. Participants were presented with a screen which consisted of a grey section at the bottom third of the screen whereas the top two thirds of the screen appeared blue. The sample stimulus appeared at the left of the blue section of the screen; followed one second later by the contextual cue to the right (therefore appeared central) and after a further one second a third blank square appeared towards the right of the screen. One second later the three comparison stimuli appeared in the grey section of the screen below. The positioning of the comparison stimuli was randomised on all trials.

To make a response, participants were required to select one of the comparison stimuli, then drag and drop it in the blank square in the blue section of the screen. This made two new buttons appear below the comparison stimuli, with the options 'Finish Trial' or 'Start Again'. Clicking 'Start Again" resulted in the comparison stimuli being reset. Clicking the 'Finish Trial' button ended the trial, therefore clearing the screen and presenting feedback. A correct response produced the word 'Correct' whereas an incorrect response produced the word 'Incorrect'. Once feedback had been presented a new trial commenced.

The sample and comparison stimuli in Phase 1 consisted of shapes or objects that differed along a physical dimension. For example, one stimulus set consisted of a tall tree, a medium sized tree and a small tree. A total of six stimulus sets were used during training, presented pseudorandomly. Once a participant responded correctly across ten consecutive trials, they progressed to non-arbitrary testing.

The non-arbitrary relational test was identical in format to training except that no feedback was given following trials and six novel stimulus sets were employed. Ten consecutive correct responses were required to complete Phase 1 and progress to

Phase 2. If this criterion was not met, participants were re-exposed to non-arbitrary training. This cycle continued until participants met criterion.

Phase 2: Arbitrary relational training and testing.

The purpose of Phase 2 was to train a relational network of images using the contextual cues of same and opposite that had been trained during Phase 1. The network was identical to that trained in Chapter 4, with the exception of the actual stimuli used. The format of arbitrary relational training was identical to that of the non-arbitrary training trials, except that the stimuli were arbitrary, that is, did not differ along a physical dimension. All the stimuli used were images that commonly appear on slot-machine reels (specifically, cherry, plum, lemon, watermelon, bell, and the number seven) except for stimulus A1 which was a nonsense word (CUG). In arbitrary training, sample stimulus A1 was presented, followed by the contextual cue for same or opposite, and then the blank square. Following this the three arbitrary comparison stimuli were displayed at the bottom of the screen. Participants were required to select one of the comparison stimuli, drag and drop it in the blank square. On confirming their choice, feedback was given. For example, if presented with the contextual cue for SAME with sample stimulus A1, and the comparison stimuli B1, B2 and X2, selecting comparison stimulus B1 was reinforced. There were four training trials in total, with correct response shown in italics: SAME/A1 [*B1*-B2-X1], SAME/A1 [*C1*-C2-X2], OPPOSITE/A1 [B1-*B2*-X1], OPPOSITE/A1 [C1-*C2*-X2]. Training trials were presented in eight trial blocks so that each trial was presented twice per block. A criterion of ten consecutive correct trials was required before a participant could progress to testing.

The purpose of the test phase was to identify whether participants could respond correctly to derived relations. The format of this part of the experiment was identical to that of arbitrary training except that no feedback was given. The following eight novel trials were presented during the test (correct response italicised): SAME/B1 [*C1*-C2-X2], SAME/C1 [*B1*-B2-X2], SAME /B2 [C1-*C2*-X1], SAME/C2 [B1-*B2*-X1], OPPOSITE/B1 [C1-*C2*-X1], OPPOSITE/C2 [*B1*-B2-X1], OPPOSITE/B2 [*C1*-C2-X1], and OPPOSITE/C1 [B1-*B2*-X1]. The test phase consisted of two blocks of eight trials, with each trial being presented once during a block of eight trials. This generated 16 trials as each trial was presented twice. A criterion of 14 consecutive correct was required in order to pass the test and complete this phase of the experiment. If participants did not meet this criterion or if 14 correct responses were made but these were not consecutive then the participant was re-exposed to Phase1, the non-arbitrary training. This cycle continued until participants met criterion.

Phase 3: Slot-machine discriminative function training.

The purpose of this phase was to present participants with displays of wins, near-misses and losses on a computer simulated slot-machine in which a winning trial always consisted of the B1 stimulus (B1, B1, B1), a near-miss consisted of the B1 and X1 stimuli (B1, B1, X1, or X1, B1, B1), and a loss consisted of one B1 stimulus with the X1 and X2 stimuli (X1, B1, X2, or X2, B1, X1). Participants were presented with a block of twelve slot-machine trials consisting of two winning trials, four near-miss trials (two of B1, B1, X1, and two of X1, B1, B1), and six losing trials (three of X1, B1, X2, and three of X2, B1, X1). The number of wins, near-misses and losses were determined by the literature of the near-miss which has suggested that the optimum number of near-misses for persistence in play is approximately 30% (Kassinove & Schare, 2001). Ten blocks of trials were presented generating a total of 120 trials. Following each block of trials participants were presented onscreen with three images of the payout line of a slot-machine which depicted different outcomes; a win, a near-miss and a loss. The winning image consisted of B1 B1 B1, the near-miss image consisted of B1 B1 X1, and the losing image consisted of X1 B1 X2. Participants were required to rate how closely they thought each image was to a win. A likert scale was presented underneath each image with a scale of 1 to 10, where 1 was not a win and 10 was a win. Upon rating each image, a button appeared which said 'Next' and clicking on this button took the participant to the next block of slot-machine trials.

All participants started with 100 credits. To play the slot-machine required pressing the Bet 1 button which deducted one point from the total credits box, and then pressing the Spin button. Participants were awarded five credits for a winning spin. It was predicted that participants in both the Experimental and Control condition would rate the win slot-machine outcome images as being a win (i.e. 10), the total loss images as a loss (i.e. 1 or 2), and the near-miss images as being closer to a win than the total loss images.

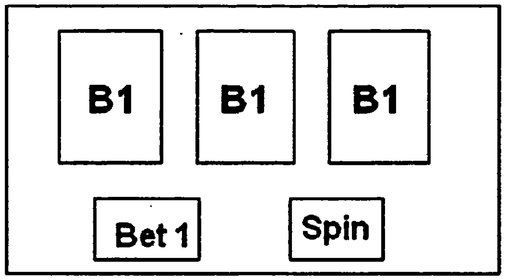


Figure 6.1. Graphical representation of the slot-machine training phase.

Phase 4: Slot-machine outcomes ratings test

The purpose of Phase 4 was to present participants with images of the payout line of a slot-machine depicting wins, near-misses, and losses using combinations of all the arbitrary stimuli that had been presented in the arbitrary test. These were a C1 win (C1 C1 C1), C2 win (C2 C2 C2), C1 near-miss (C1 C1 X1 and X1 C1 C1), C2 near-miss (C2 C2 X1 and X1 C2 C2), C1 loss (X1 C1 X2), and C2 loss (X1 C2 X2). Participants were asked to rate how close each image was to a win using a likert scale (where 1 = *not a win* and 10 = *a win*). Each image was presented five times generating a total of 40 trials. Due to a programming error, the C2 near-miss trials were not presented for Participants 1 to 4.

In Phase 4, it was predicted that participants in the Experimental condition would rate the slot-machine outcome images containing a stimulus C1 as being closer to a win than displays containing the C2 stimulus (as stimulus C2 participated in a derived opposite relation with B1.) It was predicted that participants in the Control condition would give all winning outcomes equally and all losing outcomes equally, regardless of the stimuli presented in each outcome. It was predicted that the C1 C1 X1 and C2 C2 X1 near-miss outcomes would be rated equally , and that the the X1 C1 C1 and X1 C2 C2 outcomes would also be rated equally. Additionally, it was predicted that the near-miss outcomes in which the matching symbols appeared on the left hand side would be rated more highly than those in which the matching symbols were on the right hand side.

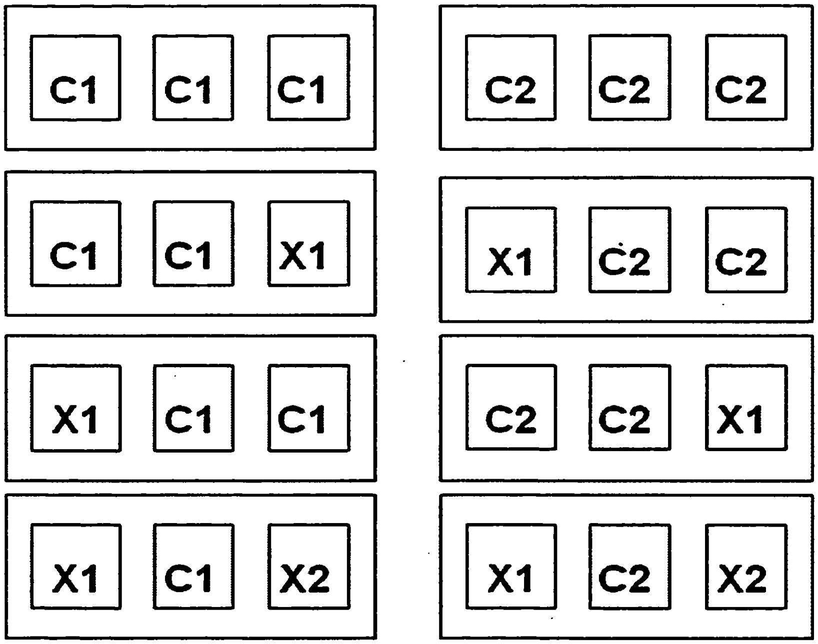


Figure 6.2. All the combinations of slot-machine outcomes presented during Experiment 14.

Results and Discussion

Experimental Condition

Table 6.1 shows that all participants met criterion responding for non-arbitrary and arbitrary relational training and testing. Five participants, namely P1, P2, P4, P9 and P10, met criterion responding with only one exposure to the task. The participant who required the most exposures to the task was P6 who passed on her seventh exposure. The mean number of trials required to meet criterion was 2.6 (*SD* = 2.22).

Table 6.1. Number of trials required to meet criterion responding in the non-arbitrary training and testing (Phase 1) and arbitrary training and testing (Phase 2) of Experiment 14.

Participant	Non-arbitrary training	Non-arbitrary test	Arbitrary training	Arbitrary test
P1	11	10	13	14
P2	11	10	14	14
P3	79	10	17	6
	10	10	10	8
	11	10	10	8
	10	10	10	10
	10	10	10	14
P4	11	10	14	14
P5	13	10	12	12
	10	10	10	14
P6	61	13	34	5
	10	10	15	8
	11	15	10	12
	10	11	10	4
	19	10	10	12
	10	10	10	14*
	10	10	10	14
P7	40	13	19	6
	11	15	-	-
	10	10	10	9
	10	10	10	14*
	10	10	10	14
P8	11	10	14	13
	10	10	10	14
P9	46	10	24	14
P10	18	10	12	14
Mean	18.19	10.65	13.12	11
SD	17.86	1.52	5.59	3.46

* indicates that although the participant responded correctly across 14 trials, these correct trials were not consecutive therefore participants were re-exposed to the task.

Figure 6.3 shows that participants rated the near-miss outcome more highly than the loss outcome with the mean rating of 4.93. The winning outcome was rated very highly, with most participants rating it as a win (10), whereas the total loss stimuli were rated at a mean of 2.03. A Kruskal-Wallis revealed a statistically significant difference between the ratings for the win, near-miss and loss where χ_2 (2) = 102, $p = 0.001$. A Dunn's Multiple Comparison Test revealed a statistically significant difference between the wins versus near-miss, the wins versus total loss, and the near-miss versus total loss.

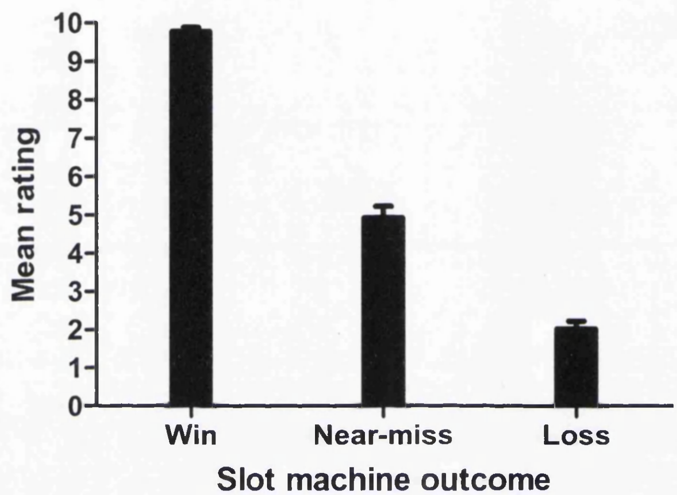


Figure 6.3. Mean ratings towards the win (B1B1B1), near-miss (B1B1X1) and loss (X1B1X2) stimuli across all participants during Phase 3 of Experiment 14 where 1 represents not a win and 10 represents a win. Error bars indicate standard error mean.

For each individual participant's mean ratings, see Appendix 11. When the C1 win stimulus displays (C1C1C1) were compared with the C2 win stimulus displays (C2C2C2), ratings differed significantly, $U = 427.5$, $p < 0.05$ ($p = 0.0001$). The C1C1X1 near-miss and the C2C2X1 near-miss outcomes differed significantly, $U = 328$, $p < 0.05$ ($p = 0.0001$). Moreover, the X1C1C1 and X1C2C2 near-miss outcomes were also significantly different, $U = 325$, $p < 0.05$ (p = 0.0001) and, finally, the total loss stimuli also differed significantly, $U = 840$, $p < 0.05$ (p = 0.0009). The two types of win were then compared with four types of near-miss, and two types loss, therefore forming three groups of win, near-miss and loss, and tested for a statistically significant difference between the three groups. The Kruskal-Wallis test revealed that there was a statistically significant difference, χ_2 (2) = 102.4, p =

0.0001 between the win ratings, the near-miss ratings and the total loss ratings. A Dunn's Multiple Comparison Test indicated that significant differences existed between the win group versus near-miss group, the win group versus the loss group, and the near-miss group versus the loss group. This is consistent with the ratings data following slot-machine function training (Phase 3) that near-misses are rated more highly than total loss outcomes.

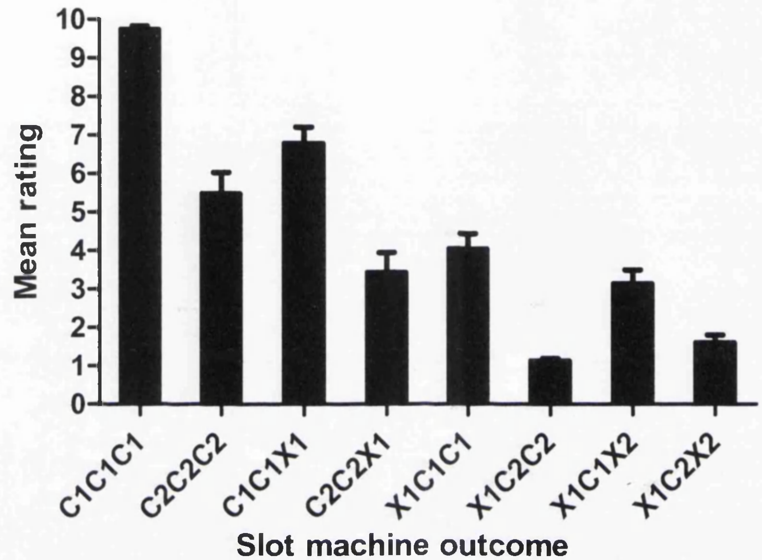


Figure 6.4. Mean ratings of the slot-machine outcomes for Phase 4 of Experiment 14. Error bars indicate standard error of the mean.

Figure 6.4 shows that participants rated the C2 slot-machine win outcome significantly lower than the C1 slot-machine win outcome. The C1C1X1 near-miss was on average, rated more closely to a win than the C2 win outcome. The X1C1C1 near-miss was rated more highly than the C2C2X1 near-miss. This supports previous research that near-misses in which the matching symbols appear on the left and middle of the reel tend to be rated more highly than when they matching symbols appear on the middle and right of the reel (Maclin et al. 2007; Strickland & Grote, 1967). Additionally, the C1 losing outcome achieved a similar mean rating to the C2C2X1 near-miss outcome. These data can only be explained in terms of a transformation of function in accordance with same and opposite relations, where C1 participated in a derived same relation with B1 and a derived opposite relation with C2, and given that B1 was the stimulus that appeared as a win during slot-machine function training.

Control condition

Participants' mean slot-machine ratings following slot-machine function training are shown in Figure 6.5. The mean ratings made by participants were consistent with the experimental condition with participants in both conditions rating, on average, a near-miss trial as closer to a win. A Kruskal-Wallis revealed a statistically significant difference between the ratings for the win, near-miss and loss where χ_2 (2) = 104.8 p = 0.001. A Dunn's Multiple Comparison Test revealed a significant difference between the win group versus near-miss group, the win group versus the loss group, and the near-miss group versus the loss group.

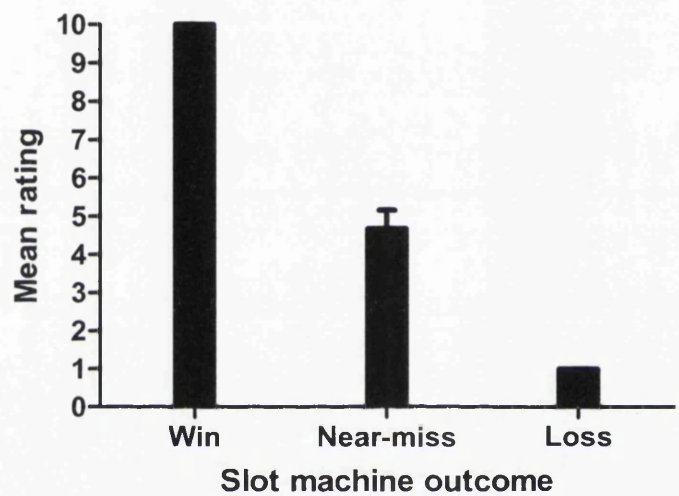


Figure 6.5. Mean ratings towards the win (B1B1B1), near-miss (B1B1X1) and loss (X1B1X2) stimuli across all participants during Phase 3 of the Control condition of Experiment 14 where 1 represents not a win and 10 represents a win. Error bars indicate standard error mean.

Figure 6.6 shows the mean ratings made to the slot-machine outcomes that were presented in Phase 4. As predicted, participants rated the win stimuli as a win (10), and the total losses were rated as losses. With regard to the near-miss stimuli, these were rated more highly than the losses, with the near-miss where the matching symbols appeared on the left on the reel (e.g., C1C1X1), being rated more highly than those in which the matching symbols appeared on the left of the reel (e.g., X1C1C1). A Kruskal-Wallis was conducted which compared all wins, near-misses and losses as three groups, revealing a statistically significant difference, χ_2 (2) = 119.2, p = 0.0001. A Mann-Whitney U test did not find any statistically significant differences between any of the control outcomes. These findings suggest that in the

Control condition participants' ratings were based solely on the non-arbitrary properties of the win, near-miss and loss, whereas the ratings made by participants in the Experimental condition were as a result of a transformation of function of the arbitrary relations trained during Phase 2. This suggests that a non-arbitrary stimulus, such as a winning outcome, may acquire functions of an arbitrary stimulus where some of the properties of that stimulus participate in derived relations. These findings seem to suggest that even the properties of a slot-machine reel may be influential in gambling and that gamblers may regard certain near-misses as being closer to a win depending on the matching images that occur on the near-miss trial.

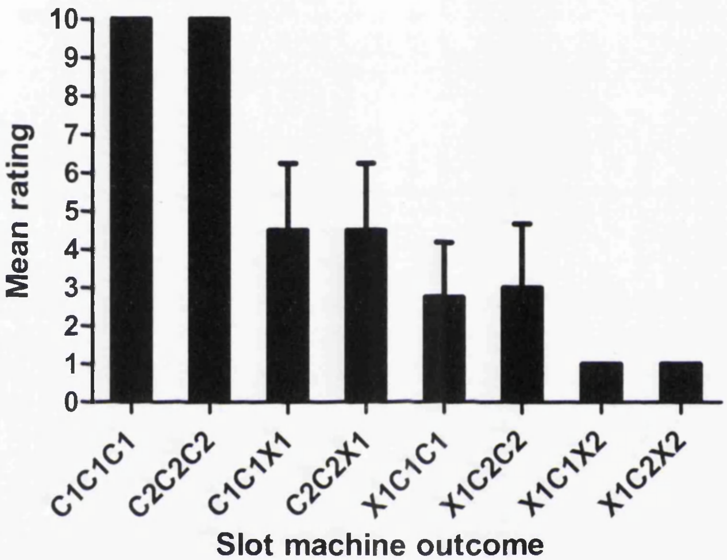


Figure 6.6. Mean ratings to each of the slot-machine outcomes for Phase 4 of the Control Experiment. Error bars indicate standard error mean.

Experiment 15

In Experiment 15, the number of near-misses presented was increased from four out of 12 trials, to eight out of twelve trials. Research suggests that when more than 45% of trials are near-misses, the effect of the near-miss diminishes therefore participants are more likely to rate a near-miss trial as a loss than closer to a win (Kassinove & Schare, 2001). It was predicted that if the effects of the near-miss diminished due to an increased frequency of such trials, then this would result in a smaller difference in ratings between the C1 and C2 stimuli being observed in the test phase.

Method

Participants

Seven participants, five males and two females, aged between 26 and 38 (*M* = 31, *SD* 3.92), were recruited from Swansea University. The mean SOGS score was 0.43 (*SD* = 0.79).

Procedure

The procedure for Experiment 15 was identical to that of Experiment 14 except that during *Phase 3 Slot-machine Function Training*, participants were presented with two winning trials, six near-miss trials (three B1B1X1 and three X1B1B1) and four total loss trials. There was no control condition in Experiment 15.

Results and Discussion

Table 6.2 shows that all participants met criterion for non-arbitrary training and arbitrary training and testing therefore proceeded to the slot-machine phases of the experiment. Participants P11, P13, P14, and P16 met criterion responding with only one exposure to each task. The mean number of exposures to the entire task required to meet criterion for arbitrary testing was 1.67 (1.21).

Table 6.2. Number of trials required to meet criterion responding in the non-arbitrary training and testing (Phase 1) and arbitrary training and testing (Phase 2) of Experiment 15.

Participant	Non-arbitrary training	Non-arbitrary test	Arbitrary training	Arbitrary test
P11	27	11	13	14
P13	18	10	14	14
P14	11	10	14	14
P15	13	10	29	10
	10	10	10	9
	11	10	15	14*
	10	10	10	14
P16	21	10	14	14
P17	11	10	10	14*
	10	10	10	14
Mean	14.20	10.10	13.90	13.10
SD	5.87	0.32	5.69	0.60

* indicates that although the participant responded correctly across 14 trials, these correct trials were not consecutive therefore participants were re-exposed to the task.

Figure 6.7 shows that participants rated the B1 win stimuli as a win. The mean rating for the near-miss stimuli was 2.83, which was not much higher than the ratings for the total loss stimuli (1.77). A Kruskal-Wallace revealed a statistically significant difference between the ratings for the win, near-miss and loss; χ_2 (2) = 151.3, $p = 0.0001$. A Dunn's Multiple Comparison Test revealed a statistically significant difference between the win group versus the near-miss group, and the win group versus the loss group, but not the near-miss group versus the loss group, suggesting that participants rated the near-miss as closer to a loss compared to participants in Experiment 14. It is noteworthy that the mean near-miss ratings in the Experimental and Control group of Experiment 14 who had been presented with the same number of near-miss, were 4.93 and 4.68, respectively. These findings are consistent with previous research that presenting a higher frequency of near-misses results in those stimuli being rated as closer to a loss (Kassinove & Schare, 2001).

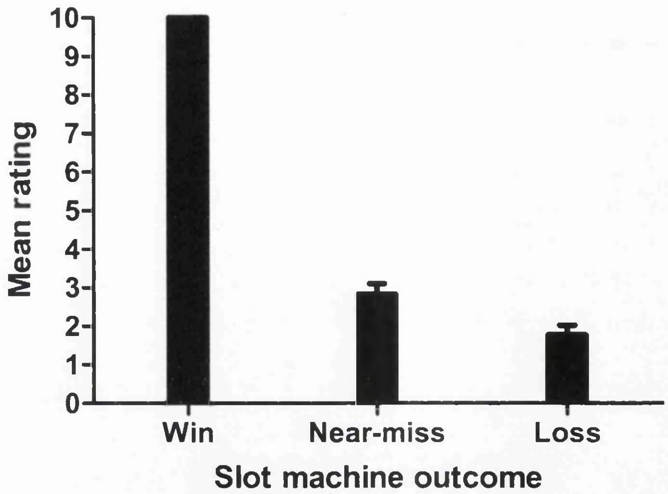


Figure 6.7. Mean ratings towards the win (B1B1B1), near-miss (B1B1X1) and loss (X1B1X2) stimuli across all participants during Phase 3 of Experiment 15 where 1 represents not a win and 10 represents a win.

Figure 6.8 below shows that the C2 win stimuli are not rated as close to a win as the C1 win stimuli, and that the C1C1X1 near-miss is given approximately the same rating as the C2 win stimuli. There is little difference in ratings between the C2C2X1, X1C1C1, and X1C2C2 stimuli or the total loss stimuli. In comparison with the mean ratings data from Experiment 14, participants rated all the near-miss stimuli as closer to a win in Experiment 14 compared to Experiment 15. A Mann-Whitney U test found a significant difference between the C1 win and C2 win outcomes, $U = 90$, $p < 0.05$ ($p = 0.0001$), as well as between the C1C1X1 and C2C2X1 near-miss, $U = 274.5$, $p < 0.05$ ($p = 0.0061$). However, no significant differences were found between ratings for the total loss stimuli, $U = 442.5$, $p < 0.86$; or the X1C1C1 near-miss and the X1C2C2 near-miss, $U = 420.0$, $p < 0.6$. A Kruskal-Wallis compared all the win, near-miss, and loss outcomes as three separate groups. A significant difference was found between the three groups, χ_2 (2) = 92.85, $p = 0.0001$. A Dunn's Multiple Comparison Test revealed a significant difference between the win group versus near-miss group, the win group versus loss group, and the near-miss versus loss group.

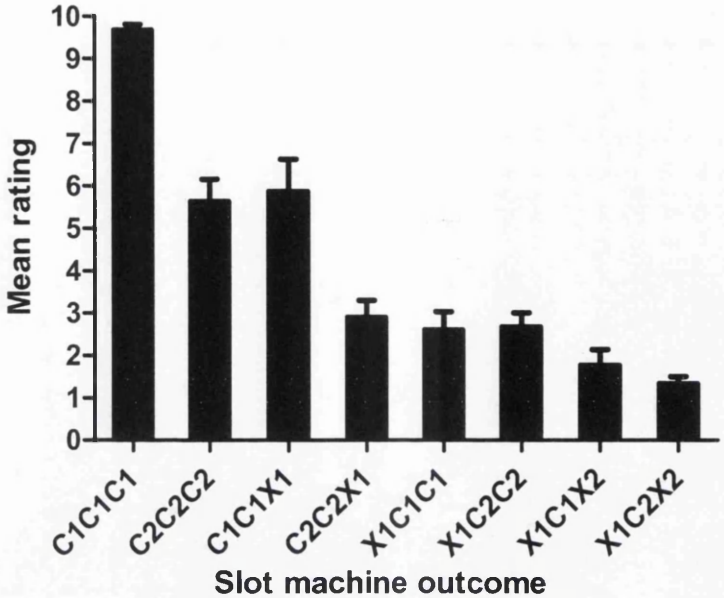


Figure 6.8. Mean participant ratings to the slot-machine outcomes for Phase 4 of Experiment 15.

Comparison of Experiments 14 and 15

A Mann-Whitney U test found significant differences between the X1C1C1 ratings in Experiment 14 and 15, $U = 529.5, p < 0.05$ ($p = 0.0197$) and for the X1C2C2 near-miss $U = 340, p < 0.05$ ($p = 0.0286$). A significant difference was also found between the C1 loss image, $U = 498.5, p < 0.05$ ($p = 0.0037$) across experiments. No statistically significant differences were found between the C1 wins, the C2 wins, the C1C1X1or C2C2X1 near-misses, or the C2 loss image across the two experiments. This demonstrates that increasing the number of near-miss trials may influence ratings for trials in which the matching symbols occur on the right hand side of the reel, such that these trials are rated as being closer to a win when more near-miss trials have been presented. This suggests that when the numbers of near-misses are increased, the reinforcing effect of a near-miss trial being "close to a win" is weakened.

A Kruskal-Wallace test was conducted between the experimental condition of Experiment 14 and Experiment 15 collapsed groups, which compared wins, near-misses and losses. A significant difference was found between the three groups, $\chi 2$ $(2) = 190, p > 0.0001$. A Dunn's Multiple Comparison test was conducted as a follow up and found that statistically significant differences existed between the win versus the near-miss column, the wins versus the losses, and the near-misses versus the losses. These findings show that across both experiments participants rated total loss outcomes significantly differently than near-miss outcomes, even though both of these outcomes are in fact a losing trial. There were also significant difference in ratings for the winning outcomes compared to the near-miss trials, suggesting that although participants may rate a near-miss trial as *closer* to a win than a loss, these outcomes do not completely share the same properties of a winning trial and are viewed differently.

General Discussion

Experiment 14 and Experiment 15 both demonstrated that discriminative functions of slot-machine wins, near-misses and losses may be transformed in accordance with same and opposite relations. Slot-machine outcomes containing displays consisting of the C1 stimuli were rated as being significantly closer to a win than outcomes containing the C2 stimuli. The Control group rated the C1 and C2 win stimuli equally, and the C1 and C2 near-misses equally, further strengthening the conclusion that results of the Experimental group were at least partially the result of transformation of functions. It was also found that the near-miss ratings in Experiment 15, in which the proportion of near-miss trials was increased, were significantly lower (i.e., closer to a loss) than the near-miss ratings in Experiment 14.

What is interesting about these findings is that the B1 stimulus was not trained as 'better-than' the B2 stimulus during arbitrary training, it was merely trained as 'opposite', and although the B1 stimuli were the images on the slot-machine during a winning trial, it was also present on losing trials. In other words, although the B1 may have come to represent a win, it could also be said that the B1 stimuli could represent a loss. However, when it came to rating the C1 slot-machine outcomes (where C1 participated in a derived same relation as B1), the C1 winning slot-machine was always rated as a win, whereas the slot-machine outcomes depicting a C2 win (C2C2C2) only achieved a mean rating of 5.5. To the novice reader this finding may appear surprising as this was a winning trial. However, this demonstrates that transformation of discriminative function in accordance with the derived relations exerted control over these ratings despite the fact that three matching symbols on a slot-machine is, unambiguously, a win.

The present findings support those of Dixon et al. (2009) that the near-miss is a verbal event that can be altered, and extends these findings by demonstrating that wins and losses may also be altered in accordance with derived relations. The finding that even ratings of the win stimuli may be altered in accordance with derived relations came as a surprise, as three matching symbols on a three-reel slot-machine is non-arbitrarily always a win. It remains likely, therefore, that the relations specified by the contextual cues exerted more control over behaviour than the non-arbitrary property of three matching symbols on a slot-machine being equal to a win.

The wording of the questions used to obtain ratings of wins, near-misses and losses in the present study differed somewhat to the study by Clark et al. (2011). Upon initiating a trial, therefore before the reels had started to spin, participants in the Clark et al. study were asked before a third of trials, "how do you rate your chances of winning?" Once the reels had stopped spinning, participants were then sometimes asked "how much do you want to continue to play". The wording of these questions differed considerably from the questions in the present study in which participants were asked how *close* they thought they were to a win. Additionally, asking participants to rate their chances of winning is likely to be influenced by the preceding trials as Dixon and Schreiber (2004) reported that following a near-miss, response latencies before initiating the next trial are more similar to wins than compared with losses. It is possible then that following a losing trial, participants may rate their chances of winning as higher, compared to following a winning trial. In the present study, the wording of the question only allowed for participants to rate the structural properties of a win, near-miss, or total loss therefore does not inform how the near-miss may affect persistence in gambling or encourage the gambler to initiate another trial.

The current study supports the findings of Kassinove and Schare (2001) that presenting 30% near-misses was the optimum frequency of near-misses for persistence in slot-machine play, as participants in Experiment 15 were presented with a higher frequency of near-misses and tended to rate them as closer to a loss than participants in Experiment 14. Although Kassinove and Schare (2001) measured persistence in gambling and did not obtain ratings, both sets of findings seem to suggest that the effects are diminished when near-misses are presented on at least 45% of trials.

In summary, Experiments 14 and 15 found that discriminative functions of wins, near-miss and losses of a slot-machine may be transformed in accordance with same and opposite relations, such that participants rated near-miss and losing images as closer to a win where the stimuli in that image participated in a derived same relation with stimulus B1 which had been appeared on the winning line of a computer simulated slot-machine.

Chapter 7

General Discussion

Summary of findings

Chapter 2 (Experiments 1 to 3) replicated previous findings (Hoon et al., 2008; Zlomke & Dixon, 2006) showing that preferences for concurrently available slot-machines may often be subject to control by factors other than direct-acting contingencies of reinforcement. It was found that participants showed increased preferences for the slot-machine that was the same colour as the contextual cue for more-than. However, such effects diminished with extended exposure to the slot-machines.

In Chapter 3, it was found that the presence of experimenter-delivered accurate and inaccurate instructions influenced preferences for concurrently available slot-machines. Experiment 4 showed that when given Minimal or Unspecified instructions, participants allocated the greater proportion of responding to the slot-machine that participated in a derived same relation with the machine that had been rated as being of higher payout. In the Specified group, participants allocated greater responding to the slot-machine that had been specified, or instructed, as paying out more often that the others. In Experiment 5, when given accurate rules regarding the payout percentages, participants distributed responding relatively equally. However, when given an inaccurate rule, participants allocated greater responding to the slot-machine instructed as paying out the most. Additionally, participants given inaccurate rules gambled for longer.

Chapter 4 demonstrated that participants' preferences for concurrently available slot-machines were transformed in accordance with same and opposite relational frames. In Experiment 7, participants showed a preference for slot-machine C2, which participated in a derived relation of sameness with B2 (via two combinatorially entailed opposite relations), which had been established as discriminative for high payout functions. When slot-machine B1 was trained as the high payout slot-machine, participants showed a preference for slot-machine C1, which participated in a relational frame of sameness with B1.

In Chapter 5 it was found that discriminative functions of slot-machines may transform in accordance with derived comparative (more-than and less-than) relations. Experiments 9A, 9B, 11, and 13 demonstrated a clear increase in preferences for the slot-machines labelled with the highest ranking stimuli from the relational network, with slot-machines labelled with the lower ranking stimuli being least preferred. However, the slot-machine preferences of participants in Experiments

10 and 12, in which the network was trained with the less-than cue, did not demonstrate clear evidence of transformation of functions.

Finally, Chapter 6 demonstrated that discriminative functions of slot-machine win, near-miss and loss outcomes may be transformed in accordance with same and opposite relations. In Experiment 14, it was found that participants rated images of a near-miss outcome as closer to a win when the near-miss consisted of stimuli that participated in a derived sameness relation with the stimulus that had been presented as a win. On those instances where the stimuli from the near-miss outcome participated in a derived opposite relation, participants rated them as closer to a loss. Experiment 15 found that when the proportion of near-miss trials was increased, ratings for the near-miss were significantly lower (i.e., closer to a loss) than the near-miss ratings in Experiment 14.

Implications for a greater understanding of gambling behaviour

It has been suggested that verbal rules may supersede the contingencies of reinforcement in gambling and increase the likelihood of future gambling (Weatherly & Dixon, 2007). Chapters 2 and 3 provided empirical support for this suggestion showing that gambling behaviour is not solely maintained by contingencies of reinforcement. Chapter 2 demonstrated that gamblers may generate self-rules regarding the structural characteristics of a slot-machine which may in turn influence choice over concurrent slot-machines that are identical in payout probability. It is possible that inaccurate self-rules such as these may develop when an individual is gambling and may persist even when these rules are not reinforced (Hoon et al., 2007). Chapter 3 showed that externally-delivered rules can influence preferences towards two slot-machines that are identical in payout probability, even when the rule does not accurately describe the schedule in place. Additionally, it was found that when inaccurate rules overstated the likelihood of a slot-machine paying out, participants gambled for longer periods of time compared to those who were told that the slot-machines were of equal payout probability. These findings are important because in a casino environment a gambler is presented with many verbal stimuli, whether from a fellow gambler stating how often they think a particular slot-machine pays out, or perhaps a sign in the casino claiming how "loose" the slot-machines are (Dixon & Delaney, 2006). This suggests that if a gambler encounters an inaccurate rule, whether a rule the individual has conceived themselves or an externally delivered rule, these rules may have a detrimental effect on the individual and encourage them to gamble for longer. It may also reinforce fallacies about the likelihood of a slot-machine paying out when, in fact, the odds are stacked against them.

An additional problem that a gambler may face is discerning how often a slot-machine pays out. It was found that, consistent with Weatherly et al. (2009) given a relatively brief exposure to a slot-machine, participants were not always sensitive to the payout probabilities of that machine. In Chapter 3, following slot-machine function training, some participants rated one slot-machine as being more likely to payout than the other, even though these slot-machines were identical in schedule and magnitude of reinforcement. This, in turn, influenced choices of the preferred slot-machine when presented concurrently. This finding suggests that inaccurate perceptions of payout percentages may also influence slot-machine choice, and these functions may then transform the discriminative functions of other, arbitrarily and indirectly related slot-machines. In terms of casino gambling, this may result in a gambler continuing to play a slot-machine even though it has a poor payback percentage. Casino slot-machines are often programmed on different payback percentages; therefore, if a gambler is not sensitive to the difference in payback, they may continue to gamble on a machine which is less likely to pay out and lose much money.

Although it was found that schedules of reinforcement may not exert exclusive influence over gambling behaviour, it is possible that an interaction may occur between the self-rule or the externally-delivered rule and the actual schedule in place. In Chapters 2 and 3, the participants that were presented with prolonged exposure to the slot-machines seemed to show responding that was initially in accordance with the rule (for example, when given the rule that C1 pays out, slot-machine C1 is selected most), however, as the trials continued, these preferences diminished such that responding that was more sensitive to the matched schedules in place began to prevail. It is possible then that although the decision to gamble and which machine to play may initially be influenced by verbal rules, the contingencies of reinforcement in place may begin to exert control over behaviour (Dymond & Roche, 2010).

Overall, these findings suggest that rules, whether generated by the gambler or an externally delivered source, may override the schedule of reinforcement in place, thus influencing slot-machine choice and persistence in play. Specifically, the structural characteristics of a slot-machine may encourage a particular individual to choose to play that slot-machine due to the characteristic of that machine being associated with something positive in that gambler's learning history (Dixon & Delaney, 2006). As well as the structural characteristics of slot-machines influencing slot-machine choice, it was shown that externally delivered rules may promote gambling by superseding the contingencies of reinforcement of a particular game, even when the odds are against the gambler. This suggests that signs, adverts within the casino, or even a friend in the casino, may have a detrimental effect on the way in which an individual gambles which may encourage persistence. Clearly, gambling involves more than just responding to the contingencies of reinforcement that are in place and although there is truth in Skinner's (1953) claim that the variable-ratio schedules (or indeed random-ratio schedules; Crossman, 1988) in effect make gambling behaviour resistant to extinction, it cannot account for the behaviour demonstrated in many of the present experiments.

Although it has been shown that rules may influence gambling behaviour, the findings of Chapter 2 do not contribute towards a verbal account of gambling, as defined by RFT. In Chapter 2, the non-arbitrary relations of more-than and less-than were directly trained, for example, in the presence of blue select the less-than stimulus. Therefore when presented with a yellow or blue slot-machine, by selecting the yellow (more-than) slot-machine, participants were merely responding to the contextual cues that have been trained. Furthermore, for an organism to be considered to be responding verbally as defined by RFT, behaviour should participate, at least in part, in arbitrary relations and transformation of function (Hayes et al., 2001). The experimental designs in Chapter 2 did not require responding to these defining features of verbal behaviour.

Dymond and Whelan (2007) called for gambling research to be conducted in which a functional definition of verbal behaviour is employed and suggested that research involving derived relational responding would allow for "an empirical investigation of the intriguing possibility that, for verbally able humans, all gambling is verbal activity" (Dymond & Whelan, 2007, p.20). Therefore, experiments which allow for the study of gambling in terms of derived relational responding and transformation of function are necessary as they may be able to explain "how verbal processes might interact with and overcome, the directly experienced contingencies of games of chance" (Dymond & Roche, 2010, p.41).

Chapters 4 and 5 suggest that gambling may well be a verbal activity as it was demonstrated that the discriminative functions of slot-machines may transform in accordance with the derived relations of same, opposite and comparative relations. When participants could freely choose between concurrently available slot-machines under conditions of non-reinforcement, it was found that participants showed preferences for a particular slot-machine even though they had no prior experience of playing that machine, and no experience of the payout probability of that slot-machine. Therefore, although participants were not contacting the contingencies of reinforcement, arbitrary characteristics of the slot-machines participated in a derived relation with a slot-machine that had paid out often, therefore the discriminative functions of high payout were transformed to the novel slot-machine.

It is possible that just thinking about the winning slot-machine which was indirectly related to the novel slot-machine may have been reinforcing, thus influencing slot-machine choice (Dymond et al., 2011). These findings may explain how an individual persistently plays a particular slot-machine in the absence of any or very little direct reinforcement on that slot-machine (Dymond et al., 2011) or why a gambler may choose to play one particular machine despite there being many other slot-machines available which are identical in payout probability, but differ in some structural characteristic (Dixon & Delaney, 2006). Perhaps then, slot-machines which contain familiar themes, images and symbols pose a greater threat to the gambler as they encourage the individual to play a particular machine even when the contingencies of reinforcement may be at their disadvantage.

The present findings show that contemporary approaches to verbal behaviour, such as RFT, may help explain why gamblers show preferences for particular slot-machines without any direct history with that particular gaming machine. In so doing, they demonstrate that arbitrary, unrelated features of a slot-machine may come to participate in derived relations with other stimuli within an individual's learning history and influence gambling behaviour. The stimuli on the slot-machines were arbitrary stimuli that is, the stimuli were not physically similar in any way and were not symbolic for a slot-machine paying out, yet because participants had learned that these stimuli participated in derived relations from an earlier, unrelated task; participants came to show preferences for certain slot-machines. In the present experiments, there was no direct relation between the characteristic of a slot-machine and the chances of it paying out, and no feedback was given from these machines, yet preferences for slot-machines could be determined depending on which stimulus appeared on the slot-machine. These findings suggest that gambling behaviour may be influenced by remote contingencies that are completely unrelated to the actual gambling situation (Dymond & Roche, 2010) and reveals just how complex the role of verbal behaviour may be in gambling.

As well as arbitrary properties of a slot-machine transforming through derived relations, ratings for non-arbitrary properties of a slot-machine may also be altered in accordance with derived relations. The discovery that ratings for wins and losses could also be altered in accordance with derived relations was not expected as the properties of these stimuli were non-arbitrary, that is, three symbols on a three reel slot-machine payout line is always a win, and three different symbols on a slot-machine does not resemble a win or look 'close' to a win. It is possible that these unexpected ratings were in part due to way in which these trials were presented, that is, the slot-machine outcomes were presented as images. This meant that participants were not actually experiencing a slot-machine but were merely rating images. It would be interesting to examine whether presenting a slot-machine in which the reels spun before landing on the same combinations of outcome images, would result in the similar ratings for those outcomes as was seen in Chapter 6.

In the mean time, however, these findings further support the notion that derived relational responding and transformation of function may result in gamblers making evaluations about slot-machines that are at odds with the non-arbitrary properties of a slot-machine. Given that participants rated slot-machine outcomes differently depending on the stimuli that appeared on the reel, it begs the question as to whether gamblers might show preferences for slot-machines due to the images that are on the reels of that machine. For example, say a gambler holds the belief that seven is his lucky number. Will he then only play the slot-machine that contains that particular number on the reel, and equate a near-miss in which the number 7 appears on two of the reels as closer to a win than a near-miss consisting of any other stimuli?

Given that the findings of the present studies demonstrate that slot-machine choice participates in derived relations and transformation of function, this indicates that gambling is at least in part, a verbal event. This conclusion may provide an alternative explanation to the cognitive account of gambling that an individual develops a problem with gambling due to an inherent personality trait and faulty cognitions. Griffiths (1994) and Wagernaar (1988) claimed that faulty cognitions may predispose an individual to pathological gambling. Whilst cognitive accounts of gambling have contributed much to literature on gambling behaviour, it is possible that derived relational responding and transformation of function may explain *how* such cognitions develop. On the surface, Chapters 4 and 5 could possibly be interpreted as having demonstrated some of the irrational thinking that gamblers apply when playing a gaming machine, as continually selecting one particular slot-machine over another because of an arbitrary property of that machine being indirectly related to other slot-machines, seems to indicate irrational behaviour. Similarly, rating a winning outcome on a slot-machine as close to a loss, due to a property of that win participating in derived arbitrary relations, may also be considered illogical. Although this behaviour does seem consistent with the irrational cognitions account, these cognitions had effectively been manipulated in the participant by the experimenter. A behaviour analytic interpretation of this therefore would suggest that these cognitions were not an inherent trait, but rather participants were responding verbally, that is responding in accordance with relational networks. Therefore, these irrational behaviours were under experimental control, could be directly observed and had been manipulated by the experimenter, and were not due to an enduring trait of the participant. Furthermore, if developing a problem with gambling is due to faulty, irrational cognitions, then it might be expected that only the participants that met criterion for pathological gambling would show irrational slot-machines machine choices or make illogical slot-machine ratings. However the majority of participants were not problem gamblers yet emitted behaviour which without prior knowledge of the relational networks that had been trained, could be regarded as irrational or illogical. The implications of this are that, if such responding is verbal behaviour, then such behaviour is not a permanent trait of an individual and can be changed (Dixon et al., 2010). Additionally, the causal role of irrational cognitions on developing a gambling problem is called into question.

Implications for relational frame theory

The present thesis indicates that the fundamental principles outlined in RFT can account for those instances of gambling behaviour which may not be explained by direct contingencies of reinforcement in a gambler's learning history. Furthermore, these findings suggest that RFT can provide a means of conducting laboratory gambling research which may be able to describe aspects of real-life gambling and add further support to the RFT literature that verbal behaviour is a defining feature of human behaviour. Although gambling behaviour has not been 'solved' as such through RFT explanations, the studies presented indicate that empirical RFT research can provide a worthy analogue of gambling behaviour.

The results of Chapter 6 raised a few questions regarding the extent to which non-arbitrary properties of a stimulus may participate in derived relations. Although there is little published work on the transformation of function of non-arbitrary relations, there is some evidence that derived relations may interact with the non-arbitrary features of a stimulus. Stewart, Barnes-Holmes, Roche, and Smeets (2002) demonstrated that non-arbitrary properties of colour could be ignored when the colour conflicted with equivalence relations. Stewart et al. (2002) reported that when the colour of the sample stimulus conflicted with the colour of the correct comparison stimulus, participants ability to respond correctly was hindered, compared to participants who were presented with trials in which there was no colour difference between samples and comparison stimuli. However, Stewart et al. (2002) demonstrated that although the non-arbitrary properties of stimuli may interfere with arbitrary relations, participants were still able to derive relations that were at odds with these properties. Stewart et al. (2002) suggested that there may be certain conditions under which arbitrary and non-arbitrary relations interact such that although non-arbitrary properties may hinder responding to derived arbitrary relations, the non-arbitrary relation can nevertheless be overridden. Stewart, Barnes-Holmes, Hayes, and Lipkens (2001) point out that "when relational frames are applied nonarbitrarily, the source of control is mixed. The relevant history involves both arbitrary and nonarbitrary features of the environment" (p. 89). In Chapter 6, the images of the slot-machine payout lines could be considered as having both arbitrary and non-arbitrary properties: that is, there was an arbitrary relation *between* the individual stimuli, for example B1 was opposite to C2, but also when these arbitrary stimuli were presented on the payout line of a slot-machine, the stimuli were being presented in a non-arbitrary form (for example, B1 B1 B1 presented together is in the form of a win). For some participants, their ratings were consistent with the non-arbitrary form, for example C2 C2 C2, would be rated as a win, whereas other participants' ratings were consistent with the derived arbitrary relation between the stimuli such that C2 C2 C2 would be rated as closer to a loss. This was due to stimulus C2 participating in a derived opposite relation with B1, therefore in such cases the physical form in which the stimuli were presented was perhaps de-emphasised.

In summary, RFT accounts of gambling behaviour provide a useful means of conducting translational research on gambling behaviour (Dymond & Roche, 2010). The present studies showed how verbal behaviour impacts upon slot-machine choice and win estimations of a slot-machine, however what is needed now is research that examines the role of verbal behaviour on other aspects of gambling (e.g. roulette, betting on horses, lottery gambling).

Towards a verbal account of gambling behaviour

Table 7.1 serves as a summary and a reminder of the experimental methods employed in Chapters 3 to 6. The table details the three different arbitrary relational networks that were established (that is, equivalence, same/opposite and more-than/less-than), the function that was tested, and the way in which the dependent variable was measured for each experiment.

Table 7.1.

Overview of the relational networks, and contextual cues established in each chapter.

Chapter	Relational network	C_{rel}[1]	C_{func}[2]	Dependent variable
3	Equivalence relations	Sameness	Discriminative: e.g. "B2 pays out more"	Concurrent slot-machine choice
4	A1 same B1 A1 same C1 A1 opposite B2 A1 opposite C2	Same and opposite	Discriminative: payout probability	Concurrent slot-machine choice
5	A < B < C < D < E	Comparative (more-than/less-than)	Discriminative: payout probability	Concurrent slot-machine choice
6	A1 same B1 A1 same C1 A1 opposite B2 A1 opposite C2	Same and opposite	Discriminative: payout probability	Ratings of slot-machine outcomes

[1] Contextual cue that specifies a relation

[2] Contextual cue that specifies a function

Chapter 3 demonstrated that presenting a rule about a slot-machine could influence responding on a novel slot-machine (see Figure 7.1). The only way in which this can be explained is by considering how the experimenter delivered rules may participate in derived relations. Given the rule "Slot-machine C2 pays out more", the actual slot-machine labelled C2 participates in a mutually entailed relation with the instruction that it pays out more. Therefore, given the choice between slot-machine C1 and C2, preference was seen for slot-machine C2 over slot-machine C1. However, in the control condition in which no rule had been presented, equal responding to these slot-machines was seen. This was due to the discriminative payout functions of slot-machine B1 and B2 in the earlier task participating in derived relations with C1 and C2, respectively. Where the rules were inaccurate, participants initially followed these rules even though they did not describe the schedules in place; therefore responding was under the control of this rule and not a transformation of function of the equal payout probabilities of slot-machines B1 and B2. In the rule-governed behaviour literature, following a rule under the control of social reinforcement is termed pliance. Although pliance may initially have exerted control over behaviour, as participants were repeatedly exposed to the contingencies of reinforcement, behaviour was no longer under the control of the rule and responding became schedule sensitive.

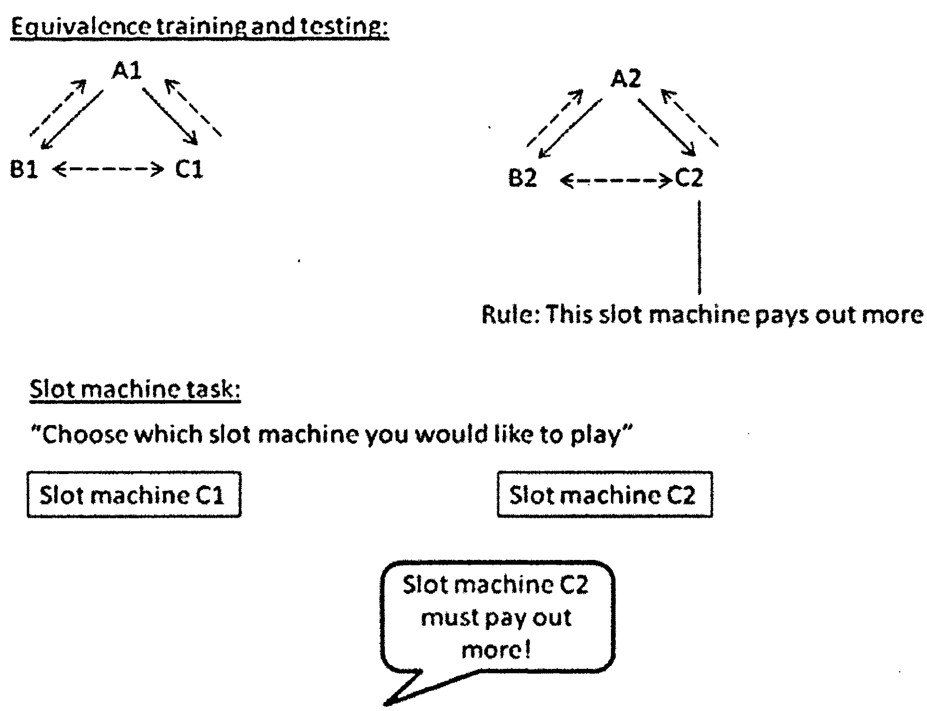


Figure 7.1. Overview of the experimental procedure in Chapter 3. Solid lines indicate a trained relation whereas dashed lines indicate a derived relation.

In Chapters 4 and 5, participants showed preferences for slot-machines that not only did they have no prior experience of playing, but they were unable to decipher the payout probability of their preferred slot-machine. These findings can only be explained when we consider that the stimuli on the slot-machines had, in a prior task, participated in derived same and opposite relations (Chapter 4) or more-than and less-than relations (Chapter 5) with other stimuli. In Chapter 4, participants had derived that B1 was the same as C1, B1 was opposite to C2, and B2 was the same as C2. Then, having played slot-machine B1 and slot-machine B2 and learned that "B2 always pays out", when later presented with a choice between slot-machine C1 and C2, participants chose to exclusively play slot-machine C2 as stimulus C2 participated in a derived same relation with B2. This shows how individuals relate events, even when they are not necessarily related, and that any functions that have become associated with that event such as "this slot-machine must pay out more" or "I will win on this slot-machine" transform to those seemingly unrelated stimuli.

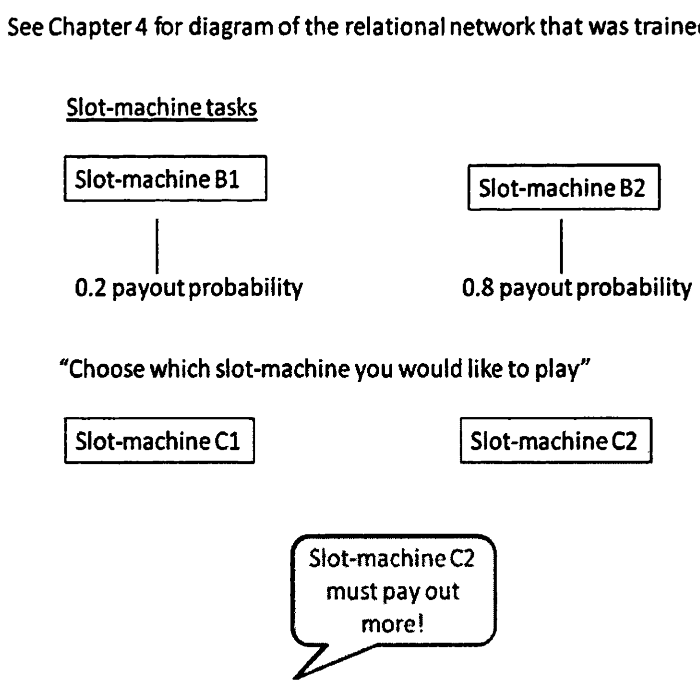


Figure 7.2. Overview of experimental procedure in Chapter 4.

In Chapter 5 (see Figure 7.3), participants' preferences for slot-machines were transformed in accordance with more-than and less-than relations. These findings were particularly interesting as they suggest that preferences for slot-machines may be relative. Having been trained a relational network in which A < B < C < D < E, slot-machine A will be the least preferred whereas slot-machine E will be the most preferred, however, given the choice between slot-machine B and C, slot-machine C will most likely be chosen, but given a choice between slot-machine C and slot-machine D, slot-machine C will not be chosen as slot-machine D is ranked more highly in the network. This suggests that in a casino environment, a gambler may rank their preference of the slot-machines available to him by the structural characteristics of those machines, and not due to the payout probabilities of the slot-machines available.

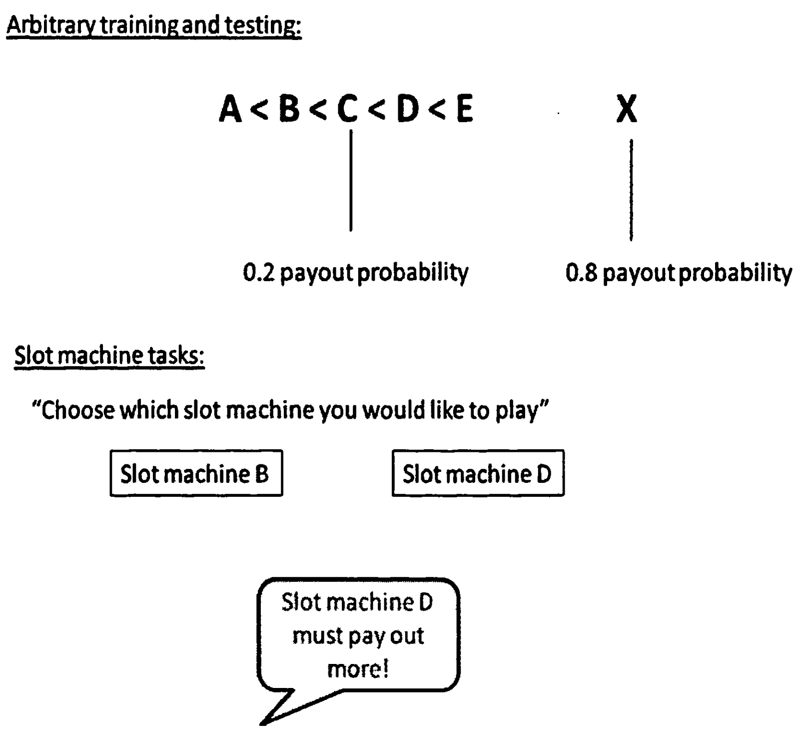


Figure 7.3. Overview of experimental procedure in Chapter 5.

In Chapter 6 (see Figure 7.4), it was demonstrated that ratings for images of wins, near-misses and losses could be transformed in accordance with derived same and opposite relations to the extent to which the ratings made by participants conflicted with the non-arbitrary property of the slot-machine. As with Chapters 4 and 5, participants were responding verbally to these images, that is, their behaviour could only be accounted by appealing to the derived relations that had been learned in the arbitrary training and testing task. These findings suggest that even the non-arbitrary property of a slot-machine may be overruled by the way in which those properties are related to other events within that individual's learning history.

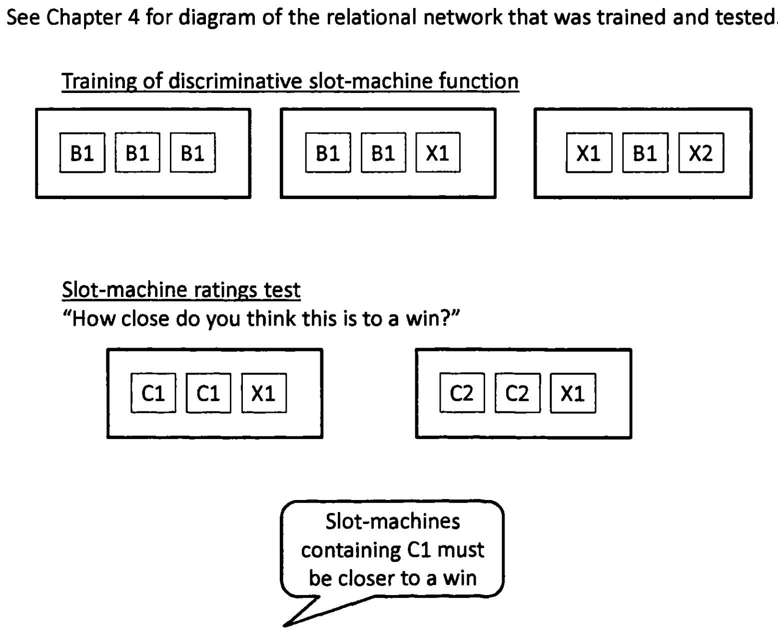


Figure 7.4. Overview of the experimental procedure in Chapter 6.

The present thesis has demonstrated that gambling behaviour may be under the control of derived relations and transformation of function, but how does this translate to real-world gambling? Consider the gambler who goes to a casino in Las Vegas. She is faced with many choices regarding which casino to enter. What factors influence this choice? Perhaps there is casino a called the "Goldengate casino". For this individual the words "golden" or "gold" may participate in a frame of co-ordination or 'similar to' the words "rich" or "money". Perhaps even through derived relations, the name of this casino conjures evokes functions of being a gateway to money. Before even setting foot in the casino, the verbal behaviour of this individual is influencing her choice. Having entered the casino, a vast array of slot-machines will be available to her. How then, will she choose which slot-machine to play? Why choose one particular slot-machine over another? Perhaps given the choice between a slot-machine named "Enchanted" and another named "Lucky diamonds", this individual will choose to play Enchanted due to the functions that are transformed from tales of enchantment she read as a child. What is key to explaining this behaviour, is the way in which the word "enchanted" or the features of the slot-machine that depict enchantment are related to other stimuli. It may be that such features are indirectly related to 'magic', luck, or fairy tales of happily ever after. The functions that these stimuli evoke are then transformed to the slot-machine, such that responding to that slot-machine is not under the control of the contingencies of reinforcement of that slot-machine or the probability of a win on that machine; rather, this individual is behaving verbally. Given that every individual's learning history is unique to that individual, this means that the way in which the structural features of a slot-machine are related and the functions that transform accordingly are potentially different for every individual. This highlights the complexities of the behaviour involved in gambling.

Clinical implications

The present findings may have clinical implications for the way in which gamblers are both prevented from developing pathological gambling and in terms of finding an effective treatment for gamblers. The findings of Chapter 6 could have implications for harm minimisation strategies in programming slot-machines. Harm minimisation works on the assumption that moderate levels of gambling can and should be enjoyable (Sharpe, Walker, Coughlan, Enerson, & Blaszczynski 2005). However, designing slot-machines that remove some properties of the slot-machine that lead to greatest persistence or reduce the amount of money spent may reduce the level of harm incurred by gambling. This may involve altering the structural characteristics of slot-machines such as reducing the maximum bet and duration of reel spin, therefore reducing harm (Sharpe et al., 2005). The findings of Chapter 6 suggest that programming slot-machines which present a near-miss on at least 45% of trials may reduce persistence and lead to a more accurate perception of a near-miss is a losing trial. It is possible that presenting a near-miss on 30% of trials may be detrimental for the gambler as participants rated these trials as closer to a win compared to the participants who were presented with a near-miss on 66% of trials. These findings are in line with those of Kassinove and Schare (2001) who reported that presenting a near-miss on 30% trials lead to greatest persistence in gambling whereas presenting a near-miss 45% resulted in fewer gambles. Although Chapter 6 measured ratings and Kassinove and Schare measured persistence, both findings seem to suggest that when a near-miss is presented on at least 45% of trials, the effects are diminished. It seems that with repeated exposure to near-misses, the initial 'almost winning' effect is lost to extinction, as the gambler is being continually presented with near-miss trials but not winning any money.

Perhaps the most important findings of the current studies which could inform treatment of pathological gambling is the finding that gambling is a verbal event characterised by derived relational responding and transformation of function. Treatments therefore, which focus on the role of verbal relations in psychopathology may be very effective for treating pathological gambling. One such therapy is Acceptance and Commitment Therapy (ACT; Hayes, Strosahl, & Wilson, 1999, 2011). ACT is directly linked to RFT in that according to ACT, the ability to derive relations between stimuli and transform the function to indirectly related stimuli, is at the root of human suffering (Harris, 2006; Hayes, Luoma, Bond, Masuda, & Lillis, 2006). Therefore the therapy works by attempting to "change the way one interacts with or relates to thoughts by creating contexts in which their unhelpful functions are diminished." (Hayes et al., 2006, p.8). ACT differs from mainstream therapies such as CBT in that the goal of treatment is not symptom reduction, rather symptom reduction is a by product. Additionally, clients are encouraged to embrace rather than avoid their feelings and fears whilst committing to live in accordance with their values (Hayes et al., 1999).

Currently there is no published research into the effectiveness of ACT interventions on gambling, however, given that gambling behaviour is influenced by the same verbal process that ACT deals with, namely derived relations and transformation of function, it is possible that ACT could have a good clinical outcome for the treatment of pathological gambling. The six core processes of ACT are acceptance, cognitive fusion, being present, self as context, values and committed action. Clients are taught that acceptance is an alternative to avoiding a particular thought or behaviour (Hayes et al., 2006), as research has shown that trying to avoid or suppress a thought may be counterproductive (Hooper, Saunders, & McHugh, 2010). In terms of gambling, in therapy the gambler may be encouraged to notice any urges to gamble and experience the emotions that occur when thinking about gambling as opposed to trying to avoid or suppress these feelings. Acceptance is employed in conjunction with encouraging a life consistent with the client's values. For example, for a gambler, it may not necessarily be the act of gambling or losing money that is causing a problem, but by going to the casino the gambler may be neglecting to spend time with his family which then leads to feelings of guilt about gambling, if family life is something that the gambler values.

Cognitive fusion refers to "excessive or improper regulation of behavior by verbal processes, such as rules and derived relational networks" (Hayes et al., 2006, p.6). Therefore, through cognitive defusion, ACT aims to change the way an individual relates to their thoughts and alter the functions of those thoughts without trying to alter the form or frequency of these thoughts. Dymond and Roche (2010) give the example of a gambler being required to say aloud the phrase "I am going to gamble today" and repeat this phrase until the functions of that sentence and the feelings associated with going to gamble, begin to diminish. Similarly, the gambler may be taught to label the thought as just a thought by saying "I am having the *thought* that I am going to gamble today".

The process of being present involves "ongoing non-judgmental contact with psychological and environmental events as they occur" (Hayes et al., 2006, p.9). Therefore a client may be required to sit at a slot-machine and notice the thoughts or urges to gamble that they may be having, but encouraged to just notice those thoughts and not judge them. Finally, ACT encourages committed action which involves the client setting achievable goals to ensure living in accordance with their values. It may also include exposure techniques, goal setting and behaviour shaping.

Future research is required which examines the effectiveness of ACT in treating pathological gambling, in which randomized control trials are conducted to compare treatment outcomes with the current prolific gambling treatments, as well as control groups who receive no treatment.

Conclusions

In conclusion, the present findings suggest that gambling behaviour is not solely controlled by schedules of reinforcement, but rather those schedules can be overridden by verbal behaviour. It was shown that slot-machine preference and ratings of slot-machines may participate in derived relations and transformation of discriminative functions such that individuals may show preferences for particular slot-machines despite having not having a history of that slot-machine and having never experienced a win on that slot-machine. The present findings provide empirical support for the suggestion that gambling is a verbal event, and suggests that the contingencies that are controlling a gambler behavior are highly complex and remote, however , they are accessible to an experimental analysis and can be modelled. Although these studies may only scratch the surface of gambling behaviour, they form part of a growing body of experimental, translational research on relational frame accounts of gambling behavior, which will hopefully lead to a better understanding of this behaviour as well as informing parameters for safer gambling, and enabling effective treatments to be developed.

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Appendices

Appendix 1

Chapter 2

Participant Information Sheet

In this study, you will receive a series of instructions and tasks presented on the computer. Your job is to read the instructions and to follow them to the best of your ability.

The tasks involve performing simulated slot machine gambling. The slot machines are virtually identical to those seen in casinos.

You will be presented with two slot machines on-screen, each of a different colour, and your task is to click the mouse on the slot machine you wish to play and to earn as many points as possible.

Later, you will be given some relational learning tasks in which you will be required to select one stimulus in the presence of another stimulus. Again, full instructions will be provided to you at the time.

We will also ask you to complete a brief questionnaire about your history with gambling. Most people have gambled once in their life, for instance, on scratch cards, Lotto tickets, or bingo. Doing so does not mean that people have a problem with gambling. We are interested in any experience of gambling that you might have, so please just complete the questionnaire honestly.

In the rare event of someone reporting a potential likelihood of developing a gambling problem, as indicated by scores on the questionnaire, we may wish to contact you in order to let you know about this. It will merely be to inform you about this; it won't represent a formal, medical or clinical diagnosis because the questionnaires are being used solely for research purposes.

You can leave the study, or request a break, at any time.

Your rights as a participant, including the right to withdraw at any point without penalty, are ensured.

This study is conducted in accordance with British Psychological Society and Departmental ethics guidelines.

It is anticipated that the findings of the study will be written up for publication in a peer-reviewed journal and presented at international conferences. All results will be anonymised and it will not be possible to identify participant's data.

Please contact for further information: Alice Hoon (294189@swansea.ac.uk)

If you have any questions at all, please ask them now.

If you would like to participate, please ask the researcher for a consent form.

Appendix 2

Chapter 2

Debriefing Form

This study was designed to examine the way in which people behave on simulated slot machines. We first asked you to complete the South Oaks Gambling Screen in order to obtain a measure of your experience with gambling. Next, we gave you a slot machine task in which the probability of obtaining a reward (a winning spin that resulted in the gain of one point) was identical on the two machines. They were, however, of different colours.

Then, we taught you that one of the colours stood for, or represented, 'more-than' or 'less-than'. Finally, we tested to see if you would spend more time on the slot machine related to 'more-than'.

This study was designed to replicate and extend a study by Zlomke & Dixon (2006): Modification of slot-machine preferences through the use of a conditional discrimination paradigm (2006). *Journal of Applied Behavior Analysis, 39*, 351-361.

It is important that you are aware that the questionnaire was used purely for research purposes. Occasionally, however, some people produce extreme scores on this questionnaire. Later, we will score the questionnaire and if you happen to have an extreme score, then we may contact you just to let you know about this.

I hope that this has helped to clarify for you the purpose of the study you have just undertaken. Your participation in the study is greatly appreciated.

If any aspects of participating in this study have caused you concern. please contact Alice Hoon (294189@swansea.ac.uk)

We would also like to draw your attention, should you need it, to the counselling and advice services specific to Gambling that are available from GamCare charity (http://www.gamcare.org.uk/)

Appendix 3

Chapter 3
Participant Information Sheet

The study involves several tasks, presented in successive phases. You will first be presented with some relational learning tasks in which you will be required to learn to select the correct stimulus. You will be given feedback on your choices. Full instructions about the task will be given to you on screen. Please follow them to the best of your ability.

The next task involves playing simulated slot machines. The slot machines are very similar to those seen in casinos. Again, you will be given full instructions on how to play the slot machines.

You will have the chance to win up to £7 in cash on the gambling tasks. Additionally, the person who makes the least errors during test phases of the learning tasks will win an extra £10 cash.

You will also be asked to complete a brief questionnaire about your history with gambling. Most people have gambled once in their life, for instance, on scratch cards, Lotto tickets, or bingo. Doing so does not mean that people have a problem with gambling, however. The questionnaire that you will be asked to complete merely assesses your experience of gambling, so please complete it honestly.

In the rare event of someone reporting a potential likelihood of developing a gambling problem, as indicated by scores on the questionnaire, we may wish to contact you in order to let you know about this. It will merely be to inform you about this; it won't represent a formal, clinical diagnosis because the questionnaires are being used solely for research purposes.

During the study, you can ask the experimenter for further clarification at any stage.
You can leave the study, or request a break, at any time.
Your rights as a participant, including the right to withdraw at any point without penalty, are ensured.
This study is conducted in accordance with British Psychological Society and Departmental ethics guidelines.
It is anticipated that the findings of the study will be written up for publication in a peer-reviewed journal and presented at international conferences. All results will be anonymised and it will not be possible to identify participant's data.
Please contact for further information: Alice Hoon (294189@swansea.ac.uk)
If you have any questions at all, please ask them now.
If you would like to participate, please ask the researcher for a consent form.

Appendix 4

Chapter 3
Debriefing Form

This study was designed to examine the way in which people behave on simulated slot machines. We first asked you to complete the South Oaks Gambling Screen in order to obtain a measure of your experience with gambling. Then we gave you some training tasks in which you learned which words went together.

You were then presented with two slot machines to play containing words from the previous task. Both of these slot machines paid out on 50% of trials.

In the final phase you were presented with two more slot machines containing words from the earlier phase of the experiment and asked to try to win as many points as possible. This was to see if you had a preference for either of the slot machines.

It is important that you are aware that the questionnaires used were purely for research purposes. Occasionally, however, some people produce extreme scores on such questionnaires. Later, we will score the questionnaires and if you happen to have an extreme score, then we may contact you just to let you know about this.

I hope that this has helped to clarify for you the purpose of the study you have just undertaken. Your participation in the study is greatly appreciated.

If any aspects of participating in this study have caused you concern, please contact Alice Hoon (294189@swansea.ac.uk)

We would also like to draw your attention, should you need it, to the counselling and advice services specific to Gambling that are available from GamCare charity (www.gamcare.org.uk) or alternatively Swansea University Student Support Services: student.services@swansea.ac.uk.

Appendix 5

Chapters 4
Participant Information Sheet

The study involves several tasks, presented in successive phases. You will first be presented with some relational learning tasks in which you will be required to learn to select the correct stimulus. You will be given feedback on your choices. Full instructions about the task will be given to you on screen. Please follow them to the best of your ability.

The next task involves playing simulated slot machines. The slot machines are very similar to those seen in casinos. Again, you will be given full instructions on how to play the slot machines.

You will also be asked to complete a brief questionnaire about your history with gambling. Most people have gambled once in their life, for instance, on scratch cards, Lotto tickets, or bingo. Doing so does not mean that people have a problem with gambling, however. The questionnaire that you will be asked to complete merely assesses your experience of gambling, so please complete it honestly.

In the rare event of someone reporting a potential likelihood of developing a gambling problem, as indicated by scores on the questionnaire, we may wish to contact you in order to let you know about this. It will merely be to inform you about this; it won't represent a formal, clinical diagnosis because the questionnaires are being used solely for research purposes.

During the study, you can ask the experimenter for further clarification at any stage.
You can leave the study, or request a break, at any time.
Your rights as a participant, including the right to withdraw at any point without penalty, are ensured.
This study is conducted in accordance with British Psychological Society and Departmental ethics guidelines.
It is anticipated that the findings of the study will be written up for publication in a peer-reviewed journal and presented at international conferences. All results will be anonymised and it will not be possible to identify participant's data.
Please contact for further information: Alice Hoon (294189@swansea.ac.uk)
If you have any questions at all, please ask them now.
If you would like to participate, please ask the researcher for a consent form.

Appendix 6

Chapter 4
Debriefing Form

This study was designed to examine the way in which people behave on simulated slot machines. We first asked you to complete the South Oaks Gambling Screen in order to obtain a measure of your experience with gambling. Then we gave you some training tasks in which you learned a network of words that were 'same' or 'opposite' to each other.

You were then presented with two slot machines to play, one which contained one of the words from the previous task and had a high payout probability and the another slot machine which contained another of the words and never paid out. In the final phase you were presented with two more slot machines containing words from the earlier phase of the experiment. This was to see if what you learned when playing the slot machines, and the network of words you learnt in the first task would affect which slot machine you chose in the final phase. So for example, if you had learnt that nonsense word A was 'opposite' to nonsense word B, and that the slot machine containing nonsense word A never paid out, would this mean that you were more likely to play the slot machine containing nonsense word B.

It is important that you are aware that the questionnaires used were purely for research purposes. Occasionally, however, some people produce extreme scores on such questionnaires. Later, we will score the questionnaires and if you happen to have an extreme score, then we may contact you just to let you know about this.

I hope that this has helped to clarify for you the purpose of the study you have just undertaken. Your participation in the study is greatly appreciated.

If any aspects of participating in this study have caused you concern, please contact Alice Hoon (294189@swansea.ac.uk)

We would also like to draw your attention, should you need it, to the counselling and advice services specific to Gambling that are available from GamCare charity (www.gamcare.org.uk) or alternatively Swansea University Student Support Services: student.services@swansea.ac.uk.

Appendix 7

Chapter 5
Participant Information Sheet

The study involves several tasks, presented in successive phases. You will first be presented with some relational learning tasks in which you will be required to learn to select the correct stimulus. You will be given feedback on your choices. Full instructions about the task will be given to you on screen. Please follow them to the best of your ability.

The next task involves playing simulated slot machines. The slot machines are very similar to those seen in casinos. Again, you will be given full instructions on how to play the slot machines.

You will also be asked to complete a brief questionnaire about your history with gambling. Most people have gambled once in their life, for instance, on scratch cards, Lotto tickets, or bingo. Doing so does not mean that people have a problem with gambling, however. The questionnaire that you will be asked to complete merely assesses your experience of gambling, so please complete it honestly.

In the rare event of someone reporting a potential likelihood of developing a gambling problem, as indicated by scores on the questionnaire, we may wish to contact you in order to let you know about this. It will merely be to inform you about this; it won't represent a formal, clinical diagnosis because the questionnaires are being used solely for research purposes.

During the study, you can ask the experimenter for further clarification at any stage.
You can leave the study, or request a break, at any time.
Your rights as a participant, including the right to withdraw at any point without penalty, are ensured.
This study is conducted in accordance with British Psychological Society and Departmental ethics guidelines.
It is anticipated that the findings of the study will be written up for publication in a peer-reviewed journal and presented at international conferences. All results will be anonymised and it will not be possible to identify participant's data.
Please contact for further information: Alice Hoon (294189@swansea.ac.uk)
If you have any questions at all, please ask them now.
If you would like to participate, please ask the researcher for a consent form.

Appendix 8

Chapter 5
Debriefing Form

This study was designed to examine the way in which people behave on simulated slot machines. We first asked you to complete the South Oaks Gambling Screen and the Gambler's Functional Analysis in order to obtain a measure of your experience with gambling. Then we gave you some training tasks in which you learned a hierarchy of nonsense words.

Then you were presented with two slot machines to play, one which contained the middle ranked nonsense word from the previous task and had a low payout probability. The other slot machine contained a new nonsense word, and had a high payout probability.

Finally, you were given many choices of slot machines to select. These slot machines contained the words you had been taught previously. This was to see if the relations learned in the earlier tasks would affect your slot machine choice. For example, if you had learned that one word was "greater-than" another word in the previous tasks, would you then prefer to play the slot machine containing word that was "greater-than" the other?

It is important that you are aware that the questionnaires used were purely for research purposes. Occasionally, however, some people produce extreme scores on such questionnaires. Later, we will score the questionnaires and if you happen to have an extreme score, then we may contact you just to let you know about this.

I hope that this has helped to clarify for you the purpose of the study you have just undertaken. Your participation in the study is greatly appreciated.

If any aspects of participating in this study have caused you concern. please contact Alice Hoon (294189@swansea.ac.uk)

We would also like to draw your attention, should you need it, to the counselling and advice services specific to Gambling that are available from GamCare charity (http://www.gamcare.org.uk/)

Appendix 9

Chapter 6
Participant Information Sheet

The study involves several tasks, presented in successive phases. You will first be presented with some relational learning tasks in which you will be required to learn to select the correct stimulus. You will be given feedback on your choices. Full instructions about the task will be given to you on screen. Please follow them to the best of your ability.

The next task involves playing simulated slot machines. The slot machines are very similar to those seen in casinos. Sometimes you will be asked to rate how close you think the slot machine is to a win. Again, you will be given full instructions on how to play the slot machines.

You will also be asked to complete a brief questionnaire about your history with gambling. Most people have gambled once in their life, for instance, on scratch cards, Lotto tickets, or bingo. Doing so does not mean that people have a problem with gambling, however. The questionnaire that you will be asked to complete merely assesses your experience of gambling, so please complete it honestly.

In the rare event of someone reporting a potential likelihood of developing a gambling problem, as indicated by scores on the questionnaire, we may wish to contact you in order to let you know about this. It will merely be to inform you about this; it won't represent a formal, clinical diagnosis because the questionnaires are being used solely for research purposes.

During the study, you can ask the experimenter for further clarification at any stage.
You can leave the study, or request a break, at any time.
Your rights as a participant, including the right to withdraw at any point without penalty, are ensured.
This study is conducted in accordance with British Psychological Society and Departmental ethics guidelines.
It is anticipated that the findings of the study will be written up for publication in a peer-reviewed journal and presented at international conferences. All results will be anonymised and it will not be possible to identify participant's data.
Please contact for further information: Alice Hoon (294189@swansea.ac.uk)
If you have any questions at all, please ask them now.
If you would like to participate, please ask the researcher for a consent form.