An examination of deception as a conditioned stimulus.

Tomash, J. James

Swansea University
Prifysgol Abertawe

An Examination of Deception as a Conditioned Stimulus

J. James Tomash

Submitted to the University of Wales in fulfilment of the requirements

for the Degree of Doctor of Philosophy (Ph.D)

Swansea University

September 2011

Summary (Abstract)

The polygraph, and other methods of lie detection, measure the physiological arousal thought to accompany attempts to deceive. Traditional methods of lie detection, however, have failed to acquire the accuracy and consistency necessary to be relied upon in important applications. The reason for this is that there is not a sufficient understanding of why people exhibit physiological arousal when they are deceptive, and how they come to have these responses. The current thesis explores how classical conditioning can be used to explain the physiological arousal a person has to their own deception, and how this might come about in the normal social conditioning of the individual. Chapters 1 discusses the background of lie detection to this point, current methods in use, and the current understanding of why people exhibit physiological arousal when they are deceptive. Chapter 2 covers some of the technical aspects of the experiments presented in this thesis, such as the experiment programs and environment used. Chapter 3 of the current thesis examined the punishment of verbal behaviors in a person's past conditioning can cause them to exhibit increased physiological arousal when engaging in that behavior. Chapters 4 and 5 explored the classical conditioning of eyeblink and skin conductance responses to deception and truth-value in a laboratory setting. Chapter 6 further explored the classical conditioning of a skin conductance response to instances of deception regarding an internally consistent context, and the generalization of these conditioned responses to instances of deception that only the subject knew about. In conclusion, the current thesis argued that the responses relied upon by traditional methods of lie detection can be explained using a behavioral explanation based on classical conditioning and past punishment. Classical conditioning, it is argued, can provide a more direct explanation of the responses exhibited, and potentially a powerful tool for improving the responses we rely upon to detect deception.

DECLARATION

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

Signed .. .. (candidate)

Date ....29/9/2011.........................

STATEMENT 1

This thesis is the result of my own investigations, except where otherwise stated. Where correction services have been used, the extent and nature of the correction is clearly marked in a footnote(s).

Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

Signed .. .. (candidate)

Date ....29/9/2011.........................

STATEMENT 2

I hereby give consent for my thesis, if accepted, to be available for photocopying and for inter-library loan, and for the title and summary to be made available to outside organisations.

Signed .... (candidate)

Date ....29/9/2011.........................

NB: *Candidates on whose behalf a bar on access has been approved by the University (see Note 9), should use the following version of Statement 2:*

I hereby give consent for my thesis, if accepted, to be available for photocopying and for inter-library loans **after expiry of a bar on access approved by Swansea University.**

Signed .... (candidate)

Date ....29/9/2011.........................

Table of Contents

Acknowledgement

Special thanks go to my parents, Jim Tomash and Marilyn Netolicky, for supporting me through my higher education. Without their love, guidance, and support my education would never have come this far. It has ended, and well, and I thank them from the bottom of my heart.

Many thanks also go to my supervisors, Phil Reed and Louise McHugh, who helped me in Swansea in very different ways, but ways I am convinced are equally as valuable.

Beyond this, I want to thank the many friends I have made throughout my studies. I have been lucky to come to a new land, knowing nobody and nothing of the terrain. I leave a town full of dear friends that I shall henceforth never miss an opportunity to meet. They have helped me, taught me, bettered me, and amused me on countless occasions.

Research

Conference Publications/Presentations

Tomash, J. J., & Reed, P. (2011). *Detecting deception via classical conditioning.* PsyPag, Bangor, Wales, August 2011.

Tomash, J. J., & Reed, P. (2010). *Classically conditioning a skin conductance response to artificially elicited instances of deception.* Association for Behavioral Analysis, San Antonio, TX, May 2010.

Tomash, J. J., & Reed, P. (2009). *Some properties of deception as a conditioned stimulus.* Association for Behavioral Analysis, Phoenix, AZ, May 2009.

Tomash, J. J., & Reed, P. (2008). *Classically conditioning an eyeblink response to the truth-value of statements.* European Association for Behavioral Analysis, Madrid, Spain, September 2008.

Academic Studentships

Tomash, J. J. (2008/2009). *Detecting deception through classical conditioned responses.* Overseas Research Studentship Award Scheme (ORSA).

Figures

Chapter 1:

Deception and its Detection

1.1 Deception

> *"A wonderful fact to reflect upon, that every human creature is constituted to be that profound secret to every other" (Dickens, 1859, pg. 21).*

Everybody lies. Studies have shown that practically everyone asked lies about something, and people lie on the average 1 to 2 times per day (Depaulo et al., 1996; Ennis, 2008; Kashy & Depaulo, 1996). Not all deception is harmful, of course. Interpersonal deception is often whimsical, and even sometimes apparently for the benefit of the deceived (Hoogstraten & Terwogt-Kouwenhoven, 1997).

Deception is commonly employed to manipulate the behavior of other organisms. The orchid may have a petal simulating the appearance of a female insect, tricking male insects into "mating" with it and spreading pollen (Campbell, 2001). Butterflies in South America will mimic, in colouring pattern, their unpalatable relative the Heliconidae to avoid being devoured (Darwin, 1871). The killdeer fakes a broken wing, luring predators away from its young (Davis, 1943). These are all instances where natural selection has chosen individuals that avoid predation or spread their seed more successfully.

Human deception is different, primarily in its complexity and diversity. Unlike most animals, humans are able to communicate their environments, past and present, to a tremendous extent. One human can report to another where they typically live, what they typically do, where they will be the next day, what they will be doing, and who they will be with, all in a matter of minutes. This is impossible in any other species, as they do not have the capacity for verbal behavior. Despite the capacity we can communicate with each other, it is not always in an individual's best interest to be accurate. Hence humans are deceptive. It is the attempted detection of this deception that will be the topic of this thesis. While deception as an operant behavior is a fascinating field, and much could be written about it, the present work will focus on the side-effects of deception that have made its detection possible.

While it could be argued that not all deception is verbal behavior, verbal deception seems to be the most common among humans, and certainly the most troubling. The current work will therefore focus primarily on verbal instances of deception. Additionally, this work will focus on instances of deception where the speaker knows that they are being deceptive.

1.1.1 Practical implications of deception

Perhaps the most obvious general situation in which an individual is likely to be deceptive is when one seeks information from another regarding the latter's engagement in punishable behavior. Obviously, the truthful disclosure of such behavior will be punished, making the truthful reporting of such behavior also punishing. Thus the child "did not" put their hand into the cookie jar. This has been perhaps the core problem plaguing criminal justice systems since there have been what could be called criminal justice systems (Fisher, 1997). A person's verbal behavior will not predictably tell us whether they have engaged in the crime for which they are questioned. If it did, criminal justice systems would be so precise, scientific, and effective by our own time that they, and the society they serve, would be unrecognizable to us. If it were known, in every case, with certainty whether a particular suspect had, or had not, committed an offense, a mild consequence would be the lack of need for juries, courts, and judges; a major consequence would be that few people would ever engage in offenses. Very seldom do people engage in highly or mildly punishable behaviors for which they are certain to be caught. If the criminal justice system were more precise and effective in determining guilt, there would be a small fraction of the guilt to determine.

As such, every criminal justice system ever conceived and implemented has had its various means of determining whether a suspect is deceptive in proclaiming their innocence (little of any system's effort has ever been expended in cases where suspects readily admit to the offense). Witnesses have been called, questioning has been harsh in seeking inconsistencies, and interrogation has sought- through negative reinforcement via all forms of aversive stimuli- to reward confessions. This has been the state of all criminal justice systems throughout our history: the capacity for a suspect to deceive has made them less effective, and more brutal. As argued by Fisher (1997), in our own time jury trials have become accepted as the most reasonable means to this end. Two parties debate the guilt of a suspect, presenting evidence and witnesses, and a panel of non-professional peers have the burden placed upon their shoulders to decide who made the best argument: prosecutor or defence. In this way, the modern jury system avoids the appearance of barbarity, while masking its ineffectiveness in discovering deception and guilt by resting the responsibility upon randomly selected peers (Fisher, 1997). This is the modern solution to the problem, despite the fact that humans, judges, and jurors are little better than chance when it comes to detecting deception- meaning they are nearly as likely to confidently report an innocent person deceptive as they are to report them innocent (Andrewartha, 2008). The core of the problem remains, as it always has been: deception. Given the importance of deception to systems of criminal justice, the possibility of directly detecting it has not, of course, been overlooked.

1.2 The Detection of Deception

1.2.1 Historical Methods

The endeavour of lie detection is old, and the methods that have been employed are various. Many early attempts at lie detection utilized methods such as torture to negatively reinforce confessions (Fisher, 1997). In medieval English courts, for example, a suspect's honesty was often determined using the fire or water ordeal (Sullivan, 2001), in which the suspect was allowed to choose fire or water. If fire was chosen, the suspect would be forced to endure walking on hot coals, put their tongue to hot iron, or some other exposure to extreme heat. If they were not burned, they were telling the truth. If they were burned, they were lying and punished (often with death). If the suspected liar chose the water ordeal, they were stuffed in a sack and tossed into a body of water. If they floated, they were thought a liar, and executed. If they sank, they were thought honest and released (It is interesting to reason that one cause for a suspect to float is inhaling and holding their breath prior to hitting the water- as they might do if they expected to sink). The above methods of determining deception were based on magical and religious assumptions that the innocent were protected from false punishment (Sullivan, 2001).

Other historical methods used primitive means of measuring physiological arousal. In ancient China, it was said that putting a handful of rice into one's mouth, producing a statement in question, and then attempting to spit the rice forth would tell if one was telling the truth (Ford, 2006); a method that holds a tenuous association with physiological arousal as a dry mouth is often associated with stress and increased arousal. Since these times, the advancing technologies have driven forward attempts at lie detection, often without any advancement in the theoretical underpinnings of the methods employed. We still, on the whole, measure physiological arousal, on the same assumption that "guilt" or "fear" will connect this arousal to the deceptive situation more than the truthful situation. Below is an outline of some of the modern approaches that have developed to detect deception.

1.2.2 Modern approaches to lie detection:

From measures of autonomic arousal to voice stress analysis (which measures the changes in vocal cord tension accompanying stress), the underlying premise of most modern approaches to lie detection is that deception is accompanied by increased arousal of the sympathetic nervous system. As will be seen in this section, each practical method of detecting deception used today relies on this assumption. Different methods of measuring deception are, in fact, simply different methods of measuring physiological arousal. The exception, perhaps, to this rule is brain imaging, which will be discussed below.

1.2.2.1 Autonomic indicators

The polygraph is the best known, and perhaps most successful, technique of measuring the physiological arousal thought to accompany deception (National Research Council (NRC), 2003), and will be discussed in more detail below. The polygraph, however, is one of many methods of detecting deception that relies directly on arousal of the sympathetic nervous system. For example, studies have attempted to use thermal facial imaging technology, in which infrared cameras are used to detect the increased blood flow to the face that accompanies physiological arousal (Pollina & Ryan, 2002). While the authors report high success rates in detecting deception using this method, as reported by the NRC (2003), this study does not provide sufficient scientific evidence to support the use of this technology in the detection of deception. Pavlidis et al. (2002) used a mock crime scenario to test the accuracy with which thermal facial imaging could identify guilty and innocent subjects. They correctly identified 75% of the guilty subjects, and 90% of the innocent subjects, upon which they claimed to have acquired comparable accuracy to the polygraph. They had therefore discovered a more convenient method of results similar to the polygraph. While some have argued that future research should attempt to combine thermography with traditional polygraph measures to try to improve the combined result (Pollina et al., 2006), this simply creates a more complicated measure of physiological arousal- based on a combination of measures that each received comparable results to begin with.

1.2.2.2 Voice stress analysis

Related to physiological arousal is the assumption that deception causes increased stress, which affects the vocal cords during speech- increasing vocal tension and pitch (NRC, 2003). Theoretically, this should provide similar (if somewhat less sensitive) measurements to the polygraph and other measurements of stress during deception. Voice stress analysis received much attention for a period (BPS, 2004; NRC, 2003). The results of voice stress analysis, however, are as precariously related to deception as in other methods, probably because numerous other stimuli can cause vocal tension besides the act of being deceptive. For these reasons, the National Research Council concluded that the research on voice stress analysis offers "little or no scientific basis for the use of … voice measurement instruments as an alternative to the polygraph …" (NRC, 2003). Other researchers have drawn similar conclusions regarding its lack of reliability (Waln & Downey, 1987). Voice stress analysis is of interest, for our purposes, simply because it is another example of an attempt to measure deception by physiological arousal.

1.2.2.3 Demeanor and body language

Another technique commonly used to detect deception is observation of a person's overt behavior. This includes their posture, gaze, facial expressions, the sound of their voice, and body movements during an interview or interrogation. The use of demeanour is unique in that it does not require equipment, relying only on the observation of trained experts. While this method is used in many government organizations in the U.S., and probably helps improve the effectiveness of their agents in everyday functioning, as an independent method of detecting deception it is not as effective as the polygraph. According to Ekman et al. (1991), a group of trained U.S. secret Service agents averaged 64% accuracy in correctly identifying deceptive responses, when chance is 50%. This is far below any practicable accuracy for relying on a method of deception detection.

1.2.2.4 Brain function

With the improvement of technology capable of measuring brain functioning, various attempts have been made to apply this to detecting deception. For example, the fMRI measures the amount of oxygen contained in the blood flow to regions of the brain, allowing researchers to measure activation levels of various regions. Several approaches have been made to using this capacity for detecting deception and hidden information. Studies have shown that seeing familiar names and faces produce distinguishable differences in activation from unfamiliar names and faces (e.g. Tsivilis, Otten, & Rugg, 2001; Shah et al., 2001). This could potentially lead, with further development, to methods of determining if a suspect has specific information that provides evidence in their case. Another method of using this technology involves measuring activation in regions of the brain associated with anxiety (e.g. the amygdala and regions of the prefrontal cortex) (Davidson, 2002). While further development of these techniques and technologies may eventually lead to more reliable methods of detecting deception, there are reasons to believe that this will not be as straightforward as finding the patterns associated with deception (NRC, 2003). Identifying areas of brain activation associated with deception, according to NRC (2003) is not on the horizon. Nor is it clear that such areas exist or will ever be identified. Additionally, fMRI studies rely on averaging across subjects to find patterns in activation. While this may be useful in research attempting to associate particular regions of the brain with particular "functions," in the case of deception detection- in which individual deception is the target to be measured, this is not practical (NRC, 2003).

Other attempts at applying brain activation to detecting deception have come from the use of EEG and event-related potentials. Laboratory studies have shown that the P300 component of the event-related potential can be used to classify roughly 85% of deceptive examinees (e.g., Farwell & Donchin, 1991; Johnson & Rosenfeld, 1992; Allen & Iocono, 1997). This level of accuracy is comparable, however, to that attained using skin conductance measurement (see, e.g., MacLaren, 2001, for review).

1.2.2.5 The polygraph

The most successful attempt to detect deception to date is the polygraph (OTA, 1983; NRC, 2003). The polygraph is employed by thousands of practitioners across the world, to address the issue of deception in numerous fields and applications (Lykken, 1981). In the United States, the CIA uses the polygraph to test employees, applicants, and assets (sources of intelligence) (Sullivan, 2007). American police departments use it to develop leads in criminal investigations, and to test suspects. Since its development over a century ago, the polygraph has become a household word, and a commonly used tool.

Like other methods, the polygraph relies upon the assumption that physiological arousal reliably accompanies attempts at deception (BPS, 2004; NRC, 2003). The polygraph measures physiological arousal through several independent measurements (e.g. skin conductance, heart rate, respiration). These changes are thought to accompany attempts to deceive on the part of subjects being tested. When a person answers a question deceptively, they exhibit an increase in these physiological indicators that is measured and displayed by the polygraph device. Given the right situation and a competent tester, these measurements can supposedly indicate when a subject is answering deceptively on a particular question of interest.

Figure 1-1: Portable polygraph device, with connectors.

Studies have found the accuracy of the polygraph to range from 61% to 82% (Office of Technology Assessment (OTA), 1983; see Kircher, Howlitze, & Raskin, 1988 for meta-analysis). Given the potential personal and social consequences of the polygraph's applications, this is a very low accuracy rate. These failings have lead critics of the polygraph to argue that there is no direct method available of measuring deception (Saxe, 1985; NRC, 2003). The physiological indicators, they argue, are not specifically responses to deception, but rather to any number of stimuli- such as fear of detection, or nervousness regarding other matters. The non-specific nature of the response makes interpreting these measurements as deception problematic, and potentially dangerous (OTA, 1983; NRC, 2003). The connection between the physiological arousal measured and the deception inferred has been one of the primary problems faced by the polygraph (OTA, 1983). We will turn next to this connection.

1.2.3 Theories for physiological arousal

All of the above mentioned technologies and techniques for detecting deception have relied on the same underlying observation: deception appears to be accompanied by increased physiological arousal. From measures of autonomic arousal to voice stress analysis, the underlying premise of these methods is that deception will be accompanied by increased activation of the sympathetic nervous system. The most successful of these techniques is the polygraph, simply because it is the most accurate measure of such arousal- relying on several different indices. The one exception to this rule is perhaps the newer methods based on the measurement of brain function, the limitations of which were discussed earlier.

One thing shared by nearly every previous method of lie detection, besides reliance upon physiological arousal, is an apparent disinterest in why physiological arousal should accompany deception in the first place. Very little research has gone into explaining the connection between instances of deception and increased arousal. There is agreement in the literature that it seems unlikely that there is a specific physiological "lie response" (Podlesny and Raskin, 1977). A couple of distinct theories can be distinguished for why deception elicits physiological responses.

1.2.3.1 'Fear of detection' theory

Perhaps the most commonly held theory today for the arousal exhibited during deception is what has been called the 'fear of detection' theory (OTA, 1983). This theory holds that it is not the deception, per se, that causes physiological arousal, but rather the person's fear that they will be detected and punished. This theory makes a great deal of sense, and explains most of the factors that have been found to influence the accuracy of the polygraph (see below). However, there is the difficulty that this theory explains the physiological arousal by reference to an internal event (fear), which can only be inferred from the subject's behavior and situation. What is really pointed to in this theory, it seems fair to assume, is the current situation and how it elicits the fear that a subject's deception will be detected. As will be seen below, the more apparent the situation makes it that one is about to be caught being deceptive, the stronger their responses to their own deception.

This is only a portion of the explanation, however. Even postulating an intermediate event, "fear", provides only a partial explanation of what is causing the physiological arousal. Certainly, to get to the point where a person can "fear" being detected in a given situation, things must have happened in the past for them to learn that the given situation is likely to end in their getting caught and punished. The real explanation must lay in the past conditioning that produces the "fear" *and* the physiological arousal when a person is deceptive.

1.2.3.2 Conditioned response theory

The fear of detection theory points to the current environment of the individual as the cause of the physiological arousal they exhibit, which is certainly very important in explaining the responses measured (see below for a discussion of the situational variables involved). The question still remains, however, as to how subjects come to exhibit these responses in these sorts of situations. One possibility, proposed by Skinner in 1953, is that the past environment of the subject conditions the responses measured by the polygraph. Deception is usually punished in our society, when detected (Wang & Leung, 2010). It is, on this theory, this past punishment for deception that causes it to elicit physiological arousal. This explanation has the benefit of pointing to the past of the individual for the original explanation of the responses observed. Whereas the 'fear or detection' theory above simply points to the individual's current environment, Skinner's explanation points to the current environment and the past environments of the individual in which they have been deceptive and punished. The polygraph, on this theory, measures a conditioned response similar to other conditioned responses (Skinner, 1953).

Understanding the response measured by the polygraph, it follows, requires looking not only at the situations in which this response is strongest when a person is deceptive, but previous situations in which they have been deceptive and the consequences that have followed. The next section will explore some of the situational factors that have been found to cause strong responses to one's own deception.

1.3 Situational factors effecting the polygraph's accuracy

To understand the above theories of why people exhibit physiological arousal when they are deceptive, it is instructive to examine some of the situational variables that have been found to influence this arousal. These situational variables, which can be categorized as the consequences and the probability of being detected, strongly support the 'fear of detection' theory, and in fact many of the studies cited had the goal of testing this theory. As will be seen, however, will show that for these factors to have an influence, the subject must first learn the types of situations in which their deception is likely be detected, and the types of situations in which being detected is likely to have severe consequences.

1.3.1 Consequences of detection

The primary factor influencing the accuracy of the polygraph is the potential consequences of the subject's deception being detected (OTA, 1983). Several studies have demonstrated that increasing a subject's motivation to successfully deceive makes them more easily detected when deceptive (Bradley & Warfield, 1984; Elaad & Ben-Shakhar, 1989; Gustafson & Orne, 1963; Kircher, Howlitze, & Raskin, 1988;). For example, Gustafson & Orne (1963) found that deceptive answers were more easily detected in subjects that were instructed to try to successfully deceive than in subjects who received no such instructions. Bradley & Warfield (1984) found that subjects with greater monetary incentive to deceive were more detectable. Bradley & Janisse (1981) threatened subjects with an electrical shock that would be "painful, but not permanently damaging" if they failed to beat the lie detection test, finding that this made subjects more detectable.

Perhaps the strongest evidence for the effect of consequences comes from comparison of the accuracy rates of polygraph tests in laboratory settings (in which subjects have relatively little motivation to deceive successfully), and criminal investigations (in which detection could mean prosecution and incarceration) (Vrij, 2008). The OTA's review of studies in the two areas found that the percentage of subjects correctly identified as deceptive or truthful in laboratory experiments (61%) was more than 20% lower that the percentage of crime suspects correctly identified (82%) (OTA, 1983; see Kircher, Howlitze, & Raskin, 1988 for meta-analysis). Thus, the greater the consequences for being caught being deceptive, the greater the physiological arousal a subject will exhibit during deception.

This overlaps strongly with the 'fear of detection' theory, which would predict that situations that make a person more scared of being caught, or motivated to deceive effectively, increase the arousal they exhibit when being deceptive. By associating the physiological arousal a person exhibits when deceptive with the probability of punishment in the given situation, this evidence also supports the conditioned response theory. The more similar the current situation to previous situations in which punishment has been received, the more likely that the punishment received in those situations will cause the subject to exhibit physiological arousal. The data support both theories, but for different reasons. The 'fear of detection' theory is supported because it points to future likelihood of punishment, and the conditioned response theory because it points to the probability of past punishment.

1.3.2 Subject's belief that the test is accurate

The second main factor influencing the accuracy of the polygraph is the subject's belief that the test will accurately detect their deception. Numerous laboratory tests have investigated subject's "belief in the machine." For example, an experiment by Bradley and Janisse (1981) investigating the effect of staged pre-test accuracy demonstrations of the lie detector ("stimulation tests") found that the more accurate subject's were led to believe the test was, the more detectable their deception on the subsequent test was (Bradley & Janisse, 1981). The more effective the apparatus seemed to be, they found, the more that innocent subjects scored as non-deceptive, and the more guilty subjects scored as deceptive. Waid et al. (1979) showed that subjects who were tricked into believing the polygraph machine was switched off prior to the examination had significantly lower responses to relevant questions, and not to control questions.

This relates to the theories described above in much the same way as likely consequences of detection. By relating the likelihood of being caught to the magnitude of the responses acquired, it supports the notion that the more subject's are afraid that they will be caught, and hence punished, the greater their responses.

The conditioned response theory, as before, would point to the similarity of the current situation to previous situations in which deception has been detected.

1.3.3 Situational factors and punishment

As can be seen, both of these situational factors are directly related with punishment. The first relates to the likely magnitude of the punishment that will follow the given situation, and the second relates to the probability that punishment will be forthcoming in the given situation. This is in line with the 'fear of detection' theory discussed earlier, as it describes the situations in which punishment is likely to occur and to be severe, and claims that a subject's fear is a function of these variables. A better explanation should point to how the individual comes to have such a response in situations where they are likely to receive relatively severe punishment. How does the individual come to fear detection, and come to fear punishment? To understand this, we must look at the basic process by which punishment changes behavior.

1.4 Behavioral principles and their relation to deception

The present thesis draws heavily on research into basic behavioral processes demonstrated in animals and humans in the laboratory. This section will discuss some of the behavioral processes that are pertinent to the research in this thesis.

1.4.1 Classical Conditioning

Classical conditioning is a behavioral phenomenon first demonstrated by Ivan Pavlov in his research with dogs. Pavlov discovered that his dogs, which tended to salivate when they were presented with their food at feeding time, soon began salivating when presented with other stimuli that were associated with feeding time, such as him walking into their room. This process, which he went on to study in detail, became known as classical, or Pavlovian, conditioning. When a stimulus that tends to elicit a response (an unconditioned stimulus or UCS) is repeatedly presented shortly after, or "paired," with a previously neutral stimulus (the conditioned stimulus or CS), the conditioned stimulus can come to elicit responses similar to those of the unconditioned stimulus (there are instances where the CR is not directly related to the UCR, but these instances will not be used in the present thesis). This new response is called a conditioned response, or CR. The acquisition of conditioned responses is highly dependent upon many factors, such as the time between the CS and the UCS, the number of pairings, previous exposure to the CS, and numerous others (Pavlov, 1927). Classical conditioning is seen in many aspects of behavior, and often results as an accidental by-product of other conditioning processes, as we will see with punishment.

1.4.2 Punishment

When a stimulus immediately follows a behavioral response, and the future probability of that response is decreased, this stimulus is defined as a punisher, and the overall event is called punishment (Hake & Azrin, 1965). Another effect of this process is that stimuli associated with the punisher come to elicit conditioned emotional responses on future presentations. Watson & Rayner (1920) demonstrated this in the Little Albert experiment. When the authors paired a rat with a loud noise, not only did Little Albert have an initial emotional response to the loud noise, but also upon later presentations of the rat similar emotional responses were elicited (conditioned responses). These conditioned emotional responses can be heavily context specific (Hall & Honey, 1990). Following strong punishment in a particular situation, an organism will exhibit physiological arousal when presented with the situation again (Brown & Wagner, 1964). According to Skinner, it is this conditioned physiological arousal that is measured by the polygraph (Skinner, 1957).

As a general rule, deception is typically punished in our society. From an early age, the child caught lying to their parents is likely to be reprimanded or punished in some manner. This holds true through adulthood, those we deceive are typically "irritated" at this behavior, and likely will rebuke it if it is caught (Wang & Leung, 2010). Within this general rule, however, there are important exceptions having to do with the nature of deception as a behavior.

1.4.3 Multiple causation of conditioned responses to deception

This explanation holds that the physiological arousal exhibited during deception is a classically conditioned response based on previous punishment following deception and the situations in which it occurs. The social situations surrounding deception are complicated, however. The conditioning that a person has received in their past regarding deception is complicated and extensive. In the first place, not every instance of deception is punished. By its very nature, deception is difficult to detect, and typically acquires its reinforcing properties directly from this fact. This creates an incredibly complex set of contingencies surrounding the relation between deception and punishment. Any situational variables paired with instances of deception that are detected should tend to increase the subsequent conditioned emotional responses exhibited during deception in the presence of these variables. Alternatively, situational variables paired with instances of deception that are not detected will likely not elicit strong emotional responses when deception subsequently occurs in their presence. This section will attempt to cover some of the complex ways in which different situations may come to control the responses that a person exhibits to their own deception.

1.4.4 Intermittent nature of deception's consequences

Perhaps the most obvious property of deception as a conditioned stimulus is that deception is only punished when it is caught. "Successful" deception goes undetected, and hence unpunished. The intermittent pairing of deception with punishment will have an effect on the situations that will elicit a conditioned response to deception. Properties of the situations in which deception has escaped detection will not be paired with punishment, and hence undergo extinction, later eliciting smaller physiological responses. Situations in which deception has been more consistently detected, however, will more likely have been paired with punishment and elicit stronger responses. This helps to explain why a person exhibits stronger responses in situations where their deception is more likely to be detected.

In addition to this, deception is emitted in situations ranging from relatively trivial, to relatively important. As such, the magnitude of potential punishment paired with each stimulus surrounding deception varies. Some stimuli in the environment (such as an authority figure being present) will likely have been paired with far worse consequences than situations where such stimuli were not present. The presence and absence of these stimuli combine with stimuli indicating the probability of detection, causing overlaps and complex multiple causation of the conditioned responses exhibited during deception.

Some examples of these complex instances of causation where a higher physiological arousal is likely to be exhibited are (*A* indicates that present stimuli are more likely to have been paired with deception that was detected; *B* indicates that stimuli present are more likely to have been present in high-punishment situations):

- Situations in which one is questioned by an authority figure. [*A* + *B*]
- Being told that there is evidence that one is being deceptive. [*A*]
- The presence of evidence contradicting what one is saying. [*A*]
- A disapproving look, or an awkward silence, when one is hiding something. [*A*]

Some examples of situations where a lower physiological arousal are likely to be exhibited are:

- Deception regarding relatively trivial matters ("white lies"). [*B*]
- Deception in the presence of a person that has not previously tended to punish (or "catch") instances of deception, or, by generalization, around someone that "could not know" that one is being deceptive. [*A*]
- Deception that will not have immediate consequences, for example via email or post. [*A* + *B*]

This strong situational contingency of the response to deception may be the reason the polygraph gets such inconsistent results. As such, it is not likely that reliance upon the unmodified responses a person has to their deception will ever provide a reliable means to detecting their deception. The past conditioning is highly variable, and the responses it creates reflect this. To acquire more controlled results, the conditioning surrounding deception needs to be controlled. By controlling the conditioning surrounding deception in the laboratory, it is believed that more consistent responses can be acquired during actual testing of deception.

1.5 Overview of Thesis

The aim of the current thesis is to examine deception as a conditioned stimulus based on past punishment. This will primarily include conditioning experiments in which deception serves as the conditioned stimulus. Other experiments will investigate whether punishment in a person's natural environment influences their physiological arousal, whether components of deception (e.g. the truth-value of statements) can serve as conditioned stimuli, and whether other types of response can be conditioned to verbal stimuli related to deception. Together, these experiments will investigate the overall process by which deception comes to serve as a conditioned stimulus to the physiological arousal measured by the polygraph.

Given that a primary premise of this research is that previous punishment in a person's conditioning history for forms of verbal behavior leaves a tendency to exhibit physiological arousal when engaging in those forms of behavior, the first empirical chapter (Chapter 3) will explore the physiological arousal exhibited during a form a behavior commonly punished in our society: swearing. This chapter will hopefully help to establish the connection between broader conditioning in a person's history of verbal behavior and a tendency to exhibit arousal when engaging in that behavior in a controlled setting.

The second empirical chapter (Chapter 4) will examine conditioning responses to verbal behavior related to deception in a controlled setting. The truth-value of statements will serve as the conditioned stimuli. Rather than using physiological arousal, which presumably already has developed conditioned responses, this chapter will use a conditioned response that is neutral with relation to truth-value: eyeblink responses.

The third empirical chapter (Chapter 5) will expand on the second by using skin conductance as the conditioned response, and examine the conditioning of responses to truth-value and deceptive statements.

The final empirical chapter (Chapter 6) will take what was learned in the previous chapter, and expand on it by conditioning a skin conductance response to instances of deception in an internally consistent context. Specifically, subjects will be truthful and deceptive regarding a Cluedo-type scenario, and their responses will be differentially conditioned during the experiment.

Chapter 2:

Technical Chapter

2.1 Experiment overview for thesis

The experiments in this thesis required a complex interaction of hardware and software. This is primarily because, while measuring a subject's physiological responses, the program running the experiment also needed to present various stimuli that were synchronized with the measurements. This required a relatively complicated software program to accomplish. A software development program called LabView was selected for creating this software. The way in which this was done for the chapters included in this thesis will be outlined in this chapter, to avoid repetition in later chapters.

2.2 Experiment Room

All experiments in this thesis were conducted in a small, quiet room with no windows. This room contained two computers situated such that the participant could see the screen of one, but not the other (see Figure 2-1). One of these computers was used to present subject's with tasks, and the other to record their physiological responses. It would have interfered with the experiment had subjects been able to see their own physiological measurements. During the experiments, the experimenter would generally sit in the room for the first few trials of the experiment and monitor the recording of the subject's skin conductance or eyeblink responses, to ensure that the measurements were done correctly. Following this, the experimenter left the room, as their presence could interfere with the subject's skin conductance.

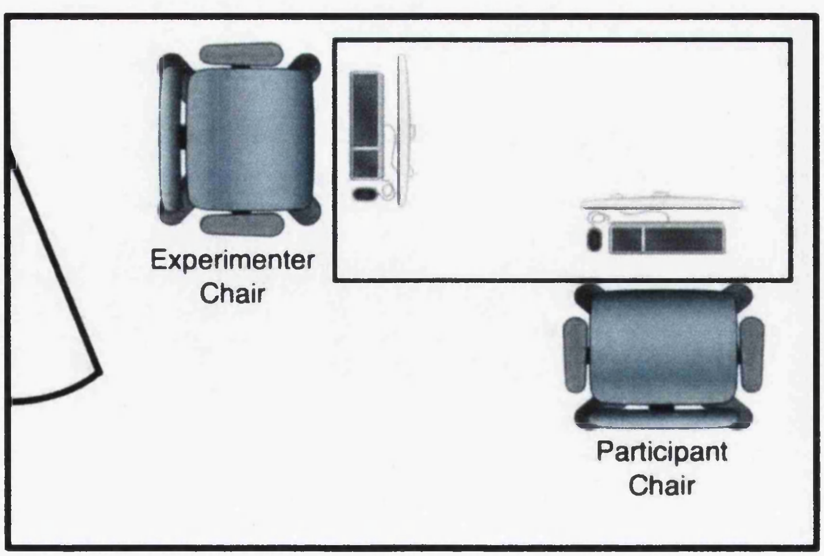


Figure 2-1: Outline of experiment room used throughout the thesis, with door at left.

2.3 Hardware

2.3.1 Computers

One computer in the laboratory was used to measure subjects' physiological responses (Eyeblink in Chapter 3; skin conductance in Chapters 2, 4, and 5). The other computer presented subjects with tasks and stimuli, acquired their input when necessary, and controlled the runtime of experiment programs. The computers were networked together via their serial ports to allow the synchronization of trial events in execution and measurement. LabView programs on each computer were then able to share the status and manipulation of variables between the computers.

2.3.2 Skin conductance measurement

The experiments in Chapters 2, 4, and 5 measured participant's skin conductance responses using ADInstruments© PowerLab 2/25 data acquisition system (ML825), which converted analogical signals to digital signals by means of a 16-bit A/D converter. Skin conductance was measured with an ADInstruments© model ML116 GSR Amp and MLT116F Finger Electrodes attached to the palmer surface of the intermediate phalanges of the first and third fingers of the non-dominant hand. Participants were instructed in each experiment to rest this hand on the table, and to refrain from talking and moving their hand during the test to avoid interfering with the measurement. The SCR data was recorded by ADInstruments Chart 5.2 software, and was sampled continuously at 1k/sec. throughout the experiment. This is a common setup for skin conductance experiments.

2.3.3 Electric stimulator

For the purposes of conditioning skin conductance responses, Chapters 5 and 6 of the present thesis employed electrical stimuli to serve as the unconditioned stimuli. These stimuli were presented from ADInstruments© Stimulus Isolator (ML180), and delivered via electrodes attached to the participant's inner lower dominant arm. The shock intensity was individually adjusted for each participant by using a shock workup procedure that went as follows: The shock intensity was set to a level below the threshold where the subject could feel it, and then increased in steps of 0.1 mA. At each step, the subject was asked how the shock was compared to the last one, and if they were comfortable increasing it. This process was repeated until the highest intensity the subject was comfortable with was found. The range of final values used was from roughly 2 mA to 8 mA, with most subjects being at roughly 4 mA. These shocks were never painful, and were described by subjects as "irritating" or strange feeling. This type of setup has been used before, and the equipment employed was designed for these types of experiments and procedures.

2.3.4 Eyeblink conditioning system

Chapter 4 examined eyeblink conditioning. The participant's eyeblink response was conditioned and recorded using San Diego Instruments Eyeblink Conditioning System© hardware. This system measures subject's eyelid activity using an infrared emitter/receiver pair positioned in front of their right eye. Since the eye absorbs light, the amount of closure of the eyelid can be monitored by bouncing infrared light off the eye, with the amount light bounced back being proportional to the occlusion of the eyelid over the eye. The system comes with an airpuff delivery unit that delivers airpuffs to the right eye. The airpuffs used were 11 psi. The airpuffs were not painful, but could be considered slightly annoying. The delivery of the airpuff produced a small sound, which occurred at exactly the same time as the airpuff.

2.4 Software

2.4.1 LabView

Given the complexity of the hardware interaction required for these experiments, a program called LabView was employed for developing the experiment programs (see Figure 2). LabView is graphical development environment developed by National Instruments (www.ni.com), used primarily in engineering and other technical fields (Travis & Kring, 2007). It is used extensively for data acquisition and hardware control, but apparently has rarely been adapted for the purposes of psychological testing.

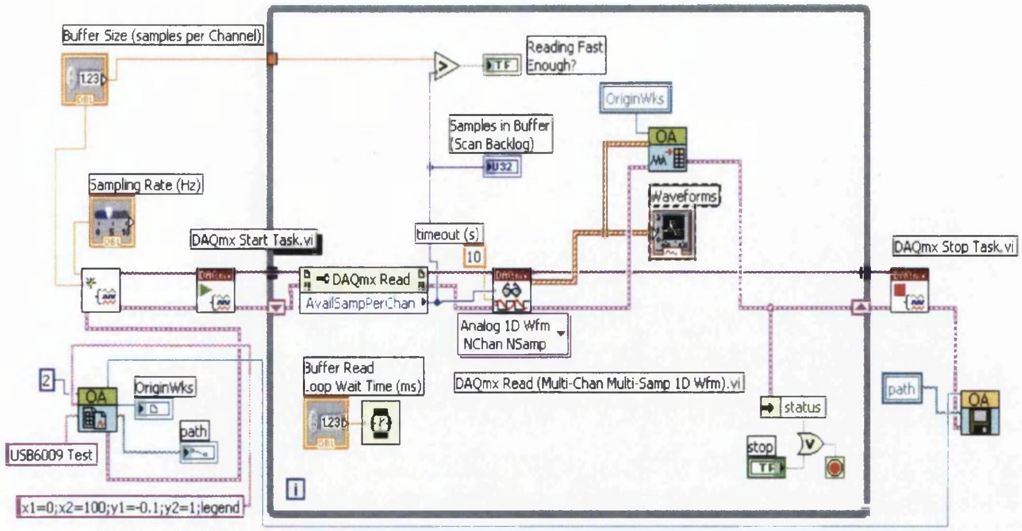


Figure 2-2: Screenshot of LabView visual programming environment.

The LabView program written for the experiments used a state-machine design to control the flow of the experiment. This means that each frame of the program waited for a specific event, before moving on to another stage, or state. These events were often simply the timing out of a timer, as in inter-trial intervals. Other times, external events such as the subject's keystroke triggered the program. In this manner, the experiment program timed and executed trial events.

For the basic experiment trial setup, the program did the following (this is an example trial from Chapter 5, Experiment 1):

- Begin trial
- Wait 3 seconds for baseline SCR reading
- Present a statement on the screen- send signal to Powerlab to mark event on chart
- Wait for subject to respond to statement by pressing 'z' if it is false, 'c' if it is true
- Send signal to Powerlab to mark answer time and type on chart
- Calculate whether subject's answer was truthful or deceptive by comparing answer to truth-value of statement
- Wait for 3 second CS-UCS interval
- If statement was deceptive, send signal to Powerlab to deliver shock and mark event on chart

- Wait for randomized inter-trial interval of between 10 and 12 seconds before beginning next trail.

In that particular experiment, this process was repeated for each trial in the experiment. In other experiments, such as the Cluedo experiments (Chapter 6), modified versions of this were used, but with the same basic format. The program had to compare the presented card with the murderer card, and then the subjects answer to determine whether the subject was telling the truth or being deceptive (see Chapter 6 for details). Further details of how the program executed each experiment will be explained in later chapters.

2.4.2 Chart

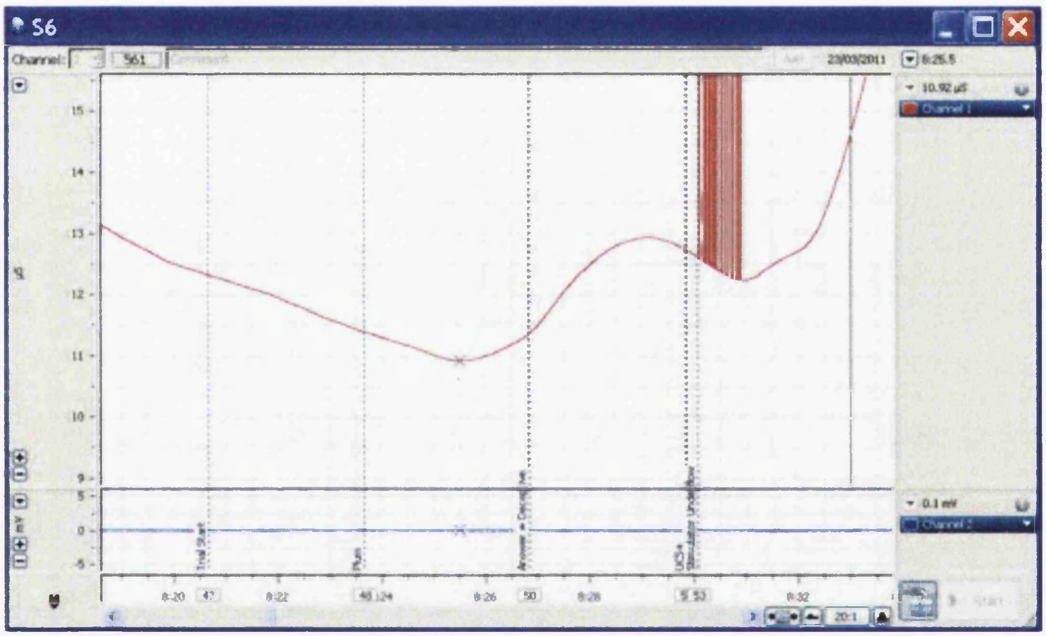


Figure 2-3: Screenshot of Chart software used for recording and analyzing skin conductance measurements

Skin conductance responses were measured and recorded using the program Chart 5.5 by ADInstruments (Figure 2-3). This program reads the digitalized signals from the Powerlab channels and stores them to the computer's hard-drive. It also allows subsequent analysis of these measurements.

To synchronize the measurements taken with trial events that occurred on the program computer, a hardware/software workaround was used, in which program computer's parallel port was used to send signals to the digital input of the Powerlab signal. Each trial event was given a distinct digital signal, and a macro[1] for Chart continuously polled the Powerlab digital input, and upon receiving one of these signals marked the appropriate trial event on the chart.

2.4.3 Subject data storage

Subject data were stored on the computers in the laboratory, which remained locked when not in use. For analysis, the data was moved to the personal computer in the experimenter's office, where response scoring and statistical analysis were conducted. The data remained anonymous and secure throughout the entire process. All experiments in this thesis were conducted in accordance with Swansea University Psychology department ethical guidelines, and after acceptance of the ethical committee's approval.

[1] Special thanks to Gary Freegard, Technician in the Swansea University Psychology Department for writing this macro.

Chapter 3

Previous Social Punishment and Skin Conductance Responses

3.1 General Introduction

A primary premise of the current thesis is that the punishment in a person's previous conditioning history leaves a tendency to exhibit physiological arousal during certain verbal behaviors, and in the situations in which they occur (see Chapter 1). It is this arousal that is then measured by the polygraph (NRC, 2003; OTA, 1983). It is important to demonstrate this connection between punishment and physiological arousal, as this will then provide a basis on which to better understand and potentially improve the results of the polygraph. The current chapter explores the connection between physiological arousal and past punishment of verbal behaviors.

There are certain types of verbal behavior that are likely to have been punished in the past conditioning of the individual. An example of this is swear, or taboo, words (Jay et al., 2006). Although there is nothing inherently harmful in the speaking or hearing of swear words, cultural, historical and social contingencies (e.g., being spoken by lower classes), have caused them to become undesirable in certain social circumstances (Jay & Janschewitz, 2008). As such, parents and other figures of relative authority often punish the use of these words (Jay et al., 2006). The typical child will receive some form of punishment, ranging from the mild to severe, for the use of words such as "fuck" in the wrong company. As such, it would be expected that this punishment would leave a tendency for swear words to elicit increased physiological arousal- making them a good opportunity to test this hypothesis.

Studies have also shown that taboo words, such as swear words, elicit stronger skin conductance responses than neutral words (Dinn & Harris, 2000; Gray, Hughes, & Schneider, 1982). Harris et al. (2003) tested the SCR exhibited by multilingual participants to taboo words presented visually and auditory in their primary and secondary languages, finding higher responses to taboo words in participants' native language, than in their secondary language. This makes sense in the context of the view articulated in Chapter 1, considering that a person is likely to have been exposed to far more punishing contingencies in their primary language than in other languages learned, especially in early childhood (Schrauf, 2000). Indeed, historically the physiological arousal caused by swearing was explained by punishment received in childhood via one's parents (Ferenczi, 1916; Harris et al., 2003). It should be noted, however, that a person is likely also to be exposed to other sources of punishment during their social conditioning, such as from friends, colleagues at work, and other social encounters where verbal behaviors that are appropriate in one context become inappropriate.

Physiological arousal is not only caused by swear words, but can also be stimulated by other words that a person encounters or speaks. For example, emotional reactions can be caused by words associated with negative events (e.g. illness, death, misfortune; see Hill & Kemp-Wheeler, 1989; Wischner & Gladis, 1969). It is not likely that such words have acquired their arousal effect because of direct punishment for their usage, but rather because they tend to be used in situations with an increased probability of aversive events. When one uses the word "cancer", for example, it is more likely that they are discussing a traumatic event in their life than when they use the word "duck." Given their tendency to elicit emotional arousal, and their lack of a direct punishment history, non-taboo emotional words provide a good opportunity to compare the effect of directly punished words to emotional words without a direct punishment history.

The present studies, therefore, compared words that have likely been previously punished (swear words) with emotional and matched words, examining whether previous punishment for saying particular words increases physiological arousal when speaking those words, as suggested above. This was done by creating four lists of words: one list containing words that are typically punished in everyday life (swear words); a list of words with high emotionality; a list of words that are matched for frequency and length; and a list of simple filler words to break up the trials (Experiment 1). Subject's skin conductance was measured while saying these words aloud, to see if the words more likely to have been previously punished elicited stronger physiological arousal than the other words (Experiment 2). Finally, these measurements were related to subjects scores on questionnaires used to measure subjects' previous punishment for swearing, and swearing frequency to see if this punishment effected their arousal when saying the swear words (Experiment 3). It was expected that higher previous punishment for swearing would cause higher skin conductance responses when swearing.

3.2 Experiment 1

The first experiment in this chapter focused on developing lists of swear-, emotional-, and matched-words, which participants could rate on their offensiveness and emotionality. These words would then be used in Experiment 2 to test subject's skin conductance when saying them aloud. Additionally, subjects' ratings gave the opportunity to compare the words to subjects' previous punishment for swearing and frequency of swearing, as measured using questionnaires. It was anticipated that subjects who had been more strongly punished for swearing would rate swear words as more offensive than subjects with less punishment for swearing.

3.2.1 Method

3.2.1.1 Participants

Twenty-six undergraduate psychology students were used in this study (24 female and 2 male). The participants had a mean age of 19.9 (±1.7) years. The participants were recruited through the Psychology Department's online participant pool, and received course credits for participation in the experiment. All participants provided informed written consent prior to participating.

3.2.1.2 Materials and Procedure

Subjects were presented with 3 questionnaires. The first two were lists of swear words, emotional words, matched words, and filler words. Subjects were asked to rate all words on offensiveness (see Appendix B for example), and emotionality (see Appendix C for example), using a Likert scale from 1 (lowest) to 5 (highest). These words were from a list compiled by the authors, which consisted of 10 swear words (e.g. "shit"), 10 emotional words (e.g. "cancer"), 10 words matched for both word length and frequency in common usage, and 20 filler words (see Appendix A for a complete list). Each word was between 4 to 12 letters long (Overall Mean = 6 ± 2 letters; Swear Word Mean = 6.2 ± 2.9 letters; Emotional Word Mean = 6.9 ± 2 letters; Matched Word Mean = 5.9 ± 2.8; Filler Word Mean = 5.45 ± 1 letter). The matched words were matched for spoken frequency to the swear words using the spoken word frequency list provided by Leech, et al. (2001). For each word in the swear word list, an emotional and matched word of the same length (+/- one letter) was selected that had roughly the same spoken frequency in the English language (+/- 5%).

The third questionnaire was designed by the experimenters to measure participant's frequency of past swearing and previous history of punishment for swearing (see Appendix B). This brief questionnaire asked questions regarding how frequently the subject swears each day, and whether they were often punished them for swearing (e.g. "Did your parents often punish you for swearing").

3.2.2 Results

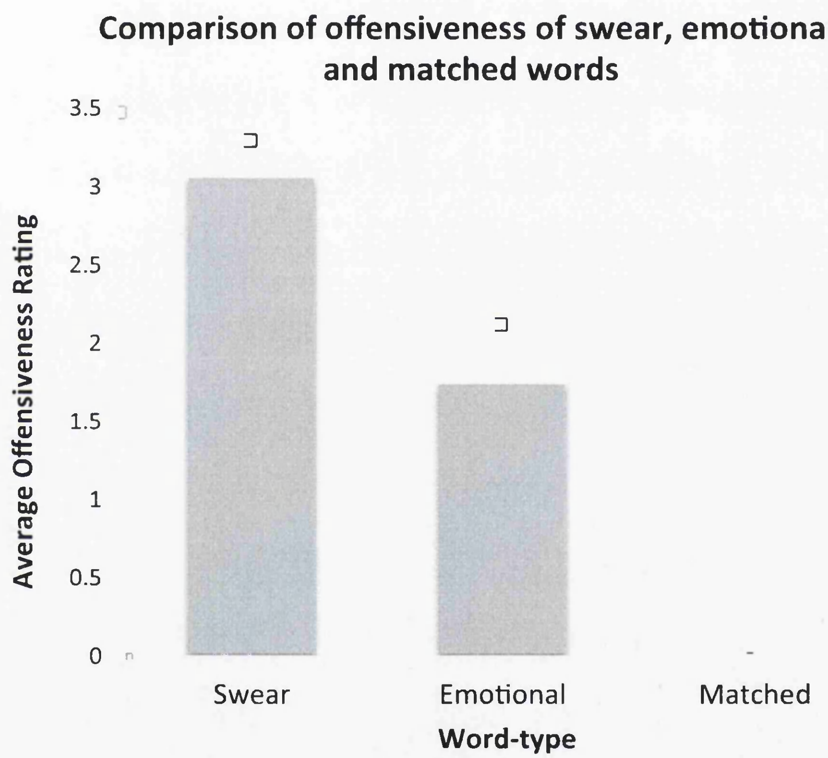


Figure 3-1: Participants' rating of offensiveness for swear words, emotional words, and matched words.

Figure 3-1 displays the mean subject ratings of offensiveness for swear words, emotional words, and matched words. As can be seen, swear words had far greater ratings of offensiveness than emotional- and matched words. A one-way repeated-measures analysis of variance (ANOVA), with word-type as a within-subject factor found a significant effect of word type on offensiveness ratings: *F(2,* *50) = 209.22, p < .001* (A rejection criterion of $p < 0.05$ was adopted for this, and all subsequent, analyses).

As word-type yielded a significant effect, further analyses were conducted to compare the specific word types. A series of protected t-tests was performed comparing each word type to the others. These tests found a significant difference in rated offensiveness between swear and emotional words: t(25) = 8.01, p < .001, and swear and matched words: t(25) = 27.63, p < .001. There was also a significant difference between emotional and matched words: t(25) = 10.38, p < .001.

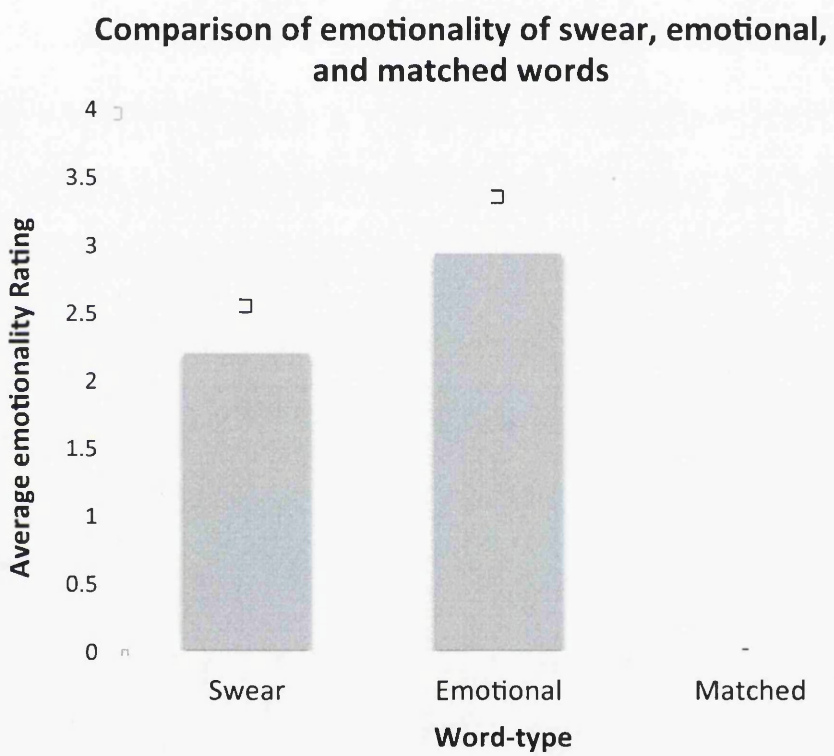


Figure 3-2: Participants' rating of emotionality for swear words, emotional words, and matched words.

Figure 3-2 displays the mean subject ratings of emotionality for swear words, emotional words, and matched words. As can be seen, emotional words had slightly greater ratings of emotionality than swear and matched words. A one-way repeated-measures analysis of variance (ANOVA), with word-type as a within-subject factor found a significant effect of word-type on emotionality rating: $F(2, 50) = 123.19, p < .001$.

As word-type yielded a significant effect on emotionality ratings, further analyses were conducted to compare the specific word types. A series of protected t-tests was performed comparing each word type to the others. These tests found a significant difference in rated emotionality between emotional and swear words: $t(25) = 3.16, p < .005$, and emotional and matched words: $t(25) = 16.03, p < .001$. There was also a significant difference between swear and matched words: $t(25) = 13.95, p < .001$.

To analyze the impact of the participant's answers on the punishment and swearing frequency questionnaires on offensiveness and emotionality, subjects were divided into two groups, one for high, and one for low, previous punishment; and one for high, and one for low, swearing frequency, based on a median split. Subjects who scored higher than the overall median score for previous punishment were in the High-Punishment group (N = 13, Mean Score ± SD = 8.4 ± 1.0). Subjects who scored lower than the median were in the Low-Punishment group (N = 13, Mean Score ± SD = 5.3 ± 1.7).

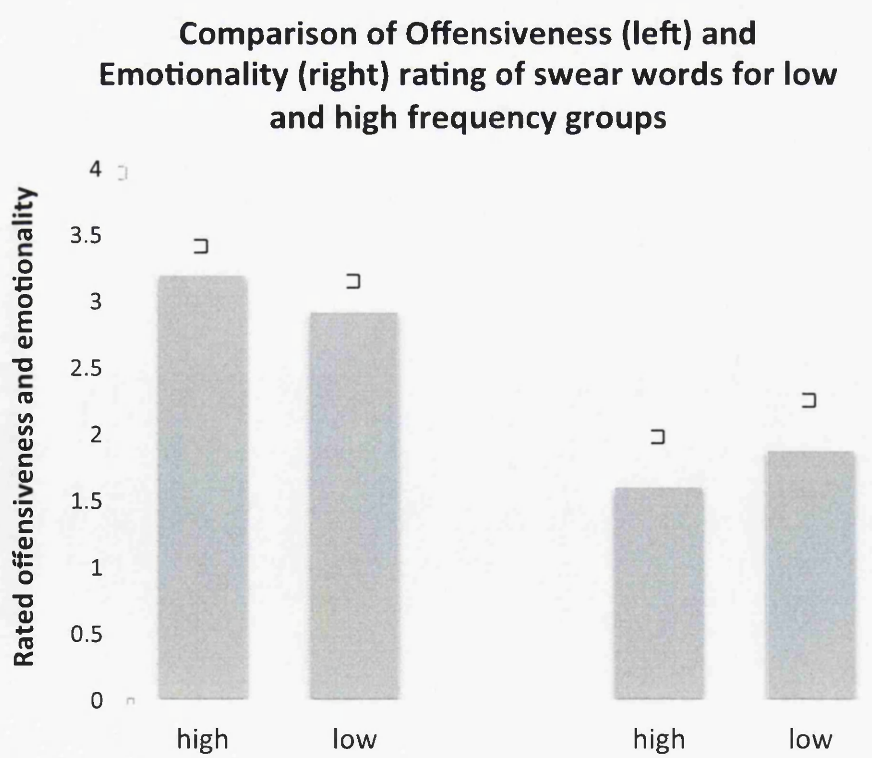


Figure 3-3: Offensiveness (left) and emotionality (right) ratings of swear words for participants with high and low punishment questionnaire scores.

Figure 3-3 shows the participant's ratings of offensiveness (left) for high and low punishment groups, and ratings of emotionality (right) for high and low punishment. As can be seen, the high-punishment subjects rated the swear words slightly more offensive than the low-punishment subjects. A matched one-tailed t-test comparing offensiveness ratings between high and low punishment groups nearly approached finding a significant difference ($p > .09$). Likewise, a similar test for differences in emotionality scores between high and low punishment groups did not find a difference ($p > .35$). Swearing frequency had an even smaller effect on the rated offensiveness ($p > .10$) and emotionality ($p > .20$) of swear words.

3.2.3 Discussion

The words created for the swearing, emotional, and matched lists clearly matched up with offensiveness and emotionality as expected (swear words were more offensive than matched words, and emotional words were more emotional than matched words). Swear words were clearly more offensive, and less emotional, than emotional words. Likewise, emotional words were more emotional, and less offensive, than swear words. This provides support that there is a difference between these words in offensiveness and emotionality, supporting the use of these lists in the next experiments to test physiological arousal.

Relating these ratings to previous punishment, however, was more elusive. Subjects' ratings of offensiveness were not clearly influenced by their previous punishment scores on the questionnaires, but this does not rule out this being a power issue. Previous punishment, however, did seem to have a marginal effect on offensiveness ratings of swear words. It could be that with more sensitive questionnaires this effect would become apparent. It could also possibly be that previous punishment does play as strong a role as believed in determining how offensive a person finds a swear word to be. This makes sense, as it could be that contingencies of reinforcement shape how a person answers that question more than their direct experience with being punished for using the word. People often report things to be more offensive than their other behaviors would suggest. Perhaps this reflects, not their direct conditioning with the behavior being discussed, but rather their conditioning with answering questions about it. When asked a question, there is often an answer more likely to be reinforced by agreement and further conversation on the topic than other possible answers (Skinner, 1957, pg. 148). Perhaps these sorts of contingencies are more likely to shape the reported offensiveness of swear words than previous direct punishment for swearing.

3.3 Experiment 2

The second experiment in this chapter used the words developed for the first experiment to test whether subjects had stronger physiological arousal (measured via skin conductance) to swear words than to other word types. Given that people are far more likely to have been consistently punished in their past for using swear words than for using other words of a non-offensive nature, this should cause them to have higher physiological arousal when uttering swear words than the other words in our list. The studies mentioned above (Dinn & Harris, 2000; Gray, Hughes, & Schneider, 1982) used taboo words presented on a screen and auditory. Most of the punishment received regarding swear words, it seems likely, will be following verbal utterances of the word, rather than simply reading, seeing, or hearing the word. Accordingly, the second experiment in this chapter measured subjects' skin conductance responses when speaking these words aloud, to test whether swear words elicited more physiological arousal than other word types. This extends the field, as no other known research has directly tested the spoken capacity of swear words to elicit skin conductance responses. It was expected that subjects would exhibit stronger skin conductance responses following the swear words than the other word types.

3.3.1 Method

3.3.1.1 Participants

The same twenty-six undergraduate psychology students were used in this study as in the previous experiment (see Experiment 1 for details). They participated in this experiment prior to filling out the questionnaires described in the first experiment.

3.3.1.2 Apparatus

The experiment was conducted in a small room containing a desk and two computers. The computers were organized such that the participants could be seated before one computer monitor, on which the stimuli were presented, while unable to see the screen of the other computer, which was used to control the experiment.

Acquisition, amplification, and filtering of participants' SCR were carried out by an ADInstruments© PowerLab 2/25 data acquisition system (ML825), which converted analogical signals to digital signals by means of a 16-bit A/D converter. Skin conductance was measured with an ADInstruments© model ML116 GSR Amp and MLT116F Finger Electrodes attached to the palmer surface of the intermediate phalanges of the first and third fingers of the non-dominant hand. Participants were instructed to rest this hand on the table, and to refrain from talking and moving their hand during the test to avoid interfering with the measurement. The SCR data was recorded by ADInstruments Chart 5.2 software, and sampled continuously at 1k/sec. throughout the experiment.

The same list of words used in Experiment 1 was used in this experiment, and was randomized prior to the experiment, and presented one at a time over the course of the experiment. No word was presented more than once. These words were presented on a 27 x 54 mm computer monitor in black text on a white background. They were presented in standard font, with letters 15 mm tall.

A program written using the LabVIEW© programming environment was used to present statements on the display computer, time trial events (see Technical Chapter for details).

3.3.1.3 Procedure

Each participant received 50 trials during a single 20-minute experiment session. At the start of each trial, a word was presented on the screen, and remained visible until the participant read the word and pressed the spacebar. Participants were asked in the briefing to simply read aloud each word that was presented on the screen. During the experiment, an experimenter remained sitting in the room and monitored the computer recording the participant's skin conductance. This experimenter interacted with the participant as little as possible, and gave no feedback regarding any of the words read aloud. Each trial was followed by a random inter-trial interval (ITI) of between 6 and 9 seconds before the next trial began, which was made variable to avoid any effect of predictability.

3.3.1.4 Response measures and statistical analysis

Skin conductance responses for each trial were scored as the magnitude (in microSiemens) from trough to apex of the first response occurring with an onset latency of 1-4 s after the CS-onset (participant's speaking the word aloud). This is a common response window for SCR conditioning studies (e.g., see Purkis & Lipp, 2001). For between subject analyses, each subject's SCR on each trial was scaled to a maximum of 100.

For statistical analysis, the skin conductance of participants on trials where swear words, emotional words, and matched words presented were averaged. Statistical analysis was conducted on these averaged results to test for significant differences.

3.3.2 Results

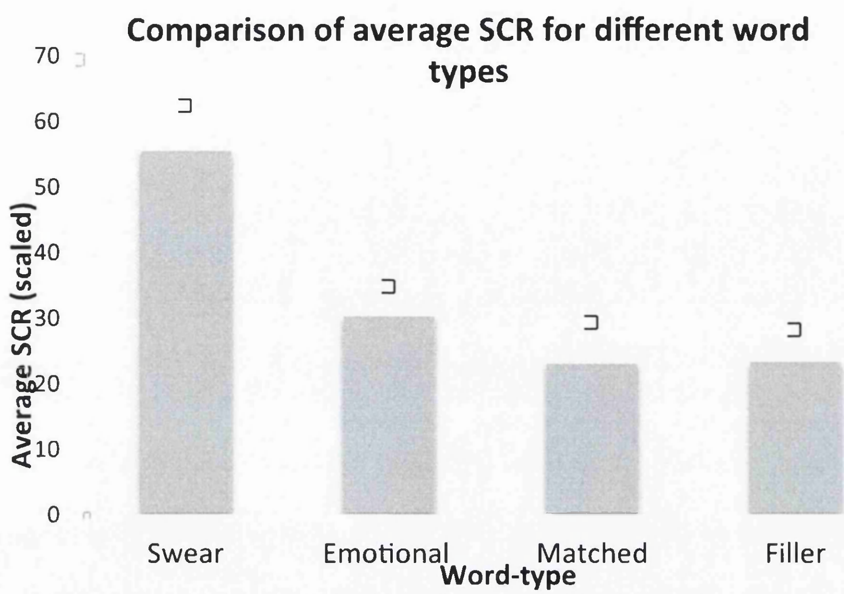


Figure 3-4: Averaged SCR across participants for swear words, emotional words, matched words and filler words.

Figure 3-4 displays the average SCR across participants for swear words, emotional words, matched words, and filler words. As can be seen, there is a larger average SCR following swear words than the other types. Emotional words had only slightly stronger responses than the matched and filler words.

A repeated-measures ANOVA, with word-type (swear vs. emotional vs. matched vs. filler) as a within-subject factor, as between-subject factors was conducted on participant's SCR scores. This ANOVA revealed a statistically significant effect of word-type: $F(3, 75) = 122.60$, $p < .001$.

As word-type yielded a significant effect, further analyses were conducted to compare the specific word types. A series of protected t-tests was performed comparing each word type to the others. These tests found a significant difference between swear and emotional words: $t(25) = 9.92$, $p < .001$, swear and matched words: $t(25) = 12.93$, $p < .001$, and swear and filler words: $t(25) = 14.20$, $p < .001$. Likewise, there was a significant difference between emotional and matched words: $t(25) = 5.39$, $p < .001$, and emotional and filler words $t(25) = 5.47$, $p < .001$. There was not a significant difference between matched and filler words ($p > .87$).

3.3.3 Discussion

The current study provided evidence that spoken swear words elicit stronger physiological arousal than control words matched for spoken frequency and length. Given that swear words are more likely to be punished in everyday interactions than most other words, this provides support for the hypothesis that commonly punished words tend to elicit stronger physiological arousal than non-punished words. We also found that emotional words elicit stronger SCR's than their matched counterparts, understandable considering that the usage of emotional words tends to be in situations where some sort of negative consequence has an increased probability (e.g. the word "cancer" is often used in conversations where there is a probability of a fatality, perhaps of a loved one). Swear words, it was found, elicit stronger physiological responses than emotional words- consistent with the direct punishment hypothesis described above.

3.4 Experiment 3

As Experiment 2 found higher skin conductance responses to swear words than the other word types, it was important to follow up and see if past punishment for swearing influenced this skin conductance. The third experiment in this chapter therefore used the questionnaires mentioned in Experiment 1 to divide subjects into high and low groups based on their previous punishment for swearing, in order to see if this impacted on their skin conductance following swear words. The same was done for swearing frequency.

3.4.1 Method

This experiment employed the same measurements as Experiment 2, and analyzed the results based on subjects' previous punishment and swearing frequency. As discussed above, subjects were divided into high and low punishment and high and low swearing frequency groups based on a median split. This left a group that had previous been punished more for swearing (high-punishment group, N=13), and a group that had previously been punished less for swearing (low-punishment group, N=13). It also left a group that swore more frequently (high-frequency group, N=13) and a group that swore less frequently (low-frequency group, N=13).

3.4.2 Results

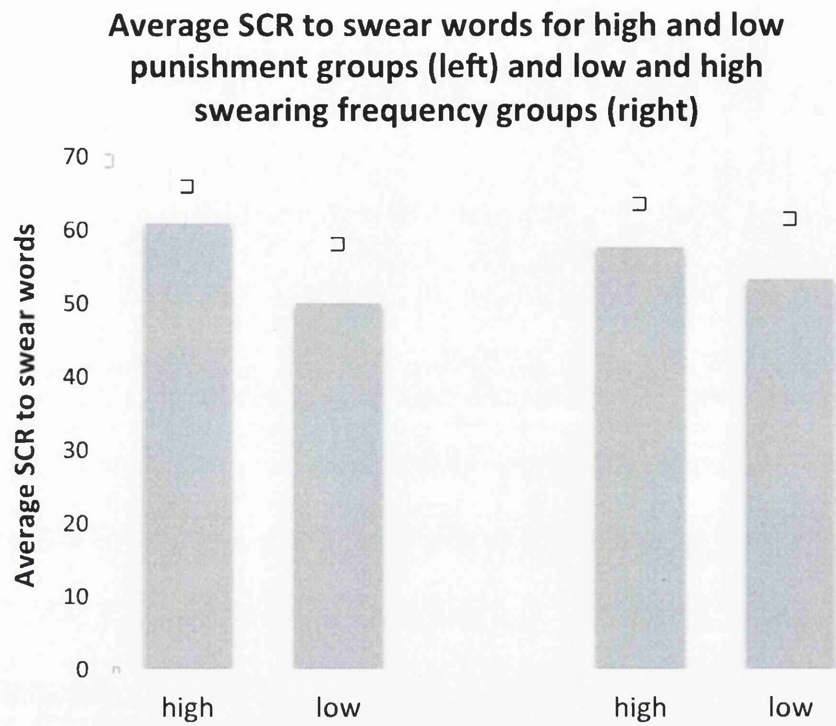


Figure 3-5: Averaged SCR to swear words for high and low punishment groups (left), and high and low swearing frequency groups (right).

Figure 3-5 shows the average SCR to swear words for subjects after being divided into high and low groups for punishment (left side) and swearing frequency (right side). There appears to be a slightly higher SCR to swear words in the high punishment group than in the low punishment group. A matched one-tailed t-test supported this, finding a significant difference between high and low punishment groups ($t(24) = 1.85, p < .04$). The figure shows no difference, however, in SCR between the high and low swearing frequency groups, and neither did a t-test ($p > .24$).

3.4.3 Discussion

The present experiment found that past punishment significantly impacts the skin conductance response a person exhibits following saying swear words aloud. Skin conductance monitoring found a stronger effect of past punishment than selfreported offensiveness ratings of the swear words (Experiment 1), supporting a position that direct measurement is more sensitive then reliance upon self-report. Swearing frequency, however, did not impact subjects' skin conductance when swearing, as had been expected. This is consistent with the results from the first experiment, which also found little effect of swearing frequency. It could be that a more direct measurement of swearing frequency in subject's behavior might have yielded better results, as there may have been self-report biases involved.

3.5 General Discussion

Experiment 1 found that swear words are rated as more offensive and less emotional than emotional words, and more offensive and more emotional than a list of words matched for spoken frequency and length. This experiment did not, however, find that previous punishment for swearing had a significant impact upon the offensiveness rating of swear words. Given that there was some effect, however, this could be because the questionnaire used to measure previous punishment was not sensitive enough. Perhaps a more thorough questionnaire with more questions would have found a stronger effect. Another possible explanation, however, is that previous punishment does not so much effect how offensive we find a swear word to be as how much we are taught to report it as being bad.

The results of Experiment 2 support previous findings showing that swear, or taboo, words elicit stronger SCR's than matched words (Dinn & Harris, 2000; Gray, Hughes, & Schneider, 1982; Harris et al., 2003), and expand upon them by showing this is true when the words are spoken aloud by participants. Perhaps the most interesting finding of this study was that swear words elicit stronger physiological responses than emotional words. There is evidence that emotional words elicit stronger physiological responses than control words (Hill & Kemp-Wheeler, 1989; Wischner & Gladis, 1969). This is understandable as emotional words tend to be spoken and heard in situations where some sort of negative consequence is of a particularly high probability. The use of the word "cancer," for example, tends to be used in contexts where a very dangerous and life threatening illness is being discussed. The same is true for words such as suicide, murder, rape, etc. While in these situations a sort of punishment is implied by the context, swear words have an even closer connection to punishment. Namely, the very utterance of a swear word is often the context for impending punishment. Punishment is often contingent upon the utterance of swear words, meaning that the physiological arousal that speaking such words elicits is more directly related to punishment in the individuals history than even for emotional words. This is not, of course, always the case. An individual currently undergoing a crisis in which a loved one is diagnosed with cancer will very likely exhibit a far stronger emotional response to the word cancer than to many swear words. It is therefore evident that individual variance will be found in this based on the specific contingencies that an individual has been exposed to. As a general rule, however, it appears that previous punishment for particular patterns of verbal behavior can have a significant effect on the physiological arousal exhibited while engaging in them in a controlled setting. Experiment 3 provided further support for this assertion, finding that previous punishment for swearing significantly increased the skin conductance subjects exhibited when speaking swear words aloud. This is an important point, as the remainder of the thesis will be dedicated to trying to control the conditioning that creates such conditioned responses, and applying this specifically to the responses used by the polygraph to detect deception.

Chapter 4:

Conditioning a discriminatory eyeblink response to the truth-value of statements

4.1 General Introduction

Chapter 3 explored whether verbal behaviors that are more punished in one's social conditioning will elicit stronger skin conductance responses (SCR) than similar non-punished verbal behaviors. It provided evidence that the types of words more likely to be punished (swear words) elicit stronger skin conductance responses than control words (Experiment 2). It also provided evidence that past punishment for swearing increases subject's skin conductance when swearing (Experiment 3). If previous punishment in a person's environment will condition an increased SCR to verbal behaviors, it might be possible to actively classically condition a similar response in the laboratory. Hence, the present chapter turns towards actively conditioning a response to instances of verbal stimuli in a controlled setting. The truth-value of statements was chosen as the verbal stimuli for this experiment, as truth-value is an important component of what makes a particular verbal response deceptive or truthful (Skinner, 1953, pg. 187).

The status of a verbal response as truthful or deceptive depends upon the context. If one states that the world is round, this statement is truthful on a round world, deceptive on a flat world (assuming the claimant knows the shape of their world). Deception, it follows, depends upon the truth-value of the statement being uttered. As such, the question arises whether the truth-value of a statement can itself serve as a conditioned stimulus.

It therefore seems important to be able to determine if a well-defined, and easily measurable response, can be conditioned to an abstract property, or a property shared by many stimuli, of a class of stimuli (in this case, their 'truth value', or the property of 'truth' shared by all true statements). There are cases where a conditioned response has been associated with 'categories' of stimuli (e.g., Vaughan, 1984), but it is not clear if such responses were attached to some abstract property defining the category, or to the physical characteristics of each of the stimuli involved (see Macphail, Reilly, & Good, 1992).

There have also been a limited number of studies exploring the conditioning of non-verbal responses to the abstract properties of verbal stimuli. Some such studies have explored the putative classical conditioning of differential responses to 'true' and 'false' verbal statements (e.g., El'kin, 1957; Fleming, Grant, & North, 1968), and to the "correctness" of presented arithmetic problems (Fleming et al., 1968). A summary of this research can be found in Grant (1972; see Chapter 1). These studies were mainly interested in exploring the *differences* between what Pavlov called the "second signalling system" (i.e. language), and neutral conditioned stimuli. As such, they tended not to focus on the potential of conditioning such responses with the aim of using them to determine facts about the individuals past (e.g., determining whether participants think a particular statement is false, when there is no other way of determining it).

Given the potentially important results that could stem from a demonstration that an abstract property of a stimulus class (in this case 'truth value') can serve as a stimulus in a conditioning experiment, the experiments presented here attempted to explore whether a non-verbal response (i.e. an eye-blink) could be brought under the control of the abstract property of verbal stimuli (the truth-value of presented statements). This was accomplished by repeatedly pairing statements with a particular truth-value (such as being false) with an unconditioned stimulus that tends to elicit an eyeblink response (corneal airpuff).

4.2 Experiment 4

The first experiment in this chapter attempted to explore whether an eyeblink response could be conditioned to the 'truth value' of presented statements (i.e. their being false). Given that most work has focused on detecting *deceptive* statements through their association with overt responses (see Chapter 1), false statements were targeted for conditioning. To this end, a series containing both true and false statements was presented, and the false statements were followed by an air puff. In this way, a discriminated conditioned response should be established, with statements that are false resulting in a clear conditioned response, and those that were true resulting in no conditioned response.

4.2.1 Method

4.2.1.1 Participants

Nine undergraduate psychology students were used in this study (7 female). The participants had a mean age of 19.6 (± 1.2) years. The participants were recruited through the Psychology Department's online subject pool, and received course credits for participation in the experiment. All participants provided informed written consent prior to participating. One participant was excluded from the analysis because of very abnormal data recordings (probably due to equipment malfunction), leaving eight participants for the final analysis.

4.2.1.2 Apparatus

As described in Chapter 2, the experiment was conducted in a small room containing a desk and two computers. The computers were organized such that the participants could be seated before one computer monitor, on which the stimuli were presented, while unable to see the screen of the other computer, which was used to control the experiment.

The participant's eyeblink response was conditioned and recorded using San Diego Instruments Eyeblink Conditioning System© hardware. As the software included with this system could not be easily adapted to the experimental situation, a custom software program was written using LabVIEW© to present stimuli on the display computer, deliver the unconditioned stimulus, and record eyeblink responses (as discussed in the Chapter 2).

The conditioned stimuli were short simple true or false statements (e.g., "*Humans lay eggs*", "*You are sitting in a chair*") (see Appendix E for complete list). Each statement was approximately 3 to 7 words long (Mean ± SD = 4 ± 1 words). Fifty different true statements, and 50 different false statements were used for the experiment, and a different statement was presented on each trial. These statements were presented in the centre of the screen on a 27 x 54 mm computer monitor in black text on a white background. The statements were presented in standard font with letters 15 mm tall.

The unconditioned stimulus was a corneal air puff, of approximately 11 psi, delivered to the participant's right eye, delivered using the San Diego Instruments Eyeblink Airpump Unit that accompanied the above conditioning system.

4.2.1.3 Procedure

Each subject received 100 trials during a single 25-minute experiment session, which should be adequate to establish a conditioned eyeblink response (Papka & Woodruff-Pak, 1996). At the start of each trial, a statement was presented on the screen, and remained visible for 1000 ms. The order in which the statements were presented was randomized, and different for each participant. On trials where the statement was false (CS+), its offset was followed immediately by the air puff (US). On trials where the statement was true, no air puff was presented. Each trial was followed by a random inter-trial interval (ITI) of between 6 and 9 seconds before the next trial began.

4.2.1.4 Response measures and statistical analysis

The circuit employed in the San Diego Instruments EBC system outputs a signal proportional to the change in eye closure, with positive representing a closing movement of the eyelid. This allowed the standard deviation of the measured signal to be taken as an indicator of the amount of activity of a participant's eyelid over a given period. To measure the eye-blink response on each trial, we used the SD of the period between 500ms after statement presentation and when the UCS was presented (Figure 4-1). This response window is common in eyeblink conditioning experiments (Smith *et al*, 2005).

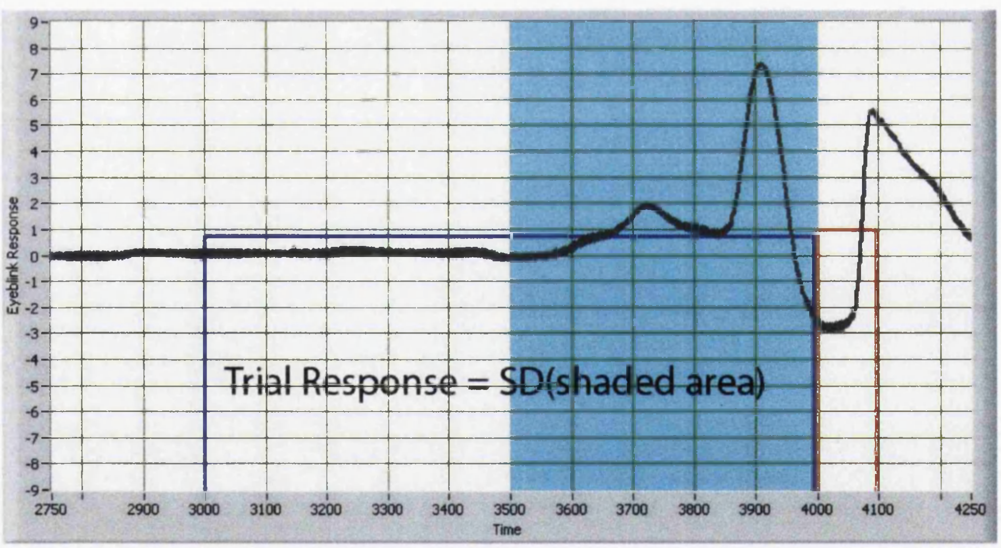


Figure 4-1: In Experiment 4, example of trial analysis method, with the dark rectangle indicating duration of CS and the lighter rectangle indicating duration of UCS. The shaded area shows the window in which conditioned responses were measured.

To standardise this value for each trial across participants, these measurements were normalized for each participant, to a maximum of 100, using the maximum measured UCR for each participant, as done by Tracey, *et al.* (1999). While not changing the within subject relative score of each response, this allows comparison across subjects. The response for each trial was thus acquired using the following equation:

$$\text{Response} = SD(RW_{CR}) * \left[\, 100 / \max(\, SD(RW_{UCR})\right]$$

where: RW_{CR} = Period from 500 ms after CS onset to UCS onset

RW_{UCR} = 500 ms period after UCS onset

For statistical analysis, the trials were broken into ten blocks of 10 trials each, and the responses measured in all CS+ (false statements), and CS- (truthful statements), trials in each block were averaged. A repeated-measures analysis of variance was employed to test whether a significant change in eyelid activity had occurred over successive trial blocks between CS+ and CS- statements.

4.2.2 Results

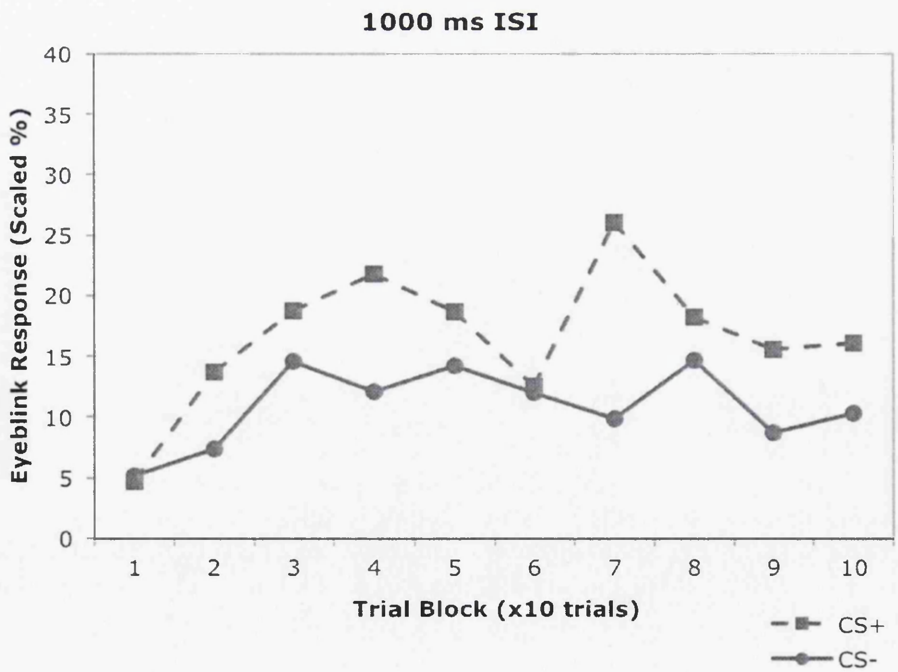


Figure 4-1: Experiment 4 chart of averaged eyeblink responses in each training trial block.

Figure 4-1 displays the mean magnitude of conditioned responding on each 10-trial training block for CS+ (false) and CS- (true) trials. Inspection of these data shows that there came to be more responding to the CS+ than to the CS- presentations over the course of conditioning.

A repeated-measures analysis of variance (ANOVA), with block and CS as factors was conducted on these data. A rejection criterion of $p < 0.05$ was adopted for this, and all subsequent, analyses. This ANOVA revealed a statistically significant change in eyeblink activity over blocks, $F(1,7) = 2.92$, and a statistically significant interaction of block and CS, $F(1,7) = 2.33$. There was not a statistically significant main effect for CS, $p > .10$. Simple effect analyses revealed that false statements were significantly higher than true statements on blocks 2, 4, 7, and 9 (smallest $F(1,7) = 6.52$).

4.2.3 Discussion

The current study provided evidence that the abstract truth-value of a statement can serve as a conditioned stimulus in an eyeblink conditioning procedure, at least when the truth-value is false. This replicates previous demonstrations of such an effect (e.g., Fleming, 1968). However, the terminal discrimination acquired was less than had been expected. One possible explanation for this is that a discriminatory response to the abstract properties of verbal statements requires a time-consuming intervening behavior (reading), and the terminal discrimination was possibly limited by the relatively short duration of the statement presentations. Experiment 5 tested this explanation by using a longer statement duration during the procedure, which should allow subjects more time to respond to the statements presented.

4.3 Experiment 5

The results from Experiment 4 suggest that the abstract truth-value of a statement can serve as a conditioned stimulus. However, the terminal discrimination of the response seemed limited, and this could potentially have been due to insufficient time to read some of the statements. This may have resulted in poor terminal discrimination, and excessive variability in the response. The second experiment attempted to attain a more reliable response by increasing the ISI to 2000 ms, rather than 1000 ms, giving subjects more time to read and respond to the statements. In all other respects, this study was the same as Experiment 4.

4.3.1 Method

4.3.1.1 Participants

Eight undergraduate psychology students were recruited via the same means as in Experiment 4 (7 female). The participants had a mean age of 22 ($\pm$ 4) years. As before, the participants gave informed consent prior to participation.

4.3.1.2 Apparatus and Procedure

The same apparatus was used as that described in Experiment 4. The procedure was also exactly the same as in the last experiment, with the exception that statements were presented for 2000 ms, as opposed to 1000 ms. As before, participants each received 100 training trials, in which false statements were paired with the UCS. The analysis employed was the same as in the previous experiment.

4.3.2 Results

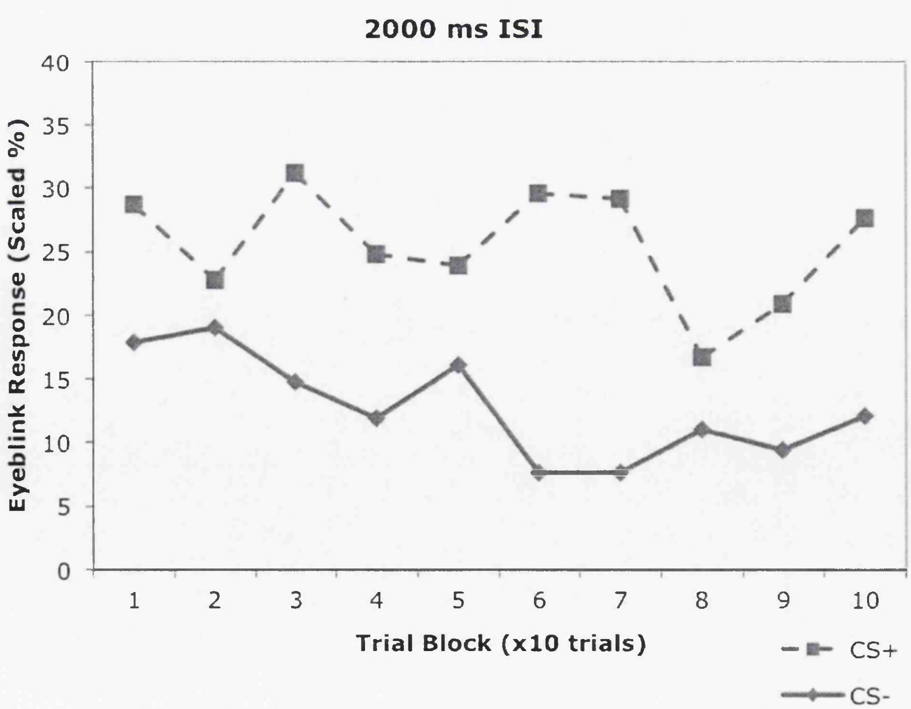


Figure 4-2: Experiment 5 Chart of Averaged Eyeblink Responses in each training trial block.

Figure 4-2 displays the mean magnitude of conditioned responding on each block of training trials for CS+ and CS- trials. Inspection of the data from the training trials shows that there was a strongly discriminated response between true and false statements, which was apparent from the first trial block.

A repeated-measures ANOVA (Block x CS) revealed a statistically significant main effect of CS, $F(1,7) = 15.94$, but did not find a statistically significant main effect of Block, nor an interaction between the two factors ($p > .30$).

These results indicate that, with the longer CS duration, a discriminated response was apparent within the first few trials, and continued throughout the course of acquisition. Thus, this study found a strong discriminatory response, corroborating what was apparent from Experiment 4, and previously (Fleming, 1968), and it also established a stronger terminal discrimination. Figure 4-3 displays the mean response on the final trial block for subjects that received a 1000 ms and 2000 ms ISI, showing that terminal discrimination was greater for subjects that had a longer ISI. A two-way ANOVA (ISI vs. CS) on the final trial-block from these subjects did not find any significant effects (p > .37).

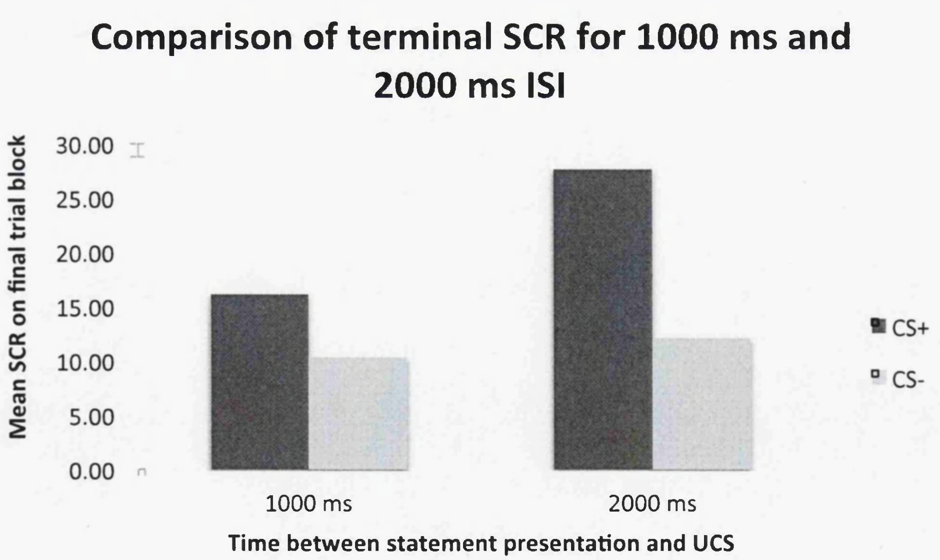


Figure 4-3: Chart of averaged eyeblink responses in each training trial block from experiments 4 and 5.

4.4 Experiment 6

Experiments 4 and 5 appear to show that a conditioned response can be reliably associated with the abstract 'truth value' of a statement (at least when that truth value was 'false'). Prior to discussion of the implications of this finding, and the potential causes of such a behavioral change as a result of the conditioning procedure, the final study attempted to determine if a similar behavioral change could be obtained when the truth-value of the statement was 'true', as well as when it was 'false'. To this end, some participants were conditioned to true statements, and some to false statements.

In addition, the current experiment also attempted to assess the effect of introducing a partial reinforcement schedule on the conditioning and maintenance of the responding associated with the truth-values of the statements. In part, this manipulation was conducted in order to replicate more fully the work of Fleming (1968), who used such a partial conditioning procedure, to fully show correspondence between the procedures, and strengthen the converging lines of evidence that truth-value is a conditionable property of a class of stimuli. Also, this manipulation was conducted to indicate if the failure of Experiment 4 to produce a strong terminal discrimination was the product of an effect partial schedule (due to some stimuli not being fully read, perhaps producing the impression of a partially reinforced stimulus class), or to the effect of the CS duration. If it were the latter, then the current study should show strong terminal discrimination, and if it were the former, then the current study might not show such a strong effect.

4.4.1 Method

4.4.1.1 Participants

Twelve undergraduate psychology students (12 female) were recruited via the same means as in the first two experiments. The participants had a mean age of 20.4 (± 1.0) years, and were recruited as described in Experiment 4.

4.4.1.2 Apparatus and Procedure

This experiment employed the same apparatus used in the other two experiments. The same statements and order were used as in the previous experiments. However, whereas in the first two experiments all participants were reinforced following *false* statements, in this experiment half of the participants were reinforced following *true* statements.

As before, each subject received 100 training trials. In the first 50 training trials, the UCS was presented on every CS+ trial. In the second 50 trials, the UCS was presented on only 50% of the CS+ trials (each CS+ trial had a 50% probability of being reinforced, as randomly determined by the program in run-time). The ISI was the same as in the second experiment (2000 ms).

The analysis employed was the same as in the previous experiments.

4.4.2 Results

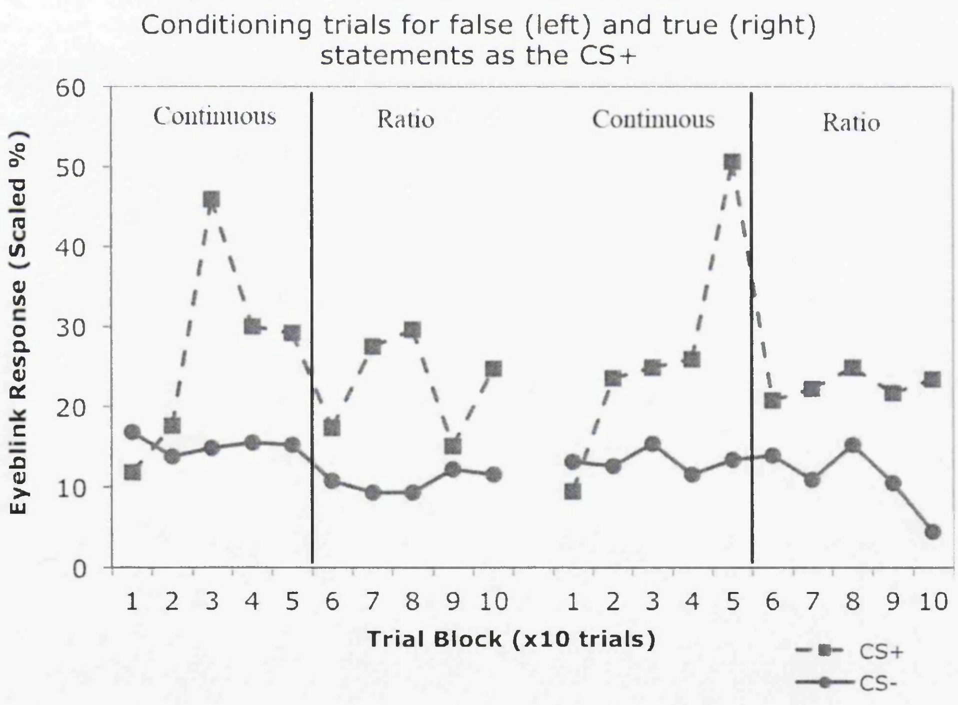


Figure 4-4: Experiment 6 Chart of Averaged Eyeblink Responses for false statements as CS+ (left), and true statements as CS+ (right) in each trial block of ten trials.

Figure 4-4 displays the mean magnitude of conditioned responding on each block of training trials for CS+ as false statements (left), and as true statements (right). As can be seen in the figure, a discriminative response to CS+ develops for both groups relatively early in the experiment, and remains throughout the first 50 trials (continuous reinforcement). These responses seem to drop off over the next 50 trials (partial reinforcement). A mixed-model repeated-measures ANOVA was conducted on all 100 trials with CS (CS+ vs. CS-) and block (10 blocks) as within-subject factors, and Group (True vs. False statements reinforced) as a between-subject factor. It found a statistically significant main effect of CS ($F(1,10) = 6.02$, $p < .035$), and a significant effect of Block ($F(9,90) = 2.37$, $p < .02$). There was also an interaction between Block and CS ($F(9,90) = 2.20$, $p < .03$). There were no interactions with group, however (all $p > .2$).

A closer look at just the continuous conditioning trials (first 50 trials for each subject), using the same analysis, also found a statistically significant main effect of CS ($F(1,10) = 8.00$, $p < .02$), a significant effect of block ($F(4,40) = 3.38$, $p < .02$) and an interaction between the two ($F(4,40) = 3.78$, $p < .02$). The interaction between Block and Group for the continuously reinforced trials just missed significance (p > .065). The main interaction of Group, CS, and Block was not significant (p > .1).

A closer look at just the ratio conditioning trials (last 50 trials for each subject), using the same analysis, found no significant effects.

4.4.3 Discussion

These results from the 100% reinforcement blocks replicate those noted in Experiments 4 and 5, and show a clear effect of conditioning, but also finding it irrespective of the truth-value of the statement. However, when a partial reinforcement schedule was introduced, the discrimination was reduced markedly, suggesting that, even with a stimulus duration long enough to produce an effect, a partial schedule was not enough to support such a discrimination. This further expands on the findings from the previous two experiments, and previous research by other authors demonstrating eyeblink conditioning with truth-value (Fleming, 1968).

4.5 General Discussion

The current series of studies explored whether the abstract property of 'truth value' among presented statements could be reliably associated with an overt response in an eyeblink conditioning procedure. The series of findings suggested that such a response could be conditioned. Such conditioning, however, may depend upon on the ISI employed in the procedure (Experiment 5). Additionally, truth-value can serve as a conditioned stimulus regardless of whether the truth-value conditioned is true or false (Experiment 6). These findings corroborate and extend the previous reports of such conditioning discussed in the introduction of this chapter (section 4.1; see Grant, 1972, for a review). Whereas Experiments 2 and 3 (Chapter 3) demonstrated that the previous social conditioning a person has undergone leaves a measurable skin conductance response when they engage in verbal behaviors that have been previously punished (swearing), the present chapter shows that similar conditioning can be accomplished in the laboratory. The truth-value of statements, which is strongly related to deception, can apparently be conditioned to serve as a conditioned stimulus in an eyeblink conditioning procedure.

The current series of experiments extend these previous reports by showing the effect of different ISI's. For reasons that will be discussed shortly, this property of the conditioning contingencies appears to play a vital role in determining the properties, and even nature, of the response. As such, this study sheds light on previous studies attempting to condition responses to the abstract properties of statements (e.g. Fleming, 1968), which used an ISI of around 1900 ms (very close to that used in Experiment 5 above). The present study brings attention to new variables that may need to be addressed in future experiments in this area.

That the current findings demonstrated that an abstract property of a stimulus class could serve as a stimulus in a conditioning experiment raises some questions about the nature of this abstract property. In this case, the stimuli that were conditioned did not share any physical properties with one another, and this suggests that it was, indeed, the abstract truth-value of the stimuli that was conditioned. It is unclear whether stimuli classes connected by other arbitrary relationships would be similarly impacted by such conditioning, or what the limits to the conditioning of arbitrary stimulus properties might be (i.e., would this extent to nonverbal stimuli, or extend to non-humans). However, the current study is one of the first to demonstrate such an effect, and this does have some implications for the practical detection of deception. Further research in this area could perhaps sharpen and improve the stimulus control acquired by such abstract properties of verbal statements, even to the point of being able to use them to see if a person believes a statement to be true when this is otherwise unknown. The demonstrated scope of potential generalization may hint at the possibility of generalization crossing the overt/private barrier, as done in the polygraph.

A final issue that should be discussed is the nature of the behavioral change that resulted from this procedure. Ostensibly, the method used was a classical conditioning procedure. However, this does not preclude the possibility that the emergent response was in fact operantly controlled. In fact, there is some evidence that the latter form of control, rather than the former classical control, may be more powerful in these studies. A stronger discriminated response was obtained in Experiments 5 and 6, compared to Experiment 4, and there was a conspicuous change in the characteristics of the responses and their acquisition in the former experiments. In Experiment 4, which used a 1000 ms ISI, there was a typical conditioned response pattern, with a small response (CR) following the CS, and a larger response (UCR) following the UCS. In Experiments 5 and 6, however, few responses followed this specific pattern. In approximately one-third of the participants, the presentation of the CS caused them to close their eyes and open them following the UCS (a typical avoidance response, as described by Martin, 1969). In other participants, the presentation of the CS caused a rapid blinking of eyes. The common characteristic of all these responses, however, was that they did not follow the pattern of a classically conditioned response. Rather, they had the characteristics of operant avoidance responses (Martin, 1969).

If the responses obtained in the second experiment were operant, this may help to explain the failure to acquire significant effects for either block or interaction. The responses were acquired too rapidly (within the first 10-20 trials) to exhibit an effect over blocks. Such a rapid acquisition would be very unlikely in classically conditioned responses (Kimble, 1968). In operant responses however, this could be explained as stimulus induction to a strongly pre-conditioned abstract stimulus (whether statements are "true" or "false"; Skinner, 1956). It is not the aim here to explain the specifics of this process; it will suffice to say that it appears to lie outside the area of classical conditioning. As mentioned above, previous studies in this area have used CS-UCS intervals roughly equivalent to that used in the second experiment, making the present discussion very likely relevant to their findings as well. This topic will be returned to as later chapters explore conditioning other response types to truth-value (Experiment 8, Chapter 5).

In summary, the Experiment 4 found that using a relatively short 1-second ISI, it was possible to condition an eyeblink response to the abstract property of "falseness" in unique visually presented statements. The terminal discrimination achieved, however, seemed to be hindered by the short ISI not allowing subjects time to respond to all statements. In correcting this problem in Experiment 5, with a longer ISI, however, it was found that the effect of conditioning is lost, and a seemingly operant avoidance response is found. Experiment 6 narrowed the cause of this problem by ruling out the possibility that a naturally imposed partial reinforcement schedule in the first experiment limited the discrimination developed, and established that true as well as false statements could be conditioned. This study has revived an important line of inquiry into the use of conditioning to access otherwise inaccessible portions of a person's behavior. Even more so, it has brought attention to an important variable (ISI) that may perhaps have been at the root of the previous loss of interest in the line of inquiry. As such, the developments of these studies is certainly original in making clear the next step for future research: to find a method of making the temporal requirements of responding to complex verbal stimuli consistent with those of establishing discriminatory conditioned responses. For this reason, the next chapter turned to the use of skin conductance conditioning, which is a slower response, and can therefore potentially accommodate slower and more complex conditioned stimuli.

Chapter 5

Properties of Deception and Truth-value as a Stimulus for a Conditioned Skin Conductance Response

5.1 General Introduction

Chapter 4 explored the conditioning of an eyeblink response to the truth-value of statements. The findings suggest that truth-value can serve as a conditioned stimulus, but that the temporal limitations of eyeblink responses presented difficulties when using verbal stimuli. Eyeblink responses are very fast, usually having very short inter-stimulus intervals in conditioning (Woodruff-Pak & Steinmetz, 2010; Kimble, 1961); whereas verbal stimuli are relatively complex and can require more time for responding. As the aim of the present chapter was to follow up on Chapter 4 by further examining verbal stimuli and deception as conditioned stimuli, the use of skin conductance was employed rather than eyeblink responses. Skin conductance is a slower response (Kimble, 1961), allowing conditioning with longer and more complex stimuli. Additionally, the use of skin conductance response brings us closer to the polygraph, as it is one of the responses the polygraph employs (National Research Council, 2003).

As seen in Chapter 1, the polygraph measures changes in various indices of arousal of the sympathetic nervous system that purportedly accompany attempted deception (e.g., heart rate, skin conductance, etc.) (NRC, 2003). Unfortunately, the association between these measured responses and the inferred deception is often unreliable and inaccurate, meaning that people often have large responses when truthful, and no responses when deceptive (NRC, 2003; see Chapter 1). These problems make reliance upon the polygraph perilous (Iacono, 2001; National Research Council, 2003; OTA, 1983). This lack of reliability has been a main failing of the polygraph, and, indeed, there has been no solid scientific explanation for the apparent association between deception and increased arousal it relies upon (OTA, 1983), making significant improvement of the polygraphs accuracy nearly impossible (see National Research Council, 2003).

The most commonly accepted theory that accounts for the emergence of the responses that are measured by the polygraph is that a person's 'fear of detection' produces an increase in physiological arousal (OTA, 1983; Reid & Inbau, 1966; see Chapter 1). As was seen in Chapter 1 (section 1.3), the 'fear of detection' theory maps very strongly onto the situational factors that have been found to influence the accuracy of the polygraph. For example, experiments have demonstrated that the accuracy with which a participant's deception can be detected by the polygraph increases when they have greater incentive to deceive successfully (Gustafson & Orne, 1963; Kircher, Howlitze, & Raskin, 1988), and when they are more convinced that the test will accurately detect their deception (Gustafson & Orne, 1965; Janisse & Bradley, 1980; Waid, Orne & Wilson, 1979). Moreover, as noted by Reid and Inbau (1966), the polygraph relies upon the manipulation of such variables to increase participants' responses to deception: seasoned polygraphists have admitted that, without the use of methods like "stimulation tests", a pre-test procedure for demonstrating the device's accuracy to the participant (often staged), they cannot detect deception with any appreciable accuracy (Reid & Inbau, 1966)).

The 'fear of detection theory' does not address, however, how subjects come to have a skin conductance response to deception in the first place, or indeed how they come to have a 'fear of detection.' Certainly a person is not born "knowing" that uttering deceptive statements will be socially punished, or knowing that deception in one situation is more likely to be caught and punished than in another situation. Hence, there are other variables involved in causing the response in question. Such issues are more directly addressed by another theory regarding the responses to deception discussed in Chapter 1 (section 1.2.2, Chapter 1): the conditioned response theory. This theory focuses on the way in which the responses measured by the polygraph are originally formed, claiming that they are conditioned like other responses (Skinner, 1953). As discussed in Chapter 1, Skinner's analysis of emotional conditioned responses as a side effect of punishment provides a reasonable explanation for how such responses could be established in a person's typical conditioning history. Chapter 3 showed how past punishment in a person's experience for a particular behavior can leave a tendency to have increased physiological arousal when engaging in that behavior. Deception is typically associated with punishment from a very early age (when detected), and the responses measured by the polygraph could feasibly be the same sort of effect as was seen with swear words.

Given that the 'fear of detection' theory focuses on situational factors likely to increase the arousal exhibited by subjects when deceptive, and the conditioned response theory tends to focus on the past conditioning likely to have caused such arousal, one way to possibly tease apart these theories is to condition such arousal in a situation devoid of the factors that typically increase the physiological arousal accompanying deception. The conditioned response theory provides an objective way of re-creating and analyzing such responses in a controlled environment. By simply pairing instances of deception with an unconditioned stimulus (e.g., a mild electric shock), it should be possible to create a conditioned response similar to that measured by the polygraph. This re-creation of the response used by the polygraph may provide an important step towards understanding its origin and being able to improve its properties for practical use in detecting deception. At the same time, avoiding the situational variables eluded to by the fear of detection theory can show that, despite the fear of detection itself, a response to deception can be established that does not necessarily rely on the previous experience of the individual.

Other studies have tested whether deception can serve as a conditioned stimulus using other types of responses. For example, Jaffee, Millman, and Gorman (1966) purportedly demonstrating the classical conditioning of an eyeblink response to instances of verbal deception. In this study, twelve participants were asked a series of questions, and told to respond deceptively on half of their answers. For 200 conditioning trials, deceptive answers were paired with an airpuff (100% CS-UCS ratio in first 100 trials, followed by 50% variable ratio in the next 100 trials). Following this conditioning stage, the authors attempted to use the participants' eyeblink responses to detect deceptive answers on 20 trials, employing questions similar to the conditioning questions, but unique to the participant. The authors were able to detect roughly 1/3 of the participants' deceptive answers in the test phase, with a strong indication that most of the error was due to rapid extinction of the eyeblink responses between the first and second unreinforced deception in the testing phase (Jaffee et al., 1966). While the use of eyeblink conditioning avoids the interference of previously acquired skin conductance responses to deception and the situational variables mentioned above, the problems seen in Chapter 4 preclude its use in the present experiments.

As already seen, laboratory studies tend to acquire less accuracy in polygraph tests than field research (section 1.3, Chapter 1). Additionally, mock crime scenes, by simulating the contingencies involved in real-life punishable situations, also tend to increase accuracy. Accuracy demonstrations of the hardware and motivation to deceive successfully also greatly increase the arousal exhibited (see section 1.3, Chapter 1 for review of these factors). The present experiments avoided the situational variables that the fear of detection theory would predict to increase physiological arousal to deception. Relatively uninterested psychology students were tested in a laboratory. They were deceptive regarding topics that did not concern them personally, and they were not threatened with any sort of social reward or punishment for their deception. The similarity between the current experiment situation and real-life polygraph tests was minimized.

Experiment 7 attempted to classically condition a discriminative SCR response to participants' deceptive answers regarding whether statements presented on a computer monitor were true or false. Skin conductance was chosen as the target measure of physiological arousal, as it has been shown to be the most reliable and sensitive of the measurements employed by the polygraph (Bell, Kircher & Bernhardt, 2008). Care was taken to isolate the participant's deception from all aspects of the situation normally surrounding it – no incentive was given for deceiving successfully, and the answers on which participants were deceptive was made contingent upon an arbitrary criterion (as described below). Experiment 8 elaborated on this study, and those in Chapter 4, by further investigating whether the simple observed truth or falsity of the statements used in the first experiment could serve as a discriminative stimulus. By investigating whether an SCR can be conditioned to deception in a controlled setting, the present experiments aimed to test Skinner's explanation of the responses measured by the polygraph, and demonstrate a functional relation between these responses and the environmental events purported to shape them.

5.2 Experiment 7

The first experiment investigated whether a discriminated SCR can be classically conditioned to the deceptiveness of participants' responses. Participants were presented with a series of short statements on a computer monitor, half of which were true, and half of which were false. These statements were similar, but not identical to those used in Experiments 4, 5, and 6 (Chapter 4). The participants were instructed to indicate whether each presented statement was true or false via key-presses. To induce deception, participants were instructed to respond deceptively on half of their answers based on an arbitrary criterion: if the statement referred to them personally, or to the room that they were in presently.

Two groups of participants were used: one in which deceptive answers served as the CS+, and one in which truthful answers served as the CS+. All CS+ responses were followed by the UCS (a mild electric shock). The extent to which this differential reinforcement conditioned a discriminatory SCR was compared in each group. This allowed comparison between the effectiveness of deceptive responses and truthful responses as conditioned stimuli, which might have both interesting theoretical and practical consequences for lie detection. By demonstrating the conditioning of an SCR to deception in a controlled environment, in isolation from the variables that are usually relied upon by the polygraph for improved accuracy (e.g. those alluded to by the 'fear of detection' theory), it was hoped that this would improve our understanding of the initial causes for the physiological arousal relied upon by the polygraph. It was expected that the group in which deception served as the conditioned stimulus would develop a strong conditioned response to their own deception, and the group in which truthful answers served as the conditioned stimulus would develop a somewhat weaker response.

5.2.1 Method

5.2.1.1 Participants

Twenty undergraduate psychology students were used in this study (12 female). The participants had a mean age of 20.6 ($\pm$ 1.4 SD) years. They were recruited through the Psychology Department's online subject pool, and received course credits for participation in the experiment. All participants provided informed written consent prior to participating.

5.2.1.2 Apparatus

As discussed in the Chapter 2, the experiment was conducted in a small, quiet room containing a desk and two computers. The computers were arranged such that the participants could be seated before one computer monitor, on which the stimuli were presented, while unable to see the screen of the other computer, which was used to control the experiment and record the participant's SCR.

Acquisition, amplification, and filtering of participants' SCR were carried out by an ADInstruments© PowerLab 2/25 data acquisition system (ML825), which converted analogical signals to digital signals by means of a 16-bit A/D converter.

Skin conductance was measured with an ADInstruments© model ML116 GSR Amp and MLT116F Finger Electrodes attached to the palmer surface of the intermediate phalanges of the first and third fingers of the non-dominant hand. Participants were instructed to rest this hand on the table, and to refrain from talking and moving their hand during the test to avoid interfering with the measurement. The SCR data was recorded by ADInstruments Chart 5.2 software, and sampled continuously at 1k/sec. throughout the experiment.

The UCS was a mild electrical shock presented from ADInstruments© Stimulus Isolator (ML180), and delivered via adhesive electrodes attached to the participant's inner lower dominant arm. The intensity of this shock was calibrated prior to the experiment, based on the participant's report, to be "unpleasant, but not painful." To accomplish this, a shock workup procedure was used. For each participant, the intensity of the shock was initially set far below the threshold at which they could feel it. An initial shock was delivered at this setting (1mA), and the participant was asked if they could feel it (none reported that they could). Following this, the intensity of the shock was increased by .3mA, and another shock was delivered. The participant was asked if they could feel this, and if they said no the shock was again increased by the same amount. This was repeated until the participant reported that they could feel the shock, and they were then asked if the shock was "alright" and if they minded going any higher. If they said they didn't mind going higher, the shock was again increased by the same amount. As soon as the participant said they preferred not going higher, they were asked if they were comfortable at the current level, or if they would rather lower it. The shock intensity was therefore set according to their wishes at this point.

The statements were short, simple true or false statements (e.g., "*You are sitting in a chair*"; see Appendix E for a complete list), similar to those used in Chapter 4. Each statement was between 3 to 7 words long (Mean = 4.0 ± 1.1 words). Twenty true and twenty false statements were presented. The statements were randomized prior to the experiment, and no statement was presented more than once during an experiment session. These statements were presented on a 27 x 54 mm computer monitor in black text on a white background. They were presented in standard font, with letters 15 mm tall.

As described in the technical chapter, a program written using the LabVIEW© programming environment was used to present statements on the display computer, time trial events, acquire and analyze the participant's answers, and trigger presentation of the UCS.

5.2.1.3 Procedure

Participants were tested individually, and asked not to discuss the experiment with other students. Each participant received 40 conditioning trials during a single 35 min session. The experiment was counterbalanced, with half the participants (10) receiving the UCS following deceptive answers, and half (10) following truthful answers.

Upon arriving for the study, each participant was seated and given an information sheet to read. The information sheet said that they would be receiving mild electric shocks during the experiment, but did not give any details regarding when the shocks would occur. After reading this, the participant filled out the written consent form. The participant was attached to the SCR monitor and the shock electrodes. The SCR recording software was software zeroed. The shock intensity was individually adjusted as described above in the Apparatus section.

Following this, the participant was given instructions for the experiment. They were instructed to respond to whether each statement presented on the monitor was true or false by pressing the 'z' key on the keyboard if it was false, and the 'c' key if it was true. To ensure they would answer deceptively on half the trials, they were told to answer deceptively (by pressing the wrong key) if the statement referred to "[them] personally, or to the room [they] were presently in,"- which exactly half of the statements in the list did.

At the beginning of each trial, the program paused 5 seconds to provide a baseline measurement. Following this the statement was presented on the computer monitor, and the program waited for the participant to respond whether the statement was true or false. Once the participant responded, the program analyzed whether their answer was deceptive or truthful by comparing it to pre-defined truth-values assigned to each statement. On reinforced trials, the UCS followed 3 seconds after the CS+ (participant's answer). The trial statement remained visible until immediately after the UCS (or equivalent time on non-reinforced trials). No electric shocks were delivered on CS- trials. The program was written such that if a participant accidentally answered wrongly, this was treated as a deceptive answer. In practice, however, this was found to happen rarely, if ever. Each trial was followed by a randomized inter-trial interval of between 10 and 12 seconds before the next trial began.

5.2.1.4 Response measures and statistical analysis

Skin conductance responses for each trial were scored as the magnitude (in microSiemens) from trough to apex of the first response occurring with an onset latency of 2-4 seconds after the CS-onset (participant's keyboard response). This is a common response window for SCR conditioning studies (e.g., see Purkis & Lipp, 2001), with the modification that rather than using start of 1 sec. after the CS-onset, as is more common, we chose a start of 2 seconds following the CS-onset to avoid the tail end of SCR's to the previously presented statement.

For statistical analysis, the trials were broken into blocks of 10 trials, and the SCR's for CS+ and CS- trials in each block were separately averaged to produce the CS+ and CS- responses for that trial block. Statistical analysis was conducted on these blocks to test whether a significant change in SCR's had occurred over successive blocks between CS+ and CS- trials blocks.

5.2.2 Results

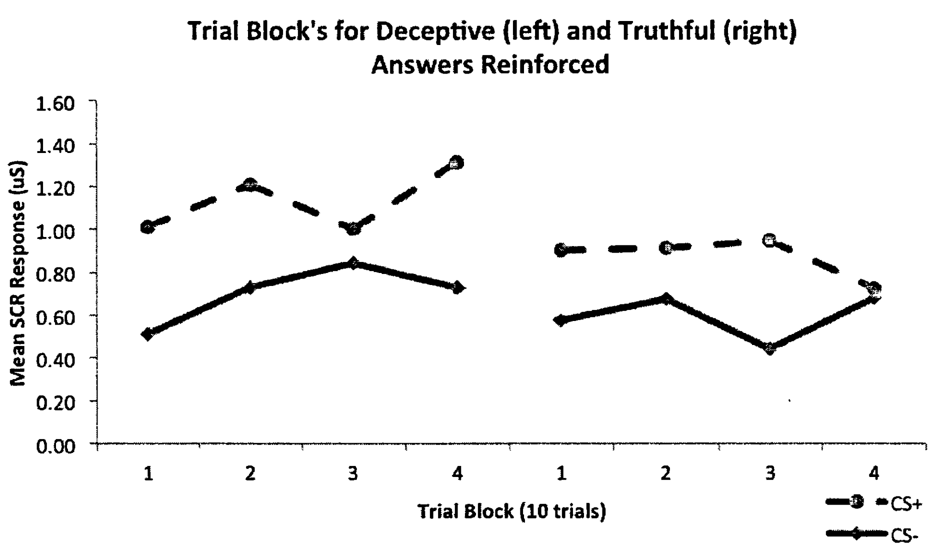


Figure 5-1: From Experiment 7, chart of averaged SCR's in each trial block for subjects reinforced following deceptive answers (left) and truthful answers (right).

Figure 5-1 displays the mean trial block SCR to CS+ and CS- trials for both the deception group (in which deception served as the CS+; left panel), and the truthful group (in which truthfulness was the CS+; right panel). As can be seen in Figure 5-1, for the deception group some discrimination between deceptive and truthful answers was apparent from the first trial block. Over the course of training trials participants' responses seem to increase to deceptive answers, while responses to truthful answers remain relatively stable. The truthful group appears to develop far less discrimination to the CS+ (truthful answers) over the course of training trials. By the end of training, there appears to be a strong discrimination apparent for the deception group (CS+ = deceptive answers; left panel), but there was little difference between CS+ and CS- where truthful responses were the CS+ (right panel).

A mixed-model analysis of variance (ANOVA), with group (truthful answers reinforced vs. deceptive answers reinforced) as a between-subject factor, and block and CS (CS+ vs. CS-) as within-subject factors, was conducted on these data. A rejection criterion of $p < 0.05$ was adopted for this, and all subsequent, analyses. This analysis found a statistically significant main effect of CS, $F(1,18) = 5.02$, indicating overall higher SCR's to CS+ trials. There were no other statistically significant main effects or interactions ($p > .20$).

As the numerical data hinted at a potential difference in the conditioning levels depending on whether the CS+ was truthful or deceptive statements, the data were further analyzed using a separate two-factor ANOVA's (CS x block) for each group as outlined by Howell (1997). Inspection of the data from the deception group (CS+ = deceptive answers) revealed a statistically significant main effect of CS, $F(1,9) = 9.46$, but did not find a statistically significant main effect of block ($p > .60$), nor an interaction between the two factors ($p > .60$). Inspection of the data from the truthful group (CS+ = truthful answers) found no significant effects, (all $p > .15$), indicating that this group acquired far less discrimination from the conditioning trials than did the deceptive group.

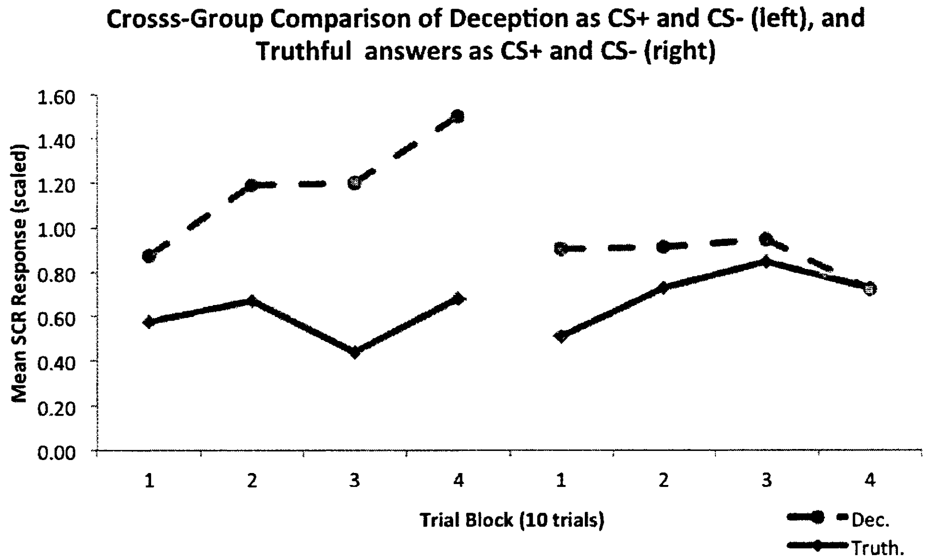


Figure 5-2: From Experiment 7, cross-group comparison of SCR's for deceptive responses as CS+ (deception group) and CS- (truthful group) (left), and truthful responses as CS+ (truthful group) and CS- (deceptive group) (right).

To present the effect that UCS pairings had on participants' SCR's to deceptive and truthful answers, Figure 5-2 directly compares SCR responses to deceptive answers when they served as CS+ (deception group), and as CS- (truthful group), in the left panel; and likewise truthful answers as CS+ (truthful group), and CS- (deception group), are compared in the right panel. As can be seen in the left panel of Figure 5-2, the initial SCR to deception remains relatively stable when not paired with the UCS (truthful group), but increases when paired with the UCS (deception group). Less discrimination is seen in the SCR to truthful answers, however, which does not appear to be heavily influenced by pairing with the UCS. This provides support that, while there was clearly an initial SCR to deception, pairing it with the UCS did have an effect of strengthening the discriminative SCR to deception over the course of the trials.

5.2.3 Discussion

The findings of the current experiment, particularly that deceptive answers can be conditioned to serve as a discriminative CS, support the previous findings reported by Jaffee et al. (1966). The current findings further expand upon the previous data by demonstrating the effect using SCR (as such, avoiding the potential interference of 'voluntary' responses found in eyeblink conditioning; Kimble, 1961). Additionally, the present experiment showed that the results do not apply equally for truthful answers.

By demonstrating the re-creation/strengthening of a conditioned SCR to deception, these results support Skinner's (1953) explanation and the conception of the physiological arousal accompanying deception as conditioned responses. Deception in the abstract, it seems, can serve as a strong CS, in the absence of other factors generally relied upon by the polygraph to increase responses to deception. This implies that the responses relied upon by the polygraph can be manipulated and strengthened in a more direct, and less situation-contingent, manner than has been previously possible. This lends support to the conditioned response theory of the responses measured by the polygraph, suggesting that these responses can be more directly manipulated than the 'fear of detection' theory would have us believe.

5.3 Experiment 8

As discussed in Chapter 4 (see section 4.1, Chapter 4), deception cannot be defined by a verbal response alone, but requires taking into account the situation in which it occurs. In the first experiment in this chapter, this situation consisted of participants' past conditioning regarding the statements that they were presented with (specifically, whether they had been taught to respond towards the statements as true or false). The deception of the participant's answers in Experiment 7 was, therefore, defined by their answers, and by the truth-value of the statements to which they were answering. Experiment 8 expanded on the results of the first experiment by testing whether the simple truth-value of presented statements could serve as a discriminative stimulus in a similar procedure. Such a test could have both practical and theoretical implications. Practically, it is valuable to establish whether a procedure in which participants passively view statements can be used to establish whether they believe the statements to be true or false. Theoretically, such a test may help to further explain the previous conditioning upon which a conditioned response to deception relies. Given that truth-value is an important component to what makes a response deceptive, it is important to know if truth-value in itself can serve as a conditioned stimulus. To this end, the present experiment was similar to the series of experiments described above in that the truth-value of statements served as the CS. It differed, however, in that in the present experiment, participants passively observed the statements presented in Experiment 7 on a computer screen, and the truth-value of the statements served as the CS (half of the statements were true and half false). As before, the experiment was counter-balanced, with false statements serving as the CS+ in half the participants, and true statements serving as the CS+ in the other half. As in the first experiment, the UCS (a mild electric shock) was paired with all instances of the CS+.

5.3.1 Method

5.3.1.1 Participants

Sixteen undergraduate psychology students (13 women) were recruited via the same means as in Experiment 7. To avoid any effects of re-conditioning or desensitization to the procedure, none of the participants had been used in the previous experiment for this and all subsequent experiments. The participants had a mean age of 20.9 ($\pm$ 1.3) years. As before, participants provided written consent prior to participation.

5.3.1.2 Apparatus

Experiment 8 was conducted in the same room as the previous experiment, and employed the same equipment and software (see Chapter 2 for description). Additionally, this Experiment employed the same statements as Experiment 7 (See Appendix E for complete list). Exactly half the statements were true, and half false. The statements were randomized prior to each experiment session.

Given that reading would take time between when each statement was presented and when it would become apparently true or false, it was important to ensure that the response time to these statements was within the intended CS-UCS interval of the experiment. A preliminary study was conducted using four psychology students. The statements were randomized and sequentially presented on screen, and participants were instructed to respond to whether the statement was true or false via the same key-presses used in the previous experiment. Participant's response times to these statements were measured. These measurements found that the time required to respond to the statements was well within the intended CS-UCS interval for the experiment (Mean = 1.53 ± .74 seconds). No statement required longer than 3 seconds to respond to by any participant.

5.3.1.3 Procedure

The participants were randomly divided into two groups of eight. In the first group, true statements served as the CS+, and in the second group false statements served as the CS+. Participants went through a similar setup processes as in the first experiment, except that this time they were instructed to simply "hold still and pay attention to the statements presented on the screen."

Each participant received 40 trials, during a single 35 min experiment session. At the start of each trial, a statement was presented on the screen, and remained visible for 3 seconds. On CS+ trials, the UCS immediately followed the statement's offset. On CS- trials, the UCS was not presented. As before, each trial was followed by a random inter-trial interval (ITI) of between 10 and 12 seconds before the next trial began.

5.3.1.4 Response measures and statistical analysis

Skin conductance responses for each trial were scored as the magnitude (in microSeimens) from trough to apex of the curve that began within a response window of 2 to 4 seconds following CS-onset (statement appearing on the monitor). SCR responses were blocked into blocks of 10 trials, as in the previous experiment. Statistical analysis was conducted on these blocks to test whether a significant change in SCR occurred over successive trial blocks between CS+ and CS- trials.

5.3.2 Results

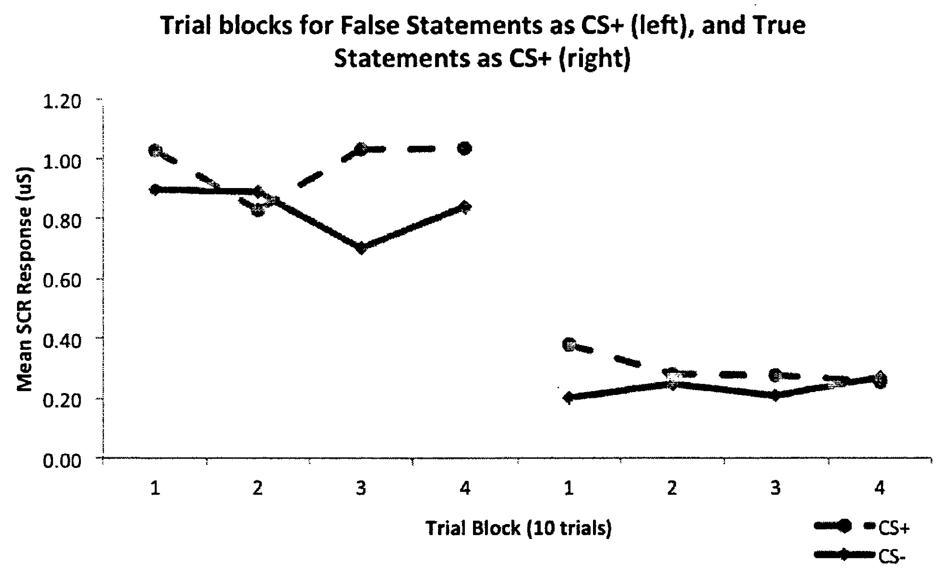


Figure 5-3: From Experiment 8, chart of averaged SCR's in each trial-block for subjects reinforced following false statements (left) and true statements (right).

Figure 5-3 displays the mean SCR to CS+ and CS- trials in the false group (CS+ = false statements; left panel), and the true group (CS+ = true statements; right panel). As can be seen, little discrimination occurs in either group. For the false group (CS+ = false statements), however, a slight discriminative response appears to develop between the second and third trial blocks of conditioning. For the true group (CS+ = true statements) there appeared to be no significant discrimination, as both the response to true (CS+) and false (CS-) statements remain roughly stable over trial blocks. A mixed-model repeated-measures ANOVA (block x CS as within-subject factors, and group as a between-subject factor) revealed no statistically significant effects of Block ($p > .8$), CS ($p > .13$), Block x CS ($p > .7$), or Block x CS x Group ($p > .7$).

The graph of the data from Experiment 8 hints that false statements may have served as relatively stronger discriminative stimuli than true statements (some discrimination appears to be acquired in the last two trial blocks for the false group). To test this, separate repeated-measure ANOVA's were run on each group. The test on the false group found no significant effects: (Block: $p > .9$; CS: $p > .35$; CS x Block: $p > .7$). A test on the true group found a similar lack of significant results: (Block: $p > .14$; CS: $p > .97$; CS x Block: $p > .31$).

5.3.3 Discussion

The results of the current experiment show that the truth-value, whether true or false, of passively observed verbal statements, do not serve as a strong conditioned stimulus in an SCR procedure. This is the first known experiment attempting this with SCR, and is at odds with previous research attempting this with eyeblink responses (e.g. Fleming et al., 1968). This is also at odds with the findings of Experiments 4, 5, and 6 (Chapter 4), which found at least a marginal conditioned eyeblink response to false statements. This does support the previously raised suspicion (section 4.5, Chapter 4) that the responses conditioned in Experiments 5 and 6 were potentially operant avoidance responses, and the same could be argued for those in Experiment 4. The results of this experiment support that argument. As will be discussed in more detail below, one possible reason why this experiment failed to acquire significant conditioning with true and false statements might be that there are not sufficient contingencies in a person's environment to shape a conditioned response to passively viewed statements. A person is not typically punished in the presence of false statements, as they are when they are deceptive. This raises an important point, that the past conditioning of the individual is very important in the responses we are capable of conditioning in a single session. The previous conditioning history of the individual plays a great role. Whereas false statements have not likely received any classical conditioning, deceptive responses likely have, making the latter susceptible to new conditioning (periodic reconditioning), and the former not. This is a very important point, and will be returned to later.

5.4 General Discussion

The current studies investigated deception and truth-value as conditioned discriminative stimuli in an SCR procedure. Experiment 7 provided evidence that a participant's deception can be conditioned as a discriminative stimulus, but that their truthful answers cannot. The results of this experiment also demonstrated the conditioning of an abstract property of a stimulus class, in this case the stimulus class being the participant's verbal reports and the abstract property being the property of deception possessed by some of those reports. Similarly, these results demonstrate the classical conditioning of a behavior as a CS, an effect commonly talked about (e.g. Skinner, 1953; Skinner 1957), but lacking explicit experimental demonstration in the literature. The second experiment extended these results and the results of Chapter 4 by examining whether the observed truth-value of the same statements could alone serve as a discriminative stimulus. This experiment found that the truth-value (whether true, or false) of passively viewed statements does not serve as a strong discriminative stimulus. This established more firmly that the functional CS in the first experiment was the participants' deception.

For convenience, the responses measured have hitherto been described in terms of acquisition of classically conditioned responses to the stimuli. There is a certain difficulty, however, in interpreting the responses to deception examined in Experiment 7 purely in terms of acquisition of a new response, as they have purportedly been pre-conditioned by past punishment to elicit physiological arousal. Under normal circumstances, this interference of pre-conditioning might be considered a liability to the validity of the conditioning acquired. In the current situation, however, there are two reasons why this may not be the case.

In the first place, as described earlier, comparison of the SCR's to deceptive responses in Experiment 7 when it served as CS+ (deceptive group) and CS- (truthful group) shows that pairing with the UCS had a significant effect of maintaining and increasing the SCR to deception (see Figure 5-2). This demonstrates that, even while deception has arousal associated with it to begin with, pairing with the UCS increased this arousal significantly. Likewise, when not paired with any aversive stimulus, the arousal exhibited following deception remained roughly unchanged and similar to the responses to truthful answers over trials.

In the second place, it could be argued that previous conditioning in participants' histories provides the most parsimonious explanation for the difference in discrimination acquired between groups and between the experiments. Of the CS's used in the four groups between the two experiments, deception is the only one that seems likely to have been punished in the typical history of an individual. Given that there is a connection between punishment and conditioned skin conductance responses (Waid, 1976; Skinner, 1953), the simplest explanation for why deceptive answers normally served as strong CS's, while the other stimuli (truthful answers, true statements, and false statements) did not, seems to be that: firstly, the properties of all four of these stimuli make it difficult for them to serve as CS's (verbal, complex, or simply inadequately conditioned[2]); secondly, the peculiar social significance of deception exposes it to consistent and generalized punishment from an early age (similar to swearing in Chapter 3), making it possible to bring an SCR under its control via discriminative training.

The results of the current studies support Skinner's explanation for the responses measured by the polygraph. The study re-created Skinners postulation of how an emotional response could come under the control of deceptive behavior via pairings with punishment. As such, it demonstrated (perhaps for the first time) a direct relationship between the responses to deception and the past environmental events that cause them.

In this manner, Experiment 7 provides a more useful account of the origin of the responses measured by the polygraph than the 'fear of detection' theory. Such theories of lie detection could only propose indirect methods for the improving the accuracy of the polygraph, typically involving the manipulation of any possible aspect of the situation that might increase the similarity of the testing situation to past situations where deception had been paired with punishment (e.g., see "stimulation tests"; Reid & Inbau, 1966). The current studies, however, demonstrate that a CR to instances of deception can be manipulated in the absence of the factors that normally increase this "fear of detection." It is the effect of past conditioning, not anticipation of future events, causing the response. Likewise, more accurate measurement of deception from physiological responses requires manipulation of conditioning, not anticipation.

By conditioning a response to deception in isolation from the other variables that tend to surround it, the present experiments demonstrate that the consistency and magnitude of the responses accompanying deception need not be dependent upon other factors. Rather, deception in the abstract can serve as a salient and distinct conditioned stimulus. As such, the current results suggest that by targeting deception in the abstract using a classical conditioning procedure, the CR to deception can be

[2] As seen in the analysis of verbal behavior (Skinner, 1957), bringing a verbal response under the control of an appropriate verbal stimulus (e.g. the response "true" to the stimulus "you are sitting in a chair") requires a great deal of discriminative reinforcement. Bringing a classically conditioned response under the control of similar verbal stimuli would presumably require similarly extensive conditioning, and this occurring would be rare for the vast majority of verbal stimuli, given that there is no practical benefit to the verbal community for doing so.

brought more precisely under the control of deception, possibly freeing it from extraneous factors affecting the accuracy and reliability of traditional polygraph tests. The process can be seen as a form of discrimination training, in which all properties of the situations typically surrounding deception are trimmed away- leaving only the property of deceptiveness in control of the conditioned response.

Given the claim that this method could form the basis for a more direct measurement of deception, it should be noted that the discrimination between truthful and deceptive answers acquired in Experiment 7 was probably far below what would be ideal for this purpose. It is worth noting at this point, however, that in controlled laboratory experiments, without the use of a "mock-crime" scenario, or other means of artificially increasing the similarity to "real-life" instances of deception, the polygraph itself gets little better than chance results (Reid & Inbau, 1966). While the present experiments sought only to demonstrate that such conditioning was possible, it will be the task of continued research to discover modifications of the methods used here to bring this discrimination to a practical level. Manipulation of the number of conditioning trials, truthful/deceptive trials ratio, CS-UCS ratio, and perhaps even number of conditioning sessions will hopefully find more distinct control of the deception over the CR. Further research must also test generalization of the CR to more realistic instances of deception (e.g. regarding real-world events and information of a more hidden nature).

In conclusion, the present chapter used statements that relied upon external conditioning to be true or false (e.g. "The world is flat"), and then tested whether the truth value of these statements in itself could serve as a conditioned stimulus. Alternatively, the next chapter used a similar conditioning procedure, but with instances of deception where the context that made the statement true or false was controlled in the laboratory. This allowed a minimum amount of personal involvement, and increased control in isolating the deceptive response as the conditioned stimulus.

Chapter 6

Using Classical Conditioning to Amplify Skin Conductance Responses to Deception in a Cluedo-Type Scenario

6.1 General Introduction

The results of Experiment 7 (Chapter 5) suggested that deception can serve as a conditioned stimulus in a skin conductance conditioned paradigm. The deception in Chapter 5 was regarding the truth-value of simple statements presented on the screen. Subject's knowing the truth-value of these statements relied upon their past conditioning. The present experiment further examined deception as a conditioned stimulus by developing an ecologically valid context for deception to be elicited in.

There has been a great deal of interest in developing new methods of lie detection (e.g., Sartori, Agosta, Zogmaister, Ferrara, Castiello, 2008; Tsiamyrtzis, Dowdall, Shastri, Pavlidis, Frank, Ekman, 2007; Walczyk, Schwartz, Clifton, Adams, Wei, Peijia, 2005). While valuable, most of these methods have rested upon assumptions about the same deception-arousal relationship relied upon by the polygraph, and, hence, they are vulnerable to the same problems that have limited the utility of the polygraph. They do not aim to understand the relation between deception and physiological arousal, or its origin. If this relation is imperfect, so are these methods.

As previously argued (see section 1.2, Chapter 1), improving the utility of this relationship may require an examination of how it is originally formed. Skinner (1953) presented a simple explanation of how deception comes to elicit physiological responses. According to Skinner, the polygraph measures, not deception *per se*, but "[*the*] *emotional responses generated when the individual engages in behavior for which he has previously been punished*" (Skinner, 1953, p. 187). According to this theory, the responses exhibited are a side effect of the punishment individuals often receive in everyday life when their deception is detected. For example, as was seen in Chapter 3, people exhibit higher physiological arousal when saying swear words than non-offensive control words (Experiment 2, Chapter 3), and those who are punished more for swearing exhibit stronger SCR's when swearing (Experiment 3, Chapter 3). The main difference between swear words and less offensive words is that the former are likely to have been punished by parents and other authority figures in a person's environment (Jay et al., 2006). Experiment 7 (Chapter 5) demonstrated that deception can serve as a conditioned stimulus- supporting the assertion that previous punishment is what leads to the increased skin conductance when deceptive.

As mentioned in Chapter 5, there has been some related work to this theory, but not much. For example, Jaffee, Millman, and Gorman (1966) classically conditioned an eyeblink response to instances of verbal deception by pairing instances of deception with a corneal airpuff. Their results supported the notion that deception can serve as a conditioned stimulus, but there have been, to our knowledge, no known attempts to expand upon this research in the last 40 years. Chapter 4 of the present thesis followed up on this research by exploring whether the truth-value of statements can serve as a conditioned stimulus in an eyeblink conditioning paradigm. Chapter 5 then tested the conditioning of a skin conductance response to instances of deception regarding statements with obvious truth-value (e.g. "grass is blue") (section 5.2.1.2, Chapter 5).

The use of true and false statements, however, potentially presented a confound- as false statements are in themselves novel stimuli. The present chapter followed up on this research by exploring the conditioning of a skin conductance response to instances of deception that were made true or false given the context of the experiment, rather than externally. An internally consistent context was developed in which participant's could answer questions both truthfully and deceptively, while at the same time minimizing the influence of personally relevant variables that would normally increase SCR. It was expected that deception within this contextually controlled setting could come to serve as a conditioned stimulus, expanding upon the results of previous chapters.

6.2 Experiment 9

To create an internally consistent context in which subjects could be deceptive with minimal personal involvement, this experiment used a paradigm similar to the game Cluedo™ (Clue™ in the U.S.) In this variation, subjects had to deceive the computer regarding the identity of a murderer in a series of questions. Over the course of these trials, deceptive answers were paired with mild electric shocks according to the group that each subject was in (see below). Previous chapters had difficulty establishing an effect of conditioning due to a pre-existing tendency for subjects to exhibit skin conductance following deceptive answers (see Experiment 7, Chapter 5). This experiment, therefore, included a control group for comparison. Rather than deliver no shock in the control group, which would leave open the possibility the experimental group was exhibiting sensitization because they were receiving shocks when the control group was not, the control group received very mild shocks. As previous experiments (e.g. Experiment 6, Chapter 4) had found an effect of ratio UCS presentation, the present chapter tested whether ratio UCS presentation influenced the results acquired.

6.2.1 Method

6.2.1.1 Participants

Forty-eight Swansea University Psychology students (27 female) participated in exchange for course credits. The participants had a mean age of 22.8 ($\pm$ 2.9 SD) years. As in previous experiments, participants were recruited through the Psychology Department's online subject pool. All participants provided informed written consent prior to participating.

6.2.1.2 Apparatus

Participant's SCR was measured using the ADInstruments© PowerLab 2/25 data acquisition system (ML825), which sampled continuously at 1k/sec. Finger Electrodes were attached to the palmer surface of the first and third fingers of the participant's non-dominant hand. The SCR for each trial were scored as the magnitude (in microSiemens) from trough to peak of the first response occurring with an onset latency of 1-4 s after the participant's keyboard response. These responses were normalized within each subject prior to analysis by dividing the SCR on each trial by the maximum SCR exhibited by that subject during the session.

The UCS was a mild electrical shock presented from ADInstruments© Stimulus Isolator (ML180), and delivered via electrodes attached to the participant's inner lower dominant arm. The shock intensity was individually adjusted for each participant using a shock workup procedure- by starting at a setting so low they could not feel it, and increasing it slightly in steps until the subject rated it as "uncomfortable, but not painful" (see section 5.2.1.2, Chapter 5, for further detail). In the low-shock condition, the final intensity was then reduced by half- resulting in a shock that the subject could barely feel.

6.2.1.3 Procedure

To provide a context in which participants could answer questions deceptively and truthfully with consistency and minimal personal involvement, a scenario similar to the game Clue™ was used. After the electrodes were attached, the participant was given instructions. They were told that they would take part in a game similar to the game Clue, in which they would be presented with a murder and a murder weapon at the beginning of each set of trials, and that they would need to memorize these. They were told that they would then be asked a series of questions regarding this murderer and murder weapon, for example "was this the murderer"- [showing a card with a suspect on it], or "was this the murder weapon" [showing a card with a weapon on it]. Subjects were told that they could answer these questions using the keyboard, pressing "z" for no, and "m" for yes. Additionally, participants were told to "try to deceive the program regarding the identity of the murderer," and that this would involve not only answering "no" when asked whether the murderer was the murderer, but also "framing" one of the innocent suspects by saying that they were the murderer. They did not need to always claim the murderer was the same person, and it was up to them to choose which person to claim the murderer was.

At the beginning of each set of six trials, the computer presented two randomly selected cards on the screen: the murderer and the murder weapon (Figure 6-1), which participants were asked to memorize (see Appendix G for complete listing of suspect cards and Appendix H for a listing of murder weapon cards used).

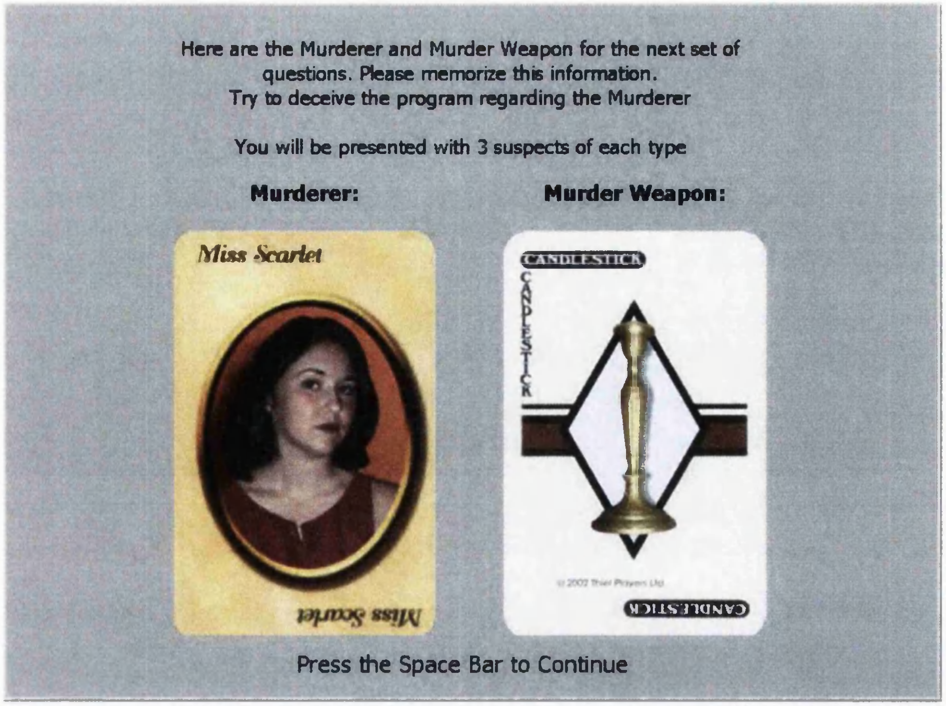


Figure 6-1: Screen shot of Clue task used in experiments, showing the screen in which the murderer and murder weapon were presented at the beginning of each set of trials.

Following this, participants were presented with a series of six trials in which the program presented a randomly selected suspect or weapon card, and asked whether this was the murderer or the murder weapon, respectively. At the beginning of each trial, the program paused 5 seconds to provide baseline. The card and question were then presented on the computer monitor (Figure 6-2). Once the participant answered using keystrokes, the program determined whether their answer was truthful or deceptive. On reinforced trials, the shock followed 3 seconds after deceptive answers. If the answer was deceptive, an electric shock was delivered-depending on the group (see below). No electric shocks were delivered on truthful trials.

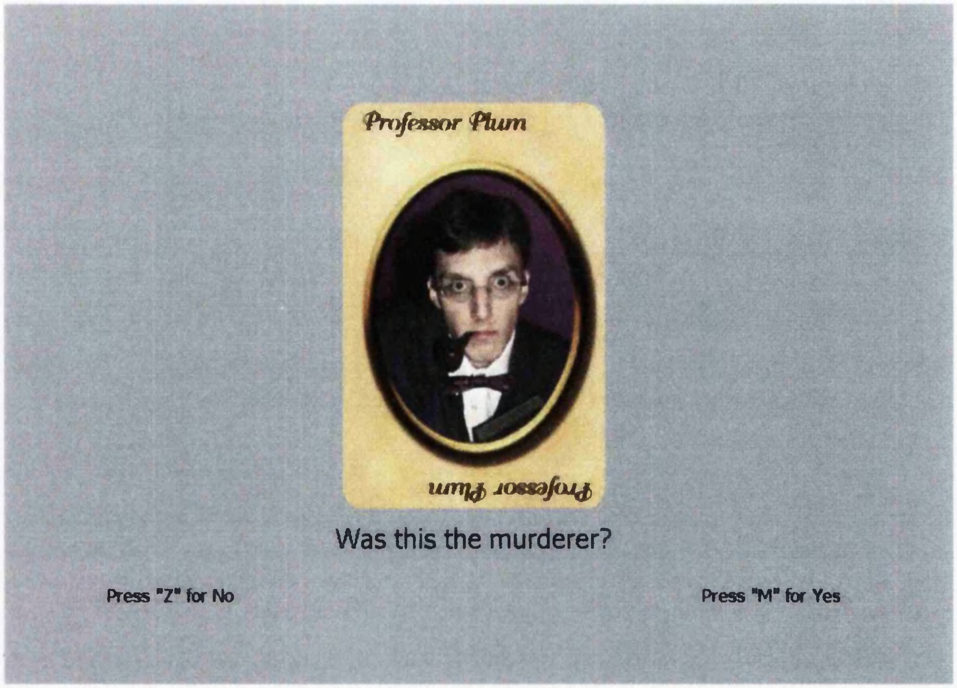


Figure 6-2: Screen shot of Clue task used in experiments, showing the screen in which participants answered whether the presented card was the murderer or murder weapon.

For each set of 6 trials, the subject answered deceptively twice: once to say that the murderer was not the murderer, and once to say that an innocent subject was the murderer. Following the set of six trials, the program presented a feedback screen telling the participant whether they had "successfully deceived the program," i.e. whether they had answered truthfully regarding the murder weapons, and lied twice regarding the identity of the murderer.

For conditioning, participants were divided into 4 groups, based on two variables: shock intensity and unconditioned stimulus (UCS) ratio. The shock intensity was varied between participants, with half receiving the full electric shock [high-shock group] and half receiving a much milder shock [low-shock group] (see procedure). The UCS ratio was varied so that half the participants received the shock following every deceptive answer [non-ratio group], and half received the shock following 60% [ratio-group] of their deceptive answers.

To only include the fully learned responses, we used only the last half (30 trials) of the trials from each subject in the analysis. For statistical analysis, the SCR on deceptive and truthful trials for each subject were averaged to produce a final subject mean for deceptive and truthful trials.

6.2.2 Results

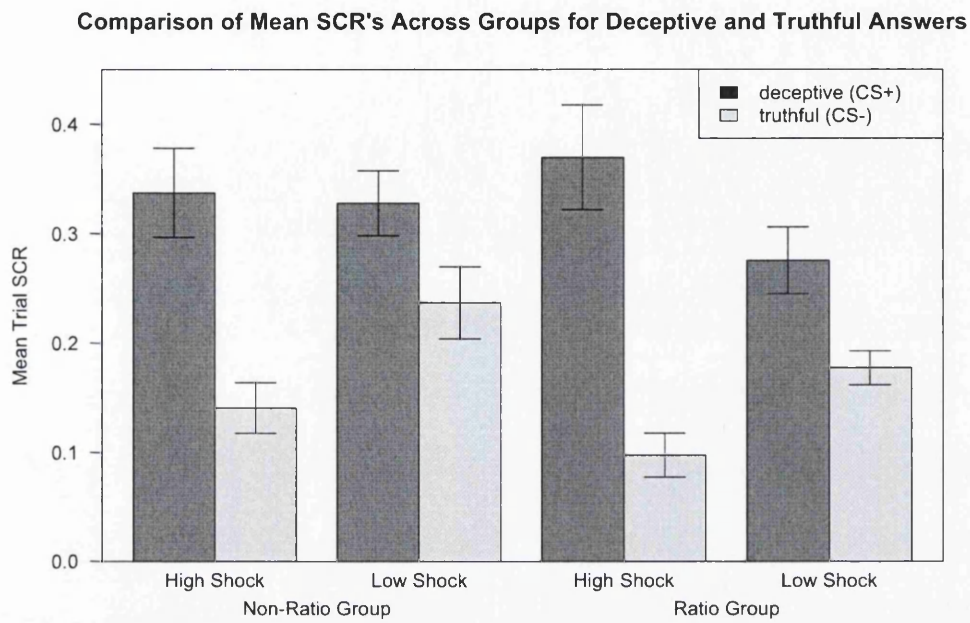


Figure 6-3: Mean SCR across subjects for Deceptive and Truthful trials in ratio, non-ratio, high-shock and low-shock conditions. Error bars show standard error.

Figure 6-3 displays the group mean SCR to both deceptive and truthful answers over the last 30 trials (high shock vs. low shock; ratio vs. non-ratio). Within all groups there was a difference between the SCR to deceptive and truthful answers, but this difference was greater in the high-shock conditions. There was an apparent difference between ratio and non-ratio groups, but to a far lesser extent than that seen for shock intensity.

A mixed-model analysis of variance with 2 between subject factors (UCS Ratio: 100%, 60%; Shock Intensity: High-Shock, Low-Shock), and one within-subjects factor (CS: Deceptive, Truthful) was conducted, and a significance level of .05 was adopted. This test found a significant main effect of CS: $F(1, 86) = 5.61$, $p = .02$, indicating a discriminated responding between deceptive (CS+) and truthful (CS-) answers across all groups. There was also a significant interaction between CS and shock intensity: $F(1, 86) = 4.49$, $p < .04$, indicating that in the high-shock condition the difference between deceptive and truthful responses was significantly different than that between the low-shock condition. Ratio vs. Non-ratio did not have a significant effect, and there were no other significant effects to report ($p >$ .30).

6.2.3 Discussion

The present experiment found a significantly higher SCR to deception than to truthful answers across all groups, which is to be expected. When paired with a salient UCS, however, deception acquired a stronger discriminative SCR than when paired with a barely perceptible shock. This suggests that the conditioning procedure had an effect on the SCR to deception. Given that deception was the only stimulus that predicted the presentation of the shock, this shows that it was the abstract deception that was serving as the CS.

Based on observation of the data, ratio UCS presentation seemed to have some effect on the SCR differentiation acquired, but the statistics did not find a significant difference. As can be seen in Figure 6-3, the main effect of ratio UCS presentation was on the SCR's exhibited following truthful answers, rather than on deceptive answers. Whereas the deceptive responses stayed roughly the same between ratio and non-ratio subjects, the responses on truthful answers were slightly lower for ratio subjects, suggesting perhaps that the presentation of fewer shocks over the course of the experiment led to less generalization to truthful answers. This effect was not strong, however, and did not reach statistical significance.

By demonstrating the conditioning of an SCR to deception, these results expand upon the results from Experiment 7 (Chapter 5), and are consistent with Skinner's (1953) explanation for the origin of the physiological responses that accompany deception. As such, these results show overlap between two very different research fields (lie detection and classical conditioning). This new direction in understanding the responses a person exhibits during tests like the polygraph could have significant consequences for the development of these fields. This implies that the responses relied upon by the polygraph can be manipulated and strengthened in a more direct manner than has been previously possible. Reliance upon the physiological arousal that a person already exhibits when deceptive has provided some positive results for previous lie detection, but has also proven perilously inconsistent and situation-contingent (e.g., see National Research Council, 2003). Even attempts to replicate polygraph results in the laboratory have proven difficult, undermining its scientific basis. By pointing out the way in which these responses originate, however, we can not only re-create the responses in the laboratory, but also potentially manipulate and improve them in practical use. While it may be that applying procedures like those above prior to a polygraph test could significantly improve the accuracy of the test, further research is needed to test generalization of these results to "real world" deception. The second experiment in this chapter examined generalization of this conditioned response to questions where the subject knew the experimenter and computer were ignorant of the correct answer.

6.3 Experiment 10

The results from Experiment 9 indicate that classical conditioning in a Cluedo-type scenario can be used to improve the SCR discrimination that subject's exhibit to deceptive answers. While this is valuable, for such discrimination to be applicable to lie detection in the field, it needs to be known whether this discrimination will last when subjects are deceptive regarding questions where they know the experimenter and computer do not know when they are being deceptive. That is, would the effects of such conditioning generalize to situations where the subject is deceptive on truly private matters? Stimulus generalization is the tendency of responses conditioned to one stimulus to be elicited by other stimuli that share similar properties to the initial stimulus (Skinner, 1938;Pavlov, 1927). The second experiment in this chapter, therefore, focused on exploring whether this conditioning would generalize to questions where only the subject knew the correct response. The deception was similar in all its properties, except that only the subjects knew the true answer. It was anticipated that the conditioned responses to deception regarding known murderers exhibited would at least partially generalize to instances of deception regarding unknown murderers.

6.3.1 Method

6.3.1.1 Participants

Fourteen Swansea University Psychology students (8 female) participated in exchange for course credits. Subjects had a mean age of 23 (± 4.3) years. As in previous experiments, participants gave informed consent prior to participating.

6.3.1.2 Apparatus

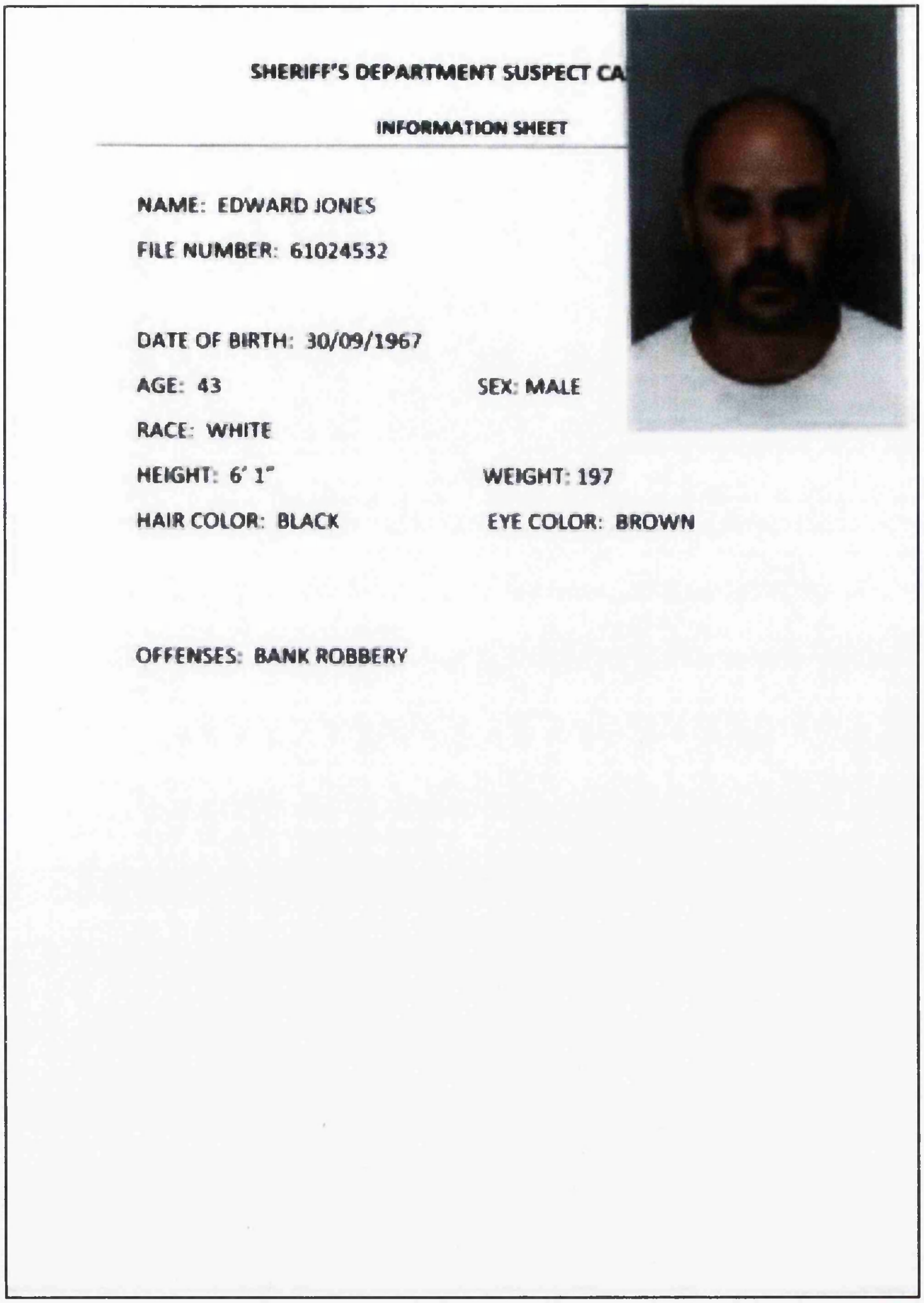
The same equipment was used in this experiment as in the previous for measuring subjects SCR and delivering stimuli. SCR's were scored in the same manner as before.

As before, for statistical analysis, the SCR on deceptive and truthful trials for each subject were averaged over each block of 6 trials (conditioning sets) and 5 trials (generalization sets) to produce a final subject mean for deceptive and truthful trials.

6.3.1.3 Procedure

Participants were divided into 2 groups (control, which did not receive shocks, and experimental, which received shocks). To allow comparison with previous experiments, it was decided to deliver no shocks in the control group, rather than mild shocks as had been done in the previous experiment.

This experiment employed exactly the same procedure as the last, except that generalization trials, in which the subject was asked questions regarding a murderer that only they knew, were added. To accomplish this, prior to each experiment the subject was presented with 5 envelopes containing different mock suspects. These suspects had fictional names, demographics, crimes, and an image taken from minor offense wanted lists in the United States (see Appendix I for all images used). Figure 6-4 presents an example suspect file.



SHERIFF'S DEPARTMENT SUSPECT CA

INFORMATION SHEET

NAME: EDWARD JONES

FILE NUMBER: 61024532

DATE OF BIRTH: 30/09/1967

AGE: 43 SEX: MALE

RACE: WHITE

HEIGHT: 6' 1" WEIGHT: 197

HAIR COLOR: BLACK EYE COLOR: BROWN

OFFENSES: BANK ROBBERY

Figure 6-4: Scanned copy of a suspect file from Experiment 10.

The participants were asked to randomly select one of the five possible envelopes, memorize the information on the file contained within it, and put the file back in the envelope without telling the experimenter which suspect they had drawn. Following this, they were taken to the laboratory and instructed as in the previous experiment regarding how to complete the conditioning trials. In this experiment however, suspects were given additional instructions for the generalization trials they would receive. Subjects were told "you would periodically be presented with questions regarding the suspect you have just read about on the file. The computer will present a series of possible suspects and ask if each was the person you drew. You should try to deceive the computer on these trials in exactly the same way you do with the murderer in the Cluedo game, lying and saying that one of the other suspects is the one you drew." To assure subjects that they were being deceptive regarding information that only they knew, they were further instructed "neither the computer nor the experimenter knows which suspect you have drawn."

The trials were run as in the previous experiment: at the beginning of each set of six conditioning trials, the computer presented two randomly selected cards on the screen: the murderer and the murder weapon, which participants were asked to memorize (Figure 6-1). They would then go through six trials being asked about the murderer and weapon, trying to deceive the computer regarding the murderer's identity. As in Experiment 9, at the beginning of each trial, the program paused 5 seconds to provide baseline. Following this the card and question were presented on the computer monitor (Figure 6-2). Once the participant answered using keystrokes, the program determined whether their answer was truthful or deceptive. On reinforced trials, the shock followed 3 seconds after deceptive answers. If the answer was deceptive, an electric shock was delivered- depending on the group (see below). No electric shocks were delivered on truthful trials.

For each set of generalization trials, the computer would go through 5 generalization trials- sequentially presenting the possible suspects from the envelopes in random order, and asking on each if the suspect was that which the participant had seen from the envelope (Figure 6-5). These trials were the same as the conditioning trials. One of five possible suspects was presented on the screen, and the subject was asked if this was the suspect they had drawn. As on conditioning trials, subjects answered via keystrokes. Following this answer, the suspect was removed and there was a randomized inter-trial interval of 9 to 11 seconds before the next suspect was presented. No shocks were delivered on the generalization trials.

Figure 6-5: From Experiment 10, screen shot of Clue generalization trial, showing the screen in which participants answered whether the presented suspect was the one they had previously drawn.

Each participant received a total of 97 trials, 25 of which were generalization trials (four rounds of 24 conditioning trials followed by 5 generalization trials). Prior to any conditioning, they received a set of 5 generalization trials for an initial baseline measurement. Following the experiment, the participant was asked which suspect they had drawn prior to the experiment, so that their deceptive answers could be identified for analysis.

6.3.1.4 Analysis

For analysis, trials were divided into 3 types: Those on which the subject had told the truth (truthful trials), those on which the subject had deceptively claimed that the suspect was innocent (negative deception); and those on which the subject claimed an innocent suspect was the murderer (positive deception). Subject's SCRs on these types of trial were then compared for each group.

6.3.2 Results

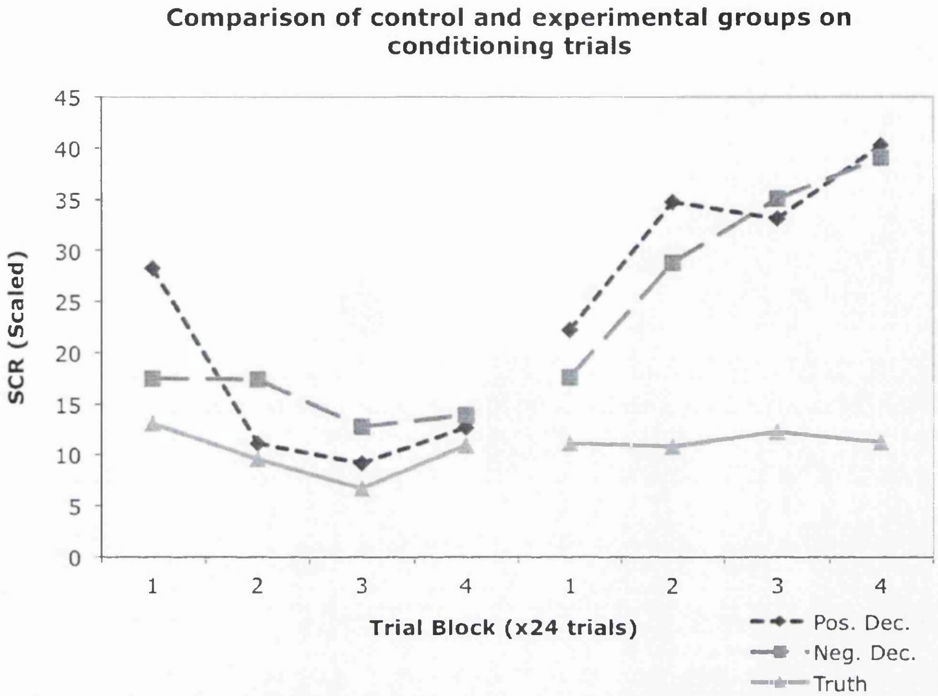


Figure 6-6: Comparison of conditioning trials over course of training for control subjects (left) and experimental subjects (right).

The results from the conditioning trials support the results of Experiment 9. Figure 6-6 displays the group mean SCR to positive deceptive answers (when participants deceptively claimed an innocent suspect was the murderer), negative deceptive answers (when they deceptively claimed the murderer was innocent), and truthful answers for every set of 24 training trials (4 blocks) over the course of the experiment. As can be seen in the figure, participants in the control group did not exhibit much discrimination between deceptive and truthful answers, whereas participants that received conditioning appear to acquire strong discrimination to both types of deception on conditioning trials over the course of the experiment.

A mixed-model analysis of variance with one between subject factor (Control vs. Experimental group), and two within-subject factors (CS: Positive Deceptive vs. Negative Deception vs. Truthful, and Block) was conducted, and a significance level of .05 was adopted. This test found a significant main effect of Answer-type: $F(2, 24) = 14.22, p < .001$, indicating a discriminated responding between the two types of deceptive answers and truthful answers across all groups. There was also a significant interaction between Answer-Type and Group: $F(2, 24) = 4.92, p < .02$, indicating that in the group where shocks were delivered the difference between deceptive and truthful responses was significantly different than that between the control condition. A significant interaction was also found between Block and Group: $F(3, 36) = 4.7, p < .01$, indicating more change in responding in the experimental than the control condition. There was no significant interaction between Block, Answer-Type, and Group ($p > .097$).

Figure 6-7 displays the group mean SCR to positive deceptive answers, negative deceptive answers, and truthful answers for the last 3 blocks of generalization trials (because there was only one of each type of deceptive answer per trial block, the last 3 blocks were averaged to reduce noise). As can be seen in the figure, participants in the control group seem to have lower SCR's to truthful and deceptive answers, whereas participants that received conditioning came to exhibit stronger discrimination over the course of the experiment.

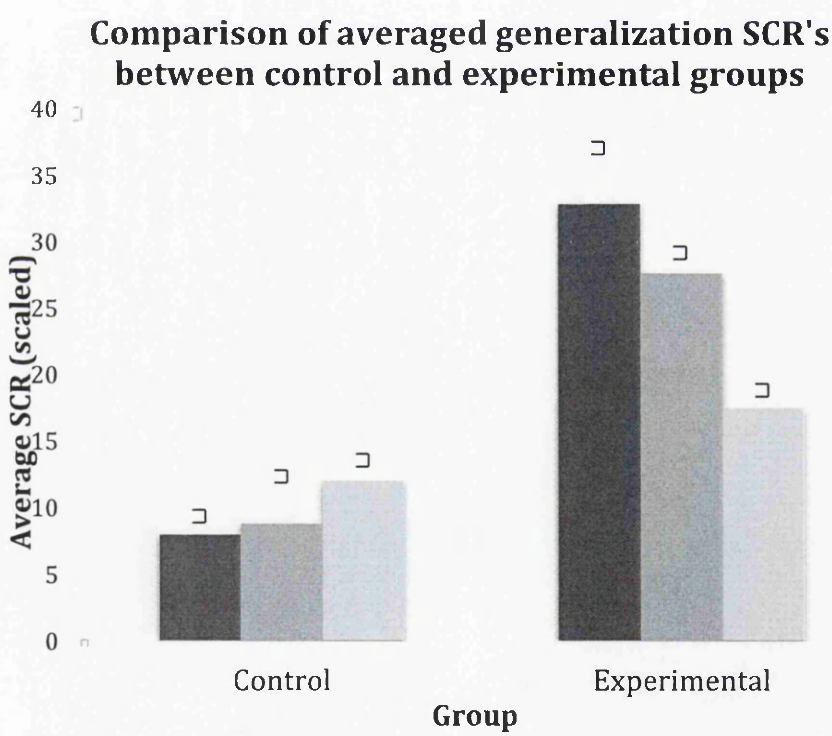


Figure 6-7: Comparison of averaged SCR's on last 3 blocks (15 trials) of generalization trials between control (left) and experimental (right) subjects.

A repeated-measures analysis of variance was conducted on the averaged results from the last 3 blocks for each subject, with Trial-type as a within-subject factor (Positive Deception vs. Negative Deception vs. Truthful) and Group as a between-subjects factor (Experimental vs. Control). This test found a significant interaction between Trial-type and Group ($F(2, 24) = 4.31, p < .03$), indicating that in the experimental group subjects exhibited significantly different responses to the types of trials. There was not a significant effect of Trial-type alone ($p > .25$).

As trial-type yielded a significant effect, further analyses were conducted to compare the specific trial types. A series of protected one-way t-tests was performed comparing each trial type in the experimental group to the others. These tests found a significant difference in SCR between positive deception trials and truthful trials: $t(6) = 3.56, p < .006$, but not between negative deception trials and truthful trials ($p > .07$). There was also not a significant difference between positive and negative deception trials ($p > .2$).

6.3.3 Discussion

The results from this experiment show a strong SCR was conditioned to deceptive trials in the conditioning trials for the experimental group, and not for the control group. This is consistent with the findings of Experiment 9. In the generalization trials, however, only the trials involving positive deception (where the subject falsely claimed an innocent suspect was guilty) elicited strong responses. While the negative deception trials almost approached significance, they were not statistically different from truthful trials. This is an interesting effect, suggesting that something about deceptively claiming a suspect is guilty is a more salient stimulus for generalization than deceptively claiming the murderer is innocent. It could perhaps be that the behaviors involved in deciding whether to "frame" the innocent suspect were partially serving as the conditioned stimulus on these trials, whereas they were absent on the negative deception trials.

6.4 General Discussion

It has been known for some time that physiological arousal (including SCR) can be classically conditioned (Dawson & Furedy, 1976). Likewise it is known that deception, in some situations, elicits a strong physiological response, and that deception tends to be wrapped up in situations where punishment is likely. Despite the elegance of combining these facts into an explanation for the physiological responses a person exhibits during the polygraph, this theory has gone without empirical testing. This study presents direct evidence that deception in the abstract can be classically conditioned to elicit a strong SCR.

The present chapter presented two experiments exploring deception regarding murderers in a Cluedo-like simulation as conditioned stimuli. Experiment 9 found that a significantly higher SCR can be conditioned by pairing instances of deception in such a context with a mild electric shock. Ratio presentation of the UCS was not found to have an effect, however. This is an important finding, as it develops further the findings of Experiment 7 (Chapter 5), providing further evidence that deception can serve as a conditioned stimulus even when it is regarding topics of a relatively arbitrary and non-personal nature. The second experiment tested whether these conditioned responses would generalize across the "privacy barrier," or to instances of deception where only the subject knew if they were being deceptive. The findings suggest that, even with relatively few conditioning trials, generalization does occur. Strangely, however, this generalization was only significant for instances of positive deception- in which the subject deceptively claimed that an innocent suspect was the murderer. This is significant, as the core problem of lie detection is arguably the capacity of the test to breach this barrier between what can be known objectively through other means, and what is only known by the person being tested. If it is found that a subject will not exhibit the same responses when they "know" that only they have accurate information regarding what they are being deceptive about, then lie detection will fail in any practical sense. Luckily, the present experiment found some evidence that this barrier can be breached. Further investigation, however, is required to improve the accuracy of the results to a more practical level.

Most of the recent research on lie detection has focused on finding new ways to measure the physiological arousal that accompanies deception. As such, the assumptions of the polygraph are usually implicitly accepted uncritically. The studies presented here take a step towards understanding the cause of this relation between deception and physiological arousal. Conditioning can both explain the origin of a physiological response to deception and how this response can generalize to new situations and instances of deception never directly paired with punishment.

This is an important point, as no two instances of deception are the same, nor are the situations in which they occur.

Similar processes of conditioning can be used to manipulate this relation, increasing a subject's SCR when they are deceptive. The results of the present experiments both support this notion and point to a potential practical method of improving lie detection results.

Chapter 7

Discussion

7.1 Overview

Improvement of the polygraph at this point relies upon a better understanding of the responses that it, and other methods of lie detection, have relied upon for its results. As seen in Chapter 1, however, little effort and research has gone into understanding the physiological arousal that tends to accompany deception. Among the theories that have been put forth is that these responses are conditioned by instances in a person's life when deception is paired with punishment and aversive consequences. This theory would have us understand deception as a conditioned stimulus for the responses that accompany it. This could have great implications for lie detection and its improvement. The current thesis examined the effect of conditioning and punishment on the physiological responses a person exhibits when they are deceptive.

Ten experiments examined the direct conditioning of different responses to deception and the components of deception. Experiments 1, 2, and 3 (see Chapter 3) looked at the effect of the past punishment in a person's conditioning history on the physiological arousal they exhibit to instances of swearing in a laboratory setting. One of the core premises of the current thesis is that punishment in a person's previous experience for certain types of verbal behavior (e.g. deception) will cause increased physiological arousal when they engage in those behaviors.

The first three experiments were designed to examine the link between a person's past behavior with punishment for a type of behavior (swearing was convenient – as it is a type of verbal behavior that is commonly punished) and their physiological arousal when engaging in it now. The goal of Experiment 1 (Chapter 3) was to test whether subjects found swear words more offensive than similar matched and emotional words. To this end, subjects' rating of offensiveness and emotionality was taken using a Likert scale for a list of swear words, and compared to a similar list of emotional words and matched word. It was anticipated that subject's who scored higher on questionnaires measuring their previous punishment for swearing and lower on swearing frequency would rate swear words as more offensive than other word-types. Experiments 2 and 3 (see Chapter 3) used the same words from Experiment 1 (see Chapter 3), and examined whether subjects had higher skin conductance responses when reading aloud the swear words than the other word types (matched and emotional). It was expected that swear words would elicit stronger physiological responses (skin conductance) than the matched words (Experiment 2), and that this difference would be higher for participants that scored high on the previous punishment questionnaire and low on the swearing frequency questionnaire (Experiment 3). The goal of these experiments was to establish whether punishment in a person's past social conditioning can leave physiological responses to the behaviors punished, as is thought to happen with deception.

Experiments 4, 5, and 6 (Chapter 4) investigated the classical conditioning of an eyeblink response to the truth-value of statements presented on a computer screen. An eyeblink response was chosen because it can be readily conditioned in a controlled setting (Woodruff-Pak & Steinmetz, 2010) and because it is not normally associated with the polygraph, making it an initially neutral response. Truth-value is an important stimulus, as no response is deceptive outside of the context in which it is uttered, and the truth-value of the statement being uttered is a primary factor in determining whether the response is deceptive. It is therefore important to know if truth-value itself can become a conditioned stimulus if paired with an unconditioned stimulus (corneal airpuff in this case). These experiments employed a list of statements, half true (e.g. "Humans need air") and half false (e.g. "Humans are reptiles"), which were presented on the screen one at a time. Experiment 4 attempted to classically condition an eyeblink response to the property of falseness in the list of statements. To this end, each false statement presented on the screen was paired with a corneal airpuff 1000 ms (1 sec.) following the presentation of the statement, whereas true statements were not paired with an airpuff. It was expected that over the course of 100 conditioning trials a discriminatory eyeblink response to false statements would develop. Experiment 5 attempted the same feat, but using an inter-stimulus interval of 2000 ms, rather than 1000 ms. Experiment 6 was the same as Experiment 5, but attempted to classically condition an eyeblink response to true as well as false statements, and also tested the effect of a ratio schedule of UCS presentation on the conditioning of the response.

For reasons that will be discussed shortly, Experiments 7 and 8 (Chapter 5) returned to the use of skin conductance as target response. These experiments employed a list of statements similar to that used in experiments 4, 5, and 6. As before, half the statements were true (e.g. "Pigeons are birds") and half were false (e.g. "Rocks are alive"). In Experiment 7, subjects were asked to respond via keystroke to whether each statement presented was true or false ('z' for false, 'c' for true). Additionally, they were asked to answer deceptively if the statement referred to "them personally or the room they are in." In this way, subjects were made to answer deceptively on roughly half the presented statements. Half the subjects were given a mild electric shock following each deceptive answer in this experiment, and half were given an electric shock following every truthful response- for comparison. It was anticipated that those shocked following deceptive answers would develop a conditioned SCR to their own deceptive responses over the course of conditioning trials. It was also expected that subjects shocked following truthful responses would develop a conditioned response to truthful responses, but perhaps to a lesser extent. Experiment 8 returned to the question addressed by Experiments 4, 5, and 6 (Chapter 4), and examined the conditioning of a skin conductance response to the truth-value of the observed statements. For half the subjects, false statements served as the conditioned stimulus, and for the other half true statements served as the conditioned stimulus. It was anticipated that both true and false statements could be conditioned to elicit a skin conductance response over the course of training trials, perhaps with false statements serving as a stronger CS than true statements.

Experiments 9 and 10 (Chapter 6) examined the conditioning of a skin conductance response to deceptive responses in a more internally consistent deception scenario. A computer program was employed that engaged subjects in a Cluedo-like game where they had to deceive the computer regarding the identity of a murderer over the course of numerous trials. This required subjects to answer some questions deceptively and some truthfully. Experiment 9 employed this game to attempt to condition a skin conductance response to subjects' deceptive responses on this game. Subjects were divided into four groups to test the effect of two important variables on the conditioning: ratio vs. continuous UCS presentation and normal vs. low shock intensity. It was expected that subjects who received normal shock intensity would develop a strong conditioned response to their deceptive answers, whereas those with low shock intensity would not. It was further anticipated that ratio shock delivery would lead to a more robust and consistent conditioned response. Experiment 10 followed up on Experiment 9 by addressing the important question of whether the conditioned responses created or enhanced in this sort of a procedure would generalize to instances of deception where the experimenter did not know whether the subject was being deceptive. To this end, prior to the experiment subjects randomly drew a murder suspect from a folder, read it, and replaced it without the experimenter or computer knowing whom it was (there were 5 possible suspects). Throughout the conditioning procedure (which was the same as Experiment 9), the program would periodically question the subject regarding the identity of this murderer, and they were told to deceive the program regarding their identity. It was anticipated that, as their conditioned response to instances of deception where the computer knew they were deceptive increased, they would exhibit stronger responses as well when deceptive on these generalization questions. The results from these experiments are discussed, as well as the practical and theoretical implications of their findings.

7.2 Summary of Results

7.2.1 Chapter 3 Summary

Experiment 1 tested whether subjects with higher previous punishment for swearing in their normal environment would rate swear words as more offensive than emotional and frequency and length matched control words. It found (not surprisingly) that swear words were scored as significantly more offensive than emotional or matched words. Emotional words, additionally, were scored as significantly more emotional than offensive or matched words. Questionnaire results for previous punishment for swearing, however, narrowly missed significantly impacting the offensiveness with which subjects rated swear words, making a connection between previous punishment for swearing and offensiveness ratings of swear words elusive. Swearing frequency, likewise, did not have an impact on offensiveness ratings.

Experiment 2 compared the arousal exhibited when speaking swear words to that exhibited when speaking emotional and control words. Results found that subjects had a significantly stronger skin conductance following swear words than both emotional and matched words. This supports previous findings that being shown taboo words elicits stronger arousal than control words (Dinn & Harris, 2000; Gray, Hughes, & Schneider, 1982), and expands upon it by showing the effect with speaking the words aloud. Given that a person is more likely to have been socially punished following swearing than simply seeing swear words printed, this is an important finding. Further research comparing the arousal exhibited when swearing to that exhibited when simply seeing swear words would be very interesting, as it would likely reflect this difference in punishment probabilities. Additionally, as would be expected from previous literature (Hill & Kemp-Wheeler, 1989) emotional words had significantly strong skin conductance responses than did matched words.

Experiment 3 used the same data from the previous experiments, and analyzed subject's skin conductance responses to swear words based on their scores on the punishment and frequency questionnaires discussed earlier. It found that past punishment caused a significantly higher skin conductance response following swear words, as had been predicted. This is the first known demonstration of this, making it an interesting addition to the literature regarding swearing and skin conductance (Harris et al., 2003). Swearing frequency, however, did not have a significant effect on skin conductance following swear words.

The results from this chapter suggest that engaging in a particular verbal behavior that is likely to have been punished in one's conditioning history (e.g. swearing) elicit stronger physiological arousal than engaging in similar behaviors that are not likely to have been punished (e.g. saying control words). Additionally, those who have been more punished for this undesirable behavior are likely to exhibit even stronger physiological arousal than those who have been less punished. These results support the notion that punishment in a person's past social conditioning will lead to increased physiological arousal when engaging in the behaviors that have been punished. Given that deception is another behavior likely to be punished in a person's normal conditioning history, it is sensible to suspect that the observed physiological arousal they exhibit when deceptive is related to this punishment. The results of this chapter draw an important link between the conditioning that people in our society receive, and the physiological arousal measured by the polygraph.

7.2.2 Chapter 4 Summary

Experiment 4 employed an eyeblink conditioning paradigm to test whether the truth-value of statements could serve as a conditioned stimulus. The results corroborated previous findings that it is possible to condition an eyeblink response to the truth-value of statements (e.g., El'kin, 1957; Fleming, Grant, & North, 1968). Over the course of training trials, subjects acquired a stronger eyeblink to false (CS+) than true (CS-) statements. The effect, however, did not seem to be as strong as that reported in the previous studies on this topic (e.g. Fleming, Grant, & North, 1968). One reason for this, it was surmised, might be that the previous studies used a longer time period between the statement presentation and the presentation of the airpuff (1900 ms rather than 1000 ms)- perhaps giving subjects more time to read the statement. Experiment 5 attempted to more closely replicate these experiments by employing a longer inter-stimulus interval of 2000 ms (2 seconds).

Experiment 5 found stronger eyeblink discrimination between false and true statements, but this discrimination develops very early in the session. As was discussed in Chapter 4, however, the responses acquired in this experiment appear more like operant avoidance responses than classically conditioned responses. The duration that the eye is closed, the rapidity of conditioning, and magnitude of discrimination all hint that these were operant responses to avoid the airpuff (see Martin, 1969). Experiment 6 further investigated this by testing the effect of a ratio UCS presentation and also attempting to use true statements as the conditioned stimulus, rather than just false statements. The results showed significant conditioning in the first 50 trials (continuous reinforcement) for both the false and true-statement reinforced conditions. Over the second 50 trials, however, in which only partial reinforcement was used, these responses dropped off drastically and there was no significant learning or discrimination.

The difficulties encountered using eyeblink conditioning were unexpected. The sensitivity to ISI, and the apparently operant nature of some of the responses made it difficult to interpret the results. There may be good reason for these difficulties if one looks at the nature of the eyeblink response. Given that most conditioning regarding eyeblink responses has very limited time between the CS and UCS (Kimble, 1968), these results are not so surprising (evolutionarily, the eyeblink response is meant to protect the eyes from things like objects flying at the face, etc.- complex stimuli (e.g. verbal stimuli) are seldom consistently paired with danger to the eyes specifically). Eyeblink conditioning might therefore only have limited effect with the verbal stimuli involved in this research, so later chapters returned to the use of physiological arousal, measured via skin conductance.

7.2.3 Chapter 5 Summary

In Chapter 5, a SCR conditioning paradigm employed to examine deception and some of its components as conditioned stimuli. Experiment 7 examined subjects' deception regarding these statements as a conditioned stimulus. The results of this experiment showed that for subjects where deception was the CS+, a strong discriminative skin conductance was observed for deception, but there was not a significant effect of conditioning block- indicating that this discrimination did not change significantly over trials. This suggests that subjects had an initial response to deception when the conditioning began, obscuring the effect of conditioning over trials. This is one of the first experiments known trying to accomplish this sort of conditioning to deception. The findings support the only other experiment attempting the use of deception as a conditioned stimulus: Jaffee, et al. (1966), and extend their results to apply to skin conductance as well as eyeblink. No significant discrimination was seen in subjects reinforced following truthful trials. This indicates that deceptive responses are more readily conditioned to elicit a physiological response than truthful responses. Considering that each subject likely already had a history of conditioning regarding deceptive responses, this is understandable.

Experiment 8 followed up Experiment 7 by testing whether the truth-value alone of the statements used could serve as a conditioned stimulus in this paradigm, as was done in Experiments 4, 5, and 6 with eyeblink responses. The results suggest that, regardless of whether true or false, the truth-value alone of presented statements does not serve as a strong conditioned stimulus. No significant effects were found in either group. This result is in contrast the results of Experiments 4, 5, and 6, and other previous research that has used truth-value as a conditioned response in eyeblink research (e.g., El'kin, 1957; Fleming, Grant, & North, 1968), and the discussion early regarding the potential operant nature of the eyeblink responses acquired is relevant.

Perhaps even more curious is the implication for deception. While we were able to condition a strong skin conductance response to deception, we were not able to do so to the truth-value of the same statements. This is a very curious effect, given that the truth-value of a statement is a necessary component to what makes a response deceptive (e.g. the statement "the cat is in the dustbin" is neither truthful nor deceptive considered independently of the fact whether the cat is actually in the dustbin) (see Chapter 4 for full discussion of truth-value). If this truth-value has no impact on the classically conditioned response, it must be something more directly about the behavior itself that allows deception to become a conditioned stimulus in such situations. This will be returned to shortly.

7.2.4 Chapter 6 Summary

Following on Experiments 7 and 8 (Chapter 5), Experiments 9 and 10 (Chapter 6) further explored the conditioning of a skin conductance response to deception using an internally consistent context for deception. Experiment 9 examined subject's performance in acquiring a conditioned skin conductance response over 60 conditioning trials. Subjects in the normal shock condition acquired a significantly higher discriminatory response to their own deceptive responses over the course of conditioning than did subjects in the control condition. Ratio UCS presentation did not have a significant influence on the responses acquired. These results support the findings of Experiment 7 and the limited previous research showing that deception can serve as a conditioned stimulus (Jaffee, Millman, and Gorman, 1966), and expand upon them by showing that deception can serve as a conditioned stimulus in an artificial context without personal and situational implications. Experiment 10 tested the generalization of responses like those acquired in Experiment 9 to instances of deception that only the subject knew about. The conditioning trials from this experiment further supported the results from Experiments 7 and 9, with a strong conditioned response to deception being acquired. The generalization trials also showed a significant discrimination between deceptive and truthful trials, but only so for the trials on which subjects deceptively claimed an innocent subject was guilty, not when they deceptively said that the guilty subject was innocent. This expands on previous findings by providing evidence that the conditioned responses acquired can generalize to new instances of deception regarding different topics and levels of public knowledge.

7.3 Theoretical Implications

7.3.1 The effect of punishment on deception as a CS

According to the OTA (1983) and NRC (2003) a primary reason for the limited success of lie detection is the lack of a solid scientific explanation for the physiological responses it measures. Previous methods of lie detection have relied upon the assumption that deception is accompanied by increased physiological arousal, but little work has been done to understand the direct cause for this association.

The 'fear of detection' theory (see section 1.2.3.1, Chapter 1) states that a person exhibits physiological arousal when they are deceptive because they are afraid of getting caught and punished. This theory is supported by research into the situational variables that influence the accuracy of the polygraph (see section 1.3, Chapter 1). For example, the greater the consequences of being caught the more easily a person's deception is detected via their physiological responses (Howlitze, & Raskin, 1988; Bradley & Warfield, 1984; Elaad & Ben-Shakhar, 1989). On the assumption that greater motivation to deceive translates into greater fear of being detected, this supports the fear of detection theory.

While the 'fear of detection' theory is useful for predicting the situations in which the polygraph is likely to have more accurate results, this is the limit of its utility. This theory, in its explanatory depth, does not go beyond the situation in which the polygraph is administered, and only seems to by its reference to internal events as explanatory mechanisms. It posits "fear" as the cause of the response measured by the polygraph, but it does not explain where this "fear" comes from. The only reference to the outside of the organism it makes is the immediate situation that causes the fear, but the real question is how the situation and situations like it have come to cause fear. The origin of these responses must eventually be traced back to the conditioning history of the individual. It is in this history that the causes of the responses measured by the polygraph are to be found. Without looking at these causes, we can never hope to control or improve the responses that the polygraph relies upon, and never hope to improve the polygraph or similar methods.

Skinner (1953) proposed that the physiological responses that a person exhibits when they are deceptive are the "emotional effects of the conditioned stimuli aroused by punished behavior" (Skinner, 1953, pg. 187). On this theory, it is the previous punishment that has followed deception and the situations in which deception occurs that causes a person to exhibit physiological arousal when they are deceptive. While both theories refer to punishment in their explanations, the fear of detection theory refers to potential *future* punishment, whereas Skinner refers to *past* punishment.

The results from Experiments 2 and 3 (Chapter 3) of the present thesis demonstrated that the previous punishment a person exhibits in their natural environment can cause an increased physiological response when engaging in similar verbal behavior. This supports Skinner's assertion that past punishment in a person's conditioning history can translate into physiological arousal. This provides an important link between physiological arousal in a particular setting, and the general conditioning people receive in their normal environment- a link that later chapters would rely on in explaining the responses exhibited during deception. People are often punished for swearing, and as seen in Chapter 3 (Experiment 2), have an increased skin conductance response when they swear, and greater previous punishment causes greater skin conductance (Experiment 3). People are often punished for being deceptive, and as seen in the polygraph have an increased skin conductance response when they are deceptive.

The results of experiment 7 (Chapter 5) and experiments 9 and 10 (Chapter 6) provided further evidence for this theory by showing that a skin conductance response can be conditioned to instances of deception in a laboratory setting. When paired with a mild electric shock, deception becomes a conditioned stimulus for increased physiological arousal. This provides a direct mechanism by which the punishment a person receives in their social environment can cause a tendency to have increased arousal when they are deceptive, which is then picked up by devices such as the polygraph. Whereas the 'fear of detection' theory relies on immediate situational variables to explain why a person would be afraid of being caught, and hence have increased arousal, these experiments conditioned a response to deception in the absence of any situational variables that would tend to increase the arousal a person exhibits when deceptive. There was practically no motivation to deceive, no mock crime was employed, and the subjects used were students who had no vested interest in beating the machine. Despite relatively poor situational variables from the perspective of polygraph accuracy, a strong skin conductance response to deception was acquired.

7.3.2 Components of deception

As was discussed in Chapter 4, strongly related to the topic of deception is the truth or falsity of statements. Truth-value is a component of deception. This raises the question of whether the simple truth-value of statements can itself serve as a conditioned stimulus. This question was addressed in the present thesis using two different types of conditioned responses. Experiments 4, 5, and 6 (Chapter 4) examined whether truth-value can serve as a conditioned stimulus in an eyeblink conditioning paradigm, and experiment 7 (Chapter 5) examined whether it can serve as a conditioned stimulus in skin conductance conditioning paradigm. Taken together, these experiments provided mixed results. The eyeblink conditioning paradigm provided some evidence that truth-value can serve as a conditioned stimulus, corroborating previous findings (El'kin, 1957; Fleming, Grant, & North, 1968). Experiment 7 (Chapter 5), however, found no evidence that truth-value can serve as a conditioned stimulus for a skin conductance response. As discussed in Chapter 5, there is reason to err on the side of the Experiment 7 in this case. Eyeblink responses can be operantly as well as classically controlled by the environment (they can be "voluntary" as well as "involuntary"), whereas skin conductance responses cannot. Given that the truth-value of statements is a discriminative stimulus for much operant behavior, it is very possible that the responses acquired in Experiments 4, 5, 6 (Chapter 4), as well as in previous findings by other researchers, were operant responses. This is supported by the demonstrated effect of statement duration on the responses acquired in those experiments. The skin conductance results of Experiment 7, however, are not susceptible to such a criticism, and hence should be trusted in this case. This leaves us with the final conclusion from the results here that it is unlikely that the truth-value of statements can become a purely classical conditioned stimulus over the course of one training session. This makes sense, considering that such a classically conditioned response would have little practical value.

Another issue flagged by the examination of the components of deception in this thesis is the past conditioning histories involved in each component studied. As was mentioned in earlier chapters (e.g. section 5.4, Chapter 5), each of the verbal stimuli used in this thesis came with previous conditioning histories, and in fact relied upon those histories for their capacity to become conditioned stimuli. The core argument of this thesis is that deception is punished in a person's natural social environment and this leads to a conditioned physiological response when it is engaged in. Hence, when we attempt to condition a skin conductance response to deception in the laboratory (as in Experiments 7, 9, and 10), we are not starting with a neutral conditioned stimulus. This explains why in these experiments we were able to acquire significant discrimination between the responses to truthful and deceptive answers, but often not a significant change in this discrimination over trial block. Subjects already had some discrimination to their own deception, and hence it was difficult to show them *acquiring* such discrimination. This problem was overcome by using control groups, and showing a difference between conditioning subjects and controls (e.g., see especially Experiments 9 and 10 (Chapter 6)). This problem does have broader implications, however. In summary, people have skin conductance responses to their own deception, which are learned over many years of social conditioning, and which are difficult to overturn in a few hours of laboratory conditioning. The comparison of truthful vs. deceptive responses in Experiment 7 (Chapter 5) demonstrates exactly how difficult it is to override this previous conditioning. Whereas deception readily served as a conditioned stimulus when paired with the unconditioned stimulus, truthful responses did not. For practical purposes, it may be difficult to override this previous conditioning when attempting to create new responses for use in lie detection, and we may have to always settle for improving and building upon the previously conditioned responses already established.

An interesting topic raised by the difference between deception and false statements is that of wrong statements. In a sense, there is little difference between uttering a statement that is wrong and uttering one that is deceptive, as both involve false statements. In terms of consequences, however, there is a very real difference. Each time a child says something that is false, or untrue, they are more likely to be corrected than to be punished for being deceptive. While being corrected is likely aversive, especially if it is done in a public manner, it is arguable whether such correction can condition being wrong to be a conditioned stimulus for physiological arousal, as is done in deception. One reason for this is that people "know" when they are being deceptive, but not necessarily when they are being wrong. When one is corrected following an inaccurate statement, it is often surprising- as it was not suspected that the statement was false until it was corrected. When one is deceptive, however, they often anticipate that a very real consequence might be being detected and challenged on it. This difference in consequences between deceptive and wrong statements might be what shapes them as different classes of stimuli in verbal behavior.

7.3.3 Differences between experimental and real-life conditioning

The conditioning in this thesis regarding deception occurred primarily in a laboratory. As with all laboratory research, this raises questions regarding the similarity between the conditioning used in these studies and the sorts of conditioning that might surround "real-life" instances of deception. There are at least two ways in which the conditioning here necessarily differs from real-life conditioning that would surround deception: the nature of the consequences following the deception and the temporal relationship between the deception and the consequences. These will each be addressed separately.

7.3.3.1 Nature of punishing consequences

In real life instances of deception, the punishment following deception is probably as varied as the deception itself. Whereas in the laboratory, the same punishment followed each instance of deception (a mild electric shock of almost exactly the same magnitude), in real life each instance of deception will be followed by unique punishment. From the spanking of a parent to the loss of trust with a spouse (Cole, 2001), each instance of deception will have its own consequence. There are converging lines of evidence that variation in the punishing consequences for a behavior can impact the conditioned responses (McSweeney, Swindell & Weatherly, 1996; Rescorla, R.A., 1980).

7.3.3.2 Temporal relation between deception and punishment

In real life instances of deception, it is probably rare that punishment consistently follows 3 to 5 seconds following each instance of deception. Depending upon the occurrence of deception, it might come instantly- as when one is instantly challenged on a statement they make in an aggressive tone, to when one is addressed days later for an instance of deception that has only now been discovered. There is wide variation in the temporal relationship between deception and punishment in everyday life. This is a problem, as the effect of conditioning is highly influenced by the temporal relationship between the conditioned and unconditioned stimuli (Skinner, 1938; Pavlov, 1927). If there is a gap between the deception and the punishment, the effect of the punishment in developing a conditioned response to the deception is decreased.

In explaining this, however, there are two important facts to take into account: First, it is noteworthy that in children the punishment for deception probably comes more rapidly that for adults. Children are notoriously bad at lying, and easy to catch (Talwar & Lee, 2002). Hence their instances of deception are caught out and punished as rapidly as other undesirable verbal behaviors. This might provide an initial conditioning that is later diversified as they become better at deceiving and the consequences become more delayed and intermittent.

A second important note is that there are likely many other conditioned stimuli associated with the punishment that follows deception, and can bridge the temporal gap between instances of deception and punishment. Between the actual instance of deception and the punishment that follows if it is detected there are numerous events that will become conditioned stimuli for future emotional responses based on their association with the punishment to come. Facts emerging that contradict a deceptive story, looks of distrust from one lied to, awkward silence, repetitious asking of the same questions, all become subtle cues over the course of ones conditioning that one is not being believed, and hence punishment is likely.

7.4 Future Research

The present thesis has explored the responses measured by the polygraph as conditioned stimuli, linking them to potential events in the past of the individual that may have caused them. This is useful in presenting a new way of looking at lie detection procedures to date, and challenging the practice of passively using responses that already exist to measure deception. The implication of the present research is that these responses can be modified, and potentially improved. For interventions to be developed to improve the accuracy of lie detection methods, however, a great deal of research must further examine the contingencies surrounding natural instances of deception, and improving the strength and generalization of the responses acquired in the laboratory.

7.4.1 Future research into natural deception

The present research only scratched the surface of the intricate ways in which punishment in individual's environment can lead to the highly context sensitive physiological arousal measured by the polygraph (e.g., see section 1.4.1, Chapter 1). While the goal of the present thesis was simply to demonstrate the basic mechanism by which deception can become the conditioned stimulus for a physiological response, there are countless other conditioned stimuli in the environment of any deceptive response that overlap onto this response- either strengthening or weakening it. As mentioned in section 1.4.2 of Chapter 1, for example, the presence of an authority figure becomes one such stimulus- mediating the physiological arousal observed. It could be argued that the presence of an authority figure in itself serves as a conditioned aversive stimulus, implying that any punishment received will be greater (e.g. Milgram, 1963). Research into the ways in which other stimuli come to mediate the conditioned response a person exhibits to their own deception would be highly valuable for the potential practical improvements it might offer to lie detection.

7.4.2 Future research into improving the deception response

7.4.2.1 Improving strength of deception response

The terminal discrimination acquired in the experiments in this thesis between deceptive and truthful responses was adequate for demonstrating the effect of conditioning, but unfortunately it usually fell short of what would be required to practically detect the subject's deception. The experiments employed in this thesis used many, e.g. Experiments 9 used 48 subjects, whereas for the purposes of practical lie detection the individual subject is important. As argued by NRC (2003, pg. 160), we cannot hide behind participant numbers in lie detection research. The result is that, while the results of the current experiments were very encouraging, future research will need to shift from trying to demonstrate the effect of conditioning to looking at results in terms of accuracy- and comparing this accuracy to other methods of lie detection. Within the scope of intervention-accuracy research, there are several obvious variables that can be manipulated to test their impact. Among these variables are the number of conditioning trials used (Papka & Woodruff-Pak, 1996), the UCS ratio employed (Pavlov, 1927), the magnitude of the UCS (Wieland et al., 1963) and whether this magnitude remains constant or is made variable, and even the use of several different types of UCS in conjunction. It may be that careful manipulation of these variables and finding an optimal balance produces a conditioned response consistent and strong enough to be relied upon to infer deception.

7.4.2.2 Improving generalization of deception response

As seen in Experiment 10 (Chapter 6), the generalization of the conditioned skin conductance response to deception was not ideal. The response conditioned to instances of deception where the experimenter knew the true answer did not seem to generalize effectively to instances of deception where the experimenter didn't know the true answer. This is a very important point, perhaps the most important in the thesis- as all lie detection hinges on the barrier between what is objectively known and what is known only to the examined individual (Wolpe, Foster & Langleben, 2005). On the assumption that a strong discriminative response can be conditioned to deception using the methods discussed in the previous section, this response would be useless if it was only elicited by instances of deception that the experimenter/examiner already knew were deceptive. Somehow, it must be generalized to instances of deception that the examiner *does not know* are deceptive, and that the subject knows the examiner does not know are deceptive.

In traditional polygraph tests, something like this is done with what are called "stim-tests" (Saxe, Dougherty & Cross, 1985). A "stim-test" is basically an accuracy demonstration to the subject prior to a polygraph test, showing them that the test can detect lies even when the polygraph examiner doesn't know the true answer (Reid & Inbau, 1966). For example, in one stim-test in which a deck of cards is used, and the examiner tricks the subject into thinking they don't know which card the subject drew by using a deck of cards loaded with only that card. Then, the examiner credits the polygraph readings with telling them when the subject was deceptive regarding which card they had drawn. In this manner, the polygraph examiner attempts to generalize the subject's conditioned physiological responses to instances of deception that the subject believes the examiner to not know- with the basis that the machine will know regardless. In a sense, this demonstration is meant to extinguish the examiner's knowledge as discriminative stimulus in determining the occurrence of the conditioned physiological response to deception.

A similar procedure could be used in the conditioning methods described in Experiment 10. If partial knowledge is known of the murder suspect, this partial knowledge could be used to continue delivering the UCS on some generalization trials, and withholding it on others. This would greatly "blur the line" between what the experimenter knows and doesn't know, potentially allowing greater generalization of the response. Future research should try methods such as this to improve the generalization acquired to unknown instances of deception, while also utilizing methods like those described in the previous section.

Another type of generalization required for this research to be put into practical application for lie detection is the topic the deception is regarding. The deception in the previous experiments was regarding relatively contrived topics, such as murderers in Cluedo-type scenarios. If a conditioned response to deception acquired regarding these sorts of topics were then measured following instances of deception regarding a real-life crime investigation, the generalization of the response would probably suffer in proportion to the difference between the topics of deception (see Skinner, 1953 for a discussion of generalization and shared properties of stimuli). As was seen in Chapter 6, this is a potential confounding variable in Experiment 10, as the murder suspects were dissimilar to those used in the conditioning trials. How much greater would the lack of generalization be if applied to bits of information the subject had learned prior to the conditioning altogether, such as a car they had seen the previous week? As a rough sort of estimate, it is expected that future research will find that for a conditioning method to be used in practical lie detection, the sorts of questions used in the deception conditioning will have to be tailored in each case to fit the sort of target questions that will be asked in the actual examination, thereby limiting the differences across which generalization must occur.

7.5 Concluding Comments

The current research has implications for the traditional polygraph. As is often the case with practical methods, the polygraph has adapted to acquire the best results it can, given its initial assumptions. Without an understanding of how previous punishment has shaped the responses it uses, it relies on techniques (e.g. the "stim-tests" mentioned above) that maximize the similarities between the situation in which the subject is examined and previous situations in which their deception has been punished. Interrogation-type questioning, demonstrations of accuracy, and challenging of the subject's veracity are all calculated to make the subject feel like punishment is imminent if they are deceptive. The 'fear of detection' theory works to explain how these methods might strengthen the results acquired by the polygraph, but offers only indirect explanation of the origins of these responses. It does not provide an adequate explanation for why subjects actually have physiological arousal when they are deceptive. Reference to an internal state ("fear") masks the situational contingencies required to shape these responses to deception. As has been argued throughout this thesis, this is inadequate, and the polygraph has gone as far as it possibly can using these assumptions.

By showing that deception can become a conditioned stimulus, the work presented here provides a behavioral mechanism that bridges the gap between deception and physiological arousal. This is an important step forward, as a lack of understanding the cause of the responses relied upon by the polygraph has been a main reason for its failure to advance. If lie detection is to advance, it must begin looking into the modification and improvement of the responses it uses, not simply new ways to passively measure them. The next step in this research should be to apply the conditioning procedures developed in this thesis to mock-crime scenarios, testing whether exposure to a short conditioning session can improve the effectiveness of subsequent polygraph examination. There is reason to believe that the results could be significantly improved. Additionally, it was found in conducting the present studies that whether or not a particular subject will be a "good conditioner" could usually be guessed at with some accuracy within the first 30 trials of conditioning. Possibilities such as this will become an empirical question when this research is turned towards practical application.

References

Allen, J. J. & Iacono, W. J. (1997). A comparison of methods for the analysis of event-related potentials in deception detection, Psychophysiology, 34, 234-240.

Andrewartha, D. (2008). Lie detection in litigation: Science or prejudice? *Psychiatry Psychology and Law*, 15(1), 88-104.

Azrin, N. H. (1960-A). Sequential effects of punishment. *Science*, 131, 605-606.

Azrin, N. H. (1960-B). Effects of punishment intensity during variable-interval reinforcement. *Journal for the Experimental Analysis of Behavior*, 3(2), 123-142.

Balsam, P., & Bondy, A. (1983). The negative side effects of reward. *Journal of Applied Behavior Analysis*, 16, 283–296.

Bell, B. G., Kircher, J. C., & Bernhardt, P. C. (2008). New measures to improve the accuracy of the directed-lie test when detecting deception using a mock crime. *Physiology & Behavior*, 94, 331–340.

Bitter, R., Mohiuddin, T., & Nawrocki, M. (2007). *LabView: advanced programming techniques (2nd ed.)*. Boca Raton, FL: CRC Press/Taylor & Francis Group.

Bradley, M. T., & Janisse, M. P. (1981). Accuracy demonstrations, threat, and the detection of deception: Cardiovascular, electrodermal, and pupillary measures. *Psychophysiology*, 18, 307-314.

Bradley, M. T., & Warfield, J. F. (1984). Innocence, information, and the guilty knowledge test in the detection of deception. *Psychophysiology*, 21, 683-689.

Brown, R. T. & Wagner, A. R. (1964) Resistance to punishment and extinction following training with shock or nonreinforcement, *Journal of Experimental Psychology*, 68(5), 503-507.

Bull, R., Baron, H., Gudjonsson, G., Hampson, S., Rippon, G. & Vrij, A. (2004). *A review of the current scientific status and fields of application of polygraphic deception detection.* London: British Psychological Society.

Campbell, J. (2001). *A Liar's tale: A history of falsehood.* New York, NY: WW Norton and Co.

Cole, T. (2001). Lying to the one you love: the use of deception in romantic relationships. *Journal of Social and Personal Relationships*, 18(1), 107-129

Darwin, C. (1871). *The Descent of Man, and Selection in Relation to Sex.* London: John Murray.

Davidson, R. J. (2002) Anxiety and affective style: Role of prefrontal cortex and amygdala, *Biological Psychiatry*, 51, 68-80.

Davis, E. (1943). A study of wild and hand reared killdeers. *The Wilson Bulletin*, 55(4), 223-233.

Dawson, M., & Furedy, J. (1976). The role of awareness in human differential autonomic classical conditioning: The Necessary-Gate Hypothesis. *Psychophysiology*. 13(1), 50-53.

Dawson, M.E., Schell, A. M., & Filion, D. (1990). The Electrodermal System. In J. T. Cacioppo & L. G. Tassinary (Eds.), *Principles of Psychophysiology: Physical, social, and inferential elements* (pp. 295-324). Cambridge, U.K.: Cambridge University Press.

Depaulo, B. M., Kashy, D. A., Kirkendol, S. E., Wyer, M. M. & Epstein, J. A. (1996). Lying in everyday life. *Journal of Personality and Social Psychology*, 70(5), 979-995.

Dickens, C. (1859). *A Tale of Two Cities.*

Dinn, W. M., & Harris, C. L. (2000). Neurocognitive function in antisocial personality disorder. *Psychiatry Research, 97,* 173–190.

Ekman, P., O'Sullivan, M., Friesen, W. V. & Scherer, K.R. (1991) Face, voice, and body in detecting deceit. *Journal of Nonverbal Behavior*, 15, 125-135.

Elaad, E., & Ben-Shakhar, G. (1989). Effects of motivation and verbal response type on psychophysiological detection of information. *Psychophysiology*, 26, 442-451.

El'kin, D.G. (1957). On conditioned reflexes to complex verbal stimuli in school children. In B. G. Ananyev, A. N. Leontiev, A. R. Luria, N. A. Menuinshkaia, C. L. Rubenstein, A. A. Smirnov, & B. M. Teplov (Eds.; translated by I. Raisler), *Materials of the Conference on Psychology* (p. 370-379), Moscow: Akad. Pedag. Nauk., RSFSR.

Ennis, E. (2008). Indiividual differences and lying in everyday life. *Journal of Social and Personal Relationships*, 25(1), 105-118.

Farwell, L. A. & Donchin, E. (1991) The truth will out: Interrogative polygraphy ("lie detection") with event-related potentials, *Psychophysiology*, 28, 531-547.

Ferenczi, S. (1916). *Contributions to psychoanalysis.* Boston: Badger.

Fisher, G. (1997). The jury's rise as lie detector. *Yale Law Journal*, 107, 3, 575-713.

Fleming, R. A., Grant, D. A., & North, J. A. (1968). Truth and falsity of verbal statements as conditioned stimuli in classical and differential eyelid conditioning. *Journal of Experimental Psychology*, 78(1), 178-180.

Fleming, R. A., Grant, D. A., North, J. A., & Levy, C. M. (1968). Arithmetic correctness as the discriminandum in classical and differential eyelid conditioning. *Journal of Experimental Psychology*, 77(2), 286-294.

Ford, E. B. (2006). Lie Detection: Historical, neuropsychiatric, and legal dimensions, *International Journal of Law and Psychiatry*, 29, 159-177.

Furedy, J. J. (1986). Lie detection as psychophysiological differentiation: some fine lines. In: Coles, M., Donchin, E., Porges, S.W., *Psychophysiology: Systems, Processes, and Applications: A Handbook* (pp 683-701). Guilford, New York.

Hill, A. B., & Kemp–Wheeler, S. M. (1989). The influence of context on lexical decision times for emotionally aversive words. *Current Psychology: Research and Reviews,* 8, 219–227.

Grant, D. A. (1972). A preliminary model for processing information conveyed by verbal conditioned stimuli in classical conditioning. In A.H. Black & W.F. Prokasy (Eds.), *Classical Conditioning II: Current Theory and Research* (pp 28-63). New York, NY: Appleton-Century-Crofts.

Gray, S. G., Hughes, H. H., & Schneider, L. J. (1982). Physiologial responsivity to a socially stressful situation: The effect of level of moral development. *Psychological Record, 32,* 29–34.

Greene, William A., & Sutor, L. (1971). Stimulus control of skin resistance on an escape-avoidance schedule. *Journal of the Experimental Analysis of Behavior*, 16, 269-274.

Grezes, J., Frith, C. D. & Passingham, R. E. (2004). Inferring false beliefs from the actions of oneself and others: an fMRI study. *Neuroimage*, 21, 744-750.

Gustafson, L. A. & Orne, M. T. (1963). Effects of heightened motivation on the detection of deception. *Journal of Applied Psychology*, 4, 408-11.

Hall, G., & Honey, R. C. (1990). Context-specific conditioning in the conditioned-emotional-response procedure. *Journal of Experimental Psychology: Animal Behavior Processes*, 16(3), 271-278.

Hake, D. F. & Azrin, N. H. (1965). Conditioned Punishment. *Journal of the Experimental Analysis of Behavior*, 8(5), 279-293.

Harris, C., Aycicegi, A. & Gleason, J. B. (2003). Taboo words and reprimands elicit greater autonomic reactivity in a first than a second language. *Applied Psycholinguistics* 24, 561-579

Hill, A. B., & Kemp–Wheeler, S. M. (1989). The influence of context on lexical decision times for emotionally aversive words. *Current Psychology: Research and Reviews,* 8, 219–227.

Hoogstraten, J. & Terwogt-Kouwenhoven, K. M. (1997). Situational determinants of the acceptability of telling lies. *Journal of Applied Social Psychology*, 27(12), 1048-1062.

Howell, D. C. (1997). *Statistical methods for psychology*. New York: Duxbury.

Iacono, W. G. (2001). "Forensic 'Lie Detection': Procedures without scientific basis. *Journal of Forensic Psychology Practice,* 1, 75-86.

Jay, T., & Janschewitz, K. (2008). The pragmatics of swearing. *Journal of Politeness Research*, 4, 267-288.

Jay, T., King, K. & Duncan, T. (2006). College students' memories of punishment for cursing. *Sex Roles,* 32, 123-133.

Jaffee, C. L., Millman, E., & Gorman, B. (1966). An attempt to condition an eyeblink response to verbal deception. *Psychological Reports*, 19, 421-422.

Johnson, M. M. & Rosenfeld, J. P. (1992) Oddball-evoked P300-based method of deception detection in the laboratory. II: Utilization of non-selective activation of relevant knowledge. *International Journal of Psychophysiology*, 12, 289-306.

Kashy, D. A., Depaulo, B. M. (1996). Who lies?. *Journal of Personality and Social Psychology*, 70(5), 1037-1051.

Kimble, G. A. (1961). *Hilgard and Marquis' Conditioning and Learning*. Appleton-Century-Crofts, Inc., New York.

Kircher, J. C., Horowitz, S. W., & Raskin, D. C. (1988). Meta-analysis of mock crime studies of the control question polygraph technique. *Law and Human*, 12, 79-90.

Leech, G., Rayson, P. & Wilson, A. (2001). *Word frequencies in written and spoken english: based on the British National Corpus*. London. Longman.

Lykken, D. T. (1981). *Tremor in the Blood – Uses and abuses of the lie detector*, New York: McGraw-Hill Publishing Co.

MacLaren, V.V. (2001). A quantitative review of the guilty knowledge test. *Journal* *of Applied Psychology*, 86, 674-683.

Macphail, E. M., Reilly, S. & Good, M. (1992). Long-term memory of pigeons for stimulus-outcome associations involving multiple stimuli, each seen in a single brief trial. *Quarterly Journal of Experimental Psychology, 45B,* 81-98.

Mandler, G., Preven, D., & Kuhlman, C. (1962). Effects of operant reinforcement on the GSR. *Journal of the Experimental Analysis of Behavior*, 5, 317-321.

Martin, Irene & Levy, A. B. (1969). *The genesis of the classical conditioned response*. Oxford: Pergamon Press.

McGinnies, E. (1949). Emotionality of perceptual defense. *Psychological Review, 56,* 244–251.

McHugh, L., Barnes-Holmes, Y., Barnes-Holmes, D., Whelan, R., & Stewart, I. (2007). Knowing me, knowing you: Deictic complexity in false-belief understanding. *Psychological Record*, 57(4), 533-542.

McSweeney, F. K., Swindell, S., & Weatherly, J.N. (1996). Within-session changes in responding during concurrent schedules with different reinforcers in the components. *Journal of the Experimental Analysis of Behavior*, 66, 369-390

Milgram, S. (1964). Behavioral study of obedience. *Journal of Abnormal and Social Psychology*, 67(4), 371-378.

Moeller, G. (1954). The CS-UCS intervals in GSR conditioning. *Journal of Experimental Psychology*, 48(3), 162-166.

National Research Council. (2003). *The polygraph and lie detection.* Committee to Review the Scientific Evidence on the Polygraph. Division of Behavioral and Social Sciences and Education. Washington, D.C.: The National Academies Press.

Orne, M. T., Thackray, R. I., & Paskewitz, D. A. (1972). On the detection of deception: A method for the study of the physiological effects of psychological stimuli. In N. Greenfield, & R. Sternbach (Eds.), *Handbook of Psychophysiology*, pp. 743-785. New York: Holt, Rinehart, & Winston.

Palermo, G. B., Perracuti, S., & Palermo, M. T. (1996). Malingering a challenge for the forensic examiner. *Medicine and Law*, 15, 1, 143−160.

Papka, M, & Woodruff-Pak, D.S. (1996). Number of trials needed to assess human eyeblink classical conditioning. *Psychology and Aging*, 11(2), 373-376.

Pavlidis, I., Eberhardt, N. L. & Levine, J. (2002). Human behavior: Seeing through the face of deception. *Nature*, 415, 35.

Pavlov, I. P. (1927). *Conditioned Reflexes: An investigation of the physiological activity of the cerebral cortex.* Translated and Edited by G. V. Anrep. London: Oxford University Press.

Podlesny, J. A., & Raskin, D. C. (1977). Physiological measures and the detection of deception. *Psychological Bulletin*, 84, 782-799.

Pollina, D. A. & Ryan, A. (2002). *The Relationship between facial skin surface temperature reactivity and traditional polygraph measures used in the psychophysiological detection of deception: A preliminary investigation.* U.S. Department of Defense Polygraph Institute, Ft. Jackson, SC.

Pollina, D., Dollins, A., Senter, S., Brown, T., Pavlidis, I., Levine, J., & Ryan, A. (2006). Facial skin surface temperature changes during a concealed information test. *Annals Biomed.* 34, 7, 1182-1189.

Purkis, H.M., & Lipp, O. V. (2001). Does Affective Learning Exist in the Absence of Contingency Awareness? *Learning and Motivation*, 32, 84–99.

Reid, J.E., & Inbau, F.E. (1966). *Truth and deception: the polygraph (Lie-detector) technique*. Baltimore: Williams & Wilkins Co.

Rescorla, R. A. (1980) *Pavlovian second-order conditioning: Studies in associative learning*. New Jersey: L. Erlbaum Associates.

Russow, L. (1986). Deception: A Philosophical Perspective. In R.W. Mitchell & N.S. Thompson (Eds.), *Deception, perspectives on human and nonhuman deceit*, Albany: State University of New York Press.

Sartori G., Agosta S., Zogmaister C., Ferrara S. D., & Castiello U. (2008). How to accurately assess autobiographical events. *Psychological Science*, 19, 772–780.

Saxe, L., Dougherty, D. & Cross, T. (1985). The validity of polygraph testing: Scientific analysis and public controversy. *American Psychologist, 40,* 355–366.

Schrauf, R. W. (2000). Bilingual autobiographical memory: Experimental studies and clinical cases. *Culture and Psychology, 6,* 387–417.

Shah, N.J., Marshall, J. C., Zafiris, O., Schwab, A., Zilles, K., Markowitsch, H.J. & Fink, G.R. (2001) The neural correlates of person familiarity: A functional magnetic resonance imaging study with clinical implications. *Brain,* 124, 804-815.

Skinner, B. F. (1938). *Behavior of organisms- An Experimental analysis*. New York: Appleton-Century-Crofts, Inc.

Skinner, B. F. *(1953). Science and human behavior.* New York. The Free Press (A Division of Simon & Schuster Inc.)

Skinner, B. F. (1957). *Verbal behavior.* Cambridge: Prentice-Hall, Inc.

Smith, C., Clark, R., Manns, J. & Squire, L. (2005). Acquisition of differential delay classical conditioning is independent of awareness. *Behavioral Neuroscience*, 119(1), 78-86.

Sullivan, E. (2001). *The concise book of lying.* New York: Farrar, Straus and Giroux.

Sullivan, J. F. (2007). *Gatekeeper: Memoirs of a CIA Polygraph Examiner.* Washington, DC: Potomac Books, Inc.

Talwar, V. & Lee, K. (2002). Development of lying to conceal a transgression: children's control of expressive behavior during verbal deception. *International Journal of Behavioral Development.* 26(5), 436-444.

Taylor, J., Scott, C. R., Iacono, W. G., Lykken, D. T., & McGue, M. (1999). Individual differences in electrodermal responsivity to predictable aversive stimuli and substance dependence. *Psychophysiology*, 36, 193–198.

Tracy, J., Ghose, S., Stecher, T, McFall, R., & Steinmetz, J. (1999). Classical conditioning in a nonclinical obsessive-compulsive population, *Psychological Science.* 10, 9–13.

Travis, J. & Kring, J. (2007). *LabView for everyone (third ed.).* Crawfordsville, IN: Pearson Education, Inc.

Tsiamyrtzis, P., Dowdall, J., Shastri, D., Pavlidis, I. T., Frank, M. G., & Ekman, P. (2007). Imaging facial physiology for the detection of deceit. *International Journal of Computer Vision.* 71(2), 197–214.

Tsivilis, D., Otten, L. J., & Rugg, M.D. (2001). Context effects on the neural correlates of recognition memory: An electrophysiological study, *Neuron,* 16 , 497-505.

U.S. Congress. Office of Technology Assessment. "*Scientific Validity of Polygraph Testing: A Research Review and Evaluation.*" Washington, DC: OTA-TM-H-15. November, 1983.

Vaughan, W. & Greene, S. L. (1984). Pigeon visual memory capacity. *J. Exp. Psychol.: Anim. Behav. Process.* 10, 256–271.

Vrij, A. (2008). *Detecting lies and deceit: Pitfalls and opportunities.* London, Wiley.

Waid, W. M. (1976). Skin conductance response to punishment as a predictor and correlate of learning to avoid two classes of punishment. *Journal of Abnormal Psychology*, 85(5), 498-504.

Waid, W. M., Orne, M. T., & Wilson, S.K. (1979). Effects of level of socialization on electrodermal detection of deception. *Psychophysiology*, 16, 15-22.

Walczyk, J. J., Schwartz, J.P., Clifton, R., Adams, B., Wei, M., & Peijia, Z. (2005). Lying person-to-person: A cognitive framework for lie detection. *Personnel Psychology*, 58, 141-170.

Waln, R. F., & Downey, R.G. (1987). Voice stress analysis: Use of telephone recordings. *Journal of Business and Psychology*, 1, 379-389.

Wang, C., & Leung, A. (2010). The cultural dynamics of rewarding honesty and punishing deception. *Personality and Social Psychology Bulletin*, 36(10), 1529-1542.

Watson, J. B., & Rayner, R. (1920). Conditioned emotional reactions. *Journal of Experimental Psychology*, 3, 1-4.

Wieland, W. F., Stein, M, & Hamilton, C., (1963). Intensity of the unconditioned stimulus as a factor in conditioning out of awareness. *Psychosomatic Médecine*, 25, 124-132.

Wischner, G. J., & Gladis, M. T. (1969). Rate of formation of associations by schizophrenic and normal subjects as a function of stimulus or response placement of aversive components. *Psychological Reports, 25,* 599–605.

Wolpe, P. R., Foster, K, & Langleben, D. D., (2005). Emerging neurotechnologies for lie-detection: promises and perils. *American Journal of Bioethics*, 5(2), 39-49.

Woodruff-Pak, D. & Steinmetz, J., eds. (2000). *Eyeblink classical conditioning. Vol. 1, Applications in humans.* Boston, Kluwer Academic Publishers.

Appendices

Appendix A: Words used in Experiments 1, 2, and 3 (Chapter 3)

Swear
1 cunt
2 shit
3 fuck
4 asshole
5 cocksucker
6 motherfucker
7 wanker
8 crap
9 bastard
10 twat

Emotional
1 weapon
2 hate
3 death
4 suicide
5 humiliation
6 execution
7 torture
8 violence
9 cancer
10 murder

Filler
1 light
2 window
3 animal
4 building
5 green
6 brick
7 plaza
8 science
9 waffle
10 game
11 glass
12 carpet
13 dreams
14 local
15 bird
16 throw
17 coast
18 shirt
19 camera
20 clock

Matched
1 land
2 film
3 glass
4 chair
5 concentrate
6 candlestick
7 noisy
8 feed
9 bowl
10 pencil

Appendix B: Offensiveness questionnaire used in Experiments 1 and 3 (Chapter 3)

Please indicate how offensive you find the following words using the scale provided.

	Not Offensive				Very Offensive
shit	1	2	3	4	5
asshole	1	2	3	4	5
crap	1	2	3	4	5
bastard	1	2	3	4	5
twat	1	2	3	4	5
weapon	1	2	3	4	5
hate	1	2	3	4	5
death	1	2	3	4	5

etc.

Appendix C: Emotionality questionnaire used in Experiments 1 and 3 (Chapter 3)

Please indicate how emotionally arousing you find the following words using the scale provided.

	Not Emotional				Very Emotional
weapon	1	2	3	4	5
hate	1	2	3	4	5
death	1	2	3	4	5
twat	1	2	3	4	5
shit	1	2	3	4	5
execution	1	2	3	4	5
torture	1	2	3	4	5
violence	1	2	3	4	5

etc.

Appendix D: Previous punishment and frequency questionnaire used in Experiments 1 and 3 (Chapter 3)

Please answer the following questions

How old are you?

What is your religion?

What sex are you? Female Male

What is the highest level of education acquired by your mother?

What is the highest level of education acquired by your father?

	Never				Very Often
Roughly how often do you swear each day?	1	2	3	4	5
	Never				Always
Did your parents often punish you for swearing?	1	2	3	4	5
	Never				Often
As a child, did you often see others punished for swearing?	1	2	3	4	5
	Never				Often
As a child, did you often see others swearing?	1	2	3	4	5

Appendix E: Statements used in Experiments 4, 5, and 6 (Chapter 4)

Trial	Statement	Truth Value
1	You are sitting in a chair	TRUE
2	The world is round	TRUE
3	You are the Queen of England	FALSE
4	Books have pages	TRUE
5	You own a kangaroo	FALSE
6	Acorns are nuts	TRUE
7	Circles are round	TRUE
8	This room has a desk	TRUE
9	Elephants have scales	FALSE
10	This room is in a building	TRUE
11	The Sun is smaller than the Earth	FALSE
12	Humans are green	FALSE
13	This room has windows	FALSE
14	The world is flat	FALSE
15	Sheep have wool	TRUE
16	Mice are smaller than cats	TRUE
17	You eat rocks	FALSE
18	Beer is a liquid	TRUE
19	Lead is heavier than paper	TRUE
20	Days are longer than weeks	FALSE
21	Swansea is in China	FALSE
22	Strawberries are fruits	TRUE
23	You are in Australia	FALSE
24	Grass is blue	FALSE
25	This room has computers	TRUE
26	Pigeons are birds	TRUE
27	You live in an igloo	FALSE
28	Humans are plants	FALSE
29	Squirrels are birds	FALSE
30	Water is a liquid	TRUE
31	Pigs can fly	FALSE
32	Flowers are reptiles	FALSE
33	The sun orbits the earth	FALSE
34	Squirrels climb trees	TRUE
35	Rocks are alive	FALSE

36	This room is silent	FALSE
37	Birds have feathers	TRUE
38	Albert Einstein was a physicist	TRUE
39	You are an astronaut	FALSE
40	You are looking at a computer	TRUE
41	Penguins are reptiles	FALSE
42	Lead is worth more than gold	FALSE
43	Humans lay eggs	FALSE
44	This room has walls	TRUE
45	Carrots are vegetables	TRUE
46	Swansea has beaches	TRUE
47	Humans have feathers	FALSE
48	Birds have wings	TRUE
49	Libraries have books	TRUE
50	You own an island	FALSE
51	Sheep are mammals	TRUE
52	Humans need food to survive	TRUE
53	Jesus was a penguin	FALSE
54	London is in the U.K.	TRUE
55	You are younger than 70	TRUE
56	You are sitting on a couch	FALSE
57	You have a head	TRUE
58	Roses are flowers	TRUE
59	Paper is heavier than lead	FALSE
60	The Earth is spinning	TRUE
61	Bananas are yellow	TRUE
62	You are a tree	FALSE
63	London is in Wales	FALSE
64	Violins are instruments	TRUE
65	You are a student	TRUE
66	Paris is in America	FALSE
67	Money grows on trees	FALSE
68	Red is a colour	TRUE
69	You are a sausage	FALSE
70	Cats are larger than horses	FALSE
71	China is in Asia	TRUE
72	The Earth orbits the moon	FALSE
73	Water is heavier than air	TRUE

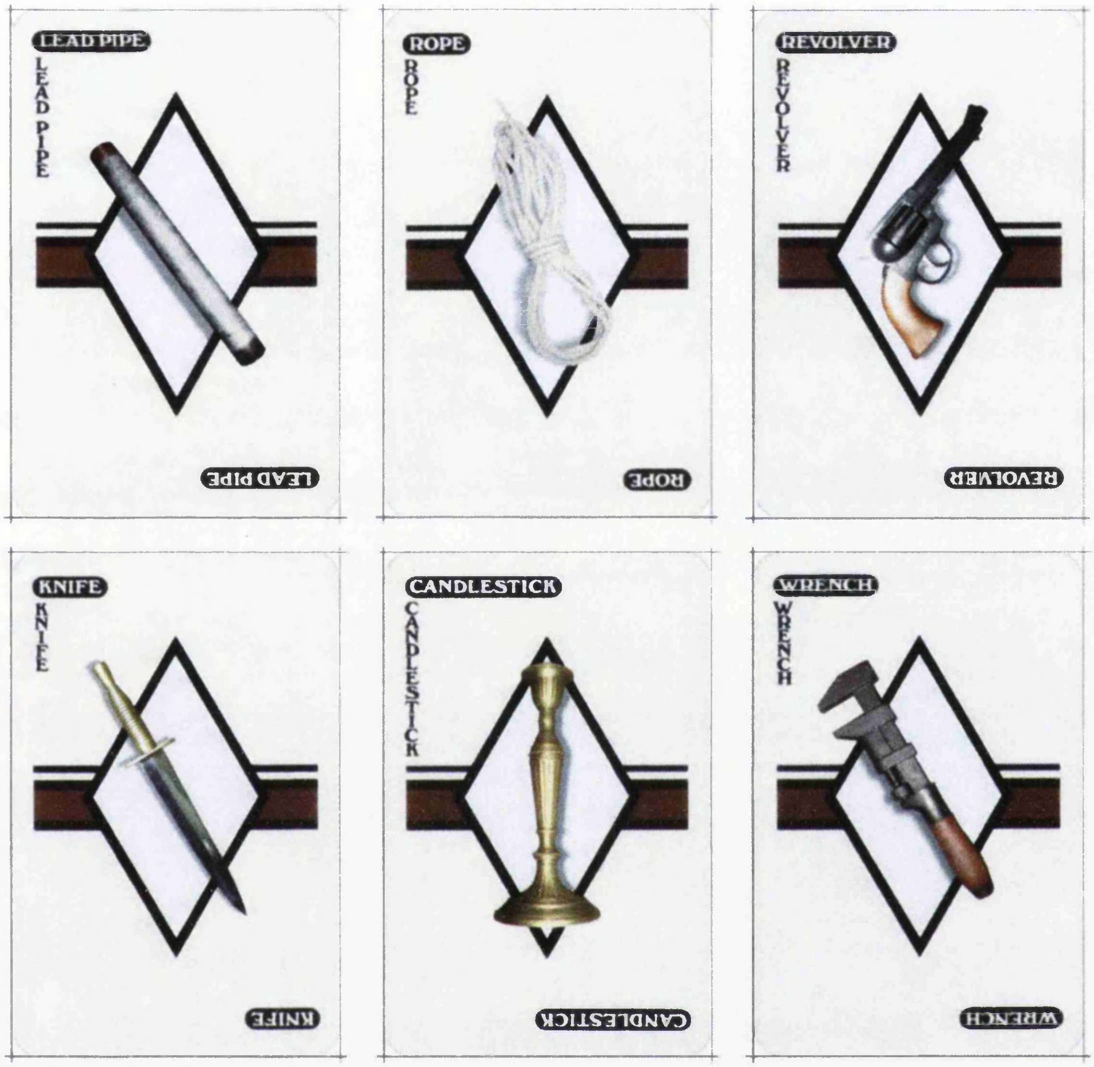
74	You are a human	TRUE
75	Snow is white	TRUE
76	You are studying dentistry	FALSE
77	You are in Wales	TRUE
78	Bananas are purple	FALSE
79	The Sun is hot	TRUE
80	Cars have wheels	TRUE
81	Humans live under water	FALSE
82	The sky is blue	TRUE
83	Lead is heavier than wood	TRUE
84	Triangles have 3 sides	TRUE
85	This room is full of water	FALSE
86	Swansea is in Wales	TRUE
87	Fish live in water	TRUE
88	Salt tastes sweet	FALSE
89	Humans are reptiles	FALSE
90	Chickens lay eggs	TRUE
91	London is in China	FALSE
92	You have 3 eyes	FALSE
93	You sleep in a bed	TRUE
94	Humans need air	TRUE
95	You sleep in a pile of hay	FALSE
96	Keyboards have buttons	TRUE
97	Pens have ink	FALSE
98	Fire is cold	FALSE
99	Humans are mortal	TRUE
100	This room has no ceiling	FALSE

Appendix F: Statements used in Experiments 7 and 8 (Chapter 5)

Trial	Statement	Truth-Value
1	You are sitting in a chair	True
2	The world is round	True
3	You are the Queen of England	False
4	Books have pages	True
5	You own a kangaroo	False
6	Acorns are nuts	True
7	Money grows on trees	False
8	This room has a desk	True
9	Elephants have scales	False
10	This room is in a building	True
11	The Sun is smaller than the Earth	False
12	Humans are green	False
13	This room has windows	False
14	The world is flat	False
15	Sheep have wool	True
16	Mice are smaller than cats	True
17	You eat rocks	False
18	Beer is a liquid	True
19	Lead is heavier than paper	True
20	Days are longer than weeks	False
21	Swansea is in China	False
22	Strawberries are fruits	True
23	You are in Australia	False
24	Grass is blue	False
25	This room has computers	True
26	Pigeons are birds	True
27	You live in an igloo	False
28	Humans are plants	False
29	Albert Einstein was a physicist	True
30	Squirrels are birds	False
31	Water is a liquid	True
32	Pigs can fly	False
33	Bananas are yellow	True
34	The sun orbits the earth	False
35	Squirrels climb trees	True
36	Rocks are alive	False
37	This room is silent	False
38	Birds have feathers	True
39	You are an astronaut	False
40	You are looking at a computer	True

Appendix G: Suspect cards used in Experiments 9 and 10 (Chapter 6)

Appendix H: Weapon cards used in Experiments 9 and 10 (Chapter 6)



Appendix I: Generalization suspects used in Experiment 10 (Chapter 6)