CARDIFF UNIVERSITY

Lies and Cognition: How do we tell lies and can we detect them?

Emma Joanne Williams

BSc (Hons) Psychology

A thesis submitted for the degree of

Doctor of Philosophy

School of Psychology

Cardiff University

2012

School of Psychology

CARDIFF UNIVERSITY

PRIFYSGOL CAERDYDD

I dedicate this thesis to my parents and my husband

Jan and Geoff Williams

&

Duncan Walker

DECLARATION

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

Signed …………………………………….... (candidate) Date……………………

STATEMENT 1

This thesis is being submitted in partial fulfilment of the requirements for the degree of PhD.

Signed …………………………………….... (candidate) Date……………………

STATEMENT 2

This thesis is the result of my own independent work/investigation, except where otherwise stated. Other sources are acknowledged by explicit references.

Signed …………………………………….... (candidate) Date……………………

STATEMENT 3

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……………………

STATEMENT 4: PREVIOUSLY APPROVED BAR ON ACCESS

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 previously approved by the Graduate Development Committee.

Signed …………………………………….... (candidate) Date……………………

Acknowledgments

I would like to thank my supervisors, Dr Lewis Bott, Dr Michael Lewis and Professor John Patrick, for all their help, advice and support during my PhD years. I would also like to thank Peter Talbot-Jones for his interest and support during the course of this research, and the EADS Foundation Wales, for funding the project and providing the financial means to enable this work to be achieved. For listening to my rants in recent months and always being there for me, no matter what, I thank my husband, Duncan Walker, as well as all my friends and family who have provided a supportive ear whenever I have needed it, particularly Tasha Kalebic, Dave Maidment, China Harrison, Laura Brimacombe, and of course, my parents, Jan and Geoff.

Thesis Summary

The present thesis focuses on two main areas of deception research. The first of these examines the cognitive processes involved in telling a lie and the second examines human ability to detect deception. Since deception research has historically lacked a solid theoretical basis, this work extends previous research by providing a greater theoretical understanding of both the processes involved in telling lies, and also those involved in successfully discriminating truthful messages from deceptive ones. In the first section, a simple response time paradigm is used to examine how cognitive processes differ when individuals lie compared to when they tell the truth. This paradigm is manipulated to examine the effect of a variety of different factors on potential processing differences, such as the number of lie response options available and the order of lie and truth responses. Overall, the contention that telling a lie is more cognitively demanding than telling the truth was supported. This additional cognitive load should aid in the discrimination of false and truthful messages by human observers. The second section of the thesis therefore examines individual differences in human ability to detect deception. A number of individual difference variables were examined, including extraversion and autism spectrum characteristics, allowing for the exploration of the potential relationship of these measures with both deception detection accuracy and degree of truth bias when judging the messages of individuals from different cultural backgrounds. Overall, reliable individual differences in ability levels were not found. A positive relationship between extraversion and degree of truth bias, however, was demonstrated when participants judged individuals from the same cultural background as themselves compared to a different cultural background.

Publications

Williams, E. J., Bott, L. A., Lewis, M. B., & Patrick, J. (submitted). Telling lies: The irrepressible truth?

Williams, E. J., Bott, L. A., Lewis, M. B., & Patrick, J. (in prep). It's all in the switch? The effect of task switching when telling lies.

Williams, E. J., Bott, L. A., Lewis, M. B., & Patrick, J. (in prep). Individual differences and deception detection.

Oral Presentations

Williams, E. J., Bott, L. A., Lewis, M. B., & Patrick, J. (2012, May). The effectiveness of psychological techniques to detect deceit. EADS PhD Showcase. Bristol, UK.

Williams, E. J., Bott, L. A., Lewis, M. B., & Patrick, J. (2012, May). Individual differences in detecting deceit. Deception Symposium. Cardiff University, UK.

Williams, E. J., Bott, L. A., Lewis, M. B., & Patrick, J. (2011, August). The ability to detect deceit: Does personality matter? Postgraduate Conference on Deception. Lancaster, UK.

Williams, E. J., Bott, L. A., Lewis, M. B., & Patrick, J. (2011, June). The ability to detect deceit: Does personality matter? Society for Applied Research in Memory and Cognition Conference. New York, USA.

Williams, E. J., Bott, L. A., Lewis, M. B., & Patrick, J. (2010, June). Telling lies. School of Psychology Departmental Seminar Series. Cardiff University, UK.

Williams, E. J., Bott, L. A., Lewis, M. B., & Patrick, J. (2010, May). The effectiveness of psychological techniques to detect deceit. Spotlight on Social Sciences Postgraduate Conference. Cardiff University, UK.

Posters

Williams, E. J., Bott, L. A., Lewis, M. B., & Patrick, J. (2010, August). Response choice when telling lies. Poster presented at the 32nd Annual Conference of the Cognitive

Science Society. Portland, USA.

Williams, E. J., Bott, L. A., Lewis, M. B., & Patrick, J. (2009, July). The role of suppression and choice when telling lies. Poster presented at the Society for Applied Research in Memory and Cognition Conference. Kyoto, Japan.

Williams, E. J., Bott, L. A., Lewis, M. B., & Patrick, J. (2009, January). The effectiveness of psychological techniques to detect deceit. Poster presented at the EADS Innovation Works Open Day. Newport, Wales.

Table of Contents

Index of Figures

Index of Tables

CHAPTER 1

General Introduction and Thesis Overview

Overview of Deception Research

It is a common belief of lay people that liars behave differently to truth tellers, with the Global Deception Team (2006) highlighting gaze aversion as the most commonly cited cue to deception internationally. Such beliefs are, however, in sharp contrast to the research literature, which has highlighted only a limited number of cues that may show promise as indictors of deception. For example, a comprehensive meta-analysis conducted by DePaulo, Lindsay, Malone, Muhlenbruck, Charlton and Cooper (2003) examined 158 behavioural cues from the deception literature and failed to support the existence of the majority of these as cues to deceit. Since limited support was shown for a small number of these cues, such as increases in pitch, pupil dilation and fidgeting when individuals tell a lie, this suggests that certain behavioural differences between liars and truth tellers may be present in particular situations. Despite a lack of empirical support for the majority of 'cues' to deception, the search for reliable indicators to detect liars has historically been the focus of deception research for a number of years, driven mainly by demand from the defence and security sector (Meijer, Verschuere, Vrij, Merckelbach, Smulders, Leal, et al., 2009). Such a research agenda has resulted in a neglect of theoretical development in the field (McCornack, 1997; Wolpe, Foster & Langleben, 2005), with much work still required to understand why, when and how behavioural differences between liars and truth tellers may occur.

Although research continues to try and identify behavioural patterns that can be used in practical contexts to detect deception through a variety of means (Caso, Maricchiolo, Bonaiuto, Vrij & Mann, 2006; Porter, Doucette, Woodworth, Earle & MacNeil, 2008; Tsiamyrtzis, Dowdall, Shastri, Pavlidis, Frank & Ekman, 2007), a second strand of deception research focuses on the examination of human ability to detect lies (Bond & DePaulo, 2008; Bond & Uysal, 2007; O'Sullivan, 2007). Overall, human ability to detect deceit has been shown to be poor, with an average detection rate of 54% shown in experimental studies (Bond & DePaulo, 2006). A lack of association between the stereotypes people hold regarding deceptive behaviour and how liars have actually been shown to behave may contribute to individuals' poor ability to detect deceit (Global Deception Team, 2006). A recent study by Hartwig and Bond (2011), however, has demonstrated that this poor detection ability is more likely linked to a lack of observable behaviours in the messages that people are judging.

Individual variation in the ability to detect deception remains a contentious issue, with some researchers claiming that variation in human accuracy rates indicate the presence of individual differences in ability levels, whereas others challenge this suggestion (Bond & DePaulo, 2008; Bond & Uysal, 2007; Levine, Kin, Park & Hughes, 2006; O'Sullivan, 2007; O'Sullivan, 2008). The current lack of research regarding individual differences and the ability to detect deceit unfortunately makes it difficult to draw any firm conclusions in this area (Aamodt & Custer, 2006; Bond & DePaulo, 2008).

Aims of the Present Thesis

The aims of the present thesis are twofold. Firstly, to examine the particular cognitive processes that are involved in telling lies, and how they differ from those involved in telling the truth, in a variety of different circumstances. Secondly, to examine the different factors that affect human ability to detect deception, with a particular focus on individual and cultural differences in both detection accuracy and response bias.

In relation to the first aim, a minimalist approach was taken, which allowed us to examine the contribution of individual cognitive processes to telling a lie. A simple computer task was developed, whereby participants lied and told the truth regarding the colour of a square and their vocal response times recorded. Response times have been shown to be greater when individuals lie compared to when they tell the truth, which supports the idea that additional processes are required in order to tell a lie. The relative contribution of these processes, and the factors that may affect this, remain unknown. Our experiments allow for an extension of previous work regarding the theoretical understanding of why telling a lie is more difficult than telling the truth, as well as the factors that may decrease or increase this difference. Since our experiments demonstrated that telling a lie does involve additional processes compared to telling the truth, and that this is reflected in measurable behavioural differences, our second aim was to examine the judgement factors that may affect the ability to identify this enhanced difficulty and accurately detect deception.

In relation to the second aim, human ability to detect deception was examined through the creation of video statements of individuals both truthfully and falsely describing an image they had previously viewed on a computer screen. Some of these statements were provided by individuals of the same cultural background as the judge, whilst others were provided by individuals of a different cultural background to the judge. Judges viewed these statements and evaluated whether they thought each one was truthful or a lie, as well as completing a variety of individual difference measures related to the ability to correctly interpret the behaviour and mental states of others. These experiments allowed us to examine possible relationships between both individual difference measures and cultural background, on response bias and judgement accuracy, thus extending previous judgement studies.

Structure of the Present Thesis

The present thesis is divided into 3 main sections. The first section provides an introduction to deception research and critically reviews previous work relating to deception detection. The second section consists of our experimental work and is divided into two subsections. The first of these subsections incorporates chapters 2, 3 and 4 and presents work addressing the first of our above-stated aims; an investigation of the cognitive processes involved in telling a lie. The second subsection incorporates chapter 5, which addresses the second of our aims; the influence of individual differences on the ability to detect deception both within and across cultures. The third and final section of the thesis provides a general discussion of our work, and considers our findings in relation to the wider deception field. A more detailed consideration of each chapter is provided below.

Chapter 1 provides a comprehensive review of previous literature in the deception field. This focuses on the examination of potential behavioural differences when people lie compared to when they tell the truth, and the theoretical considerations of why such differences may occur. Criticisms regarding the lack of theoretical development previously inherent in the deception field (McCornack, 1997) provide a context for our experiments, with a consideration of the factors that are likely to impact on deceptive cognition and behaviour, and the detection of it. Extraneous to this are wider factors that may impact on the accurate identification of such deception by human judges, with a consideration of current thinking regarding deception judgements providing the context for our work on human ability to detect deception.

Chapter 2 investigates two processes suggested to increase response times when individuals tell a lie, namely the decision to lie and the construction of a lie response (Walczyk, Roper, Seemann & Humphrey, 2003). In our first experiment, we found that response times were longer when participants chose, compared to when they were directed, to lie. In Experiments 3 and 4, we compared response times when participants had only one possible lie option to a choice of two or three possible options. There was a greater lying latency effect when questions involved more than one possible lie response. Experiment 5 extended this consideration of response choice mechanisms through the manipulation of lie plausibility. Overall, results highlight several distinct mechanisms that contribute to additional processing requirements when individuals tell a lie.

Chapter 3 examines whether switching between telling a lie and telling the truth incurs a response time cost compared to consistently responding in one manner (Experiment 6). Overall, we found that switching between these two processes increased response times compared to trials where no switch was required, indicating that the two response types involve the use of different task-sets. Furthermore, this difference was greater when participants switched from telling a lie to telling the truth rather than vice versa. In accordance with previous theories (i.e., Allport, Styles & Hsieh, 1994), this suggests that telling the truth is a more dominant cognitive task than telling a lie.

Chapter 4 examines whether it is possible to influence the lie response that is chosen through the use of priming techniques. On certain trials, participants were primed with a potential lie response. The results of Experiment 7 demonstrate that participants do not use these primes as their lie response any more than would be expected by chance. Experiment 8 increased the number of lie response options, which resulted in participants using the same response as the prime more than would be expected by chance, suggesting that the correct prime is influencing the lie response chosen. Response times were also shown to be faster when participants used the prime as their lie response.

Chapter 5 examines the relationship between lie detection ability, bias and personality characteristics when judging individuals from the same vs. a different cultural background to the judge. In Experiment 9, participants judged messages of individuals from the same cultural background as themselves (UK). Significant correlations were found between accuracy and extraversion scores on the EPQ-SF, such that high scores on the extraversion subscale of the EPQ-SF were correlated with high lie detection accuracy. Individuals higher in extraversion also demonstrated a truth bias, judging more statements as truths than as lies. In Experiment 10, participants judged messages of individuals from both the same cultural background (UK) and a different background to themselves (South East Asian). A significant positive correlation was found between truth bias for UK statements and extraversion scores on the EPQ-SF, but not between extraversion and truth bias for South East Asian statements. This suggests that extraverts lose their truth bias when judging individuals from a different culture to their own.

Chapter 6 brings the findings of our experimental chapters together in the form of a general discussion. This evaluates our findings in relation to previously discussed research, and the overall contribution of the thesis to the deception field. The limitations of the thesis are considered, in addition to future research directions that would further extend our findings and continue to benefit the research field as a whole.

General Introduction

Although a number of definitions for deception have been debated over the years (Masip, Garrido & Herrero, 2004), Vrij (2008) recently defined deception as ‘a successful or unsuccessful deliberate attempt, without forewarning, to create in another a belief which the communicator considers to be untrue' (Vrij, 2008, p.15). There are many ways in which an individual can effectively deceive another, including exaggeration (Tyler, Feldman & Reichert, 2006), presenting truthful information in a misleading manner (Vrij, 2008), concealing information (Metts, 1989) and outright falsifications (DePaulo, Kashy, Kirkendol, Wyer & Epstein, 1996; Ekman, 1997). The process of outright falsification, i.e., when an individual lies by knowingly providing false information, is the focus of investigation in the present thesis.

People lie surprisingly often. Indeed, Serota, Levine and Boster (2010) found that 40% of 1,000 American adults reported telling at least one lie in a 24-hour period. Such lies usually concern minor issues and serve a communicative function, namely to prevent us from continually offending each other (DePaulo et al., 1996), but lies can also be uttered with more criminal intent and damaging consequences. Evolutionary psychology suggests that humans have an innate, 'hard-wired' ability to deceive others, in order to ensure survival and reproductive success (Bond & Robinson, 1988; Premack & Woodruff, 1978; Whiten & Byrne, 1997). Understanding how people lie, and the behavioural differences that this may create, is therefore important both for cognition in general, and also in a wide variety of practical contexts such as law enforcement, occupational selection and fraudulent claims. This latter reason has prompted a large body of research into identifying cues to detect deception (see DePaulo et al., 2003), so that liars may be more easily differentiated from truth tellers in a variety of settings.

There are many practical situations in which lying is problematic, causing serious costs and consequences. These include a range of contexts in which applied psychologists may be involved. Evaluating the truthfulness of presented information is crucial in forensic settings, where witness statements may be false (Appelbaum, 2007; Raskin & Esplin, 1991). For instance, several judicial cases have highlighted the importance of accurately assessing witness credibility (Porter & ten Brinke, 2009), since failure to do so may lead to wrongful conviction (Wilson, 2003). In occupational settings, deception has been shown to commonly occur during selection processes, where individuals may fake responses on personality measures (Holden, 1998) or lie about previous experience / credentials (Ollian, 2003). For example, Robinson, Shepherd and Heywood (1998) demonstrated that 83% of undergraduate students interviewed would be willing to lie in order to be considered for a job. The importance of deception detection in law enforcement and security settings is also highlighted by the inclusion of information regarding deception in police interview training manuals (Inbau, Reid, Buckley & Jayne, 2001; Vrij, 2008), and the focus of security policy on potential lie detection technologies (Meijer et al., 2009). In addition, individuals may fake medical symptoms in order to fraudulently claim compensation (Frueh, Elhai, Grubaugh, Monnier, Kasdan, Sauvageot et al., 2005) or to avoid responsibility for a crime that has been committed (Oorsouw & Merckelbach, 2010). For example, the Croatian National Referral Centre found that only 37% of veterans who reported PTSD symptoms were actually suffering from PTSD (Kozaric-Kovacic, Bajs, Vidosic, Matic, Alegic & Peraica, 2004), a finding likely to be linked to compensation-seeking motives (Geraerts, Kozaric-Kovacic, Merckelbach, Peraica, Jelicic & Candel, 2009). In all of the above situations, it is important to be able to differentiate when an individual is lying from when they are telling the truth.

Despite significant technological advances in the non-intrusive measurement and identification of behavioural markers (e.g., Rothwell, Bandar, O'Shea & McLean, 2006), a reliable cue to deception that can be used in practical settings has yet to be found. This has resulted in a research agenda that has previously focused on the identification and discovery of lie detection techniques, rather than on the development of adequate theoretical models regarding deceptive behaviour. This historic lack of theoretical understanding regarding when, why and how we could expect behavioural differences between liars and truth tellers to manifest themselves, has led to the collection of vast amounts of conflicting behavioural data that have yet to be comprehensively interpreted or explained.

In this chapter, we first consider how deception research is typically conducted and the criticisms associated with such methodologies. Following on from this, we discuss the theoretical rationale of deception research and its development, before focusing specifically on research regarding the cognitive processes involved in telling a lie. Finally, we focus on techniques to detect deception. We do this by initially providing an overview of interview techniques designed to identify liars, before reviewing the literature on behavioural cues to deception and the ability to detect deceit.

Methodology of deception research

The majority of research conducted in the deception field consists of laboratory studies, whereby participants are instructed to lie and/or tell the truth in a particular situation. For example, participants may be asked to lie or tell the truth regarding their attitudes on a current issue, or regarding someone they know (Cheng & Broadhurst, 2005). Alternatively, participants may be asked to lie about objective statements, such as certain autobiographical information (Gregg, 2007), an image or film they have viewed (Ekman, Davidson & Friesen, 1990), or their possession of a particular object (Akehurst & Vrij, 1999). A further paradigm that has proved popular in deception research is that relating to the creation of a mock crime situation, whereby participants are instructed to take part in a mock criminal offence, such as removing a specific object from a lecturer's office, and then denying involvement when subsequently questioned (Gronau, Ben-Shakhar & Cohen, 2005; Verschuere, Crombez, De Clercq & Koster, 2004). Using such paradigms, behavioural data (e.g., body movements, gaze aversion) can be recorded, either visually or orally, while individuals provide free narrative statements, or are specifically questioned on particular topics. Both non-verbal and verbal behaviours can then be examined at a later date, and coded according to relative frequency by human coders or automated devices.

Alternatively, certain behaviours can be measured using specialist devices, such as a polygraph, which measures skin conductance levels (Bull, 1988); or a functional Magnetic Resonance Imaging (fMRI) scanner, which provides a measurement of BOLD responses in the brain (Ganis, Kosslyn, Stose, Thompson & Yurgelun-Todd, 2003). Where specialist neuroimaging equipment is used, it is common for participants to lie in response to computer-generated questions and stimuli, rather than to another individual. Such computer tasks often contain images of particular objects, or questions regarding the information that is being probed, and the participant is then instructed to lie or tell the truth on particular trials by pressing particular response buttons.

The above described computer tasks often use a design that relates to the Concealed Information Test (CIT; Lykken, 1959). CIT protocols are an increasingly popular lie detection technique, whereby individuals are asked specific questions related to the topic under investigation, such as ‘how much money was stolen?’ and are then presented with a variety of response options, one of which is the truthful answer. The assumption is that individuals with knowledge of the crime will recognise this truthful information, and that this recognition will be shown in differential behavioural and brain responses to the stimulus (Verschuere, Meijer & DeClerq, 2011). It has been proposed that physiological responding in the CIT for liars can be explained by orienting response (OR) theory (Lykken, 1974). This suggests that when we are presented with external information that is either significant or novel, the OR directs our attention to this information in order to further investigate the stimulus and respond to the information appropriately (Sokolov, 1963). When individuals are presented with information, such as that regarding a crime, that is salient to them, they will have a stronger orienting response than individuals who have no knowledge of the topic under investigation.

Criticisms of deception research

Unsurprisingly, given the nature of deception and the difficulty involved in experimentally examining the subject, a frequent criticism of deception research is a lack of ecological validity (O'Sullivan, 2008). This predominantly revolves around the following three main facets: the motivation of participants; the sanctioning of the lie response; and the participants sample that is used.

When individuals lie in a practical context, they are likely to receive significant penalties if discovered, such as criminal punishment, loss of reputation, or the alienation of a significant other (Vrij, 2008). For ethical reasons, this significant threat of punishment is not present in deception studies. In an attempt to negate this problem, some researchers have provided participants with financial or behavioural incentives to deceive effectively, for example, providing a monetary bonus to participants who are able to convince the interviewer they are telling the truth or informing participants that if their lie is discovered, they will be required to complete a large number of questionnaires (Leal & Vrij, 2008). DePaulo et al (2003) suggest that providing participants with an external incentive to deceive, however, does not enhance the presence of behavioural cues to deception, and that internal self-presentational motivations, such as informing individuals that effective liars have greater job success, is a more effective technique.

The motivation to deceive also relates to the second facet, which involves the sanctioning of the lie response. When individuals lie in practical settings, they have not been instructed to do so. In this situation, if their lie is discovered, they must take full responsibility for any punishment or sanction that they receive regarding this. This serious threat of punishment is absent in experimental studies, thereby reducing the likely emotional response that an individual may have. Since the majority of participants in experimental studies are typically instructed when to lie, this also negates the necessity to choose how to respond in a particular situation, possibly reducing the cognitive processes required. Although Spence, Kaylor-Hughes, Farrow and Wilkinson (2008) and Walczyk et al (2003) have attempted to provide paradigms whereby individuals choose whether to lie or tell the truth, difficulties in data analysis and interpretation mean that the majority of deception research still instructs participants how to respond on particular trials.

The third facet concerns the participant sample that is used. The majority of studies have been conducted in western universities using student samples, resulting in a considerable lack of research regarding individuals from different cultural, occupational or social groups. A small number of researchers have been able to access recordings of genuine police interviews, which provide an ecologically valid dataset for analysing the behaviours displayed by suspects in investigative interviews (e.g., Mann, Vrij & Bull, 2002; Vrij & Mann, 2001). Alternatively, researchers such as Rossini (2010) have examined potential non verbal and verbal cues in videotapes of political speeches. Such work is incredibly rare, however, since it is both incredibly time-consuming to conduct and also fails to provide any degree of experimental control over the factors involved. The complexity of any deceptive interaction means that it currently remains difficult to disentangle which of a myriad of factors are responsible for any behavioural differences.

Methodological differences in the factors discussed above likely account for the multitude of conflicting findings in the field (Porter et al, 2008; Vrij & Mann, 2001; Vrij & Winkel, 1991). Different sample populations, rating procedures, situational contexts and motivations may all impact on the behaviours that are shown by both liars and truth tellers, and hence any differences between the two. For example, Stromwall, Hartwig and Granhag (2006) failed to support previous findings of an increase in speech cues when individuals told a lie. In their study, trainee police investigators interviewed participants regarding their involvement in a mock crime. Although liars reported being significantly more nervous than truth tellers and found the task more strenuous, no differences in speech cues were demonstrated. In their study, participants were provided with approximately 2 hours to prepare for the interview, which may have reduced the propensity of behavioural cues shown in other studies (DePaulo et al, 2003). Since interrogators were allowed to use any interview strategy they chose, it is also possible that variations in interviewer and interview characteristics influenced the results (Akehurst & Vrij, 1999; Vrij, 2006). Similar conflicting findings have also been shown at the individual participant level. For instance, in their analysis of police suspect interviews, Mann, Vrij and Bull (2002) found that approximately half of the subjects studied showed an increase in speech disturbances when lying, whereas others showed a decrease in such disturbances, highlighting that even the direction of any effects remains unclear.

Although deception research conducted in experimental environments has been criticised for a lack of ecological validity, such an approach allows for the isolation of different factors, such as the subject that an individual lies about and the particular questions asked. This increases our understanding of the different elements of the deception process, and their relative contribution to potential behavioural differences. It is appreciated that such studies have only a limited ecological validity, but this does not negate their necessity. Although applied work is extremely important in highlighting predominant issues of concern and discrepancies between the laboratory and the interview room, the lack of experimental control in such work can make it difficult to interpret results, since behavioural differences may be due to extraneous factors such as the behaviour of the interviewer or the characteristics of the case. Thus, observing behavioural differences without adequately considering the large variety of possible moderating factors is not sufficient to enable the prediction and explanation of behaviour in different environments. This means that highly controlled experimental work is required to develop adequate models of deception, which can then be tested and modified in practical environments.

Theoretical development in deception research

If behavioural indicators could be shown that reliably distinguish between truth tellers and liars, the real world applications of these findings would be profound. Unfortunately, as a result of this somewhat relentless pursuance of an all encompassing cue to deception, the field has suffered from a lack of theoretical focus and direction in the past. Critics such as McCornack (1997) have challenged the assumptions inherent in the deception field, highlighting that although it is commonly believed that lies are distinct from truths because of their nature, this may not necessarily be the case:

'… the claim that deceptive messages are distinct because they must be 'internally consistent and compatible with what the recipient already knows' suggests that truthful messages are constructed without regard to internal consistency and recipient knowledge, a claim equally at odds with extant literature.' (McCornack, 1997; p.106)

The demand for psychological techniques to detect deception has continued to grow, with research and commercial efforts ranging from the automated detection of visual behaviours in airport settings (Weinberger, 2010), to the use of functional Magnetic Resonance Imaging when individuals respond to questions (Langleben, 2008). There is widespread public interest in these techniques (Spinney, 2011), with companies such as No Lie MRI commercially advertising their lie detection services (www.noliemri.com). This commercial demand has been criticised for subverting "the evolutionary process of scientific development" (Saxe, 1994; p. 72). Such a shortcoming has also been more recently expressed by Wolpe et al (2005), who claim that "premature commercialization [of certain lie detection technologies] will bias and stifle the extensive basic research that still remains to be done" (p.47). Yet if a lie detection technique is to become practically viable and usable in a legal judicial setting, it must meet stringent research criteria. For example, in the US, the *'Daubert'* guidelines (Daubert v. Merrel Dow Pharmaceuticals, Inc, 1993) present 5 criteria for evaluating 'expert' evidence, and therefore the admissibility of deception detection technologies, in court. These are:

- Is the scientific hypothesis testable?
- Has the proposition been tested?
- Is there a known error rate?
- Has the hypothesis/technique been subjected to peer review and publication?
- Is the theory behind the hypothesis/technique generally accepted in the appropriate scientific community?

Therefore, if any lie detection test is to be used in a judicial setting, an appropriate theoretical understanding of why such differences occur must be developed and accepted in the scientific community. In line with such requirements, researchers are becoming increasingly focused on examining the particular cognitive processes that may differentiate truthful from deceptive communication (Spence, Farrow, Herford, Wilkinson, Zheng & Woodruff, 2001), in an attempt to theoretically understand the mechanisms involved in deceptive communication.

In 1987, Hewes and Planalp claimed that "an understanding of the individual's knowledge, cognitive capacities and emotion is the necessary point of departure for building adequate theories of communication" (p.172). Given that deception represents a field of communication, it is important that all of these factors are considered when trying to model deceptive behaviour. Such a task is a huge feat, however, and theorists may progress further by initially focusing on the explanation of individual facets of the deception process. One particular area of recent interest relates to the cognitive processes involved in telling lies, with McCornack (1997) suggesting that the most challenging issues relating to deception research are cognitive in nature and must be addressed as such, since attempting to account for all aspects of interpersonal deception will inevitably explain very little. In accordance with this, McCornack highlighted a number of so-called myths of deception research requiring further examination, with a number of these directly relating to the cognitive processes involved in telling a lie. These were as follows: that the encoding of deceptive messages involves more active, strategic and detailed cognitive processing compared to telling the truth; that encoding deceptive messages requires greater cognitive load compared to truthful messages; and that deceptive messages have particular characteristics that differentiate them from truthful messages. The increased focus in recent years on the cognitive processes involved in telling lies will allow for such assumptions to be challenged experimentally. For such views to be understood however, it is important to consider theoretical development within deception research. This is discussed in more detail below.

Current theoretical consideration of possible differences in behaviour when individuals lie compared to when they tell the truth revolve around two main ideas: increased cognitive load and increased emotional arousal. In their review of the literature, Zuckerman, DePaulo and Rosenthal (1981) highlighted that when individuals tell a lie they engage in additional cognitive processes compared to when they tell the truth. These processes include the monitoring of nonverbal behaviour, suppression of truthful information and the production of a lie response (Seymour, Seifert, Shafto & Mossman, 2000; Walczyk et al, 2003). In support of this idea, studies investigating the effects of making lies more complex have found that they are easier to detect. For example, asking participants to recall an event in reverse order (Vrij, Mann, Fisher, Leal, Milne & Bull, 2008) or using interview techniques that require longer answers to questions (Vrij, Mann, Kristen & Fisher, 2007), have been shown to increase discrimination ability between liars and truth tellers. Although intuitive, less evidence exists in relation to the second consideration, that liars experience enhanced emotional arousal. This is mainly due to difficulties instilling adequate levels of arousal in the laboratory. Both Zuckerman et al (1981) and Ekman (1988), however, suggest that liars are more likely to experience increased levels of emotion, such as guilt, fear and excitement, when deceiving others, than individuals who are telling the truth.

Although such suggestions provide a basis for current theoretical considerations of deception, they do not adequately explain the underlying mechanisms and processes involved in deceptive communication. For example, the cognitive load approach suggests that telling a lie is cognitively more complex than telling the truth and will result in behaviour that highlights this additional mental effort, such as a decrease in body movements and an increase in response time. However, there is no in-depth explanation of precisely why deception is more cognitively challenging, or the particular processes involved in any deceptive encounter.

Cognitive processes and deception

A number of studies have found that people report lying to be more difficult than telling the truth (Caso, Gnisci, Vrij & Mann, 2005; Sporer & Schwandt, 2007; Vrij, Ennis, Farman & Mann, 2010). The heightened interest in the cognitive processes involved in telling a lie, combined with the recent advancement in brain imaging technologies such as fMRI, has provided the impetus for the cognitive mechanisms of deception to be considered experimentally. This has led to the recent development of preliminary models of deceptive cognition, such as the Activation-Decision-Construction Model (ADCM; Walczyk et al, 2003) and the Working Model of Deception (WMD; Vendemia, Schillaci, Buzan, Green & Meek*,* 2009). We now present these cognitive models and examine the evidence relating to them.

The Activation Decision Construction Model (ADCM; Walczyk et al, 2003)

The ADCM provides a theoretical cognitive framework which can be used to examine the processes related to deception. The model suggests that additional processes are involved in telling an unrehearsed lie compared to telling the truth. These additional processes should lead to liars taking longer to respond to questions than truth tellers. The model proposes that three components are involved in telling a lie: activation of the truth; the decision to lie; and construction of the lie response. The processes proposed in the model provide the basis for our experimental work in Chapters 2-4.

On initially hearing a question, the model claims that relevant information (in particular, the truth) is automatically activated in long-term memory (e.g., Kintsch, 1998). This information is then transferred to working memory (Ericson and Kintsch, 1995) and becomes consciously available to the individual. If the individual has not previously decided to respond honestly to all questions in advance, they must then consciously decide whether to lie or tell the truth in response. If divulging the truth is deemed to act against self-interest, then individuals are likely to lie to the question asked, leading to an increase in response time. If individuals have already decided to lie to a question and have rehearsed an answer, then they must remind themselves of their decision to lie on hearing that particular question, again adding to response time. Finally, if the individual has decided to lie, then the truthful response must be suppressed and an appropriate, alternative answer constructed according to the situational context. The model claims that implausible or inappropriate lies (e.g., lies that are inconsistent with other statements, see Depaulo and Bell, 1996) are inhibited in long-term memory and the most active lie following this process is transferred to working memory to be used in response to the question (see Kintsch, 1998).

Walczyk et al (2003) and Walczyk, Schwartz, Clifton, Adams, Wei and Zha (2005) supported their model in a series of experiments that showed an increase in response time of up to 230ms when individuals lied to both computer-presented and examiner-read questions, such as ‘Are you Catholic?’ In one of these experiments, participants were presented with a selection of neutral questions and questions probing embarrassing information. In one condition, participants were instructed whether to lie or tell the truth randomly on a trial by trial basis. In the other condition, participants answered truthfully unless a question probed embarrassing information which they would normally lie to a stranger about, in which case they were asked to lie. In this condition, participants needed to decide themselves when to lie and when to tell the truth. The experiment demonstrated that more time was needed to respond when individuals chose to lie compared with when they had been instructed, consistent with the decision component of the ADCM. An alternative explanation for this finding, however, is that the elevated response times are due to the evaluation of whether the question is embarrassing, rather than the actual decision to lie.

The Working Model of Deception (WMD; Vendemia et al, 2009)

The WMD highlights a number of cognitive processes involved in deceptive communication. Although the model is still in the development stage, it aims to examine the time course and cognitive aspects of deception. It proposes that deceptive behaviour is affected by attentional processes related to both internal stimuli (such as the inhibition of potential responses, decision-making and the retrieval of information from long-term memory) and external stimuli (such as the intensity of the question asked). It is claimed that executive control processes continuously monitor ongoing dialogue with another individual and, in accordance with the ADCM, when a particular question is heard, relevant information (most notably, the truth) becomes active in working memory. This truthful information interferes with the production of a deceptive response. A decision must then be made as to whether to respond truthfully or deceptively according to the risks and benefits associated with each response. Information retrieved from long-term memory is used to create a suitable lie. The authors claim that such processes require the contribution of both endogenous and exogenous attentional systems.

The idea that the truth interferes with the ability to respond deceptively, either through the necessity to suppress the truthful response or to increase the relative activation of the deceptive response (Osman, Channon & Fitzpatrick, 2009), has been demonstrated recently using a number of innovative paradigms. For instance, Duran, Dale and McNamara (2010) instructed participants to respond truthfully or falsely to autobiographical information on a large projector screen using a Nintendo Wii remote to select yes or no responses presented in either corner of the screen. In addition to findings of longer response times for lie responses, response trajectory analysis also demonstrated a dynamic curve toward the true response when participants had to lie, whereas no curve was present when participants responded truthfully. This was taken to suggest that truthful information interfered with the production of a deceptive response. Ikehara and Crosby (2009) similarly suggested that findings of an increase in pressure on a mouse button when participants intentionally chose an incorrect answer on a multiple-choice question, was indicative of increased cognitive load and interference when responding falsely.

Deceptive cognition and response time

The additional processes required when individuals lie will take time to compute, resulting in longer response times to questions (Seymour & Kerlin, 2008; Vendemia, Buzan & Simon-Dack, 2005; Walczyk et al, 2003). Differences in response time when people lie compared to when they tell the truth began to be seriously investigated in the 1920s, when William Marston (1920) claimed that deceptive subjects may show either an increase or a decrease in response times when they lied compared with when subjects told the truth. Other researchers of the era, primarily Goldstein (1923), argued that Marston's methods did not correctly distinguish between whether subjects were aware of their deception. Although Marston refuted this in 1925, more recent research has supported an increase rather than a decrease in response times when participants lie versus when they tell the truth. However, the extent that this effect is determined by situational variables is yet to be thoroughly investigated.

Although interest in response time as a symptom of deception waned after the 1930s, there has been a resurgence of research by cognitive psychologists and neuroscientists in recent years, which has corresponded with the increased desire in psychology to understand the underlying processes related to deceptive communication. Current research generally studies response time in relation to computer tasks using simple paradigms, whereby participants respond either vocally or through a keyboard to questions such as ‘do you have brown hair?’. Despite the apparent simplicity of such paradigms, longer response times for liars have generally been supported (Gregg, 2007; Seymour, Seifert, Shafto & Mossman, 2000; Vendemia et al, 2005; Walczyk et al, 2003; Walczyk et al, 2005). Research has also demonstrated that such response time differences are not shown between individuals who tell the truth and those who experience a false memory, suggesting that the additional cognitive processing is unique to the active deception process itself (Abe, Okuda, Suzuki, Sasaki, Matsuda, Mori, et al., 2008).

There is still debate regarding response time as an indicator of deception, since a number of researchers have failed to support the positive findings cited above (e.g., Buller, Comstock, Aune & Strzyzewskui, 1989; Greene, O’Hair, Cody & Yen, 1985; Gronau et al, 2005) and others have shown an opposite effect (Hsu, Santelli & Hsu, 1989; Klaver, Lee & Hart, 2007). It is possible that these conflicting findings are due to the different methods used by the researchers, since it seems likely that the accessibility of the answer and its ease of retrieval from memory present one possible moderator. For example, Greene et al (1985) asked participants to both lie and tell the truth to spontaneous questions about a holiday they had been on. Although the findings were in the predicted direction they were not significant and it is possible that this was a result of truth tellers needing longer to retrieve detailed (and possibly fairly inaccessible) information from long-term memory than in paradigms probing more accessible information.

Moderator variables and response time

Although response times have shown themselves to be a fairly robust indicator of deception, there are still areas that require further investigation. Like many cues to deception, they are likely to be affected by a number of moderator variables, such as the accessibility of truthful information in memory (Greene et al, 1985), the complexity of the question (Vrij et al, 2007), individual differences in working memory capacity / verbal efficiency (Walczyk et al, 2003), the degree of preparation (DePaulo et al, 2003) and intoxication with alcohol (Kireev, 2008). There has only been limited work conducted relating to particular moderator variables, with preparation and coaching examined in recent years, but these studies have resulted in conflicting results. For example, Seymour et al (2000) demonstrated with a CIT paradigm that neither informing nor advising participants about longer response times when lying moderated the response time effect, whereas Robie, Curtin, Foster, Phillips, Zbylut and Tetrick (2000) showed that coaching participants extinguished the response time difference between liars and truth tellers who were completing personality measures. In the latter study, however, the coached liars were unable to successfully increase their scores on the questionnaire measures that they were completing, suggesting that quicker responses in liars is detrimental to their success when responding falsely.

The idea that preparing a lie response reduces the response time difference between lies and truths has been suggested in the research literature (DePaulo et al, 2003; Gronau et al, 2005), likely through a reduction in the lie construction processes that are required when responding to a question. However, Vendemia et al (2005) failed to show an effect of practice on the lie-truth response time difference in their study. Participants were presented with autobiographical questions and were instructed to respond to some questions truthfully and others falsely using a button press. They found that lie response times remained significantly longer than truth response times when participants completed the same task over a two week period of multiple testing sessions. Although this could be attributed to a lack of motivation by participants to improve, the additional finding of a reduction in error rates over the two week period suggests against this.

The effect that the subject of the lie has on the lie-truth response time difference has also been examined. In 2005, Gronau et al. examined both response time and skin conductance responses when participants completed a deceptive Stroop task. Similar to the concept of the CIT, it was considered that if information salient to the participant was presented within the Stroop task, this would interfere with accurate and timely completion of the task. A significant increase in response time was only shown when this information was personally relevant to the participant however, and not when it related to a mock-crime scenario. Similar findings were also put forward by Verschuere et al (2004) when they examined response time and physiological responses in a CIT, whereby participants completed a mock crime and were shown both control and crime-related pictures while attached to a polygraph. Throughout the task, participants were also exposed to auditory probes and had to respond to these using a computer input button as quickly as possible. Although findings demonstrated increased electrodermal responding for crime-related pictures, they failed to find a significant increase in response time to the auditory probes when crime-related pictures were displayed, suggesting that such information did not interfere with cognitive processing time.

A further possibility is that reaction times only show an effect for information that is more salient in memory, whereas skin conductance measures may require this to a lesser degree (Johnson, Henkell, Simon & Zhu, 2008; Nunez, Casey, Egner, Hare & Hirsch, 2005). Since response times relate specifically to the cognitive aspects of lying and denial, whereas skin conductance provides a measure of physiological arousal, the mechanisms for these indicators are likely to involve different processes. For example, Gamer, Bauermann, Stoeter and Vossel (2007) highlighted different brain activity associated with both reaction times and skin conductance when participants had to lie regarding an item in their possession. Therefore, it is possible that the mock crime paradigm does not provide enough interference in relation to cognitive effects, but does so in relation to physiological effects.

The relative strength of the truthful response may also influence any response time difference between liars and truth tellers. Verschuere, Spruyt, Meijer and Otgaar (2011) allocated participants into a frequent truth, frequent lie, or control condition. Participants in each condition answered 36 yes-no questions on daily activities presented twice and had to both lie and tell the truth in response to each question. Participants also answered a further 36 questions that were also presented twice. Those in the frequent truth condition were required to respond to all questions truthfully, those in the frequent lie condition were required to respond to all questions falsely, and those in the control condition were required to respond to the questions both truthfully and falsely an equal number of times. The response time difference between truths and lies was found to be greatest in the frequent truth condition, and smallest in the frequent lie condition, with no lie effect at all demonstrated when participants had to lie more often than tell the truth.

Deceptive cognition and brain activity

The suggestion that additional processes are involved in telling a lie compared to telling the truth has led to a surge of research using brain imaging techniques, particularly fMRI, to examine potential differences in brain activity between lies and truths (Christ, Van Essen, Watson, Brubaker & McDermott, 2009). Such work has not only supported findings of longer response times in liars, but has also highlighted the additional activation of certain brain regions during lie responses (Abe, Suzuki, Tsukiura, Mori, Yamaguchi, Itoh & Fujii, 2006; Ganis, Kosslyn, Stose, Thompson & Yurgelum-Todd, 2003; Greene & Paxton, 2009; Johnson, Barnhardt & Zhu, 2004; Spence et al, 2001). The particular brain regions consistently implicated in deception thus far include the dorsolateral and ventrolateral prefrontal cortices (DLPFC; VLPFC) and the anterior cingulate cortex (ACC). These brain regions have been associated with working memory, task switching and response inhibition processes (Christ et al, 2009). Impairments in these regions have also been shown to affect deceptive responding. For example, the dysfunction in the prefrontal cortex shown in Parkinson patients has been linked with an inability to inhibit true responses and produce deceptive responses (Abe, Fujii, Hirayama, Takeda, Hosokai, Ishioka, et al., 2009). Similarly, Karim, Schneider, Lotze, Veit, Sauseng, Braun and Birbaumer (2010) demonstrated that the speed of deceptive responses could be influenced by using transcranial direct-current stimulation (tDCS) to inhibit activity in the anterior prefrontal cortex. When such brain activity was inhibited, this actually led to faster response times for lies during a CIT mock crime paradigm.

Differences in brain activation patterns have also been shown according to the different aspects of a deceptive response. Abe, Suzuki, Mori, Itoh and Fujii (2007) undertook PET scans of 16 male participants answering 48 yes-no questions relating to autobiographical semantic memory. Participants were divided into one of four conditions. In the honest truth condition, participants were instructed to tell the truth about a past memory; in the honest lie condition, participants had to lie about a past memory; in the dishonest truth condition, participants were originally asked to lie, but were then secretly requested to tell the truth by a different experimenter immediately prior to the task; in the dishonest lie condition, participants were originally asked to tell the truth, but were then secretly requested to lie by a different experimenter. Interestingly, different brain regions were associated with the different tasks given in each condition. In particular, it was shown that the left dorsolateral and right anterior prefrontal cortices were associated with the act of falsifying a response, whereas the left ventromedial prefrontal cortex and the amygdala were associated with deceiving the experimenter.

Sip, Lynge, Wallentin, McGregor, Frith and Roepstorff (2010) examined active deception strategies using a laboratory version of the deceptive dice game Meyer. Two participants took turns to throw a dice and had to decide whether to deceive the other player regarding their throw result. In addition to directly falsifying a lie response, participants could also deceive by telling the truth with deceptive intent. The authors suggested that when making a false claim, additional processes would be engaged concerned with selecting responses from among competing alternatives. It was found that claiming truthfully with deceptive intent activated similar areas to claiming falsely, which is in accordance with findings of Carrión, Keenan and Sebanz (2010) of similar response times for both false responses and truthful responses intended to deceive.

How an individual deceives, i.e., whether they are denying knowledge compared to falsifying information, has also been suggested to involve differential cognitive processing. For example, Priori, Mameli, Cogiamanian, Marceglia, Tiriticco, Mrakic-Sposta, et al. (2008) demonstrated differential response times when people denied or falsely admitted having a picture. When neuronal excitability was then increased using anodal transcranial direct-current stimulation, response time significantly increased when participants falsely denied knowledge, but not when they falsely admitted possession of a picture. Nunez et al (2005) similarly highlighted potential processing differences according to the subject of the lie, claiming that behavioural and neural effects are more robust when the information being falsified is autobiographical rather than non-autobiographical in nature. Contrasting findings have been shown by other researchers, however, with Johnson et al (2004) showing consistently slower responses when people lie than when they tell the truth regardless of whether the lie is based on denying or falsifying a response. This led the authors to claim that the executive control processes used to make deceptive responses may be general purpose in nature. Given such varied findings, a wide variety of situational variables should be explored and considered when examining both the factors that affect the behavioural cues displayed by liars and also the inherent cognitive processes that may be responsible for these differences.

Interview techniques to detect deception

In the following sub-sections we now consider interview techniques that have been developed to aid in the differentiation of liars and truth tellers; namely, cognitive load techniques (Vrij, Granhag, Mann & Leal, 2011), the Strategic Use of Evidence technique (SUE; Granhag & Strömwall, 2002), the Behavioural Analysis Interview (BAI; refs) and concealed information tests (CITs; Lykken, 1959).

Deceptive cognition as an interview strategy

The finding that telling a lie involves additional processes, and hence is more difficult, than telling the truth has provided a new range of techniques to aid in the detection of deception. Although traditional lie detection tools, such as the polygraph, have been based on arousal approaches to deception, the effectiveness of such techniques has been seriously questioned (National Research Council, 2003). This has resulted in a resurgence of interest in other approaches that may aid lie detection in practical situations. Vrij and colleagues have recently demonstrated a lie detection technique based on the cognitive load approach, which involves using a series of strategies designed to increase the cognitive load of interviewees. Since liars are already experiencing more cognitive demand than truth tellers, they should have fewer attentional resources available to them to cope with any additional demands (Vrij & Granhag, in press). It is proposed that such a strategy will result in liars demonstrating behaviour that highlights this increased mental effort. For example, asking liars to recount their story in reverse order has been shown to result in an increase in so-called 'cognitive cues' such as blinking, speech errors and hesitations (Vrij et al, 2008).

Vrij and his colleagues have also investigated other methods for increasing cognitive load in liars, such as asking temporal related questions such as 'what was the weather like when you visited the house?'(Vrij, 2008) and asking individuals to draw the restaurant that they 'supposedly' visited (Leins, Fisher, Vrij, Leal & Mann, 2011; Vrij, Leal, Granhag, Mann, Fisher, Hillman & Sperry, 2009).

The strategic use of evidence

Granhag and Hartwig (2008) highlighted that liars and truth tellers typically employ different strategies when entering an interview situation. Namely, liars attempt to avoid and deny incriminating information, whereas truth tellers are much more forthcoming with the information that they provide. These different strategies form the basis of the Strategic Use of Evidence (SUE) technique (Granhag & Strömwall, 2002; Hartwig, Granhag, Stromwall & Kronkvist, 2006). This involves a strategic use of the evidence available in order to identify these differential strategies. The technique suggests that during interviews, both open and specific questions are asked, without revealing the evidence that the interviewer has access to. It is suggested that truth tellers are more likely to mention the relevant information spontaneously, whereas liars are not. Instead, liars are more likely to deny any knowledge of the incident, and thus are more likely to contradict the evidence. This approach is also related to the claims of the ADCM, since the model suggests that liars will consider the knowledge of the interviewer and adjust their lie accordingly during lie construction (Walczyk et al, 2003).

The promise of the SUE technique as a lie detection strategy has been highlighted by multiple researchers (Clemens, Granhag & Strömwall, 2011; Hartwig et al, 2006). Hartwig et al (2006) trained half of their interviewers in the SUE technique and compared their lie detection accuracy to a cohort of untrained interviewers using a style of their choice. It was found that guilty participants contradicted the evidence more often than truth tellers, particularly when interviewed by the SUE trained interviewees. Deception detection accuracy was also shown to be higher in the SUE trained group, with these interviewers showing an average detection rate of 85.4% compared to 56.1% for the untrained interviewers.

The behaviour analysis interview

The Behaviour Analysis Interview (BAI) was developed by John E Reid & Associates, Inc, following research conducted by Frank Horvath into the nonverbal and verbal responses of suspects when asked particular questions (Horvath, 1973). The technique provides a framework of interview questions divided into 3 main types. Namely, biographical questions, which relate to personal information regarding the suspect, such as their age; investigative questions, which relate to details of the incident under investigation, such as where an individual was when the crime was committed; and behaviour provoking questions, which are designed to elicit different behavioural responses from truth tellers and liars, such as 'why would someone ...?' The initial biographical phase is used to provide a baseline of truthful behaviour. This is then compared to the behaviour that individuals show during behaviour provoking questions, with behavioural differences between the two being used to differentiate honest from dishonest responses. The technique has remained popular in applied settings, particularly in US law enforcement agencies, and is described in more detail in the interview training manual of Inbau et al (2001).

The BAI technique remains the subject of debate, with research conducted by its developers demonstrating that the technique increases deception detection accuracy (Horvath, Jayne & Buckley, 1994). Unfortunately, other researchers have failed to support the majority of the assumptions of the BAI (Kassin & Fong, 1999; Vrij, Mann & Fisher, 2006). The design of these studies has, however, been criticised by Horvath, Blair and Buckley (2008) for failing to understand the correct implementation of the BAI.

Concealed information tests

The polygraph has traditionally been used in accordance with particular questioning techniques, such as the Comparison Question Test (CQT; Reid, 1947). Such techniques remain controversial (Vrij, 2008), since they lack an adequate theoretical foundation and rigorous scientific testing (Iacono, 2000). Since such polygraph tests are regularly used in a number of countries, including the US, Japan, Canada and Pakistan to differentiate liars from truth tellers (British Psychological Society, 2004; Honts, 2004; Krapohl, 2002; Vrij, 2008), the need for reliable questioning techniques has contributed to the development of the Concealed Information Test (CITs). CITs, also referred to as guilty knowledge tests, involve the presentation of sets of stimuli (such as weapons) to an individual, with one of these items relating to the crime under investigation (such as a murder weapon) and the other objects being unrelated to the crime. Individuals are asked whether the murder weapon was one of the following objects and are instructed to answer 'no' to all items. Individuals who are lying (because they have specific knowledge of the crime) are expected to show increased physiological arousal, as well as other behavioural cues such as increased response times, to the actual murder weapon than to irrelevant items. Individuals who are telling the truth are expected to demonstrate no differences between the objects. CITs have been developed as questioning techniques for use with the polygraph, although they are also commonly used in research examining brain activation and ERPs (Gamer et al, 2007; Lui & Rosenfeld, 2008; Phan, Magalhaes, Ziemlewicz, Fitzgerald, Green & Smith, 2005).

A limitation of the CIT is the requirement for interviewers to possess detailed knowledge about the crime in order to adequately develop the questions and resulting stimuli. It is also essential that details of the crime that are used in the test are not leaked to the public, since this may lead to innocent examinees being classified as guilty. A similar problem is likely to be encountered when individuals admit to witnessing the crime (and therefore are aware of specific details), but deny actual involvement (Honts, 2004). The National Research Council (2003) has also suggested that innocent examinee's may show reactions to crime-related stimuli because they also happen to be personally relevant to them, rather than because they were involved in the crime itself.

Despite the above limitations, Seymour and Kerlin (2008) demonstrated that reaction times could efficiently detect concealed knowledge when a CIT was used. Ben-Shakhar and Elaad (2003) also supported the potential use of CITs in polygraph examinations following a review of the relevant literature, but called for further research to be conducted in applied settings in order to test the high validity that these tests have shown in experimental studies.

Indicators of deception

It is a common belief of lay people that liars behave differently to truth tellers (Global Deception Team, 2006). Consequently, a variety of different behaviours have been examined using the methodologies discussed above in an attempt to discover reliable cues to deception. These can be broadly categorised into nonverbal behaviours, such as body movements and facial expression (Ekman & Friesen, 1974; Porter et al, 2008), paraverbal behaviours, such as response time (Walczyk et al, 2003), linguistic content, such as the use of spatial and temporal information in statements (Bond & Lee, 2005), and physiologcial indicators, such as skin conductance and brain activation (Spence et al, 2001). In the sections below, the different types of indicators will be discussed.

Nonverbal indicators

Research regarding visual nonverbal behaviours and deception has generally shown nonverbal cues to be unreliable as effective indicators of deception (DePaulo et al, 2003). A recent meta-analysis examining 54 studies conducted by Sporer and Schwandt (2007) demonstrated that, despite popular stereotypes regarding the nonverbal behaviour of liars, only nodding, foot, leg and hand movements were reliably related to deception. Regardless of this, nonverbal behaviours remain a popular indicator of deceptive behaviour in applied settings (Vrij, 2008a). Previous work has emphasised the importance of moderator variables on the behaviours displayed when people lie, such as the research design that is employed, variation in the measurement and definition of indicators, and the degree of preparation time provided (Sporer & Schwandt, 2006; Sporer & Schwandt, 2007). The effect that these different factors may have on experimental results makes direct comparisons of findings across studies difficult.

Body movement

Research conducted to date regarding body movements in deception has divided movements into 5 main areas: hand/finger movements; leg/foot movements; head movements; trunk movements and gestures/illustrators. Conflicting results have been reported in the literature regarding the relationship between body movements and deception (Granhag & Strömwall, 2002; Porter et al, 2008). For example, Porter et al (2008) showed an increase in illustrators and self manipulations when individuals lied compared to when they told the truth, but found no difference in head movements between the conditions, whereas Kalma, Witte and Zaalberg (1996) supported an increase in head movements when individuals lied, but did not support differences in other body movements. Furthermore, other studies have failed to support any differences in body movement at all (Vrij & Mann, 2001).

Differences in findings across studies may be attributable to the different measurement procedures that are used by different researchers. For example, experimental work has often coded gestures as one type of body movement, whereas Caso et al (2006) differentiated between several types of gestures (self adaptor, deictic, iconic, metamorphic) and demonstrated that the occurrence of these different gestures was differentially associated with lying and telling the truth.

Research conducted in applied environments has also demonstrated a lack of reliability in body movement cues, suggesting that previous findings are not merely due to controlled experimental situations being used. For example, Mann et al (2002) examined recordings of police suspect interviews and found that approximately 50% showed an increase in head movements and 50% showed a decrease in head movements when they lied. They also failed to support differences between true and false statements for hand/finger movements, illustrators or self manipulations.

The research examined has shown considerable variability in relation to findings, but only provides consistent support for a decrease in hand and arm movements when people lie (Caso, Vrij, Mann & DeLeo, 2006; Vrij, 2006; Vrij, Akehurst, Soukara & Bull, 2004; Vrij, Edward & Bull, 2001; Vrij & Winkel, 1991), although this is dependent on a variety of moderator variables, such as the threat level of the situation, interview style and the level of cognitive load experienced by the liar (Davis, Markus, Walters, Vorus & Connors, 2005; Vrij, 1995; Vrij, 2006; Vrij et al, 2008).

A decrease in hand/arm movements can be explained by the cognitive load approach to deception, with the increased cognitive load experienced by liars resulting in a reduction in ability to direct body movements. This has been supported in work conducted by Vrij, Semin and Bull (1996), which demonstrated that self-reported cognitive load and attempted control, rather than nervousness, was associated with a decrease in subtle hand/finger and foot/leg movements.

Gaze aversion

Despite gaze aversion being the most commonly cited cue to deception internationally (Global Deception Team, 2006), the scientific evidence base regarding this is considerably lacking. Research regarding gaze fails to support either eye contact or gaze aversion as a reliable cue to deception (Kalma et al, 1996; Mann et al, 2002; Strömwall et al, 2006; Vrij, Edwards, Roberts & Bull, 2000; Vrij et al, 2008; Vrij & Winkel, 1991), although a limited number of studies have demonstrated differences in the degree of eye contact when individuals tell a lie (Bond, Kahler & Paolicelli, 1985; Granhag & Strömwall, 2002; Mann et al, 2002; Mehrabian, 1971; Sitton & Griffin, 1981). Furthermore, research regarding gaze suggests that this behaviour may be attributed more to factors such as the cultural background of the interviewee, and the interview style used, than to deception per se (Buller et al, 1989; Vrij & Mann, 2001; Vrij et al, 2006; Vrij & Winkel, 1991).

Facial cues

The scientific study of emotional facial expressions was first introduced in the mid-nineteenth century, through the work of both Guillame Duchenne on the physiology of genuine smiles, and Charles Darwin, with the publication of his book, The Expression of Emotions in Man and Animals in 1872. In this work, Darwin made mention of the possibility that emotional expressions can portray information regarding an individual's true mental state more accurately then words alone. "[W]hen movements, associated through habit with certain states of the mind, are partially repressed by the will, the strictly involuntary muscles, as well as those which are least under the separate control of the will, are liable still to act; and their action is often highly expressive" (Darwin, 1872; p.54). Specifically, it was suggested that certain facial muscles are difficult to control voluntarily, and that some emotional expressions may therefore be difficult to inhibit when individuals attempt to conceal their true emotional state.

The considerations of Darwin were expanded in relation to deception in the *leakage hypothesis* (Ekman & Friesen, 1969), which claimed that facial movements associated with particular emotions may "leak" through attempts to conceal them. In 1978, Ekman and Friesen developed the Facial Action Coding System (FACS), which provided a systematic way for researchers to measure such facial movements. Separate muscles in the face were distinguished and combinations of movements of these muscles (known as Action Units) were identified for a variety of different emotional facial expressions, providing a method to "dissect" a facial expression in relation to a particular emotion. It is these distinct muscle movements that can be examined for "leakage" when individuals attempt to hide particular emotional expressions when deceiving others. This idea was explored in a study conducted by Ekman, Roper and Hager (1980), who found that fewer than 25% of their subjects were able to control their facial expression. It was suggested that this inability to produce particular movements when instructed may also suggest an inability to voluntarily suppress such movements when required. Therefore, when individuals feel emotions such as fear and anger, they should have difficulty in preventing certain facial movements associated with these emotions from occurring, resulting in emotional facial "leakage" during deception.

Emotional leakage can be divided into two main types. The first is commonly referred to as a micro expression, which is a full emotional expression displayed for a very brief period of time (suggested at around 1/5th – 1/25th second). Such facial movements are then quickly neutralised or masked once voluntary control is re-gained. Whereas micro expressions represent a so-called full facial expression displayed for a brief moment, other subtle facial movements have also been suggested to be worthy of examination in relation to deception detection (Warren, Schertler & Bull, 2008). Rather than representing an entire facial expression, such movements may provide only fragments of an emotional expression, with muscles that are unable to be voluntarily suppressed remaining active despite attempts to conceal.

The possibility that such micro expressions and other subtle facial movements could provide a cue to deception in security settings has been of increasing interest in recent years. In particular, the US, Israel and the UK have demonstrated interest in using micro expression identification techniques in airport security settings (Weinberger, 2010). One current example is the implementation of the US SPOT programme (Screening of Passengers by Observation Techniques), which has involved the training of approximately 3,000 behaviour detection officers in the identification of suspicious behaviour in airports, with training including the recognition of micro facial expressions. Although the validity of such behaviours as indicators of deceit has not been scientifically confirmed, such programmes already cost in the region of $212 million annually (United States Government Accountability Office, GAO, 2010).

Despite such substantial investment, several reports have highlighted a lack of scientific research regarding the validity and reliability of such facial cues as indicators of deception (Honts, Hartwig, Kleinman & Meissner, 2009; Porter & ten Brinke, 2008; United States Government Accountability Office, 2010; United States Government Accountability Office, 2011). Aside from a small number of studies by Paul Ekman and colleagues in the 1970s and 1980s regarding the muscular dynamics of false smiles (Ekman & Friesen, 1982; Ekman, Friesen & O'Sullivan, 1988), only limited recent research has been published examining both the existence and efficacy of micro expressions in relation to deception (Hurley & Frank, 2011; Porter & ten Brinke, 2008; Porter, ten Brinke & Wallace, 2012; ten Brinke, MacDonald, Porter & O'Connor, 2012).

Blink rate

Although not extensively examined, the improvement in technologies that can measure blink rate has resulted in a growth in research examining this behaviour. Blink rate has been linked with cognitive processing (Stern, Walrath & Goldstein, 1984) and increased cognitive load, with Vrij et al (2008) demonstrating an increase in blink rate when liars were asked to recall their story in reverse order. Research conducted by Leal and Vrij (2008) and Fukuda (2001) has suggested that when lying, an initial decrease followed by an increase in blink rate occurs, highlighting the importance of precise temporal measurements when examining the efficacy of blink rate as a cue to deception.

Although Mann et al (2002) supported a decrease in blinking in 81% of individuals lying during police interviews, Klaver et al (2007) and Thonney, Kanachi, Sasaki and Hatayama (2005) failed to support the presence of blink rate as a cue to deception.

Differences in the conceptualisation of the behaviour (i.e., whether paradigms target blinking as an arousal-related or a cognitive-related indicator) and the measurement procedures used, are likely to have contributed to the conflicting findings shown to date.

Paraverbal indicators

It is increasingly recognised that nonverbal behaviours, such as gaze aversion, are not reliable indicators of deceit, with Vrij (2008) claiming that speech-related cues are more diagnostic of deception than nonverbal behaviours. This idea is supported by research highlighting that observers are more accurate at detecting deceit when they are exposed to auditory cues than when they are exposed to visual cues only, suggesting that more cues to deception may indeed be 'leaked' through vocal channels (Mann, Vrij, Fisher & Robinson, 2007). These vocal cues, such as voice pitch, response time, and pauses, represent potential paraverbal indicators of deception.

A meta-analysis conducted in 2006 by Sporer and Schwandt highlighted conflicting findings in relation to the validity of paraverbal indicators of deception, demonstrating significant effects for only a small number of cues, including an increase in pitch, response latency and speech errors, and a decrease in message duration, when individuals tell a lie. The relationship of these cues to deception was shown to vary as a function of a number of factors, including the content of the lie, the experimental design, how motivated the participants were to deceive, and the degree of preparation participants' engaged in.

Speech disturbances

Speech disturbances encompass several categories, including repetitions, errors, hesitations and filled/unfilled pauses. Speech disturbances have been shown to be significantly affected by the level of difficulty that the liar is experiencing when formulating their lie (Vrij et al, 2008; Vrij & Heaven, 1999). Overall there is a reasonable level of support for an increase in speech disturbances as a cue to deception (DePaulo et al, 2003; Sporer & Schwandt, 2006; Vrij & Mann, 2001; Vrij et al, 2001; Zuckerman et al, 1981), although some studies have failed to show any significant differences in relation to speech disturbance cues (Porter et al, 2008; Strömwall et al, 2006). Although speech disturbances show a degree of promise as a reliable indicator of deception, the incidence of such disturbances is affected by moderator variables, such as interview style. For example, Vrij et al (2006) highlighted that participant's show a decrease in speech disturbances when an interrogation style procedure rather than an information gathering interview procedure is used. Mann et al (2002) further highlighted inconsistencies regarding speech disturbances as a cue to deception in their examination of police suspect interviews, since only half of liars showed an increase in this cue, suggesting that examination at an individual level is required.

Pitch

An increase in pitch is associated with increased physiological arousal and therefore relies on liars experiencing stress and arousal to a greater degree than truth tellers, which cannot be guaranteed. Previous literature reviews (DePaulo et al, 2003; Sporer & Schwandt, 2006; Zuckerman et al, 1981) have shown support for an increase in voice pitch when individuals lie compared to when they tell the truth, but research examining pitch as a cue to deception is limited.

Speech rate

A decrease in speech rate has been associated with deception, with several studies supporting the idea that liars speak more slowly than truth tellers (DePaulo et al, 2003; Vrij & Mann, 2001; Vrij et al, 2001). As lying is often more cognitively demanding than telling the truth, a slower speech rate may be expected when individuals have difficulty in formulating their response. Several studies have failed to support such promising findings (Granhag & Strömwall, 2002; Mehrabian, 1972; Vrij et al, 2004) and Davis et al (2005) highlighted the impact of extraneous factors, such as the incriminating potential of the question, on speech speed in genuine police interviews.

Response time

There has been a resurgence of interest among cognitive psychologists and neuroscientists in response time as a cue to deception, since response times provide a measure of additional cognitive processing. Although research supports the idea that people take longer to respond to questions when they lie than when they tell the truth (Gregg, 2007; Seymour & Kerlin, 2008; Vendemia et al, 2005; Walczyk et al, 2003; Walczyk et al, 2005), there is still debate regarding this area, since some researchers have failed to support these findings (e.g., Greene et al, 1985; Verschuere et al, 2004) and others have shown an opposite effect (Ekman, 1988; Levine, Feeley, McCornack, Hughes & Harms, 2005).

Gregg (2007) developed a computer based lie detection technique which utilised response times to both control and target statements to identify liars. The author claimed that the system could correctly classify separate groups of liars and truth tellers with 85% accuracy; however, similar to the CIT, it relies on interviewers having detailed information regarding the crime.

Linguistic indicators

Research regarding linguistic cues to deception has grown in popularity, with the suggestion that liars use different words, phrases and descriptors when recounting their stories than truth tellers (Ali & Levine, 2008; Bond & Lee, 2005; Masip, Bethencourt, Lucas, Segundo & Herrero, 2012; Memon, Fraser, Colwell, Odinot & Mastroberardino, 2010). This linguistic analysis of statements and interview transcripts to detect deceit has increased since the development of both Criteria-Based Content Analysis (CBCA; Kohnken & Steller, 1988) and Reality Monitoring (RM; Johnson & Raye, 1981).

Criteria-Based Content Analysis was originally developed for use in child abuse cases in German courts and claims that statements based on the memory of an experienced event will differ in both quantity and quality from an imagined or false experience. Altogether, 19 criteria are used by coders to identify the presence or absence of certain words and descriptors in transcripts, such as:

- **Spontaneous corrections:** 'I had just gone upstairs when I heard it, no wait, I actually heard it before I went upstairs'.
- **Unusual details:** A witness highlighting that a suspect had a birth mark on their neck.
- **Contextual embedding:** Providing specific details of the time and place of the event.

If such words and phrases are identified in a transcript, this is taken as an indication that the individual is telling the truth.

Reality Monitoring was developed in an academic setting and has a stronger theoretical basis than CBCA, highlighting the different memory characteristics of genuine and false events. It is argued that memories of experienced events are obtained through perceptual processes, whereas false memories are created internally by cognitive processes. As such, 8 criteria have been developed that identify whether a particular memory is based upon perceptual or cognitive processing. These include the presence or absence of:

- **Perceptual information:** Statements related to smells, sounds, tastes and visual details.
- **Affect:** Information related to how the individual felt.
- **Spatial information:** Where the event happened.

Recent research regarding linguistic cues to deception has shown considerable variation, with accuracy rates between 53% and 88% (Vrij, 2008). However, certain criteria within CBCA and RM have shown themselves to be more diagnostic of honesty than others (Bond & Lee, 2005; Caso et al, 2006; Godert, Gamer, Rill & Vossel, 2005; Schelleman-Offermans & Merckelbach, 2010; Sporer & Sharman, 2006; Vrij et al, 2004). Newman, Pennebaker, Berry and Richards (2003) also highlighted differences in the effectiveness of linguistic indicators according to the subject that an individual is lying about, with linguistic markers more consistent when examining attitudes to abortion than mock crime information. Similarly, linguistic detection methods require individuals to actively falsify a lie and therefore, deception related to denials, exaggerations and minimisation of involvement may be more difficult to detect using linguistic indicators.

Like many potential indicators of deception, linguistic markers are also vulnerable to countermeasures. For example, Caso et al (2006) instructed participants in either nonverbal behaviour countermeasures regarding body movement, CBCA criteria or gave them no instructions. Participants in the CBCA group were able to significantly modify their verbal behaviour when lying, whereas participants in the nonverbal behaviour group showed no difference in body movements from uninformed liars, suggesting that linguistic behaviour may be easier to control effectively than nonverbal behaviour.

Physiological indicators

Although physiological cues have been traditionally used to identify deceit, the scientific evidence supporting this is limited (National Research Council, 2003). Physiological cues commonly relate to the arousal approach to deception, with the assumption that liars will experience increased physiological arousal to questions related to the crime under investigation than truth tellers. However, a comprehensive theory as to why this may occur is lacking and levels of arousal are vulnerable to both mental and physical countermeasures (see. www.Antipolygraph.org).

A common tool used to measure physiological arousal is the polygraph, which measures physiological responses, such as blood pressure and skin conductivity, when individuals respond to particular questions. The polygraph has been used in several countries, most notably the US, Canada and Japan, to aid in police investigations (Vrij, 2008). Despite the apparent widespread usage of the polygraph in the field, many courts of law will not allow the polygraph to be presented as evidence due to limitations and questions concerning its reliability and validity (for discussion, see Ben-Shakhar & Furedy, 1990; Honts, Kircher & Raskin, 2002; Iacono & Lykken, 1997).

In 2003, the National Research Council completed a report on the scientific status of the polygraph, with the British Psychological Society completing a similar report in 2004. These reports highlighted severe limitations in research conducted on the polygraph and suggested that other areas of deception detection be explored. Despite such concerns, the use of physiological cues to detect deceit remains popular, with the UK Home Office recently introducing regular polygraph screening for the monitoring of sex offenders (Home Office, 2005). Indeed, Langleben (2008) states that "even the presumed inadmissibility of the polygraph in courts does not preclude it from influencing the prosecutions' decision to prosecute." (Langleben, 2008; p.6).

With the recent development in neuroimaging technology, a second stream of research regarding physiological cues to deception has focused on the cognitive approach to deception, examining the cognitive processes involved in telling lies (Christ et al, 2009; Sip et al, 2010). Since additional processes have been suggested to be involved in lying compared to telling the truth, it is intuitive that such processing may be identifiable using methods that target brain activation patterns. Although such methods may be considered to be more theoretically based than early uses of the polygraph, the premature commercialisation of such technologies has been challenged (Wolpe et al, 2005).

Facial thermography

Pavlidis, Eberhardt and Levine (2002) claimed that 83% of subjects could be classified correctly as liars or truth tellers by examining heat in the facial area, particularly around the eyes and nose. This was further supported by Tsiamyrtzis et al (2007), who suggested that facial thermography presents a reliable cue to deception. The authors of this research also highlighted limitations of this technique to detect deceit, with the degree of temperature elevation shown in the face area dependant on both the intensity of the stress experienced and the individual psychophysiology of the subject.

Despite such apparently promising findings (Pavlidis et al, 2002; Tsiamyrtzis et al, 2007), work examining facial thermography is extremely limited. The National Research Council (2003) criticised the use of thermal imaging as a lie detection tool, claiming that previous work "does not provide acceptable evidence for the uses of facial thermography in the detection of deceit" (p. 157). Indeed, Pollina and Ryan (2002) demonstrated that thermal imaging of the eye and nose area was only useful to detect deceit when combined with traditional polygraph measures. Similarly, Warmelink, Vrij, Mann, Leal, Forrester and Fisher (2011) found that thermal imaging did not increase detection accuracy further than an interviewer's decision independently. Fifty-one passengers in an airport departure lounge either lied or told the truth regarding a forthcoming trip in an interview while a thermal imaging camera recorded their skin temperature. It was found that liars demonstrated an increased skin temperature during the interview, whereas truth tellers remained constant. However, whereas 64% of truth tellers and 69% of liars were correctly classified using skin temperature recordings, the interviewers were able to correctly classify 72% of truth tellers and 77% of liars independently of these recordings.

Cardio-respiratory indicators

Although traditionally used with the polygraph, cardio respiratory indicators of deception have shown promise in the research literature, with increased skin conductance and respiration line length supported by research studies using CIT paradigms (Ben-Shakhar & Elaad, 2003; Engelhard, Merckelbach & van den Hout, 2003; Gamer et al, 2007; Tarlovsky, Yechiam, Ofek & Grunwald, 2008).

Classification levels remain far from ideal and unless these indicators are used in conjunction with particular questioning techniques such as the CIT, they provide more information regarding the situation an individual is placed in than deceit per se. For example, although liars may experience increased arousal, truth tellers are also likely to experience a degree of arousal, particularly if they are placed in a situation where they are not believed. Since laboratory studies are unlikely to mirror the arousal experienced in real world situations, like many physiological cues to deceit, more research is required in field settings to reliably evaluate the effectiveness of such indicators.

Pupil dilation

Pupil dilation can provide a marker of both the level of cognitive load experienced by an individual and the level of physiological arousal. Reviews conducted by Zuckerman et al (1981) and DePaulo et al (2003) regarding deceptive behaviour have highlighted pupil dilation as a promising cue to deception, although the amount of work explicitly examining this indicator is limited. In 1996, Lubow and Fein demonstrated that guilty participants had larger pupil diameters, however, it remains uncertain whether this was due to increased physiological arousal or increased levels of information processing.

Until the factors causing increased pupil dilation can be identified, it is difficult to determine the specific situations in which pupil dilation can be reliably used as a cue to deception. For example, increased information processing may occur when individuals are constructing their lie, but also when truth tellers attempt to retrieve detailed information from their long-term memory. Work conducted by Dionisio, Granholm, Hillix and Perrine (2001) addressed this issue to a certain extent when they highlighted that pupil dilation in their experiment was linked to the amount of cognitive processing occurring and that this occurred in 92% of individuals when they responded deceptively.

Event-related potentials

Event-related potentials (ERPs) are electrophysiological responses that occur in the brain and reflect the occurrence of ongoing cognitive processes (Bressler, 2002). They are measured through the application of electrodes to the scalp and as such, require intrusive and difficult to use measurement procedures (Nakayama, 2002). Particular brain responses, such as the N190 and the P300, have been associated with deceptive responses in past research (Farwell & Donchin, 1991; Johnson et al, 2008; Kireev et al, 2008; Lui & Rosenfeld, 2008) and are generally measured using versions of CIT paradigms, whereby individuals are presented with both crime-related and unrelated objects and the resulting physiological responses are measured.

The use of ERPs to detect deception has shown promise in the research literature, with Farwell and Smith (2001) developing and advertising their ‘brain fingerprinting’ lie detection technology. This commercialisation can be considered premature however, since the utility of ERPs as an indicator of deception remains problematic. This is due to difficulties in identifying the cause of differences in brain activity, which makes is difficult to identify the specific situations that such responses may occur in for both truth tellers and liars. In addition, Rosenfeld, Soskins, Bosh and Ryan (2004) have highlighted the vulnerability of ERPs to countermeasures, with guilty participants who were instructed to press a finger or wiggle a toe on certain trials being detected with only 18% accuracy. Since studies have often been conducted in very limited laboratory based settings, where effects are highly controlled and brain activity is not affected by external factors, the reliability and validity of ERPs in field environments has yet to be adequately established.

Functional magnetic resonance imaging

Improvements in brain imaging technology in recent years has led to an increase in research examining specific regions of the brain that may be involved in telling lies. Such research has used functional Magnetic Resonance Imaging (fMRI) scanners to examine brain activation when individuals lie in response to simple questions presented by a computer, such as ‘are you catholic?’

Imaging studies have highlighted that certain areas of the brain, particularly the prefrontal cortex, show considerably greater activity when people lie than when they tell the truth, and that this activation is separate from occurrences of genuine false memory

(Abe et al, 2006; Abe et al, 2008). Since increased activation of the prefrontal cortex can be linked with a variety of executive control processes, including response inhibition, task switching and working memory (Christ et al, 2009; Spence et al, 2001), this suggests that additional cognitive processes are necessary to engage in deceptive communication.

Further research has supported differences in brain activation patterns according to whether lies have been rehearsed (Ganis et al, 2003), and whether the subject of the lie is autobiographical or non-autobiographical (Nunez et al, 2005). If different types of lie correlate with different brain responses, it seems likely that different types of lie will also correlate with different behavioural effects, highlighting the importance of examining moderator variables in more detail.

Several limitations and ethical considerations have been identified in the potential use of brain scanning techniques to detect deceit (Ganis, Rosenfeld, Meixner, Kievit & Schendan, 2011; Sip, Roepstorff, McGregor & Frith, 2008; Wolpe et al, 2005). FMRI machines are large, noisy, both time consuming and expensive to operate, and uncomfortable for the individuals being scanned. Like ERPs, research on the use of fMRI as a lie detection tool has only been conducted in highly controlled environments and has not yet established causal mechanisms for the effects shown (Sip et al, 2008). Worryingly, it has been shown that when jurors are presented with fMRI evidence in court, they are more likely to judge suspects as guilty compared to when other lie detection evidence is presented, such as polygraph or thermal imaging (McCabe, Castel & Rhodes, 2011). The potentially influential nature of such data means that all of the above issues must be addressed before the use of fMRI evidence is considered acceptable in field settings.

Human ability to detect deception

Following from our consideration of behavioural markers of deception, we next review research regarding human ability to detect deception. Although individuals' share common beliefs regarding how a liar typically behaves (Global Deception Team, 2006), it has been repeatedly shown that individuals are generally poor at detecting deceit in an experimental environment. In their meta-analysis of 142 studies, Bond and DePaulo (2008) highlighted a mean detection accuracy of 55%, even though a 50% accuracy rating is expected by chance.

A lack of association between the stereotypes people hold regarding deceptive behaviour and how liars have actually been shown to behave is likely to contribute to individuals' poor ability to detect deceit. For example, the Global Deception Team (2006) conducted an international survey examining beliefs about deception in 75 different countries and found gaze aversion to be the most commonly cited cue to deception, a belief in sharp contrast to the research literature (DePaulo et al, 2003). This possibility is highlighted in research demonstrating that police officers who hold popular stereotypes regarding deceptive behaviour, such as 'liars look away or fidget', perform less effectively when judging the honesty of presented video statements (Vrij & Mann, 2001).

Although Bond and DePaulo (2008) concluded in their review that deception judgements are influenced more by differences in an individual liars credibility than differences in the ability to detect lies, recent research has suggested that a minority of individuals are better at detecting deceit than others (detecting truths and lies with over 80% accuracy). These 'experts' have been found predominantly in law enforcement and secret service occupations (Bond, 2008; Ekman, O'Sullivan & Frank, 1999). The existence of such 'experts' has been questioned however (Bond & Uysal, 2007), with researchers highlighting a current lack of research examining individual differences in the ability to detect deception (Aamodt & Custer, 2006; Bond & DePaulo, 2008). Whether some people are actually better at detecting lies than others remains the subject of much debate (Bond & Uysal, 2007; O'Sullivan, 2007).

Truth bias and deception detection

A significant factor that affects the ability to accurately detect deceit is any response biases that an individual may have, which we investigate in Chapter 5. Levine et al (2006) highlighted a positive, linear relationship between detection accuracy and the ratio of truthful to total messages, suggesting that deception detection ability is influenced by the presence of a truth bias. In their study, 463 participants were divided into one of 9 conditions to view 14 video messages. In one of these conditions, the 14 video messages were divided into 7 lies and 7 truths, with the further 8 conditions comprising one of 8 different base rates ranging from 0-100% truths. Truth accuracy scores ranged from 29%-100% with a mean of 67%, whereas lie accuracy scores ranged between 0-71%, with a mean of 31%. Accuracy means were found to increase as the proportion of messages that were true increased.

Overall, the general population have been shown to have a truth bias, judging more messages as truths than as lies (Bond & DePaulo, 2006). Such biases have been shown to be context dependent, with participants actually showing a lie bias when judging contexts where deception is more often encountered. For instance, when judging the statements of salespersons (DePaulo & DePaulo, 1989) or when an element of suspicion is introduced (DePaulo et al, 2003). Possible explanations for the presence of an overall truth bias have been related to the existence of learned rule systems, termed heuristics, which allow us to make efficient decisions when dealing with complex environments (Fiske & Taylor, 2008; Kahneman & Tversky, 1972).

Potential rule systems related to deception judgements, such as the availability heuristic (O'Sullivan, Ekman, & Friesen, 1988) and the anchoring heuristic (Tversky & Kahneman, 1974), are in accordance with previous suggestions that the truth represents our default communicative stance (Gilbert, 1991). The availability heuristic suggests that individuals are more often presented with truthful information than false information in daily life, and as such, are more likely to judge messages as truths than lies. The anchoring heuristic suggests that people make insufficient adjustments from an initial value, resulting in a bias towards that value when making decisions. If truthful information is considered the "norm", or default, social behaviour, then extra effort will be required to make sufficient judgements away from this default setting and correctly identify deceptive messages (Elaad, 2003; Gilbert, 1991).

A third possible explanation for the truth bias relates directly to social conventions and rules. Toris and DePaulo (1984) suggest that social convention prevents us from regularly challenging the truthfulness of information we are given. Indeed, such a conversation would not only be extremely time consuming, but also considered impolite by others, therefore jeopardising the formation and continuation of positive social relationships (DePaulo, Jordan, Irvine, & Laser, 1982). Although the above suggestions may contribute to the presence of a truth bias, the precise processes affecting this social judgement remain unclear. Since the presence of such biases impacts on lie detection ability, however, examination of individual differences related to this allows for further investigation of the mechanisms involved in both social judgement bias and lie detection ability.

Training and deception detection

A small number of studies have been conducted to examine whether it is possible to increase people's ability to detect deception through the use of training programmes (Driskell, 2011; Porter, Juodis, ten Brinke, Klein & Wilson, 2010; Vrij, 2008). Vrij (2008) reviewed 22 studies examining the effects of training individuals to pay attention to, and identify, specific behavioural cues to deception and found that training only increased accuracy levels to a minimal degree (approximately 4%). Similarly, Kassin and Fong (1999) demonstrated that judges who were trained to examine the behaviours advocated by the Inbau group (Inbau, Reid & Buckley, 1986) performed worse than their untrained counterparts.

More positive findings have been reported by other researchers, with a literature review conducted by Driskell (2011) concluding that training is effective in enhancing deception detection accuracy. The length and quality of individual training programmes is likely to account for any conflicting findings in the field, with greater improvements shown when participants were trained on behavioural observation skills for a 2-day period (47% pre-training, 77% post-training; Porter, Woodworth & Birt, 2000) compared to a 2-hour period (51% pre-training, 61% post-training; Porter et al, 2010).

Interestingly, findings of Porter, Woodworth, McCabe and Peace (2007) and Levine et al (2005) suggest that the actual content of training programmes may be less important than the fact that people have undergone training at all. Porter et al (2007) demonstrated that the provision of any feedback following deception judgements, whether inaccurate or accurate, had a positive effect on deception detection ability. Similarly, Levine et al (2005) showed that even bogus training groups who were taught to focus on behaviours that are not known as indicators of deception, sometimes performed better than control groups who received no training. It is possible that following any kind of training, participants are less likely to use heuristics and automatic decision processes when making judgements, leading to improvements in situational observation skills. Alternatively, Hartwig and Bond (2011) suggest that training may enhance participants' motivation to complete the task to the best of their ability, whereas Levine et al (2005) suggest that trained observers may assess information more critically than untrained observers.

Conclusion

In this chapter we have reviewed the current literature regarding deception detection. The experimental work we subsequently present in this thesis addresses two main areas discussed above. Firstly, the cognitive processes involved in telling a lie and secondly, the factors that impact on human ability to detect deception.

The previous focus of deception research on identifying an indicator to detect deception has resulted in large quantities of data that cannot be adequately explained or understood. In order to address this issue, the continued development of theories of deceptive communication is required, so that the processes underlying deceptive behaviour can be identified. As technology advances, an increased number of researchers are focusing on the examination of deceptive cognition, particularly in relation to the brain regions involved in producing a deceptive response. Since lying encompasses a variety of psychological processes, such as the monitoring of non verbal and verbal behaviour, decision making and lie generation, there are several factors that may affect behaviour when an individual tells a lie. As shown in the above review, research has consistently highlighted the effects of moderator variables, such as interview characteristics, interviewer characteristics, subject of the lie and individual differences, on both verbal and non verbal behaviour. The development of deception theories must consider this variety of factors. The present thesis extends this work by focusing on potential factors that may influence processing differences between liars and truth tellers, and further identifies the role of distinct cognitive processes in the additional time required to tell a lie.

The ability to detect the deception of others was also examined in the current chapter, and provides a focus for our work in Chapter 5. Although human ability to detect deception has been shown to be poor, the possibility that individual differences in detection ability exist has been suggested by a small number of researchers. The existence of individual differences in degree of truth bias, and how this may interact with deception detection judgements, has been neglected in previous work, however. The present thesis therefore extends this work by focusing on potential factors that may influence accurate deception judgements through examination of both accuracy levels and truth bias when individuals make cross-cultural deception judgements.

CHAPTER 2

Decisions, Decisions: Choice when Telling Lies

Despite the apparent prevalence of lie-telling within society (Serota et al, 2010), lying is a complicated behaviour that requires breaking the normal, default rules of communication (see Grice, 1989). The liar must first of all decide not to assert the truth, and then must assert an alternative statement that is plausible and appears informative to the listener, all the while concealing any outward signs of nervousness. Such a pragmatic feat requires cognitive processes in addition to those used when telling the truth. In this chapter we investigate what those processes might be.

Our starting point is to examine the reasons given in the literature for why lying appears to be more difficult than telling the truth. Longer lie times, for example, must be indicative of additional cognitive processes involved in lying compared to telling the truth. Based on the framework developed by Walczyk et al (2003), three processes that have been implicated in lying are discussed and the empirical evidence in favour of each summarised.

Suppression of the truth

Our default communicative stance is to tell the truth. Without the assumption that speakers utter the truth most of the time, it is difficult to see how efficient communication could ever occur (see Grice, 1989, amongst others). This suggests that when people wish to lie to a question they will need to intentionally suppress the default, truthful response, which should increase the difficulty of lying relative to telling the truth.

There is indeed plenty of empirical evidence consistent with the claim that telling lies involve suppressing the truth. For example many researchers have found longer response times for lying relative to telling the truth (Holden, 1998; Vendemia, Buzan & Green, 2005; Vendemia et al, 2005; Walzyck et al, 2003), and there is neuroscientific evidence that brain regions active in lying overlap with brain regions associated with general response inhibition (Abe et al, 2008; Lee, Liu, Chan, Ng, Fox & Gao, 2005; Spence et al, 2001; Spence et al, 2008; and see Christ et al, 2009 for a meta-analysis).

These findings have meant that recent cognitive models of deception have incorporated both the automatic activation of the truth and its resultant suppression as additional processes that contribute to longer response times for liars (Vendemia et al, 2009; Walzyck et al. 2003; Walczyk et al, 2005). For example, the Activation-Decision-Construction Model (ADCM; Walzyck et al. 2003; 2005) claims that following a question, relevant information (in particular, the truth) is automatically activated in long-term memory (e.g., Kintsch, 1998). This information is then made consciously available in working memory (e.g., Ericsson & Kintsch, 1995). In order to respond to a question deceptively, cognitive resources are required to inhibit the truthful response. Similarly, the Working Model of Deception (WMD; Vendemia et al, 2009) highlights response inhibition as a pre-requisite to responding to a question deceptively.

While the need to suppress the truth is undeniably an important component of why lying is more difficult than telling the truth, there are several other reasons that have received less attention in the literature and that might also contribute. These are discussed below.

The decision to lie

Assuming that people tell the truth by default (Grice, 1989), they must make a conscious choice to lie. The decision to lie is therefore likely to be an additional cognitive process associated with lying that takes time to execute. Indeed, current models of how we lie include a lie decision component. For example, the Working Model of Deception (WMD; Vendemia et al, 2009) assumes that when an individual hears a question to which they may respond deceptively, executive control processes are used to determine the appropriate response (i.e., lie or truth), with a decision being made based on the likely risks and benefits involved. Similarly, the Activation Decision Construction Model Revised (ADCM-R; Walczyk, Mahoney, Doverspike & Griffith-Ross, 2009) considers individuals who have previously decided to lie to particular questions and have rehearsed an answer. In these cases, the model states that a decision is still required because individuals must remind themselves of their decision to lie when that particular question is heard.

Despite the inclusion of decision components in the models, there is surprisingly little work that has specifically investigated how people make the decision to lie. This is perhaps because it is experimentally much easier to instruct people when to lie than to allow them to choose. We can find only a few papers that have investigated the decision process: Walzcyk et al (2005) and Spence et al (2008). Walczyk et al. presented participants with a selection of neutral questions and questions probing embarrassing information. Participants were instructed to lie to certain questions, such as those regarding their employment history, and tell the truth to others, such as those regarding what they did on Sunday morning. However, for general questions, they were instructed to answer truthfully unless a question probed embarrassing information about which they would normally lie to a stranger, in which case they should lie. In this condition, participants needed to decide themselves when to lie and when to tell the truth. The experiment demonstrated that more time was needed to respond when individuals chose to lie compared with when they had been instructed, and both took longer than telling the truth, consistent with the idea that the decision of how to respond adds to cognitive processing load. However, it is difficult to be certain whether the elevated response times were due to the evaluation of whether a question was embarrassing or to the decision of how to respond.

Spence et al (2008) allowed participants to choose whether to lie or tell the truth to computer-generated yes-no questions regarding an embarrassing past life event, although participants were asked to achieve an approximate balance between truths and lies over the course of the experiment. Similar to findings when individuals have been instructed on how to respond (Seymour et al, 2000; Spence et al, 2001; Vendemia et al, 2005), lying showed increased activation of the ventrolateral prefrontal cortices compared to truth-telling. However, because there was no direct comparison of trials between choosing to respond and being instructed to respond, little can be concluded about the decision process itself.

Construction of the lie

Lies and truths also differ in the way in which they are constructed. Lies need to be explicitly chosen from a range of alternatives and the result must be plausible and consistent with previous information. Truths, on the other hand, seem to be generated automatically without a need to select "which" truth. The procedures needed to choose which lie to use and to verify the plausibility may be costly to operate.

Walczyk et al (2005) directly tested whether the added complexity of lie construction was a contributing factor to elevated lie response times. Their approach was to manipulate whether participants responded to open-ended questions, such as, "What colour is your hair?" or yes/no questions, such as, "Is your hair brown?"(Although it is appreciated that differing definitions of open-ended questions exist, for clarity the same terms as Walczyk et al. are used when interpreting their findings). Walczyk et al. argued that more lie construction was needed to respond to open-ended questions than yes/no questions because open-ended questions required explicit retrieval of information from long-term memory, whereas yes/no questions merely needed the production of an affirmation or denial. If lie construction was contributing to longer lie response times, then lying to open-ended questions should be more difficult than lying to yes/no questions. Consistent with these predictions, Walczyk et al. observed longer lie response times in the open-ended question condition than in the yes/no condition. There are a number of issues that make the interpretation of this result difficult, however. First, while lying to open ended questions was slow relative to yes/no questions, telling the truth was also slow. It is therefore not clear whether their effect relates to lie construction or to the difficulty of responding to open-ended questions in general. Second, Walczyk et al. did not equate the content of the question across yes/no and open-ended conditions. For example, they compared response times to questions such as “Do you like chocolate” with questions such as “How many credit cards do you own?” Differences in response times could therefore be explained by differences in the ease of accessing information, rather than the question types *per se*.

While there has been no direct evidence about how people assess the plausibility of potential lies, there is indirect evidence that plausible lies are costly to generate. First, studies investigating the effects of making lies more complex have found that they are easier to detect. For example, asking participants to recall events in reverse order (Vrij et al, 2008) and using interview techniques that require longer answers to questions (Vrij et al, 2007) have increased discrimination between liars and truth tellers. Finding that lies are easier to detect when the lie is more complex suggests that extra resources are needed to construct the plausible lie.

Secondly, if lie construction independently contributes to the processing difference between lying and truth-telling, individuals who have been given the opportunity to rehearse or prepare a lie response will require less processing time than unprepared liars. Several studies have found evidence that this is the case. In their review of the literature, Zuckerman et al (1981) found that the response time difference between lying and truth-telling only occurred when participants had not rehearsed a response. More recently, the meta-analysis conducted by DePaulo et al (2003) similarly found that longer response times for liars only demonstrated a significant effect size when participants were not given the opportunity to prepare their lie. Alternative paradigms incorporating an explicit period of rehearsal have shown smaller response time differences between rehearsed lies and truths compared to unrehearsed lies and truths (Walczyk et al, 2009).

In summary, we have reviewed the evidence for three processes involved in lying that are not involved in telling the truth. There is substantial evidence that the first process, the suppression of the truth, contributes to the extra costs involved in lying, but the evidence for the other processes is weaker. Our study therefore concentrates on testing whether the decision to lie and the construction of the lie contribute to the greater difficulty of lying, as distinct from suppressing the truth. In doing so, we hope to understand in more detail what cognitive processes are involved when people lie.

The Current Study

Our paradigm involved presenting participants with a coloured square and asking them to lie or tell the truth about the colour. We used vocal onset time as the dependent measure. In Experiments 1 and 2 we investigated the decision to lie by comparing trials in which participants chose whether to lie or tell the truth compared to being instructed. In Experiments 3, 4 and 5 we investigated the lie construction process by comparing one possible lie response to a choice of two or three lie response possibilities, and by manipulating the plausibility of particular lie responses.

The colour-naming paradigm that we have developed is different to the paradigms generally used in lie research. For example, in Granhag and Strömwall (2002), participants watched a simulated crime and lied about the protagonist, or in Porter et al (2008), an interviewer asked questions about an interviewee's background and the participant lied about certain details. The reason for the difference in methodology is that most of the previous research into lying has been concerned with lie *detection* whereas we are interested in the underlying cognitive processes. Deception researchers, understandably, are interested in the measure which is most able to distinguish lies from truths, whether that is skin conductance (Ben-Shakhar & Elaad, 2002), facial expressions (Ekman & Friesen, 1974), or offline measures such as linguistic analyses (Bond & Lee, 2005), none of which are necessarily indicative of cognitive processes. Furthermore, even when researchers have used more traditional cognitive markers of deceit, such as response times, the emphasis has been on discovering whether a difference between lies and truths exists under different lying conditions rather than discovering which cognitive processes are responsible. Because we wanted to isolate the individual components of lying, our paradigm was designed to eliminate as much variability as possible, such as preparation time (Vendemia et al, 2005), motivation (DePaulo & Kirkendol, 1989) and the subject of the lie (DePaulo et al, 2003). Of course, there are likely to be other lie factors involved that are not present in our paradigm, such as the added stress of lying (as we discuss further in the General Discussion).

Experiment 1

There were two goals for Experiment 1. First, to establish whether our paradigm produced results consistent with the past literature on lying; specifically, that lie responses require slower response times than true responses (Carrión et al, 2010; Vendemia et al, 2005). Second, we wanted to investigate the effects of deciding to lie by manipulating whether participants chose to lie, or whether they were directed to lie. Thus, prior to the presentation of the coloured square, participants were either presented with an instruction to lie or tell the truth in their response or were given a choice between the two. On the latter trials, participants had to input their decision (lie or truth) on the keyboard. Once the square was presented, participants had to vocally respond with either the true colour of the square, or lie about its colour. We reasoned that the decision-making process would be involved in the former but not the latter condition and this would be reflected in differences in lying latency.

Different decision processes make different predictions about the interaction between the type of instruction (*directed* or given a *choice*) and the *honesty* of the response (*truth* or *lie*). We consider two possibilities. First, the decision to lie could be a departure from the normal, truth-telling state. Deciding to lie, rather than adhering to the default truth, would therefore require extra processing effort. This is the basic idea behind the decision components of the ADCM (Walzyck et al, 2009) and WMD (Vendemia et al, 2009). If the decision to lie is more difficult than the decision to tell the truth, participants should need relatively longer to lie than to tell the truth in the choice condition compared to the directed condition. In short, there should be an interaction between instruction and honesty with a larger difference between lies and truths in the choice condition. Second, deciding to lie could be no different to deciding to tell the truth. There could be no default communicative stance, and so a decision must be made in both lying and truth telling.

Having to choose a response would generally be more difficult than being directed on the response, however, and so longer overall latencies might be expected for the directed compared to the choice conditions, and longer lie latencies than truth latencies. Under this account then, only main effects of type of instruction and honesty would be expected.

Method

Participants

Twenty-one Cardiff University undergraduate psychology students volunteered for this study in exchange for course credit. Of these, 20 were female. Participants had a mean age of 19.52 (*SD* = 0.68; *Range* = 18-21) and spoke English as their first language.

Design

A 2 x 2 within-subjects design was used, with the independent variables being honesty of response (lie vs. truth) and type of instruction (choice vs. directed). The dependent variable was response time. A total of 192 trials were included, with 64 from the directed to lie condition, 64 from the directed to tell the truth condition and 64 from the choice condition. The order of trials was randomised for each participant.

Procedure

The experiment progressed as a series of trials each of which began with the presentation of one of three words in the centre of the computer screen (LIE, TRUTH or CHOICE). Participants were asked to indicate whether they understood by pressing the 'T' key when presented with the word 'TRUTH', the 'L' key when presented with the word 'LIE' and either the 'T' or 'L' key when presented with the word 'CHOICE', according to whether they chose to lie or tell the truth. Participants were asked to choose to lie and choose to tell the truth at least 10 times, to enable data from both responses to be collected. The word remained on the screen until the participant pressed the appropriate button and was then replaced with either a blue or a red square. Participants then had to say either the true colour of the square or lie about the colour of the square by claiming that it was the opposite colour (e.g., blue if it was red). Voice key responses were recorded via a clip microphone. After the vocal response was made, the next trial began after 500ms. Instructions were presented on the screen and emphasised the importance of responding both as quickly and as accurately as possible. Participants took part in a practice block of 12 trials identical to the main trials. The question 'What colour is the square?' was visually presented prior to both the practice block and the block of main trials. All stimuli were presented on a black background, with the squares being of equal size and the text being presented in Arial font, size 40.

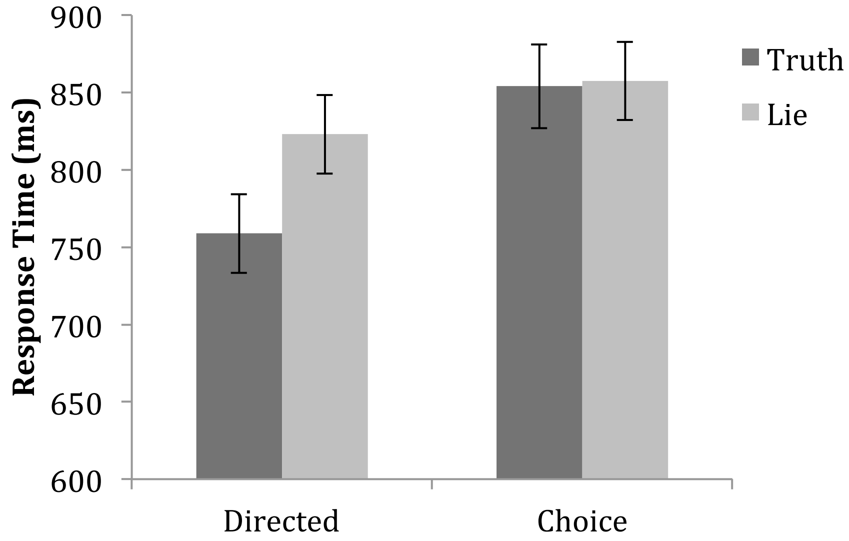
Results

Two subjects were removed from the analysis because they failed to follow experimental instructions of choosing to lie at least 10 times in the choice condition.

We treated response times greater than 2s (approximately 3 SDs above the grand mean) as outliers in all of the experiments reported in this chapter. Response times longer than this represented an excessively long time to retrieve the name of a colour, and we found that using this cut-off meant that a similar number of outliers were eliminated across conditions. There were 103 outliers in total, with 95 of these being a result of microphone problems (the microphone failed to pick up the initial answer). Inaccurate responses (132) were also removed from the analysis. Overall, there were 13 inaccurate responses in the choice lie condition, 53 in the choice truth condition, 36 in the directed lie condition and 30 in the directed truth condition. In total, 235 out of 3,648 data points were removed from the analysis.

In the choice condition, the mean number of choice lie trials was found to be 29 and the mean number of choice truth trials was found to be 32. Mean response times for the four possible conditions were as follows; (1) directed lie trials (DL; *M*: 822.98, *SD*: 110.86), (2) directed truth trials (DT; *M*: 758.85, *SD*: 111.08), (3) choice lie trials (CL; *M*: 857.39, *SD*: 109.83), (4) choice truth trials (CT; *M*: 854.02, *SD*: 118.12). Figure 1 shows the mean response time in all possible cells. In contrast to the hypotheses considered above, there appears to be a large difference between truths and lies in the directed condition but not in the choice condition. To test this pattern we conducted a repeated-measures ANOVA, with factors of type of instruction and honesty of response. We found a main effect of honesty with true responses being faster than lie responses, $F(1,18) = 7.89$, $p < .05$, $\eta^2 = .31$, and a main effect of type of instruction with responses in the choice condition being longer than in the directed condition, $F(1,18) = 17.28$, $p < .001$, $\eta^2 = .49$. The interaction was also significant, $F(1,18) = 9.97$, $p < .005$, $\eta^2 = .36$. The faster production of true than lie statements was significant in the directed condition, $F(1,18) = 21.88$, $p < .001$, $\eta^2 = .51$, but not in the choice condition, $F(1,18) = 0.40$, $p = .84$, $\eta^2 < .01$, *CI* = [-32, 38].

Figure 1. Response times of Experiment 1 as a function of type of instruction and honesty. Note: Error bars are standard error.



Discussion

When directed to lie or tell the truth, participants in our experiment needed on average 60ms longer to lie than to tell the truth. This result demonstrates that our paradigm produces data consistent with previous research investigating response time and lying (e.g., Vendemia et al, 2005; Walczyk et al, 2003; 2005). One way in which this result extends previous work, however, is that the role of the lie construction process was minimal in our experiment. Participants did not have to consider what an appropriate lie response might be (the only possible lie response was the alternate colour) nor did they have to construct a convincing lie sentence. The most likely explanation for the differences in lie times is therefore that participants needed time to suppress the truth when lying.

The main aim of Experiment 1 was to investigate the effects of deciding to lie over being directed to lie. We were interested in whether there was a cost associated with deciding to lie in particular (Walzyck et al, 2009) or whether there was a general cost associated with having to choose a response compared to being directed. Surprisingly, the findings of Experiment 1 were not consistent with either of these possibilities. Although we observed an interaction between the honesty of the response and the type of instruction, the difference between lying and telling the truth was significantly greater in the directed condition than in the choice condition; indeed, there was no significant difference between lying and telling the truth in the choice condition. Before discussing the theoretical implications of these findings, however, we consider one factor that could have obscured differences between conditions in the choice condition.

Participants were slower to respond overall when they had to choose their response type than when they were directed on the response type. In the choice condition, participants pressed a button to indicate their choice, whereas in the directed condition participants saw the word “truth” or “lie”. Participants therefore received a visual prompt regarding the response type in the directed condition but not in the choice condition. A greater degree of uncertainty about the expected response in the choice condition could therefore explain longer latencies overall, which could in turn have obscured honesty differences. We address these problems in Experiment 2 by providing a visual prompt to participants in both the choice condition and the directed condition.

Experiment 2

Experiment 2 used a similar design to Experiment 1 except that participants were given a visual reminder of their decision in the choice condition, just as they were in the directed condition.

Method

Participants

Twenty-three Cardiff University students were paid for participation in the experiment. Of these, 14 were female. Participants had a mean age of 21.65 (*SD* = 4.59; *Range* = 18-37) and spoke English as their first language.

Design

The design of the experiment was the same as that shown in Experiment 1. However, we increased the total number of trials to 200 to ensure an equal number in the choice and directed conditions overall (100 in the choice condition, 50 in the directed to lie condition and 50 in the directed to tell the truth condition).

Procedure

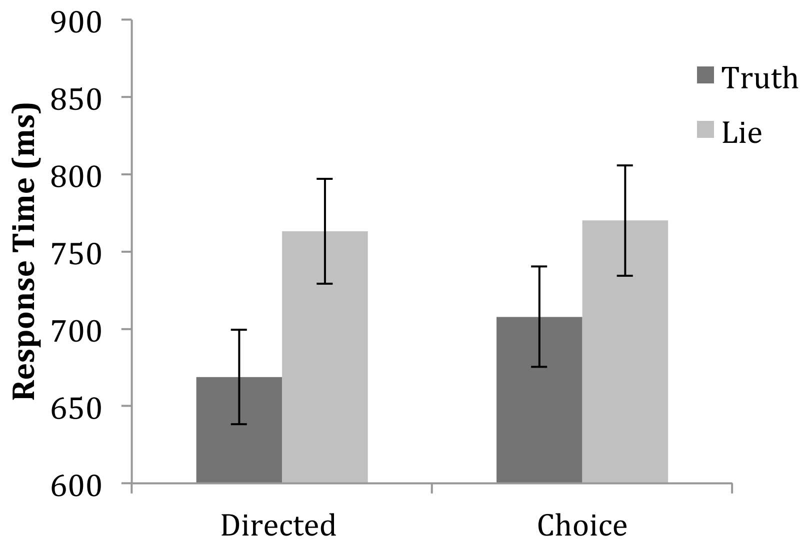
The task was a modified version of that described in Experiment 1 and involved the presentation of one of two words in the centre of the computer screen (READY or CHOICE). When the word 'READY' was presented, participants were instructed to press the space bar. When the word 'CHOICE' was presented, participants could press either the 'T' or the 'L' key, depending on whether they had chosen to tell the truth (T) or lie (L). On a 'READY' trial, the key press was followed by either the letter 'L' (relating to lie) or 'T' (relating to truth) presented in the centre of the screen for a one second period. On a 'CHOICE' trial, the key press was followed by a visual reminder of what key was pressed by presenting either an 'L' or a 'T' in the centre of the screen for a one second period. A coloured square would then appear on the screen and the participant would report its true colour or lie about it. The time taken to do this was recorded via a voice key. The presentation of visual prompt was the only aspect of the procedure that differed from Experiment 1.

Results

One participant was removed from the analysis because they failed to follow experimental instructions of choosing to lie at least 10 times, providing a final sample size of 22. There were 100 outliers in total, with 67 of these being a result of microphone problems. These were removed from the analysis. Inaccurate responses (126) were also removed from the analysis. There were 25 inaccurate responses in the choice lie condition, 53 in the choice truth condition, 28 in the directed lie condition and 20 in the directed truth condition. In total, 226 out of 4,400 data points were removed from the analysis.

In the choice condition, the mean number of choice lie trials was found to be 47 and the mean number of choice truth trials was found to be 49. Mean response times for the four possible conditions were as follows; (1) directed lie trials (DL; *M*: 763.06, *SD*: 159.57), (2) directed truth trials (DT; *M*: 668.73, *SD*: 142.87), (3) choice lie trials (CL; *M*: 769.94, *SD*: 167.12), (4) choice truth trials (CT; *M*: 707.83, *SD*: 152.75). Figure 2 shows the mean response time in all possible cells. Overall, telling a lie took longer than telling the truth, $F(1,21) = 84.66$, $p < .001$, $\eta^2 = .80$. Choosing how to respond took longer than being directed, $F(1,21) = 5.55$, $p < .05$, $\eta^2 = .21$. There was also a significant interaction between the type of instruction and honesty of response, $F(1,21) = 5.93$, $p < .05$, $\eta^2 = .22$, such that there was a greater difference between lying and telling the truth in the directed condition than in the choice condition. This shows a similar pattern to Experiment 1, where a response time difference for lies and truths was only shown in the directed condition. Simple main effects analysis found that the effect of honesty of response was present in the directed condition, $F(1,21) = 80.30$, $p < .001$, $\eta^2 = .79$ and, in contrast to Experiment 1, it was also present in the choice condition, $F(1,21) = 31.82$, $p < .001$, $\eta^2 = .60$. Participants also took longer to respond when they chose to tell the truth compared to when they were directed to tell the truth, $F(1,21) = 16.65$, $p < .001$, $\eta^2 = .44$, whereas there were no differences in response times when individuals chose to lie compared to when they were directed to lie, $F(1,21) = 0.25$, $p = .62$, $\eta^2 = .01$, $CI = [-21, 35]$.

Figure 2. Response times of Experiment 2 as a function of type of instruction and honesty. Note: Error bars are standard error.



Discussion

The results of Experiment 2 provide further support for the finding that telling a lie takes significantly longer than telling the truth. In contrast to the findings of Experiment 1, this occurred both when individuals were directed in their response and when they chose their response. Furthermore, we no longer observed that responses in the choice condition required longer than in the directed condition. These findings suggest that the extra overall processing cost of making a choice in Experiment 1 was likely due to participants having difficulty in recalling their chosen response type. Nonetheless, we observed a significant interaction between type of instruction and honesty of response, just as we did in Experiment 1. The response time difference between lying and telling the truth was smaller when participants chose their response than when they were directed to do so. In particular, participants were slower to respond with the truth when they chose the response compared to when they were directed to do so, but lying was much less affected by the choice manipulation. No explanation based on retrieval of the decision can be invoked because the visual prompt provided was identical for both conditions.

Neither of the decision making mechanisms that we discussed in Experiment 1 were borne out by the data. It is not the case that telling the truth is always the default option and that people have to choose to lie but not to tell the truth, otherwise we would have observed larger differences between truths and lies in the choice condition than the directed condition, nor is it the case that needing to choose a response is simply more difficult overall than being directed to respond. The decision mechanism involved in choosing whether to lie is therefore more complex than previously thought (c.f. Walzyck et al, 2009). Our suggestion for how the decision mechanism functions is as follows. First, we assume that when people lie they must necessarily suppress the truthful response. This accounts for longer latencies for lies relative to truths in both choice and directed conditions. Whether there is an additional cost to deciding to lie, however, depends on whether people are in a context in which they expect to tell the truth. When they are, the truth will be their default position and deciding to lie may indeed be costly. When they are expecting to lie however, the cost would occur when they choose to tell the truth. In our experiment, in which lying is expected on a large number of occasions, the default stance could have been to lie. This meant that when participants chose the truth, they would have had difficulty suppressing the competing lie response.

The more general explanation is that people can enter into default lie states or into default truth states depending on the context. Deciding to utter the alternative to the default carries some cost relative to being directed. The cost of deciding to lie is therefore context dependent, unlike the cost of suppressing the truth, which appears to be obligatory.

Experiment 3

In Experiments 1 and 2 participants did not have a choice about which lie they told. When the square was red, for example, they had to lie with "blue," and vice versa. The lie construction element was therefore minimal. Lying is often more complicated than this however, because liars have to construct a lie from a range of alternatives, as we discussed in the Introduction. Experiment 3 investigated which parts of the lie construction process contribute to longer response times.

We manipulated the range of lie and truth responses available to participants. In one condition, the square could be of one of two colours, as in Experiments 1 and 2. This is similar to yes-no questions, as in "Is your hair brown?" In the other condition the square could be one of three colours, similar to more open-ended questions, such as "What colour is your hair?" The three-colour trials therefore required a choice about which lie to use, whereas the two-colour trials did not. All participants were directed about whether to lie, as in the directed conditions of Experiments 1 and 2. If the need to choose a lie contributes to the greater difficulty of lying, longer lie response times will be observed in the three-colour lie condition than the two-colour lie condition. Alternatively, longer response times might be observed in the three-colour condition for both lie and truth responses.

Method

Participants

Thirty-six Cardiff University students participated in this study in exchange for payment. Of these, 26 were female. Participants had a mean age of 21.83 (*SD* = 3.60; *Range* = 18-38) and spoke English as their first language.

Design

We used a 2 x 2 design with honesty of response (lie vs. truth) and number of response possibilities (two-colour vs. three-colour) as within-subjects factors. The dependent variable was response time. The paradigm consisted of two blocks of trials. The two-colour block showed participants one of two coloured squares and their lie response could only be the opposite colour (hence one possible answer). The three-colour block showed participants one of three coloured squares and their lie response could be either of the other two colours (therefore a choice of two possible answers). The order of these blocks was counterbalanced across participants to minimise order effects. The colour pair that participants were given in the two-colour block (red/green, green/blue, blue/red) was also counterbalanced across participants so that all colour combinations were present in all conditions. Participants took part in a practice block of 12 trials identical to the main trials. A total of 202 main trials were used in the paradigm.

Procedure

As in Experiment 1, the task involved the presentation of one of two words in the centre of the computer screen (LIE or TRUTH) and participants indicated that they understood by pressing the 'T' key when presented with the word 'TRUTH' and the 'L' key when presented with the word 'LIE'. A coloured square (blue, red or green) was then presented. Participants were required to lie or tell the truth about the colour seen. Responses were recorded using a voice key.

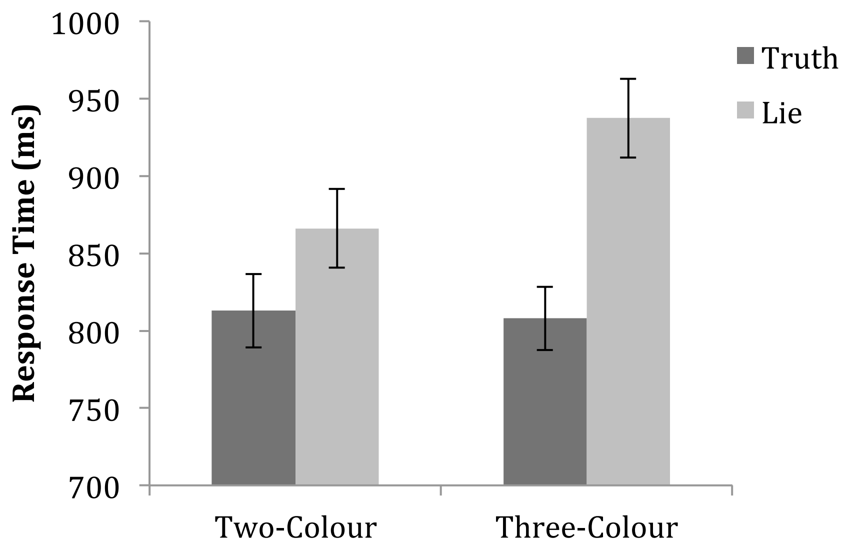
Results

There were 181 outliers in total and 62 of these were a result of microphone problems. These were removed from the analysis. Inaccurate responses (175) were also removed from the analysis. There were 38 inaccurate responses in the two-colour lie condition, 50 in the two-colour truth condition, 51 in the three-colour lie condition and 36 in the three-colour truth condition. Altogether, 356 out of 7,272 data points were removed from the analysis.

Mean response times for the four possible conditions were as follows; (1) two-colour lie trials (2C-L; *M*: 866.16, *SD*: 153.13), (2) two-colour truth trials (2C-T; *M*: 812.83, *SD*: 141.86), (3) three-colour lie trials (3C-L; *M*: 937.41, *SD*: 153.07), (4) three-colour truth trials (3C-T; *M*: 807.94, *SD*: 122.67). Figure 3 shows the mean response time in all possible cells. A repeated measures ANOVA was conducted with factors of honesty of response and number of response possibilities. Consistent with Experiment 2, telling a lie took longer than telling the truth, $F(1,35) = 139.79$, $p < .001$, $\eta^2 = .80$. There was also a main effect of number of response possibilities, $F(1,35) = 4.11$, $p < .05$, $\eta^2 = .10$ and a significant interaction, $F(1,35) = 31.78$, $p < .001$, $\eta^2 = .48$. Simple main effects analysis revealed that the effect of honesty of response was significant in the two-colour condition, $F(1,35) = 46.51$, $p < .001$, $\eta^2 = .57$ and in the three-colour condition, $F(1,35) = 112.02$, $p < .001$, $\eta^2 = .76$. The interaction was driven by longer response times for lying to questions in the three-colour condition compared to questions in the two-colour condition, $F(1,35) = 12.51$, $p < .001$, $\eta^2 = .26$ and no effect of number of possible responses on truthful responding, $F(1,35) = 0.11$, $p = .74$, $\eta^2 < .01$, $CI = [-25, 35]$.

In order to identify whether participants used one particular colour more often than any other, we also examined which colours participants chose when they lied in the three colour condition. Red was chosen 33% of the time, blue 35% of the time and green 31% of the time. However, none of the colours were chosen more often than chance, $t(35)$'s < 1.40, p's > .18.

Figure 3. Response times of Experiment 3 as a function of number of response possibilities and honesty. Note: Error bars are standard error.



Discussion

In Experiment 3 we found that lying takes longer than telling the truth in both colour conditions. More interestingly, we also found that there was a greater difference between lying and telling the truth in the three-colour condition compared to the two-colour condition. The interaction was driven by a significant increase in the time taken to lie to three-colour compared with two-colour questions and a nonsignificant difference in the time taken to tell the truth, consistent with the claim that lie construction is a costly process. Unlike other studies that have tested the difference between different question-types, for example, Walczyk et al (2005), our findings cannot be explained by differences in question content across conditions.

There are at least two explanations for why we observed a larger cost of lying in the three-colour condition compared to the two-colour condition. The first is that participants had to choose a lie in the three-colour condition but not in the two-colour condition (the lie was simply the one remaining option in the two-colour condition). Having to make any kind of choice may have slowed participants down. The second is that participants could have been evaluating each of the possible lie responses in turn for their acceptability. Because there were twice as many possible lie responses in the three-colour condition compared to the two-colour condition, participants would have had to evaluate twice as many possibilities in the three-colour condition than the two-colour condition. There may be both a fixed cost of choosing and a cost to evaluating each alternative, or there could be one or other. In Experiment 4 we test whether participants evaluate each alternative.

Experiment 4

If participants evaluate each of the possible lie responses in turn, expanding the range of possible lie options should continue to add time onto lie latencies. Conversely, if the cost we observed is a choice cost, expanding the range of options should not result in a proportional increase in lie latencies (there would be a single choice cost regardless of the number of possible lie responses). Experiment 4 tested these explanations by comparing trials with two possible lie responses (a *three-colour* condition, as in Experiment 3) against trials with three possible lie responses (a *four-colour* condition).

Method

Participants

Thirty-two Cardiff University students participated in this study in exchange for course credit. Of these, 29 were female. Participants had a mean age of 18.94 (*SD* = 0.95; *Range* = 18-21) and spoke English as their first language.

Design

We used a 2 x 2 within-subjects design, with honesty of response (lie vs. truth) and number of response possibilities (three-colour vs. four-colour) as within-subjects factors. The dependent variable was response time. The paradigm consisted of two blocks of trials. The three-colour block showed participants one of three coloured squares and their lie response could be either of the other two colours (hence two possible answers). The four-colour block showed participants one of four coloured squares and their lie response could be any of the other three colours (hence three possible answers). The order of these blocks was counterbalanced across participants to prevent order effects. The colours that participants were given in the three-colour block (red/green/blue, green/blue/purple, blue/purple/red, purple/red/green) were also counterbalanced across participants so that all colour combinations were present in all conditions. Participants took part in a practice block of 12 trials identical to the main trials. A total of 202 main trials were used in the paradigm.

Procedure

The procedure was identical to that used in Experiment 3 except that participants saw one of four coloured squares in the four-colour condition.

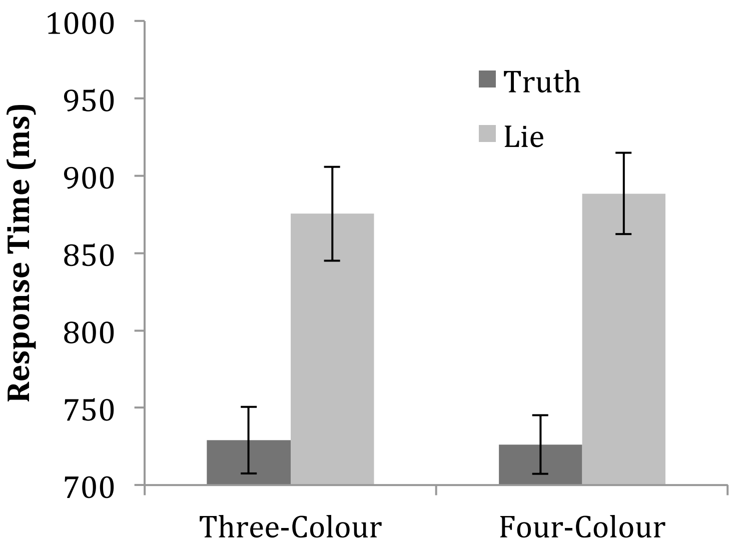
Results

There were 174 outliers in total. 78 of these were due to microphone problems. These were removed from the analysis. Inaccurate responses (260) were also removed from the analysis. There were 69 inaccurate responses in the three-colour lie condition, 75 in the three-colour truth condition, 59 in the four-colour lie condition and 57 in the four-colour truth condition. Altogether, 434 out of 6,464 data points were removed from the analysis.

Mean response times for the four possible conditions were as follows; (1) three-colour lie trials (3C-L; *M*: 875.34, *SD*: 171.42), (2) three-colour truth trials (3C-T; *M*: 728.96, *SD*: 121.51), (3) four-colour lie trials (4C-L; *M*: 888.39, *SD*: 148.72), (4) four colour truth trials (4C-T; *M*: 726.17, *SD*: 106.90). Figure 4 shows the mean response time in all possible cells. A repeated measures ANOVA was conducted with factors of honesty of response and number of response possibilities. This found a significant main effect of honesty of response with true responses being faster than lie responses, $F(1,31) = 117.06$, $p < .001$, $\eta^2 = .79$. However, in contrast to the findings of Experiment 3, a further increase in the number of possible lie responses did not affect response times in either the truth, $F(1, 31) = 0.04$, $p = .84$, $\eta^2 < .01$, *CI* = [-25, 30] or lie conditions, $F(1, 31) = 0.35$, $p = .56$, $\eta^2 < .05$, *CI* = [-58, 32], nor was the interaction between number of response possibilities and honesty of response significant, $F(1, 31) = 0.57$, $p = .46$, $\eta^2 < .02$. A power analysis revealed that if the interaction was as large as we found in Experiment 2, i.e., $\eta^2 = .26$, we would have had a 99% chance of finding the effect.

As in Experiment 3, we investigated how participants chose their lie response. In the 3-colour block, participants chose red 36% of the time, blue 31% of the time, green 31% of the time and purple 28% of the time. A one-sample t-test found that purple was used less than would be expected by chance, $t(23) = 2.53$, $p < .05$, but that red, blue and green were not, $t(23)$'s < 1.70, p's > .11. In the 4-colour block, participants chose red 29% of the time, blue 20% of the time, green 27% of the time and purple 18% of the time. A one-sample t-test found that red was used more than chance, $t(31) = 2.28$, $p < .05$, whereas blue, $t(31) = 3.18$, $p < .005$ and purple, $t(31) = 3.58$, $p < .001$ were used less than chance. The use of green did not significantly differ from chance, $t(31) = 0.83$, $p = .41$.

Figure 4. Response times of Experiment 4 as a function of number of response possibilities and honesty. Note: Error bars are standard error.



Discussion

The results of Experiment 4 support previous findings of increased response times when individuals lie compared to when they tell the truth, regardless of the number of possible lie responses available. We also found that the number of possible lie responses did not significantly affect response times when individuals told the truth, consistent with the results of Experiment 3. Unlike Experiment 3, however, in this experiment no significant differences were demonstrated when individuals lied in the three-colour compared to the four-colour block and a power analysis indicated that we had a 99% chance of detecting an effect of the same size as that observed in Experiment 3. The processing time difference between questions with multiple response possibilities and those with only one response option is therefore likely to be due to the cost of choosing between lies in working memory, and not due to costs associated with evaluating each possible lie response in turn. We are not arguing that participants will never consider additional lie options in turn (or that lie times will never increase with options greater than three); rather, that the cost of having to choose *per se* will always be at least part of the extra cost of lying in multiple lie contexts.

Experiment 5

In our previous experiments we showed that choosing between multiple lie responses increases response time. It should also be considered, however, that for the majority of lies some responses will be more plausible than others and the successful liar will choose these lies more frequently. The liar must therefore not only suppress the truthful response to a question but any implausible responses as well. What makes the task even more difficult is that responses are not necessarily implausible *per se* but depend on the question asked and the context (much like the truth). For example, “On the moon” would be a perfectly plausible (or truthful) answer to some questions, just not the location of the stolen money. This means that implausible lie responses cannot be completely suppressed during the conversation; the convincing liar must be able to retrieve these responses at any moment to avoid incurring a noticeable cost. Overall then, in any deceptive interaction there will be particular lies that cannot be used if the deception is to be successful. This discrimination of plausible and implausible lies can be considered a form of rule constraint, with limitations on effective response choice.

We are not aware of any evidence, however, that directly addresses the question of how implausible responses are discriminated and suppressed when people lie. One possibility is that plausibility computations are carried out in long term memory and that only plausible responses are transferred to working memory to be articulated. This account is consistent with recent work arguing that many pragmatic and contextual phenomena, such as irony, are incorporated very early on in processing with little apparent cost (e.g., Gibbs, 1980; 1994; Sedivy, Tanenhaus, Chambers & Carlson, 1999). The ADCM (2003) assumes a similar process. An alternative, however, is that since lying is arguably an act that works against standard communicative principles (Grice, 1989), plausibility constraints may have to be implemented at a higher level than other language mechanisms. Truthful communication might use efficient long term memory processes, but lying involves explicit, goal-oriented suppression of the default response that needs distinct processes implemented in working memory. Experiment 5 was designed to test between these two accounts.

Participants engaged in a colour naming task similar to Experiments 3 and 4. The difference was that in Experiment 5 we introduced constraints on which lies (colours) participants could use. One aspect of determining the plausibility of a potential lie response involves determining which answer can be used and which cannot, if the lie is to be believed. Having particular responses that one cannot use introduces a constraint on response possibilities. Although it is appreciated that the concept of plausibility involves more than just constraint processes, constraint remains a necessary component of plausibility. Therefore in our task, we told participants that they would have to truthfully name the colour of different squares presented on a computer screen. These squares would be either, red, green, or blue. On lie trials however, participants could only use two colours out of the three as a potential lie response, thus there was one colour they were informed that they could not use as a lie response throughout the task (e.g., you can use blue and green when telling a lie, but you cannot use the colour red). We therefore had lie and truth trials, as in previous experiments, but lie trials could be further broken down depending on the plausibility constraint. When the coloured square was the disallowed lie colour (e.g., red), participants had the choice of two lie possibilities (blue and green). We refer to these as lie *control* trials because the lie possibilities that can be used are the same as if no constraint on response was present. When the square was one of the allowed lie colours (such as green), participants had to inhibit the disallowed lie colour (red) and ensure they chose the alternative lie colour (blue) as their response. These were lie *constraint* trials. If plausibility constraints are implemented in long term memory, only allowable responses would be transferred into working memory. In the lie control trials, this would mean two potential lie responses, that is, green and blue, but in the lie constraint trials, only one possible response would be available, i.e., green. From Experiment 3 we know that choosing between two possible lie responses is more difficult than lying with only one possible response, hence RTs in the lie control trials should be slower than those in the lie constraint trials. Alternatively, if plausibility constraints are implemented in working memory, participants would have two lie responses in working memory in both conditions. They would then have to explicitly suppress the disallowed lie response in the lie constraint condition, which should take additional time, as it did when participants suppressed the truthful response throughout Experiments 1-4. RTs to the lie constraint condition should therefore be higher than in the lie control condition.

Method

Participants

Thirty undergraduate psychology students volunteered for this study in exchange for course credit. Of these, 29 were female. Participants had a mean age of 20 (*SD* = 3.2; *Range* = 18-33) and spoke English as their first language.

Design

A 2x2 within-subjects design was used, with honesty of response (truth vs. lie) and plausibility (constraint vs. control) as within-subjects factors. The dependent variable was response time measured in milliseconds (ms). A total of 408 trials were included in the main experimental task, with 68 from the lie control condition, 68 from the truth control condition, 136 from the lie constraint condition and 136 from the truth constraint condition. The order of trials was randomised for each participant.

Procedure

A similar paradigm was used to Experiments 3 and 4, with the presentation of either the word TRUTH or LIE in the centre of the computer screen. Once again, participants pressed the ‘T’ key when presented with the word TRUTH and the ‘L’ key when presented with the word ‘LIE’. This was followed by the presentation of either a blue, green or red square. As before, participants then had to say either the true colour of the square or lie about the colour of the square by claiming that it was a different colour. Prior to the main trials, participants completed a short practice block containing 4 trials.

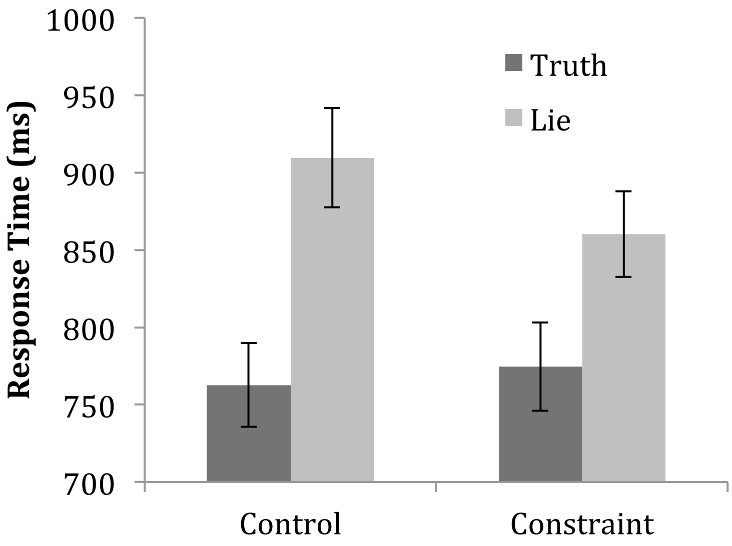
In contrast with our previous experiments, participants were instructed that they could only use two of the presented colours as their lie response and could not use the third colour as a lie answer (e.g., participants could use green or blue but not red). The particular colour (red, blue or green) that participants were instructed against using as a lie was counterbalanced across participants.

Results

There were 264 outliers in total. 256 of these were due to microphone problems. These were removed from the analysis. Inaccurate responses (363) were also removed from the analysis. Overall, there were 55 inaccurate responses when participants lied in the control condition, 162 when participants lied in the constraint condition, 53 when participants told the truth in the control condition and 93 when participants told the truth in the constraint condition. In total, 627 out of 11,970 data points were removed from the analysis.

Mean response times for the four possible conditions were as follows; (1) lie control trials (LControl; *M*: 909.56, *SD*: 175.51), (2) truth control trials (TControl; *M*: 762.73, *SD*: 148.29), (3) lie constraint trials (LConstraint; *M*: 860.16, *SD*: 151.06), (4) truth constraint trials (TConstraint; *M*: 774.53, *SD*: 156.15). Figure 5 shows the mean response time in all possible cells. A repeated-measures ANOVA was conducted with honesty (truth vs. lie) and plausibility (constraint vs. control) as within-subjects factors. A main effect of honesty was demonstrated, $F(1,29) = 145.52$, $p < .001$, $\eta^2 = .83$, such that lie response times were significantly longer than truth response times, for both control and constraint trials. In addition, a main effect of plausibility was demonstrated, $F(1,29) =14.89$, $p < .005$, $\eta^2 = .34$ and a significant interaction between honesty and plausibility, $F(1,29) = 23.27$, $p < .001$, $\eta^2 = .44$. This interaction was due to significantly longer response times when participants lied in the control condition compared to the constraint condition (LControl: $M = 909.56$, $SD = 175.51$; LConstraint: $M = 860.16$, $SD = 151.06$; $F(1,29) = 40.48$, $p < .001$, $\eta^2 = .58$). This finding is evidence in favour of constraints being applied in long-term memory. Little difference was shown between the two conditions when individuals told the truth (TControl: M = 762.73, SD = 148.29; TConstraint: M = 774.53, SD = 156.15; $F(1,29) = 2.06$, $p = .162$, $\eta^2 = .07$).

Figure 5. Response times of Experiment 5 as a function of truthful colour and honesty. Note: Error bars are standard error.



Discussion

The main effect of honesty of response shown in our previous experiments was also demonstrated in Experiment 5, with lying taking longer than telling the truth in both the constraint and control conditions. Two main predictions were considered regarding the choice between lie possibilities in relation to response plausibility. These focused on whether implausible lies entered working memory and were considered in the decision process, or whether such responses were inhibited prior to this in long-term memory systems. Our findings support the latter hypothesis because there were significantly longer lie responses in lie control trials compared to lie constraint trials. If both implausible and plausible lies were transferred to, and active in, working memory, then a choice would be required between them (as seen in Experiment 3). This would result in little response time difference between the lie control and lie constraint conditions, since a choice would be required between two possible responses in both conditions. Our findings suggest instead that the implausible lie response is inhibited prior to this decision process, so a decision between the two possibilities is not required (since only one colour can be plausibly used). This supports the suggestion (consistent with the ADCM) that implausible lies are inhibited in long-term memory and only plausible lies enter working memory systems.

General Discussion

The aim of the current study was to investigate the cognitive processes that occur when people lie. Telling a lie typically takes longer than telling the truth and we were interested in understanding why. We organised our experiments around three potential contributing factors: suppressing a truthful response; the decision to lie; and the construction of a lie. We now summarize our results and describe their implications with respect to these factors.

Suppression of the truthful response

In all of our experiments in which participants were instructed to lie, lying response times were longer than truthful response times. More interestingly, we observed this result under conditions in which many of the factors that are usually considered to slow down lying were absent. In particular, participants did not need to construct a plausible lie (in Experiments 1 and 2 only one possible lie response was available) nor did they need time to decide to lie (Experiments 3, 4 and 5 removed the decision process completely). According to models such as the ADCM Revised (Walczyk et al, 2009), the only process left to explain longer lie response times is that the truthful response needs to be suppressed. Our experiments therefore provide direct evidence that suppression of the truthful response is a contributing factor to longer lie response times.

While we agree that suppression is part of the explanation, it is important to outline the different mechanisms by which suppression might lead to slower response times. One possibility is that lying is a multi-stage, serial processing mechanism in which the truthful response is retrieved and enters into working memory first, it is then rejected (because a lie is needed), and then a lie response retrieved. Telling the truth, in contrast, is only a single-stage processing mechanism, in which the truthful response is retrieved and enters into working memory. Under this account, the difference in response times between lies and truths is due to having to retrieve two responses in the lie condition (the lie and the truth) and only one in the truth condition (the truth). An alternative but similar proposal is that lying involves rejecting a response, whereas telling the truth does not. Perhaps rejection is a conscious process that takes time.

A more distinct alternative is that the processes that underlie suppression of the truth occur in parallel, and in long-term memory, not in serial, short term memory. Assuming that response time is determined by variation in activation levels across the response possibilities (with large differences in activation levels being associated with short response times), reducing the activation of the truthful response might reduce overall variation in activation levels. This would make it more difficult to generate a response when lying than when telling the truth because it would be more difficult to select one response over the others. While this might explain why lying takes longer than telling the truth on some occasions, it is unlikely to be a general explanation. First, recent brain imaging research has found increased activation of brain areas associated with working memory when individuals lie (Christ et al, 2009). The extra cost of lying cannot therefore be restricted to long-term memory under all circumstances. Second, lying involves deliberately choosing not to say the truth (Spence, Hunter, Farrow, Green, Leung & Hughes, 2004). Now, since working memory is typically associated with conscious awareness (Dehaene & Naccache, 2001), lying should involve truthful responses entering working memory (and being suppressed in working memory).

The two types of suppression that we have identified may both be correct but apply under different circumstances. Serial suppression in working memory is likely to be the more standard, day-to-day type of suppression in which a speaker lies to an unexpected question on a single occasion. However, if a speaker has to lie on multiple occasions to the same question, or they are in a situation in which lying is likely to be common and expected, they may be able to suppress truthful answers in long-term memory, almost "forgetting" the truth because the lie response has been so frequently associated with a given question.

The decision to lie

Experiments 1 and 2 tested the role of the decision process by comparing response times in trials in which participants chose to lie with trials in which they were directed to lie. While we found effects of deciding to lie in both of our experiments, we discovered that there was a much greater cost to deciding to tell the truth than deciding to lie, relative to the cost of being directed in the response. Thus, although Walczyk et al (2009) suggested that the decision contribution to elevated lie response times is at least partially determined by the difficulty in lying, our data show that this process also occurs for decisions related to truthful responses. Our general view is therefore that there is no cost of deciding to lie *per se* but there is a cost to choosing to depart from the norm for that context. Most of the time when people lie they will be departing from a truth-telling context, which is likely to incur a cost, but in some contexts, e.g., interrogation situations, or playing poker, delays may be experienced when the decision is taken to tell the truth.

One caveat to our conclusion is that when people choose to lie they often do so on the basis of the question that they are asked, whereas in our experiments the choice was internally driven. For example, a person may choose to lie to questions about the whereabouts of a suspect but not about their own activities. Evaluating the content of the question is a component of the decision process which is not included in our task. It could therefore be that the evaluation component of the decision process contributes to elevated lie latencies. However, we feel that this cost is also caused by a departure from the normal communicative stance. This is because if the person would normally tell the truth, the question needs to be evaluated in order to decide to lie, but if the person expects to lie, the question needs to be evaluated in order to decide whether to tell the truth. Thus, the departure from the norm is the causal factor, not the decision to lie.

Second, we observed longer response times when participants told the truth in the choice condition compared to the directed condition. This occurred across both experiments and therefore was not related to differential visual availability of the response type across conditions. As a consequence of this effect, the difference between lying and telling the truth was greatly diminished in the choice conditions (to the extent that we did not observe a significant difference in Experiment 1). What is different about choosing to tell the truth compared to being directed to tell the truth? One hypothesis is that choosing how to respond means considering lie and truthful responses. For example, when deciding whether to tell the truth or lie in response to a red square, the responses “blue” (the lie) and “red” (the truth) become activated. Consequently, there was a small (or nonexistent) response time difference between truthful and lie responses in the choice condition because both responses were highly activated under both response conditions.

In contrast, being directed to tell the truth means that only the truthful response becomes activated (there is no need to consider and suppress the lie response), but being directed to lie means that the truth and the lie response become activated (the truth is always activated). In other words, both response types were activated in the choice-lie, directed-lie, and choice-truth conditions, but only the truth was activated in the directed-truth condition.

Finally, these results have important practical consequences. In almost all of the lie detection work participants are directed to lie or tell the truth rather than choosing to do so whereas when people lie in everyday situations, they choose to lie rather than being directed. Our experiments show that the difference between lying and telling the truth is much smaller when participants are given a choice, and therefore much less detectable if trying to use automated lie detection techniques relying on response time.

The construction of a lie

There is a strong intuition that lying takes longer than telling the truth because lies need to be constructed whereas truths do not. Yet, previous work is inconclusive about why, or even whether, this is the case. Our experiments make two novel contributions to understanding the construction component of lying.

First, having to make a choice about which lie to use from many, arbitrary possibilities is difficult. Experiments 3 and 4 demonstrated that when participants had to choose a lie they were slow at responding, but, crucially, the same range of response options did not slow truthful responses. Even after hundreds of trials, and with only two choices, participants experienced difficulty in making an arbitrary choice when they were forced to lie. It seems that part of what makes lying difficult is resolving all of the inconsequential decisions that are needed in order to construct a story. When telling the truth, the "decisions" are determined by fact, or by memory, and are therefore relatively resource free.

Second, and somewhat conversely, when there is a clear preference about which lie is the most appropriate, lying is relatively easy. In Experiment 5 we found that when participants were prevented from using one lie response out of two (but were required to use both responses when stating the truth), participants behaved as if there was only one possible lie available. Rejection of the implausible lie occurred in long term memory, as if no choice between lies was necessary. One caveat to this result is that our effects were obtained over many trials with the same plausibility constraint applied on each occasion. It may be the case that making plausibility assessments in unrehearsed lie situations is much more difficult. We leave this investigation to future research, however.

Whilst our study was not directly designed to aid the detection of deception, our results on lie construction nonetheless make one suggestion that contrasts with the prevailing view in the literature. Walczyk et al (2003; 2005; 2009) claimed that yes/no questions provide better indicators of deceit than open-ended questions. They demonstrated greater response time differences between lies and truths when participants lied to yes/no compared to open-ended questions. In contrast, we found a greater difference for questions with more than one possible lie response. We suggest that different patterns arose because different methodologies were used across studies. In our experiments, participants answered the same type of question in both conditions and the truthful answer was equally accessible across conditions. In Walczyk et al. however, different types of questions were asked across conditions and the truthful answer could have been more difficult to retrieve in the open-ended questions (hence truthful response times were longer in the open-ended condition). While we agree with Walczyk et al. that the difficulty of retrieving truthful information contributes to the response time difference between lies and truths, we feel that this issue is orthogonal to the issue of yes/no vs. open-ended questioning. The results of our experiments on lie construction suggest that an interviewee will need more time to lie to an open-ended question than to a yes/no question, *ceteris paribus*, because they need to choose which lie to use in the open-ended case but not in the yes/no case. We therefore suggest using open-ended questions whenever possible if detecting deceit is the goal.

Conclusion

Despite the wealth of research investigating lying in general, such as lie detection (e.g., Vrij et al, 2007), the social psychology of lying (e.g., Cole, 2001; DePaulo & Kashy, 1998) and the linguistics and philosophy of lying (e.g., Meibauer, 2005), very little work has been conducted on how we lie. This chapter has tried to address the imbalance by investigating possible reasons why people take longer to lie than to tell the truth. From these experiments, we come to three conclusions. First, lying involves suppressing truthful information and suppressing or rejecting a default response will increase response time. Second, there can be costs associated with choosing to tell the truth, just as there can be with choosing to lie. We therefore maintain that the decision to depart from the normal type of communication can be costly, and while this will often be a cost associated with a decision to lie, it is not an obligatory component of lying. Lastly, lying often requires more choice in generating a response than telling the truth. There is typically only one truth but there are many possible lie options. Choosing between these additional options is a difficult job and contributes directly to the longer time needed to tell a lie.

CHAPTER 3

The Impact of Task Switching when Telling Lies

Despite the recent growth of interest in the cognitive processes that occur when individuals tell a lie, and how these differ from those involved in telling the truth (Spence et al, 2001), there remains only a limited understanding of the mechanisms responsible for such processing differences. Conclusions commonly relate to the generic involvement of working memory, suppression and conflict resolution processes (Christ et al, 2009), with several studies suggesting that inhibition of the truthful response is a necessary process for deceptive responding (Seymour et al, 2000; Spence et al, 2001; Vendemia et al, 2009; Walczyk et al, 2003). There is less consensus, however, regarding the possible contribution of other processes to this increased cognitive load.

One potential factor that is little understood is that of switching between telling a lie and telling the truth. If telling a lie involves differential processes to telling the truth, it logically follows that different response or task-sets may be associated with each response type. Since switching between different task-sets has been shown to increase response times (Monsell, 2003) compared to consistently responding in one manner, it is possible that these switching processes contribute to the longer response times shown when individuals lie. In this chapter we test this hypothesis by reanalysing four previous experiments and presenting a fifth specifically designed to assess task-switching between lying and truth-telling.

Task-switching

Task-switching refers to situations in which there is variation in the cognitive operations required to perform a series of tasks, that is, when the task-set changes from trial to trial (see, e.g., Gilbert & Shallice, 2002). The task-set for a particular task might include stimulus-category rules, category-response rules, response threshold and response modality (Vandierendonck, Liefooghe & Verbruggen, 2010). There is now a large body of literature illustrating that switching between different task-sets incurs a response time cost compared to consistently responding to a stimulus in the same manner (Monsell, 2003). For example, Allport, Styles and Hsieh (1994) found longer response times when participants switched between reading a word and naming the colour of the word compared to doing the same task repeatedly. Such findings have also been shown when a response is only considered and not actually executed (Verbruggen, Liefooghe & Vandierendonck, 2006).

The explanation for the switch cost, however, remains controversial. Currently, debate focuses on two main viewpoints, the interference view (Allport et al, 1994) and the reconfiguration view (Rogers & Monsell, 1995), although a combination of the two accounts is increasingly preferred (Meiran, 1996; Vandierendonck et al, 2010). The interference view attributes longer response times on switch trials to task-set inertia. This refers to the previous task-set remaining active for a period of time after a response has been executed and therefore interfering with the implementation of the next required task-set (Allport et al, 1994). The switch cost is attributed to the extra cognitive effort required to resolve such interference, primarily the inhibition of unnecessary processes associated with the previous competing task-set (Allport & Wylie, 2000; Mayr & Keele, 2000). The reconfiguration view (Rogers & Monsell, 1995), in contrast, claims that switch costs are due to the requirement of an active control process reconfiguring a cognitive system for any new task prior to undertaking it. Once a particular task-set has been activated, it remains the active processing set until a different task-set is required. At this point, reconfiguration is necessary to switch from one task-set to another.

Both of the theories considered above are consistent with switch costs occurring when people lie. If lying involves a different task-set than telling the truth, switching between the two sets might cause switch costs. According to the interference view, when an individual lies in response to a question, the particular processes required to enable a false response, such as inhibition of the truth, would remain active after the falsehood has been executed, and these processes would then interfere with the ability to respond truthfully to the following question. According to the reconfiguration view, when an individual responds to a question falsely, a "lie" task-set would potentially remain active until the individual has to respond to a question truthfully, whereby cognitive reconfiguration to the "truth" task-set is then required. These reconfiguration processes would incur a response time cost, leading to longer response times when individuals switch between lying and telling the truth compared to consistently responding in the same manner (either truthfully or deceptively).

In addition to the general task-switching costs, it has also been demonstrated that switching from a weaker task to a more dominant task incurs a greater response time cost than switching from a more dominant to a weaker task (Allport et al, 1994; Phillip, Gade & Koch, 2007; Yeung & Monsell, 2003). Allport et al. suggested that this is due to a greater amount of inhibition being required to prevent the more dominant task from being performed. This inhibition then carries over into the following trial where it must be overridden and the dominant task carried out. The strength of any particular task-set therefore affects the amount of inhibition that is applied and in turn, the amount of time that is required to recover from this inhibition and subsequently perform the task. In relation to deception, therefore, if the truth is considered the more dominant, default response, then more inhibition would be required to prevent ourselves from speaking the truth and to tell a lie. This inhibition would then require more recovery time in order to subsequently respond truthfully again.

Task-switching in lying

Despite the likely contribution of task-switching to elevated lie response times, previous work has not explicitly examined the relationship between lying and task-switching. A small number of deception studies have alluded to task-switching, however, and we discuss these studies here.

A recent activation likelihood estimate (ALE) meta-analysis of 12 fMRI deception studies examined the potential contribution of working memory, task-switching and inhibitory control to the additional processing shown when individuals tell a lie (Christ et al, 2009). ALE maps from brain regions consistently involved in laboratory-based deception, such as the inferior frontal gyrus, bilateral insular regions and the right anterior cingulate cortex, were compared with ALE maps generated from previous work examining the brain regions involved in generic working memory, task-switching and inhibitory control processes. Whereas overlap was shown between those brain regions involved in deception and those involved in working memory and inhibition processes, little overlap was found between deception and task-switching processes. The authors concluded that this finding questioned "the contribution of this aspect of executive control [task-switching] to deception" (Christ et al, 2009; p. 1564). One limitation of this study, however, was that insufficient data was available to focus on particular experimental paradigms in the creation of both the task-switching and deception ALE maps, whereas this was possible for the working memory and inhibitory control ALE maps.

Fullam, McKie and Dolan (2009) are more positive regarding the potential influence of task-switching on deceptive cognition. In their study, participants underwent fMRI scanning while they both lied and told the truth regarding whether they had performed a number of everyday acts. Enhanced activation in frontopolar regions was shown when participants told the truth. Since inhibition of frontopolar regions has been suggested to be required in order to switch to, and maintain, a given response-set (Koechlin & Hyafil, 2007), Fullam et al (2009) proposed that this increased activation may be due to the requirement to reinstigate the switch back to a truthful response-set following a lie response. If this is the case, the question remains as to which process is more cognitively challenging; inhibiting the frontopolar regions to enable the instigation of a deceptive response-set, or the reactivation of such regions to enable an individual to then respond truthfully again.

The extent that the truthful response-set may hinder or facilitate deceptive responding was explored by Osman et al (2009). Participants read a short description of an event that had occurred and answered a series of questions regarding this. Participants performed the task twice and were divided into 4 groups according to how they should respond in each session: true-true, lie-lie, true-lie, lie-true. The true-true and lie-lie groups used the same response type when completing both the first task session and the second task session, whereas the true-lie and lie-true group had to switch response type when completing the second task session. Deceptive response times for participants who had previously told the truth (true-lie) were compared to those for participants who had previously responded to the task deceptively (lie-lie). In line with previous findings, slower response times in the first task sessions were shown when participants responded deceptively (lie-lie) compared to truthfully (true-lie). No significant differences between the two groups were found in the second task session, however, suggesting that switching from responding truthfully to lying did not increase response times compared to consistently responding falsely. It may be, however, that the block design of the paradigm reduced any task-switching effects. If participants were constantly and unexpectedly required to switch between lying and truth-telling, evidence for a significant role of task-switching processes may have been found.

Since incongruent responding on the Stroop task also requires the dominant response-type to be overridden, Osman et al (2009) instructed participants to complete a Stroop task following the initial computer task. This enabled an examination of the effect of previous deceptive responding on Stroop task performance. From this, they demonstrated that participants with a greater prior experience of deceptive responding (lie-lie) were faster in responding to incongruent Stroop trials than participants with no prior experience of deception (true-true). Since both incongruent and deceptive responding have been suggested to involve similar processes (Vendemia et al, 2005), this suggests that the previous execution of false responses aids the ability to respond to latter tasks with similar processing requirements, i.e., overriding the prepotent response on incongruent Stroop trials. Such findings support the idea that different task-sets are invoked when responding deceptively compared to responding truthfully.

The response time cost associated with task incompatibility has also been used by researchers in the development of lie detection tasks (Frost, Adie, Denomme, Lahaie, Sibley & Smith, 2010; Gregg, 2007; Sartori, Agosta, Zogmaister, Ferrara & Castiello, 2008). Sartori et al (2008) instructed participants to classify a series of statements presented via a computer. In the confession-true task, confessions (e.g., 'I stole the watch') were classified using the same key as true statements and denials were classified using the same key as false statements. However, in the denial-true task, confessions and false statements were classified using one key and denials and true statements were classified using a different key. Participants who were lying displayed longer response times when denials were associated with the true statement key, whereas participants who told the truth had longer response times when confessions were associated with the false statement key.

To summarise, there are suggestions in the literature that lying carries a switch cost, but no studies have directly tested this. We therefore re-analysed the data of four previously reported experiments (Williams, Bott, Lewis & Patrick, submitted; and shown in Chapter 2) to investigate switch costs when participants lied and told the truth. In addition, a fifth experiment was conducted to specifically examine whether switching between lie and truth trials increases response times compared to trials where no switching is required.

The Current Study

The task-switching literature suggests two main predictions regarding the relationship between the honesty of the response (truth or lie) and the task (switch trials or no-switch trials). Firstly, that the additional processing required when individuals tell a lie (Spence et al, 2001; Walczyk et al, 2003) suggests that differential task-sets may be involved in responding truthfully compared to responding deceptively. If this is the case, then longer response times would be expected when participants are required to switch between these task-sets (i.e., when switching between lie trials and truth trials) compared to when no switching is required (i.e., when a truth trial is followed by a truth trial or a lie trial is followed by a lie trial). This main effect of task is well documented in the research literature (Monsell, 2003), but has not previously been applied directly to deceptive cognition. Secondly, several studies have demonstrated that the relative dominance of the task affects the response time cost associated with task-switching, with a greater response time cost incurred when individuals switch from a weaker to a more dominant task than vice versa (Allport & Wylie, 2000; Allport et al, 1994). Therefore, if responding truthfully is a more dominant task than telling a lie (either through learned experience or a default response mechanism), an interaction will be found between the honesty of the response and the task, with a greater response time difference shown between switch and no-switch trials when participants tell the truth compared to when they tell a lie.

Experiment 1

The original aims of Experiment 1 were twofold. Firstly, to examine whether longer response times for lies compared to truths were demonstrated using our paradigm. Secondly, to examine whether deciding to lie or tell the truth, compared to being directed, impacted on response times. Twenty-one participants were either directed or chose to lie or tell the truth regarding the colour of a square presented on a computer screen in a within-subjects design. For further details regarding the original experimental rationale and method, see Chapter 2.

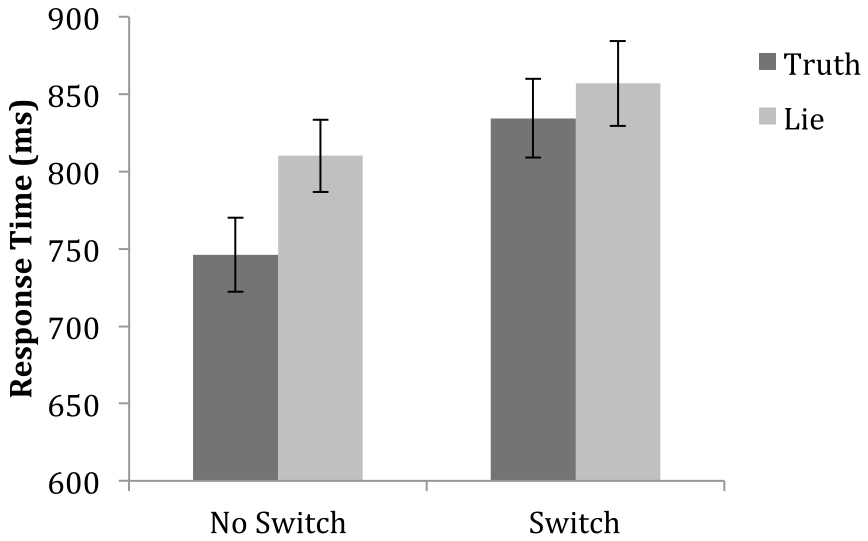
In order to re-analyse the data to examine task-switching effects, trials were re-coded into those involving a potential task-switch and those not requiring a switch in honesty response-type. If the honesty of the response was different on the previous trial compared to the current trial, this was coded as a switch trial. If the honesty of the response was the same on both the previous and current trial, this was coded as a no-switch trial. Due to limitations in the number of trials, data from the directed and choice conditions were combined for this analysis.

Results and Discussion

A total of two subjects, 103 outliers and 132 inaccurate responses were removed from the analysis (see Chapter 2 for further details).

The effect of task-switching was examined by comparing response times when a trial was preceded by one of the same type (i.e., lie followed by lie or truth followed by truth) to when preceded by one of the opposite type (i.e., truth followed by lie or lie followed by truth). The mean number of trials and mean response times for each of the four conditions was as follows; (1) lie switch trials (LS; Trials: 47; *M*: 856.87, *SD*: 119.37), (2) lie no switch trials (LNS; Trials: 42; *M*: 810.21, *SD*: 102.08), (3) truth switch trials (TS; Trials: 45; *M*: 834.48, *SD*: 110.90), (4) truth no switch trials (TNS; Trials: 46; *M*: 746.20, *SD*: 104.30). Figure 6 shows the mean response time in all possible cells. A 2 x 2 repeated-measures ANOVA was conducted with honesty of response (truth vs. lie) and task (switch vs. no-switch) as the within-subjects factors. A significant main effect of task was shown, $F(1,18) = 40.60$, $p < .001$, $\eta^2 = .69$ and a significant interaction between task x honesty of response, $F(1,18) = 4.57$, $p < .05$, $\eta^2 = .20$. Simple effects showed that participants took significantly longer to respond on switch trials compared to no-switch trials both when they told a lie, $F(1,18) = 11.61$, $p = .003$, $\eta^2 = .39$ and when they told the truth, $F(1,18) = 34.62$, $p < .001$, $\eta^2 = .66$. However, the significant interaction reveals that this difference was greater when individuals told the truth. It appears to be more difficult to switch from a lie response to a truthful response than from a truthful response to a lie response. Simple effects tests also showed that lying took significantly longer than telling the truth on no-switch trials, $F(1,18) = 13.18$, $p = .002$, $\eta^2 = .42$, but not on switch trials, $F(1,18) = 3.34$, $p = .084$, $\eta^2 = .16$, $CI = [-3.27, 48.09]$.

Figure 6. Response times of Experiment 1 as a function of task and honesty. Note: Error bars are standard error.



In summary, we found that participants took longer to respond when they had to switch from telling a lie to telling the truth, and vice versa, compared to when they consistently responded in one manner. These results suggest that telling the truth and lying involve different task-sets, and that switching between these task-sets incurs a response time cost both when they lie and when they tell the truth.

Experiment 2

Experiment 2 also examined the effect of deciding to lie or tell the truth on response time using a similar paradigm to Experiment 1. The only difference in the experimental task was that participants were provided with a visual reminder of their response choice in this experiment. Twenty-three participants were either directed or chose to lie or tell the truth regarding the colour of a square presented on a computer screen in a within-subjects design. For further details regarding the original experimental rationale and method, see Chapter 2.

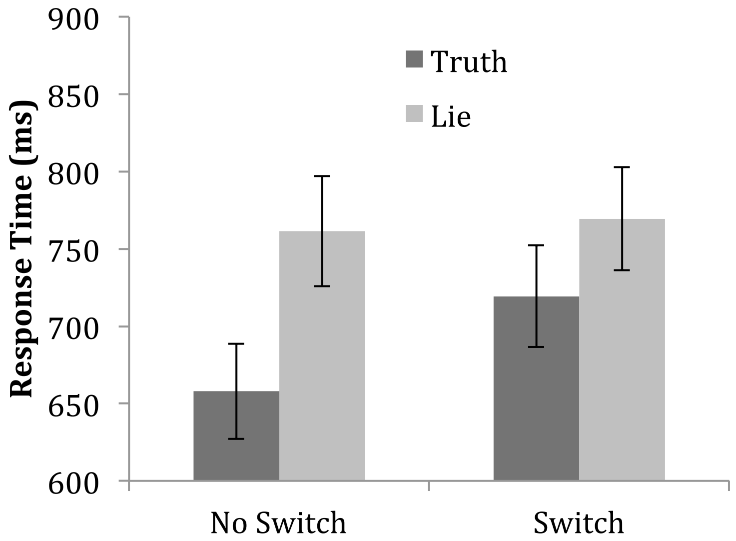
As in Experiment 1, the data were re-coded into trials involving a switch between lying and truth-telling and trials not requiring a switch in honesty of response. Once again, data from the directed and choice conditions were combined for this analysis.

Results and Discussion

A total of one participant, 100 outliers and 126 inaccurate responses were removed from the analysis (see Chapter 2 for further details).

The effect of task-switching was once again examined by comparing response times when a trial was preceded by one of the same type (i.e., lie followed by lie or truth followed by truth) to when preceded by one of the opposite type (i.e., truth followed by lie or lie followed by truth). The mean number of trials and mean response times for each of the four conditions was as follows; (1) lie switch trials (LS; Trials: 42; *M*: 769.38, *SD*: 156.25), (2) lie no switch trials (LNS; Trials: 52; *M*: 761.34, *SD*: 166.79), (3) truth switch trials (TS; Trials: 42; *M*: 719.41, *SD*: 154.09), (4) truth no switch trials (TNS; Trials: 55; *M*: 657.85, *SD*: 144.03). Figure 7 shows the mean response time in all possible cells. A repeated-measures ANOVA was conducted with honesty of response (truth vs. lie) and task (switch vs. no-switch) as the within-subjects factors. Once again, a significant main effect of task was shown, $F(1,21) = 79.18$, $p < .001$, $\eta^2 = .79$ and a significant interaction between task x honesty of response, $F(1,21) = 13.28$, $p = .002$, $\eta^2 = .52$. Simple effects showed that participants took significantly longer to respond on switch trials compared to no-switch trials when they told the truth, $F(1,21) = 32.47$, $p < .001$, $\eta^2 = .61$, but not when they told a lie, $F(1,21) = 0.674$, $p = .42$, $\eta^2 = .03$, $CI = [-12.32, 28.39]$. Simple effects tests also showed that this time lying took significantly longer than telling the truth both on no-switch trials, $F(1,21) = 77.86$, $p < .001$, $\eta^2 = .79$ and on switch trials, $F(1,21) = 20.98$, $p < .001$, $\eta^2 = .50$.

Figure 7. Response times of Experiment 2 as a function of task and honesty. Note: Error bars are standard error.



In summary, we found that participants took longer to respond when they had to switch from telling a lie to telling the truth compared to responding truthfully on both trials. In contrast to Experiment 1 however, there was no significant increase in response time when individuals switched from responding truthfully to responding falsely compared to lying on both trials. These results suggest that a greater response time cost is incurred when switching from a lie-task set to a truth task-set than vice versa.

Experiment 3

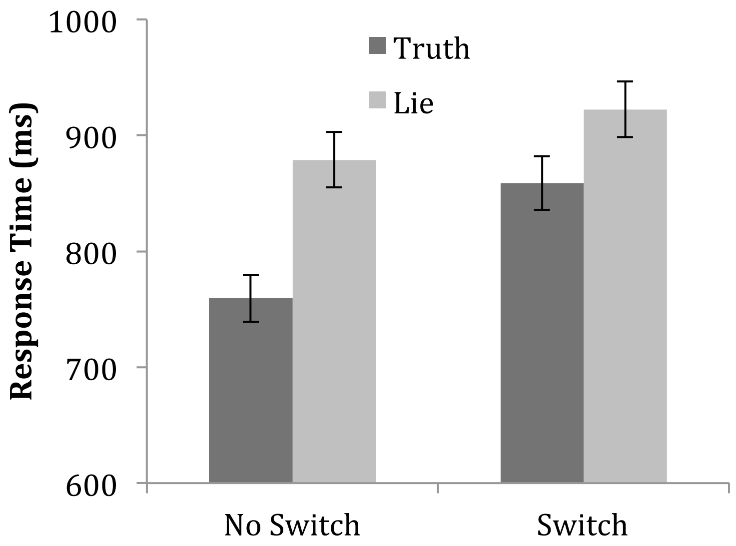
The original rationale for Experiment 3 was to examine the contribution of lie construction processes to longer response times when lying. In particular, we examined whether increasing the number of lie possibilities that participants could choose between increased response times, since a choice would be required between potential responses. Thirty-six participants were directed to lie or tell the truth regarding the colour of a square presented on a computer screen in a within-subjects design. In one condition, participants had only one lie response that they could use, whereas in the other condition, participants could choose between two lie possibilities. For further details regarding the original experimental rationale and method, see Chapter 2.

As described previously, the data were re-coded into trials involving a switch between lying and truth-telling and trials not requiring a switch in honesty of response.

Results and Discussion

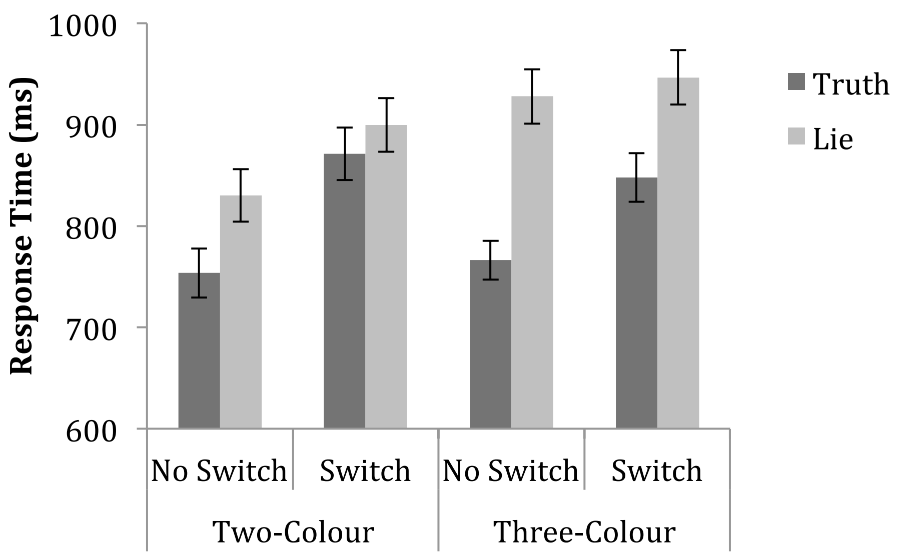
In total, 181 outliers and 175 inaccurate responses were removed from the analysis (see Chapter 2 for further details). The effect of task-switching was examined by comparing response times when a trial was preceded by one of the same type (i.e., lie followed by lie or truth followed by truth) to when preceded by one of the opposite type (i.e., truth followed by lie or lie followed by truth). At this point, data from the two-colour and three-colour conditions were combined. The mean number of trials and mean response times for each of the four conditions was as follows; (1) lie switch trials (LS; Trials: 50; *M*: 922.38, *SD*: 144.16), (2) lie no switch trials (LNS; Trials: 48; *M*: 878.98, *SD*: 142.78), (3) truth switch trials (TS; Trials: 50; *M*: 858.94, *SD*: 138.63), (4) truth no switch trials (TNS; Trials: 48; *M*: 759.37, *SD*: 121.10). Figure 8 shows the mean response time in all possible cells. A repeated-measures ANOVA was conducted with honesty of response (truth vs. lie) and task (switch vs. no-switch) as the within-subjects factors. As in Experiments 1 and 2, a significant main effect of task was shown, $F(1,35) = 71.43$, $p < .001$, $\eta^2 = .80$ and a significant interaction between task x honesty of response, $F(1,35) = 16.41$, $p < .001$, $\eta^2 = .32$. Simple effects showed that participants took significantly longer to respond on switch trials compared to no-switch trials when they told the truth, $F(1,35) = 71.05$, $p < .001$, $\eta^2 = .67$ and when they told a lie, $F(1,35) = 18.90$, $p < .001$, $\eta^2 = .35$. Simple effects tests also showed that lying took significantly longer than telling the truth both on no-switch trials, $F(1,35) = 110.22$, $p < .001$, $\eta^2 = .76$ and on switch trials, $F(1,35) = 46.52$, $p < .001$, $\eta^2 = .57$.

Figure 8. Response times of Experiment 3 as a function of task and honesty. Note: Error bars are standard error.



To examine the effect of the number of lie possibilities on the task-switching effects, a repeated-measures ANOVA was conducted with honesty of response (truth vs. lie), number of response possibilities (2-colour vs. 3-colour) and task (switch vs. no-switch) as the within-subjects factors. The mean number of trials and mean response times for each of the eight conditions was as follows; (1) two-colour lie switch trials (2LS; Trials: 25; *M*: 899.80, *SD*: 159.09), (2) two-colour lie no switch trials (2LNS; Trials: 24; *M*: 830.16, *SD*: 156.71), (3) two-colour truth switch trials (2TS; Trials: 25; *M*: 871.18, *SD*: 155.76), (4) two-colour truth no switch trials (2TNS; Trials: 24; *M*: 753.49, *SD*: 144.31), (5) three-colour lie switch trials (3LS; Trials: 25; *M*: 946.68, *SD*: 161.82), (6) three-colour lie no switch trials (3LNS; Trials: 24; *M*: 927.86, *SD*: 161.14), (7) three-colour truth switch trials (3TS; Trials: 26; *M*: 847.78, *SD*: 143.14), (8) three-colour truth no switch trials (3TNS; Trials: 24; *M*: 766.12, *SD*: 114.01). Figure 9 shows the mean response time in all possible cells. A significant interaction was found between the number of response possibilities and the task, $F(1,35) = 13.09$, $p < .002$, $\eta^2 = .27$. However, the interaction between the number of response possibilities, the task and the honesty of the response was not significant, $F(1,35) = 0.30$, $p = .59$, $\eta^2 < .01$. Simple main effects tests showed longer response times for switch trials compared to no-switch trials in the 2-colour block, both when participants told a lie, $F(1,35) = 30.85$, $p < .001$, $\eta^2 = .47$ and when they told the truth, $F(1,35) = 61.11$, $p < .001$, $\eta^2 = .64$. However, in the 3-colour block, longer response times for switch trials compared to no-switch trials were only found when participants told the truth, $F(1,35) = 39.19$, $p < .001$, $\eta^2 = .53$ and not when they told a lie, $F(1,35) = 1.43$, $p = .24$, $\eta^2 < .04$, $CI = [-13.16, 50.80]$.

Figure 9. Response times of Experiment 3 as a function of task, number of response possibilities and honesty. Note: Error bars are standard error.



In summary, our results were consistent with those of Experiment 1, in that participants took longer to respond when they had to switch both from telling a lie to telling the truth and vice versa compared to responding in the same manner on both trials. In accordance with Experiment 2 however, when the trials were broken down according to the number of lie response possibilities, a significant increase in response time for switch trials was only shown when participants responded honestly and not when they told a lie.

Experiment 4

Experiment 4 was originally conducted to examine whether further increasing the number of lie possibilities that participants could choose between further increased response times, due to the evaluation and potential suppression of each response possibility in turn. Thirty-two participants were directed to lie or tell the truth regarding the colour of a square presented on a computer screen in a within-subjects design. In one condition, participants had a choice of two lie possibilities, whereas in a second condition, participants could choose between three lie possibilities. For further details regarding the original experimental rationale and method, see Chapter 2.

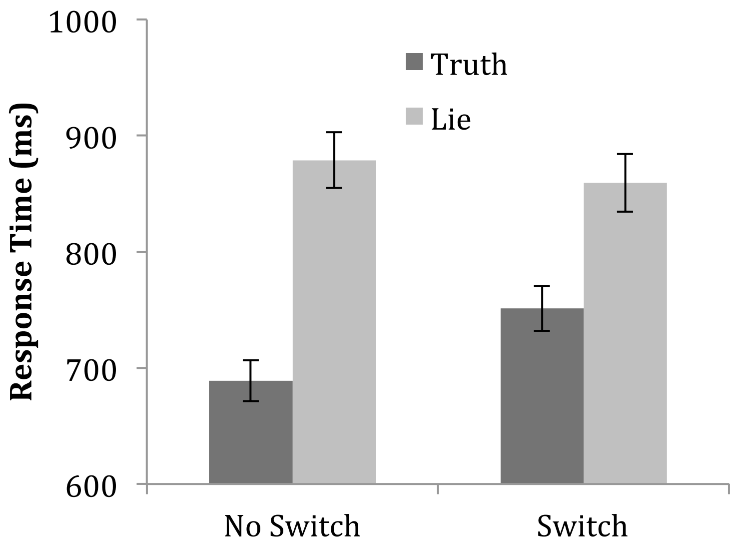
As described previously, the data were re-coded into trials involving a switch between lying and truth-telling and trials not requiring a switch in honesty of response.

Results and Discussion

In total, 174 outliers and 260 inaccurate responses were removed from the analysis (see Chapter 2 for further details). The effect of task-switching was examined by comparing response times when a trial was preceded by one of the same type (i.e., lie followed by lie or truth followed by truth) to when preceded by one of the opposite type (i.e., truth followed by lie or lie followed by truth). At this point, data from the three-colour and four-colour conditions were combined. The mean number of trials and mean response times for each of the four conditions was as follows; (1) lie switch trials (LS; Trials: 48; *M*: 859.42, *SD*: 140.59), (2) lie no switch trials (LNS; Trials: 48; *M*: 878.90, *SD*: 135.96),

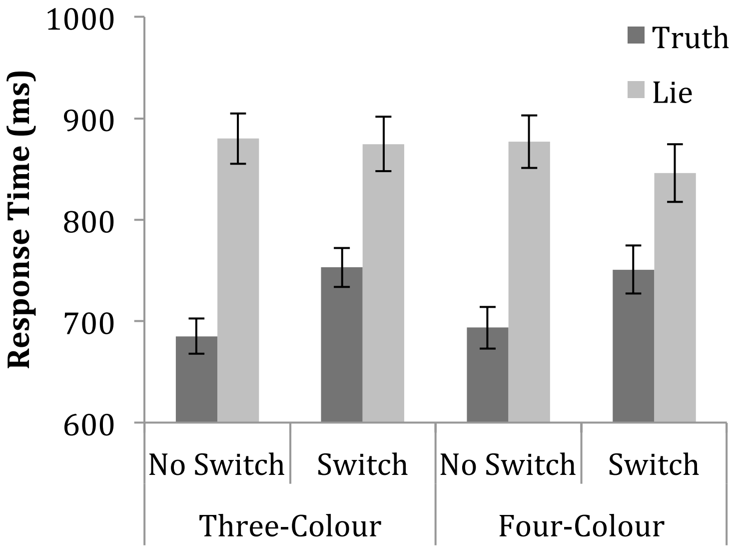
(3) truth switch trials (TS; Trials: 49; *M*: 751.32, *SD*: 110.34), (4) truth no switch trials (TNS; Trials: 48; *M*: 688.95, *SD*: 99.26). Figure 10 shows the mean response time in all possible cells. A repeated-measures ANOVA was conducted with honesty of response (truth vs. lie) and task (switch vs. no-switch) as the within-subjects factors. A significant main effect of task was shown, $F(1,31) = 8.19$, $p < .01$, $\eta^2 = .21$ and a significant interaction between task x honesty of response, $F(1,31) = 22.14$, $p < .001$, $\eta^2 = .42$. Simple effects showed that participants took significantly longer to respond on switch trials compared to no-switch trials when they told the truth, $F(1,31) = 32.065$, $p < .001$, $\eta^2 = .51$, but not when they told a lie, $F(1,31) = 2.67$, $p = .11$, $\eta^2 = .08$, $CI = [-43.81, 4.85]$. Simple effects tests also showed that lying took significantly longer than telling the truth both on no-switch trials, $F(1,31) = 176.82$, $p < .001$, $\eta^2 = .85$ and on switch trials, $F(1,31) = 46.18$, $p < .001$, $\eta^2 = .60$.

Figure 10. Response times of Experiment 4 as a function of task and honesty. Note: Error bars are standard error.



Once again, to examine the effect of the number of lie possibilities on task-switching, a repeated-measures ANOVA was conducted with honesty of response (truth vs. lie), number of response possibilities (3-colour vs. 4-colour) and task (switch vs. no-switch) as the within-subjects factors. The mean number of trials and mean response times for each of the eight conditions was as follows; (1) three-colour lie switch trials (3LS; Trials: 24; *M*: 874.60, *SD*: 152.63), (2) three-colour lie no switch trials (3LNS; Trials: 24; *M*: 879.96, *SD*: 140.35), (3) three-colour truth switch trials (3TS; Trials: 24; *M*: 752.96, *SD*: 108.74), (4) three-colour truth no switch trials (3TNS; Trials: 24; *M*: 685.24, *SD*: 98.07), (5) four-colour lie switch trials (4LS; Trials: 25; *M*: 845.98, *SD*: 161.45), (6) four-colour lie no switch trials (4LNS; Trials: 24; *M*: 876.89, *SD*: 147.87), (7) four-colour truth switch trials (4TS; Trials: 25; *M*: 750.93, *SD*: 134.17), (8) four-colour truth no switch trials (4TNS; Trials: 24; *M*: 693.55, *SD*: 116.97). Figure 11 shows the mean response time in all possible cells. This time, there was no interaction between the number of response possibilities and the task, $F(1,31) = 1.69$, $p = .20$, $\eta^2 < .06$ or between the number of response possibilities, the task and the honesty of the response, $F(1,31) = 0.26$, $p = .61$, $\eta^2 < .01$. Simple main effects tests showed longer response times for switch trials compared to no-switch trials when participants told the truth in both the 3-colour block, $F(1,31) = 28.27$, $p < .001$, $\eta^2 = .48$ and the 4-colour block, $F(1,31) = 11.75$, $p < .005$, $\eta^2 = .27$. However, there were no differences between switch and no-switch trials when individuals told a lie in either the 3-colour block, $F(1,31) = 0.12$, $p = .73$, $\eta^2 < .01$, CI = [-36.43, 25.70] or the 4-colour block, $F(1,31) = 3.53$, $p = .07$, $\eta^2 = .10$, CI = [-64.44, 2.62].

Figure 11. Response times of Experiment 4 as a function of task, number of response possibilities and honesty. Note: Error bars are standard error.



In summary, we found that participants only incurred a significant response time cost on switch trials when they responded truthfully and not when they responded falsely. This provides further support for the idea that a greater response time cost is incurred when switching from a lie-task set to a truth task-set than vice versa.

Experiment 6

The additional analyses of four previous experiments reported above have shown that response times increase when participants switch between lying and telling the truth, compared to consistently responding in one manner. However, none of these experiments were specifically designed to investigate task-switching, and our results regarding the interaction between switching and lying have been inconsistent across experiments. We were unsure whether this might have been an artefact of the post hoc classification of the pairs of trials as being switch/no-switch (e.g., different numbers of switch/no-switch trials across participants). We therefore designed Experiment 6 to analyse task-switching with an *a priori* design in which all participants had equal numbers of switch/no-switch and lie/truth trials

The hypotheses of Experiment 6 were similar to those described for Experiments 1 to 4. First, we wanted to test whether there were greater RTs for switch vs. no-switch trials when participants lied, and second, we wanted to test whether there was a greater effect of switching for truth telling than lying. We also examined the effects of practice on the switch cost.

Method

Participants

Eighteen students volunteered for this study in exchange for payment. Of these, 13 were female. Participants had a mean age of 21.72 (*SD* = 3.10; *Range* = 19-32) and spoke English as their first language.

Design

A 2 x 2 within-subjects design was utilised, with the independent variables being honesty of response (lie vs. truth) and task (no-switch vs. switch). The dependent variable was response time. A total of 208 trials were included in the computer task. Trials were created as one of four pairs as follows: a lie trial followed by a lie trial (LL), a truth trial followed by a truth trial (TT), a lie trial followed by a truth trial (LT) and a truth trial followed by a lie trial (TL). Overall, each pair was presented 52 times throughout the task, with only the second trial in each pair being analysed. The order of pairs was randomly presented by the computer for each participant. Unlike in Experiments 1 and 2, there was no choice condition in this experiment, so participants were directed to lie or tell the truth prior to each trial. The colour of the square (Red, Blue or Green) associated with each trial was also randomly controlled by the computer.

Procedure

The experiment progressed as a series of trials each of which began with the presentation of one of two words in the centre of the computer screen (LIE or TRUTH). Participants were instructed to indicate whether they understood by pressing the 'T' key when presented with the word 'TRUTH' and the 'L' key when presented with the word 'LIE'. The word remained on the screen until the participant pressed the appropriate button and was then replaced with either a blue, red or green square. Participants then had to say either the true colour of the square or lie about the colour of the square by claiming that it was one of the alternative colours according to the instruction (e.g., blue or green if it was red). Voice key responses were recorded via a headset microphone. After the vocal response was made, the next trial began after approximately 500ms. Instructions were presented on the screen and emphasised the importance of responding both as quickly and as accurately as possible. Participants took part in a short practice block of eight trials identical to the main trials. The question 'What colour is the square?' was visually presented prior to both the practice block and the block of main trials. All stimuli were presented on a black background, with the squares being of equal size and the text being presented in Arial font, size 40.

Results

There were 82 outliers in total, with 67 of these being due to microphone errors (the microphone failed to pick up the initial answer). Inaccurate responses (64) were also removed from the analysis. Overall, there were 31 inaccurate responses in the switch lie condition, 21 in the switch truth condition, 0 in the no-switch lie condition and 12 in the no-switch truth condition. In total, 146 trials out of 3,744 were removed from the analysis.

Mean response times for each of the four conditions was as follows; (1) lie switch trials (LS; *M*: 943.04, *SD*: 261.05), (2) lie no switch trials (LNS; *M*: 878.87, *SD*: 164.00), (3) truth switch trials (TS; *M*: 760.09, *SD*: 141.92), (4) truth no switch trials (TNS; *M*: 690.96, *SD*: 105.63). Figure 12 shows the mean response time in all possible cells. Monsell (2003) claimed that it is easier to re-enable a particular task-set if a task has recently been performed. Since participants in this experiment are repeatedly performing the same two tasks (lying or telling the truth about the colour of a square) in quick succession, we also examined the potential effect of practice in this experiment. Trials were further split in half and divided into those presented in the first-half of the task (trial 104 and below) and those presented in the second-half of the task (trial 105 and above). Mean response times for each of the eight conditions was as follows; (1) first-half lie switch trials (FH-LS; *M*: 970.26, *SD*: 302.58), (2) first-half lie no switch trials (FH-LNS; *M*: 907.30, *SD*: 168.32), (3) first-half truth switch trials (FH-TS; *M*: 769.51, *SD*: 159.63), (4) first-half truth no switch trials (FH-TNS; *M*: 706.54, *SD*: 111.77), (5) second-half lie switch trials (SH-LS; *M*: 923.15, *SD*: 248.15), (6) second-half lie no switch trials (SH-LNS; *M*: 857.43, *SD*: 170.40), (7) second-half truth switch trials (SH-TS; *M*: 752.10, *SD*: 133.79), (8) second-half truth no switch trials (SH-TNS; *M*: 677.80, *SD*: 108.68). Figure 13 shows the mean response time in all possible cells. A repeated-measures ANOVA was conducted with honesty of response (truth vs. lie), task (switch vs. no-switch) and practice (first-half vs. second-half) as within-subjects factors. This found a trend towards significance for the effect of practice, $F(1,17) = 4.16$, $p = .057$, $\eta^2 = .20$, with quicker response times in the second-half of the task compared to the first-half. In accordance with our previous findings, a main effect of task was found, $F(1,17) = 7.02$, $p < .02$, $\eta^2 =$

.29, with longer response times on switch trials compared to no-switch trials, and also a main effect of honesty of response, $F(1,17) = 58.43$, $p < .001$, $\eta^2 = .77$, with longer response times on lie trials compared to truth trials. No significant interaction between the honesty of response and task was found, $F(1,17) = 0.02$, $p = .89$, $\eta^2 = .001$. Simple main effects analyses, however, found that response times were longer on switch trials compared to no-switch trials only when participants told the truth, $F(1,17) = 18.03$, $p < .001$, $\eta^2 = .51$, and not when they told a lie, $F(1,17) = 2.59$, $p = .13$, $\eta^2 = .13$. Practice was not found to interact with either honesty of response, $F(1,17) = 1.09$, $p = .31$, $\eta^2 = .06$, or task, $F(1,17) =.13$, $p = .73$, $\eta^2 = .01$. The potential 3-way interaction between the factors was also not significant, $F(1,17) = .04$, $p = .84$, $\eta^2 = .01$.

Figure 12. Response times of Experiment 6 as a function of task and honesty. Note: Error bars are standard error.

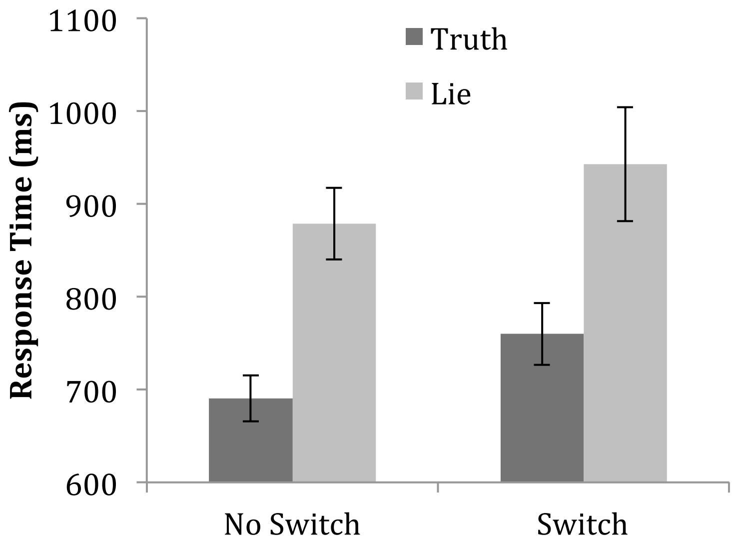
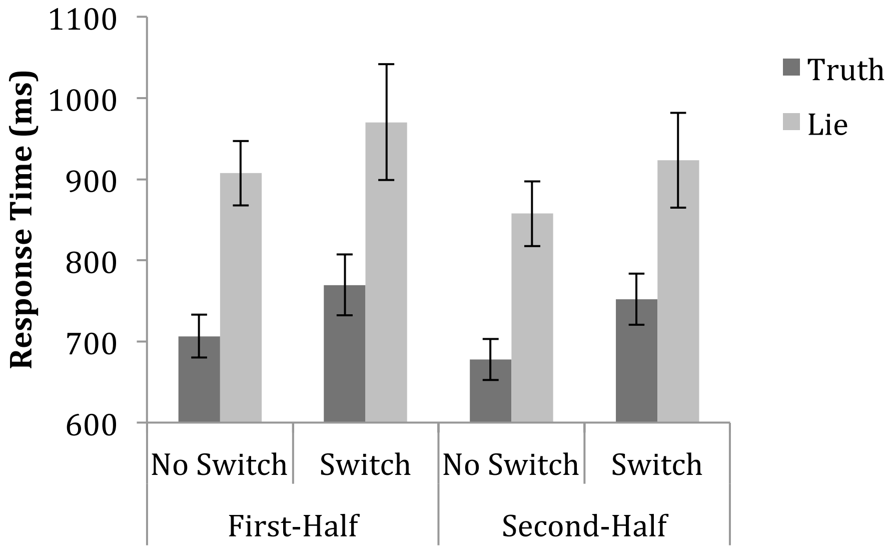


Figure 13. Response times of Experiment 6 as a function of task, practice and honesty.

Note: Error bars are standard error.



Discussion

Following our re-analysis of Experiments 1-4, whereby switching between lying and telling the truth was found to incur a response time cost compared to consistently responding in one manner, Experiment 6 was designed specifically to examine task-switching and lying. In support of the cognitive load explanation of deception, it took longer for participants to respond falsely compared to responding truthfully. This difference remained on both switch and no-switch trials. In accordance with our previous findings, longer response times were shown on switch trials compared to no-switch trials, with a greater increase shown when participants switched from lying to telling the truth than vice versa.

Since participants performed the same tasks repeatedly over many trials, we also examined the potential effects of practice on task-switching in our task. Monsell (2003) claimed that it is easier to reinstate a particular task-set if that task has recently been performed. We demonstrated, however, no reduction in switch costs over the course of the task, suggesting that repeated performance did not diminish the task-switching effect. Interestingly, the generic response time difference between lying and telling the truth was also found to withstand repeated responding.

General Discussion

The aim of the current study was to investigate whether switching between lying and telling the truth requires additional processing compared to consistently responding in one manner. Although previous research has shown that switching between different tasks incurs a response time cost (Monsell, 2003), the phenomenon of task-switching has not been directly investigated in relation to the additional cognitive processes occurring when individuals lie. If switching between lying and telling the truth are indeed linked to different response- or task-sets, then we would expect switching between the two to incur a response time cost, a finding which has both practical and theoretical applications. Therefore, data from four previous experiments were analysed and a fifth experiment was conducted to examine whether switching between telling a lie and telling the truth results in longer response times compared to responding in the same manner consecutively. Trials were divided into those where participants had to switch from telling a lie to telling the truth and vice versa (switch trials) and those where participants responded with the same response-type as on the previous trial (no-switch trials).

Overall, all five experiments showed that switching between response types increased response times compared to consistently responding truthfully. The findings in relation to telling a lie, however, were more complex. Namely, Experiments 1 and 3 found that response times were also longer on lie switch trials compared to lie no-switch trials, whereas Experiments 2, 4 and 6 found little difference between the two conditions. Possible reasons for this, and the implications of these findings, are discussed in more detail below. This suggests that task-switching may contribute to, but is not a necessary component of, the additional processing seen when individuals lie compared to when they tell the truth.

Both Rogers and Monsell (1995) and Allport et al (1994) have attempted to explain why switching between different tasks takes longer than repeating the same task again. Although their explanations for these switch costs differ, namely whether they are due to reconfiguration of task-set parameters or resolving interference from the previous task, this switch cost fundamentally occurs when two sequential tasks involve different task-sets. The original premise of this study was that the additional processes suggested to be involved in telling a lie may result in this response type also being associated with a different task-set compared to responding honestly. As previous research has repeatedly demonstrated that switching between differential task-sets incurs a response time cost, our findings of longer response times when individuals switch between telling a lie and telling the truth suggest that both of these response types invoke a different task-set.

Interference vs reconfiguration

Our task was not designed to distinguish between the interference (Allport et al, 1994) and reconfiguration (Rogers & Monsell, 1995) explanations. Nonetheless, our results appear more consistent with an interference approach to switch costs, as we describe below.

At the beginning of each trial, participants were shown the word LIE or TRUTH as their task instruction. They then had to press either the L key or the T key, and it was not until participants had pressed this key that the trial continued and the word was replaced with a coloured square. Participants should therefore have had sufficient time to perform any necessary reconfiguration processes and update task parameters for the upcoming task (either telling a lie or telling the truth). If reconfiguration was the sole determiner of switch cost, the preparation time should have been sufficient to allow the reconfiguration to take place. Instead, we observed persistent switch costs across all of the experiments. This suggests that a previous task-set (e.g., telling a lie) remains active and then interferes with upcoming task requirements.

Our findings in this regard are consistent with other researchers who have identified a residual switch cost even when preparation intervals are provided (Altmann, 2002; Logan & Bundesen, 2003). Consequently, the reconfiguration view has been modified to include a two-stage process (Mayr & Kliegl, 2000; Rogers & Monsell, 1995; Rubenstein, Meyer & Evans, 2001). This model suggests that endogenous preparation for the upcoming task can be undertaken before a stimulus is actually presented, and then continues with the activation of specific task rules once a stimulus has been shown.

Further explanations for the presence of a residual switch cost are provided by De Jong (2000), who suggested that they may be due to participants' failure to engage in preparation when provided with the opportunity. This explanation also applies to our task. On certain trials participants may choose to engage in preparation and complete reconfiguration processes, while on other trials they may fail to complete these processes prior to the stimulus being presented. The residual switch cost is merely the average of trials where reconfiguration has been completed combined with those where reconfiguration has not been completed. Indeed, residual switch costs are not always shown in the task-switching literature (Gillbert & Shallice, 2002; Meiran, 1996; Verbruggen, Liefooghe, Vandierendonck & Demanet, 2007).

Truth as a default

Although we found general response time costs associated with task-switching in our study, Experiments 2, 4 and 6 only demonstrated this cost when participants responded to truth trials and not when they responded to lie trials. Although a significant difference was found in Experiments 1 and 3 for lie trials, this was still to a lesser degree than that found on truth trials. This possible interaction was considered in our hypotheses and relates to previous findings in the task-switching literature. Namely, that switching from a weaker task to a more dominant task incurs a greater response time cost than switching from a more dominant to a weaker task (Allport et al, 1994). Allport et al. suggested that this effect results from a greater amount of inhibition being required to prevent the dominant task from being undertaken and that this inhibition then carries over into the following trial, where the dominant task must then be reinstated. Since we repeatedly found that a greater response time cost was associated with switching from telling a lie to telling the truth than vice versa, this suggests that telling the truth is the more dominant of the two response types.

There are two alternative explanations for this finding, however, that should also be considered. Firstly, that a smaller difference on lie trials is due to a response time ceiling effect. This possibility is supported by the findings of Experiments 3 and 4 in particular, since lie trials that involved the additional process of choosing between multiple lie response possibilities (i.e., the 3-colour and 4-colour blocks) do not show a task-switching effect, whereas those trials where only one lie possibility could be used (i.e., the 2-colour block) did show this effect. Since having to make a choice between multiple lie possibilities has been shown to increase response times compared to having only one lie response option (Williams, Bott, Lewis & Patrick, submitted), the task-switching effect may be encompassed in the longer response times already demonstrated in these trials. The fact that smaller switch effects were still seen in lie trials with only one lie possibility compared to truth trials may also be due to the longer response times already shown when individuals respond falsely compared to when they respond truthfully. This explanation, however, does not account for the lack of a lie switch cost in Experiment 2 where only one lie response is available.

Secondly, if task-switching costs are indeed due to interference from the previous task, the extent of this interference may be related to the task-set parameters necessary for the two different response types. Indeed, on both no-switch and switch lie trials, the truthful response interferes with the production of the lie response and has to be inhibited. Therefore on lie trials, participants have to resolve conflict between the two response types both when they switch between tasks and when they perform the same task, so either a reduced switch-cost or no cost at all may be expected. However, on truth trials, the lie response may only be active and interfere with telling the truth when participants have previously told a lie, so a greater switch cost would occur. For these different possibilities to be fully evaluated, further work is required to manipulate the activation level of both the truth and lie response.

In 2011, Verschuere, Spruyt, Meijer and Otgaar demonstrated that the relative strength of the truth response was indeed malleable. In their study, participants were assigned to either the frequent truth, frequent lie or control condition and response time and error rates were examined in relation to computer presented yes-no questions. Results showed that the response time difference between lying and telling the truth was reduced in the frequent lie condition, suggesting that telling the truth becomes more difficult when lying is more likened to the default response-type.

Practice effects

Monsell (2003) claimed that recent practice of a task makes it easier to re-enable that task-set. Although participants in the current study were not given the opportunity to explicitly practice a lie response, the quick succession of trials may lead to participants finding it easier to re-enable both the truthful and lie task-sets as the experiment progressed. Although a particular response is not practiced prior to the vocal response time measure, participants are aware of both the response type (whether they are going to lie or tell the truth) and the different colours that may be shown (i.e., red, blue or green). This design may result in potential practice effects; therefore this possibility was examined in Experiment 6.

Two main findings of interest regarding practice effects should be considered. Firstly, the overall response time difference between telling a lie and telling the truth remained throughout the task, consistent with previous deception research (Johnson, Barnhardt & Zhu, 2005; Vendemia et al, 2005). Secondly, and importantly for the practical implications of this task-switching effect, is the finding that the longer response times for truth switch trials compared to truth no-switch trials remained in both halves of the task, potentially resulting in longer response times over the course of a questioning session for all individuals who respond to any question deceptively.

Practical Applications

Recent research conducted by Vrij and colleagues has highlighted specific interview techniques that aim to increase the cognitive load that is already experienced when people tell a lie (Vrij et al, 2009), such as asking individuals to recall their story in reverse order (Vrij et al, 2008). The findings of the current study provide an additional interview technique that may be considered in relation to such practical situations, namely the alternating of questions where individuals are likely to respond truthfully (such as a known biographical fact) with those where they are likely to respond deceptively (such as those related to an event under investigation). Indeed, we have shown that when individuals have to switch between lying and telling the truth compared to responding in the same manner consecutively, additional cognitive processes are occurring related to interference from the previous response and reconfiguration for the upcoming task. These additional cognitive processes are reliably demonstrated in observable behavioural differences, namely longer response times to questions.

In addition to the basic premise that task-switching may increase the cognitive load experienced by liars, further factors related to this effect also have practical importance. Firstly, it has been suggested that the greater difficulty experienced during switch trials may elicit increased general arousal and greater error monitoring (Monsell, 2003), which would allow for a greater number of indicators and behaviours to be examined, potentially enhancing deception detection (Vrij et al, 2000). Secondly, the task-switching effect has been suggested to be increased by factors, such as anxiety, that reduce attentional control (Ansari, Derakshan & Richards, 2008). Thirdly, it should be considered that different types of lie may result in different effects, since both spontaneous and rehearsed lies, and lies related to autobiographical and non-autobiographical information, have been shown to involve different cortical regions (Abe et al, 2006; Mameli, Mrakic-Sposta, Vergari, Fumagalli, Macis, Furrucci et al., 2010; Morgan, LeSage & Kosslyn, 2009). As a result, it is possible that different categories of lies, and even the contexts that they are told in, may be associated with different task-sets, rather than with a generic ‘lie’ or ‘truth’ task-set.

Conclusions

Over the years, several interview strategies have been highlighted that can improve the discrimination of truths and lies by increasing the cognitive load that a liar experiences (Vrij et al, 2008). This increased level of cognitive processing results in behavioural differences when people lie, such as longer response times to questions (Walczyk et al, 2003). Although the precise mechanisms responsible for this additional processing are not well understood, researchers have suggested specific processes, such as inhibition of the truthful response, that are involved in telling a lie (Seymour et al, 2000; Spence et al, 2001). However, the potential role of other cognitive processes in deceptive responding, including those associated with switching between tasks, was previously unclear (Christ et al, 2009).

This study has clarified the potential role of task-switching as an additional cognitive process when individuals lie to certain questions and not others. Namely, that switching between lying and telling the truth is more difficult, and involves additional cognitive resources, than responding truthfully. Furthermore, since this difference was greater when participants switched from telling a lie to telling the truth rather than vice versa, this suggests that telling the truth is a more dominant cognitive task than lying.

CHAPTER 4

Can The Lie Response Be Externally Influenced?

The recent focus of research on cognitive techniques to detect deception has allowed for the progression of current understanding regarding the additional cognitive processes involved in telling lies (Christ et al, 2009; Vendemia et al, 2009; Walczyk et al, 2003). Theoretical considerations have generally focused on the role of truth suppression, generic executive control processes, and more recently, the decision to lie. Less work has been conducted, however, on how people construct their lie response. In this chapter, we examine how the lie response is chosen by manipulating the relative activation of particular response possibilities using priming techniques.

Priming and telling lies

Priming effects are well documented in psychology and involve exposing an individual to a particular stimulus, such as a word or image, which will then influence that individual's response to a later stimulus (Tulving, Schacter & Stark, 1982). For example, if an individual is asked to read a list of words that involves many repetitions of the word *table*, then this enhances the likelihood that they will respond *table* when presented with the word *tab* in a subsequent word completion task. Such primes can be presented either subliminally or overtly, with subliminal primes being presented for such a short period of time that they are considered outside of conscious awareness (Tulving et al, 1982).

Although priming has not generally been considered in the lie detection literature, in 2009, Lui and Rosenfeld examined the potential use of priming as a countermeasure-resistant lie detection technique using ERPs. In their study, participants provided experimenters with the last names of five people they knew very well and also selected four names from a list of twenty that did not have any personal meaning to them. These names were used as task stimuli. Participants were then shown a series of both acquaintance and non-acquaintance names and had to press a yes or no button according to whether they knew a person by that name. Participants were instructed to respond truthfully to only one of the acquaintance names and to deny knowing the other four (i.e., to lie in response). These names were also preceded by the presentation of a subliminal prime displaying either an acquaintance or non-acquaintance name. It was hypothesised that lying would orient participants sensitivities to the familiarity of names, increasing the ERP difference between the primed acquaintance and primed non-acquaintance conditions. Although no significant difference in response time was shown when individuals were primed with an acquaintance name compared to a non-acquaintance name prior to their lie response, differences in ERP amplitude between the two conditions were found. Lui and Rosenfeld's study is, as far as we are aware, the only study to directly examine priming effects when telling lies.

Priming and lie response choice

Although it is well-established in the lie detection field that additional processes are involved in telling a lie compared to telling the truth (Spence et al, 2001; Spence et al, 2008), the majority of work examining these processing differences has generally focused on internal mechanisms related to potential inhibition of the truthful response and production of an alternative. How this lie response is actually chosen, however, as well as the factors associated with this, is less well-known. For instance, if I was asked what I was doing at home yesterday, what is it that leads me to choose watching TV rather than reading a magazine when telling a lie? Both could be potentially plausible responses. One possibility is that the choice of lie response is based on cognitive demands, with the final option chosen being the least cognitively demanding and plausible possibility. Since liars are already under a higher degree of cognitive load to ensure they appear believable (Vrij et al, 2011), it is intuitive that they may choose the least challenging potential option as a lie response.

If the least cognitively challenging lie is indeed the one that is chosen as the response, then it may be possible to influence this response choice process through the external presentation of primes that are potential lie responses. Such a method would enhance the relative activation of one particular lie response compared to any other, and lead to an individual using this prime as their lie response.

Lie construction processes

There has been surprisingly little research conducted on how people choose which lie to use. The majority of discussions of deceptive cognition acknowledge that additional processes are required in the construction of an alternative, plausible lie response, but precisely how this response is chosen is not known. For example, the Activation Decision Construction Model (ADCM; Walczyk et al, 2003; 2005) highlights lie construction processes as a major contributory factor to the longer response times shown by liars.

According to the ADCM, once a decision has been made to lie to a question and the truthful response suppressed, a suitably plausible lie must be constructed. The truth is considered to provide a retrieval cue which aids lie construction through the activation of related information in semantic and episodic memory systems. The choice of which information to use when considering potential lie responses is thought to be constrained by the social context, since certain lies may be implausible, inconsistent with previous responses or will fail to achieve the goals of the liar (DePaulo et al, 1996; Ekman et al, 1999; Fiske & Taylor, 1991). Following this process, the model claims that the chosen lie is a reflection of the relative activation of possible responses, with the most active lie possibility in working memory being disclosed as the response (see Kintsch, 1998).

The extent that lie response choice represents an active or passive process is not considered by the ADCM. Namely, is the response chosen a relatively automatic and passive process? Or are possible responses actively and carefully considered before a final response is chosen? If the first option, then it is theoretically possible to influence the lie response that an individual chooses through the manipulation of relative activation levels of particular responses. Since the truth is generally considered the default communicative response (Grice, 1989) and is likely to have the strongest association with the question that is asked, this information should provide the most active response possibility. When telling a lie, suppression processes are required to prevent this truthful response from being uttered (Walczyk et al, 2003). Following this, the lie response will be the strongest competing alternative. If one particular lie response is made considerably more active than another, for example through the use of priming techniques, then this response may be the most likely to be used when telling a lie. Alternatively, if lies are more actively and carefully considered when deciding on a possible response, then the relative activation of particular lies may be irrelevant when a number of plausible and suitable responses are possible, since each lie may be actively considered and decided between.

A final point to be considered in relation to the processes involved in lie creation is the potential necessity to suppress the truthful response. Although several studies and theoretical discussions claim that suppression of the truth is a necessary process when telling a lie (Christ et al, 2009; Vendemia et al, 2009; Walczyk et al, 2003), Verschuere et al (2010) suggest that the extent that the truth is a default response, and hence the necessity to inhibit it, is affected by the relative frequency with which individuals tell lies.

If the strength of the truthful response is indeed malleable, then it is possible that the external activation of potential lie responses may reduce the relative strength of the truth response in comparison to the lie response, and similarly negate the requirement to suppress it, since the externally presented lie response may already be the strongest response option. Alternatively, the truth may remain the strongest response option, and thus still require additional suppression, with the externally activated lie response simply being the strongest possible response option following the truth.

The potential effect that priming a lie response has on the cognitive processes involved in telling a lie could mirror those involved in rehearsed and spontaneous lies. For instance, if a lie has been rehearsed, it may form the strongest association with the question and thus, negate the need to suppress the truthful response. If a lie has not been rehearsed, however, truthful information is likely to have the strongest association with the question, and thus will need to be suppressed in order to tell a lie. Since unrehearsed lies have been suggested to be more cognitively demanding, seen in longer response times to questions (DePaulo et al, 2003), this is likely to be due to both the necessity to choose a lie response and also to suppress truthful information. Providing a potential lie response may similarly reduce the response time for liars due to the removal of both of these processes, resulting in a much smaller difference, if any at all, between liars and truth tellers.

The Current Study

The aim of this chapter was to expand current knowledge of lie construction processes by manipulating the relative activation of potential lie response options. Two experiments were conducted that were designed to externally activate particular lie responses when individuals lied or told the truth.

Participants completed the same colour-naming task described in the previous chapters. They saw a square presented on the screen and had to truthfully describe the colour or lie about it. The difference was that in this task, participants were presented with a masked colour word prior to the coloured square presented on the screen. The colour words were primes and we expected the primes to interact with the lie response. There were three types of prime trials. First, *correct* prime trials provided participants with a legitimate response for the trial. Hence, when participants had to name the colour of the square truthfully, the prime word provided the correct colour, and when the participant had to lie, the prime word gave a possible lie response. Second, *incorrect* primes provided participants with an illegitimate response. When participants had to truthfully name the coloured square, the prime was of an incorrect colour, and when a lie was required, the prime was of the correct colour. Finally, there was a no-prime condition which involved the presentation of only the mask prior to the square (no colour word was presented).

Experiment 7

Experiment 7 examined the ADCM predictions regarding how a lie response is chosen from memory. As discussed previously, the ADCM predicts that the lie response chosen is the most active in working memory. If this is the case, participants primed with plausible lie responses should choose the same colour as the correct prime for their lie response significantly more often than choosing a different colour to the correct prime.

In order to test this hypothesis, participants completed a computer task whereby they were instructed to lie or tell the truth regarding the colour of a square shown on a computer screen (red, green or blue). A series of correct, incorrect or blank primes were presented prior to the square being shown. For correct and incorrect prime trials, these primes consisted of the word RED, GREEN or BLUE. Some of these primes were presented for 100ms, and were considered our high visibility primes, whereas others were presented for only 40ms, and were considered our low visibility primes. It was considered that if primes required more active processing in order to be regarded as a potential lie response (and hence required more time to be processed), participants would use correct high visibility primes as their lie response more often than low visibility primes.

In addition to examining participant response choice on each trial, we also measured and analysed response time. This allowed us to measure whether the prime is processed, and hence active, in working memory. If a response time difference is shown between prime and no-prime trials, this suggests that the prime is either aiding or interfering with lie response processes (depending on the direction of the difference), and is therefore not merely being ignored by participants.

Method

Participants

Nineteen university students participated in the study in exchange for payment. Of these, 13 were female. Participants had an average age of 21.89 (*SD* = 2.98; *Range* = 20-30) and spoke English as their first language.

Design

A 2 x 5 within subjects design was utilised, with honesty of response (truth vs. lie) and prime type (no-prime vs. low visibility correct prime vs. high visibility correct prime vs. low visibility incorrect prime vs. high visibility incorrect prime) as within-subject factors. The main task consisted of a total of 360 trials, with half of these instructing participants to tell the truth and half of these instructing participants to lie. In each honesty condition, there were 60 no-prime trials, 60 correct primes (30 low visibility and 30 high visibility) and 60 incorrect primes (30 low visibility and 30 high visibility). Since the no-prime condition just presented a blank screen between the forward and backward masks, it did not contain correct and incorrect primes. The colour of the prime (red, green or blue) and the colour of the square (red, green or blue) were counterbalanced within the task. The order of trials was randomly controlled by the computer.

Procedure

On each trial, participants were shown either the word LIE or TRUTH in the centre of the screen. Participants were instructed to press the 'L' key if the word 'LIE' was shown and the 'T' key if the word 'TRUTH' was shown. The prime-mask stimuli then appeared on the screen. This involved the presentation of '####' in the centre of the screen for a 200ms period, followed immediately with either a word (BLUE, GREEN or RED) in the low visibility and high visibility prime conditions or a blank screen in the no prime condition. In the low visibility and no prime condition, this stimuli was displayed for a period of 40 ms. In the high visibility prime condition this stimuli was displayed for 100 ms. This stimuli was immediately followed by the presentation of a backward mask, '####'. The stimulus-onset asynchrony (SOA) for all three prime types was 140 ms, therefore the backward mask was shown for 40 ms in the high visibility prime condition and for 100 ms in the low visibility and no prime condition. A coloured square was then displayed in the centre of the screen (blue, green or red) and participants either lied about the colour of the square by claiming it was one of the opposite colours (e.g. blue or green if the square was red) or told the truth about the colour of the square according to the instruction at the start of the trial. Prior to the main task participants completed a short practice trial consisting of 12 trials which were identical to the main trials. After every 150 trials participants were given the option of pausing the task for a short period of time.

Results

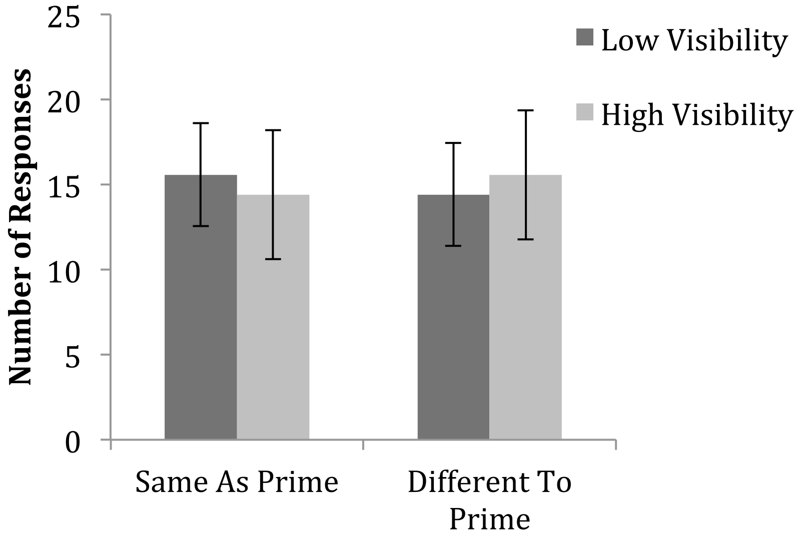
Response time outliers were defined as response times over two seconds in length. There were 67 in total and these were removed from the analysis and coded as missing data. Inaccurate responses (270) were also removed from the analysis. There were 92 inaccurate responses in the correct prime condition, 96 in the incorrect prime condition and 82 in the no-prime condition. In total, 337 out of 6,840 data points were removed from the analysis, amounting to 3% of all trials.

Response Choice

Trials where individuals were instructed to lie and were provided with a correct prime were analysed separately to examine whether participants used the prime as their lie response. A repeated-measures ANOVA was conducted with response choice (same as the prime vs. different to the prime) and prime visibility (high vs. low) as the within-subject factors and the number of responses as the dependent measure. This resulted in 4 conditions; (1) participants chose the same answer as the high visibility prime (HV-S; *M*: 14.42, *SD*: 3.80), (2) participants chose a different answer to the high visibility prime (HV-D; *M*: 15.58, *SD*: 3.80), (3) participants chose the same answer as the low visibility prime (LV-S; *M*: 15.58, *SD*: 3.02), (4) participants chose a different answer to the low visibility prime (LV-D; *M*: 14.42, *SD*: 3.02). These 4 conditions are highlighted in Figure 14. No effect of response choice was shown, $F(1,18) = 0.01$, $p = .99$, $\eta^2 = 0.001$, $CI = [-2.12, 2.12]$, and this was not affected by prime visibility, $F(1,18) = 0.92$, $p = .35$, $\eta^2 = 0.05$, $CI = [12.59, 17.41]$.

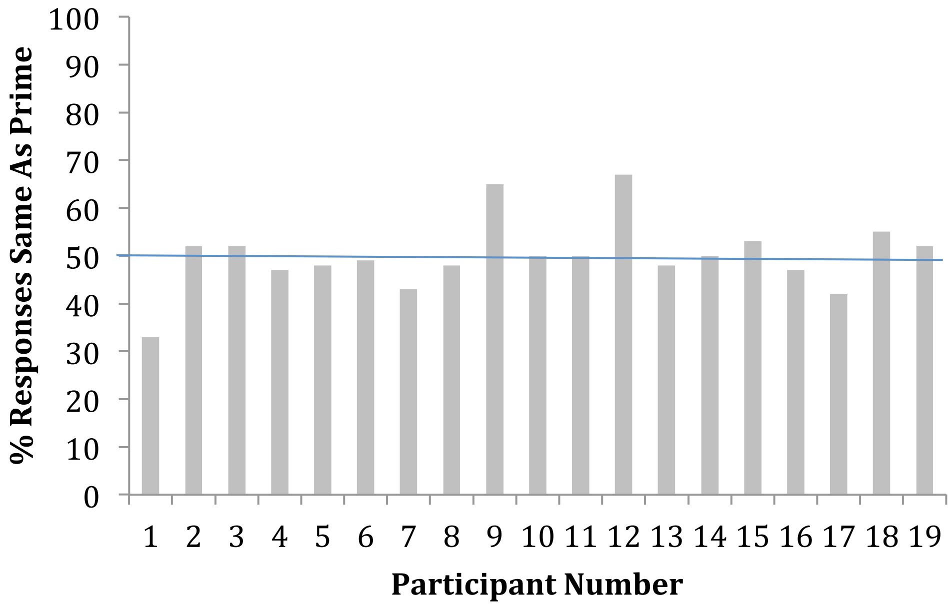
Paired sample t-tests were also conducted to test the hypothesis that participants would use the prime as their answer more often than not. This hypothesis was not supported in either the low visibility, $t(18) = 0.83$, $p = 0.41$, $CI = [-1.76, 4.07]$ or the high visibility condition, $t(18) = 0.66$, $p = 0.52$, $CI = [-4.82, 2.51]$.

Figure 14. Number of responses for correct prime lie trials in Experiment 7 as a function of prime visibility and response choice. Note: Error bars are standard error.



For this experiment, the proportion of responses where individuals used the prime as their chosen response on correct lie trials was calculated for each participant. These are shown in Figure 15. Since participants had a choice of two possible lie responses, there was a 50% probability that individuals would use either response merely by chance. A one-sample t-test was conducted to examine whether the proportion of 'same as prime' responses significantly differed from this 50% threshold. No significant differences were demonstrated, $t(18) = 0.031$, $p = 0.98$, $CI = [-3.53, 3.63]$.

Figure 15. Percentage of responses the same as the prime on correct lie trials according to participant in Experiment 7. Note: Error bars are standard error.



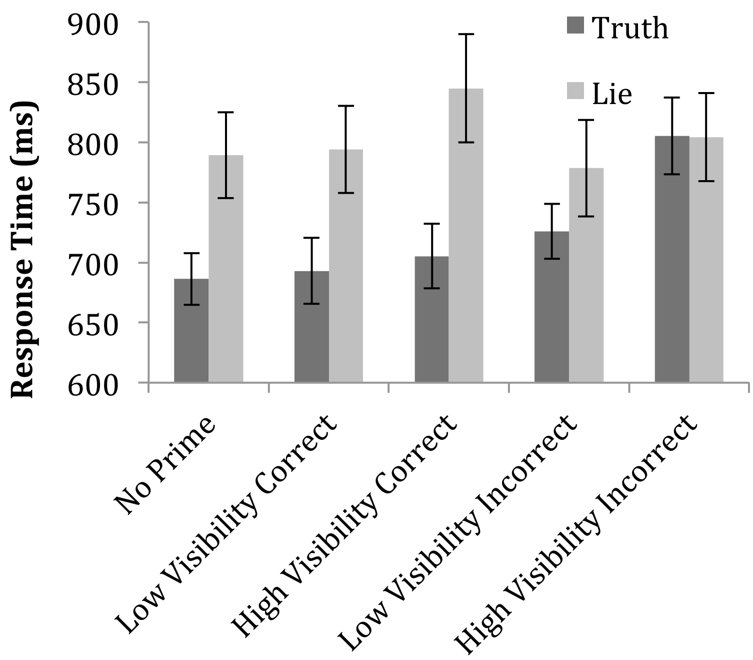
In summary, we found no evidence that the prime affected lie response choice. This finding conflicts with the predictions of the ADCM. In the next section we consider whether the prime had any effect on response time.

Response Times

To examine whether response times were faster when participants were provided with a correct prime compared to no-prime, a repeated-measures ANOVA was conducted with honesty of response (lie vs. truth) and correct prime type (no-prime vs. low visibility correct prime vs. high visibility correct prime) as within-subject factors. Response time was the dependent measure. This resulted in 6 conditions; (1) no-prime lie trials (NP-L; *M*: 789.34, *SD*: 156.33), (2) low visibility correct prime lie trials (LVC-L; *M*: 794.15, *SD*: 158.30), (3) high visibility correct prime lie trials (HVC-L; *M*: 844.92, *SD*: 197.25), (4) no-prime truth trials (NP-T; *M*: 686.20, *SD*: 93.34), (5) low visibility correct prime truth trials (LVC-T; *M*: 692.92, *SD*: 119.93), (6) high visibility correct prime truth trials (HVC-T; *M*: 705.30, *SD*: 116.76). Figure 16 shows the mean response time in all possible cells. As found in our previous work, a main effect of honesty of response was shown, with participants taking longer when lying compared to telling the truth, $F(1,18) = 33.99$, $p < .001$, $\eta^2 = 0.65$. A main effect of prime type was also demonstrated, $F(2,17) = 6.63$, $p < .01$, $\eta^2 = 0.44$, with the longest response times shown on high visibility prime trials. No interaction was demonstrated between the two factors, $F(2,17) = 2.34$, $p = .13$, $\eta^2 = 0.22$.

To examine whether response times were significantly longer when participants were provided with an incorrect prime compared to no-prime, a repeated-measures ANOVA was also conducted with honesty of response (lie vs. truth) and incorrect prime type (no-prime vs. low visibility correct prime vs. high visibility correct prime) as within-subject factors and response time as the dependant measure. This resulted in 6 conditions; (1) no-prime lie trials (NP-L; *M*: 789.34, *SD*: 156.33), (2) low visibility incorrect prime lie trials (LVI-L; *M*: 778.38, *SD*: 174.72), (3) high visibility incorrect prime lie trials (HVI-L; *M*: 804.25, *SD*: 159.44), (4) no-prime truth trials (NP-T; *M*: 686.20, *SD*: 93.34), (5) low visibility incorrect prime truth trials (LVI-T; *M*: 725.95, *SD*: 99.64), (6) high visibility incorrect prime truth trials (HVI-T; *M*: 805.42, *SD*: 139.76). Figure 16 shows the mean response time in all possible cells. Once again, a main effect of honesty of response was shown, with telling a lie taking longer than telling the truth, $F(1,18) = 7.72$, $p < .02$, $\eta^2 = 0.30$. A main effect of prime type was also demonstrated, $F(2,17) = 8.93$, $p < .005$, $\eta^2 = 0.51$, with longer response times for incorrect prime trials compared to no-prime trials. An interaction was also found between the two factors, $F(2,17) = 11.39$, $p < .002$, $\eta^2 = 0.57$, such that there were no significant response time differences between any of the prime conditions when participants told a lie, $F(2,17) = 1.38$, $p = 0.28$, $\eta^2 = 0.14$, $CI = [-50.75, 20.92]$, whereas response times were significantly slower in both the high visibility incorrect prime and the low visibility incorrect prime condition compared to the no-prime condition when participants told the truth, $F(2,17) = 15.95$, $p < .001$, $\eta^2 = 0.65$. In addition, lying was found to take longer than telling the truth in the no-prime condition, $F(1,18) = 31.95$, $p < .001$, $\eta^2 = 0.64$, but not in either the low visibility incorrect prime condition, $F(1,18) = 3.44$, $p = .08$, $\eta^2 = 0.16$, $CI = [-6.99, 111.87]$, or the high visibility incorrect prime condition, $F(1,18) = 0.004$, $p = .95$, $\eta^2 < 0.001$, $CI = [-40.11, 37.77]$.

Figure 16. Response times for Experiment 7 as a function of prime condition and honesty. Note: Error bars are standard error.



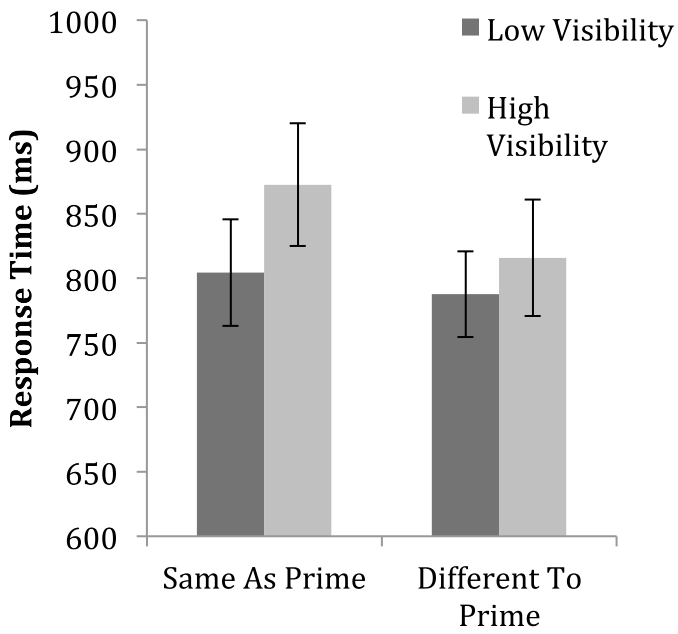
In summary, we found response time differences between prime and no-prime trials, suggesting that the prime is being processed, and is therefore active, in working memory. When participants were provided with a correct prime response, longer response times were found for high visibility prime trials compared to no-prime trials, suggesting that such primes are slowing the production of lie and truth responses. When participants were provided with an incorrect prime response, both the low visibility and high visibility incorrect primes were found to slow response times when participants responded truthfully. This suggests that incorrect primes interfere with the production of a truthful response.

Response time on correct prime lie trials

In order to examine whether using the correct prime as a lie response decreased the required cognitive processing, response times were further examined on correct prime lie trials according to whether participants used the prime as their chosen response or not. A repeated-measures ANOVA was conducted with response choice (same as the prime vs. different to the prime) and prime visibility (low vs. high) as the within-subject factors and response time as the dependent measure. This resulted in 4 conditions; (1) participants chose the same answer as the high visibility prime (HV-S; *M*: 872.51, *SD*: 207.12), (2) participants chose a different answer to the high visibility prime (HV-D; *M*: 816.04, *SD*: 196.93), (3) participants chose the same answer as the low visibility prime (LV-S; *M*: 804.35, *SD*: 180.12), (4) participants chose a different answer to the low visibility prime (LV-D; *M*: 787.69, *SD*: 145.32). Figure 17 shows the mean response time for all possible cells. A significant main effect of prime visibility was found, with longer response times for high visibility compared to low visibility prime trials, $F(1,18) = 10.46$, $p < .005$, $\eta^2 = 0.37$, and also response choice, with longer response times when participants chose a response the same as the prime compared to different to the prime, $F(1,18) = 11.69$, $p < .005$, $\eta^2 = 0.39$. The interaction between the two factors was not significant however, $F(1,18) = 1.95$, $p = .180$, $\eta^2 = 0.098$.

In summary, when participants use the same response as the correct prime when lying, it takes them longer to respond than if they use a different response. Participants also take longer to respond when the prime is shown for a longer period of time (100ms) compared to when it is shown for a shorter period of time (40ms), suggesting that increasing the length of prime exposure increases the degree to which the prime is active, and hence interferes, with working memory processing.

Figure 17. Response times for Experiment 7 as a function of response choice and prime visibility. Note: Error bars are standard error.



Discussion

If, as the ADCM predicts, it is the most active lie possibility that is used in response to a question, then it may be possible to externally influence the lie response that is used. Experiment 7 examined whether it was possible to manipulate the lie response that is chosen. The aim of this experiment was to examine whether the process of lie response choice is influenced by the relative activation level of particular lie possibilities. Our results, relating to both lie response choice and response time, failed to support the possibility that lie responses can be externally influenced or the cognitive processes associated with lie construction reduced.

When provided with potential lie response primes, participants did not use these primes as their lie response any more than would be expected by chance. Similarly, providing correct lie primes failed to make lying any easier, with response time differences actually suggesting the opposite. Indeed, when participants used the correct prime as their lie response, they actually took longer to respond than when they used a different response to the prime. These findings suggest that not only do participants appear to disregard the correct prime when choosing a lie response, but that using the prime increases the time required for lying and hence, actually interferes with the cognitive processes involved in telling a lie. One possible explanation for this finding may be that when participants were shown a correct prime, they associated this with the colour of the upcoming square which they were describing and thus categorised it as a response option that was not to be used when telling a lie. This would explain the longer response times on correct prime lie trials when the same response as the prime is used, since it may be necessary to over-ride any previously applied response inhibition processes in order to use this response.

In relation to general processing differences between lying and telling the truth, as has been shown in previous studies, telling a lie was found to take longer than telling the truth in all conditions except when incorrect primes were presented. The presentation of incorrect primes increased response times when individuals told the truth, likely due to the requirement to suppress an untruthful and incorrect response, which in turn reduced the response time difference between lying and truth telling. Since participants already had to suppress the truthful, and hence incorrect, response whenever they told a lie, no additional processing was required in the incorrect prime condition compared to the no-prime condition.

Experiment 8

Following on from Experiment 7, we conducted a second experiment with a greater choice of colours for participants to choose between. Since participants in our first two experiments only had a choice of two possible response options on lie trials, it may be that this reduced the effectiveness of the prime. By increasing the number of lie response possibilities that participants could choose between, the following could be examined. Namely, whether a wider response choice reduces or increases participants' use of the correct prime as their lie response.

If the correct prime is associated with truthful information, it may have only been used in the previous experiments to enhance variation in the responses that were given. When a greater number of responses are available to choose between, there are already multiple alternative options for participants to viably use, potentially reducing the likelihood that the prime will be considered as a plausible response option. Alternatively, since the choice between response options was a minimal one, participants may not have found the task cognitively challenging enough to focus on and utilise any visual aids that were provided, since they had sufficient time and resources to actively consider which lie response to use out of the two possibilities. By increasing the number of response options, the task of choosing between response possibilities may become more demanding, and as such, participants may rely to a greater extent on previously primed information (i.e., relative activation levels) when responding in time pressured environments. In order to examine these possibilities, the number of masked colour words was increased from three to five (red, blue, green, yellow or purple) and the potential colour of the square was also increased from three to five (red, blue, green, yellow or purple).

Method

Participants

Twenty-one undergraduate psychology students volunteered for this study in exchange for course credit. Of these, 19 were female. Participants had a mean age of 18.81 (*SD* = 0.60; *Range* = 18-20) and spoke English as their first language.

Design and Procedure

Apart from the addition of an increased number of colours for both the prime (RED, BLUE, GREEN, YELLOW or PURPLE) and the square (red, blue, green, yellow or purple), all aspects of the procedure remained identical to Experiment 7.

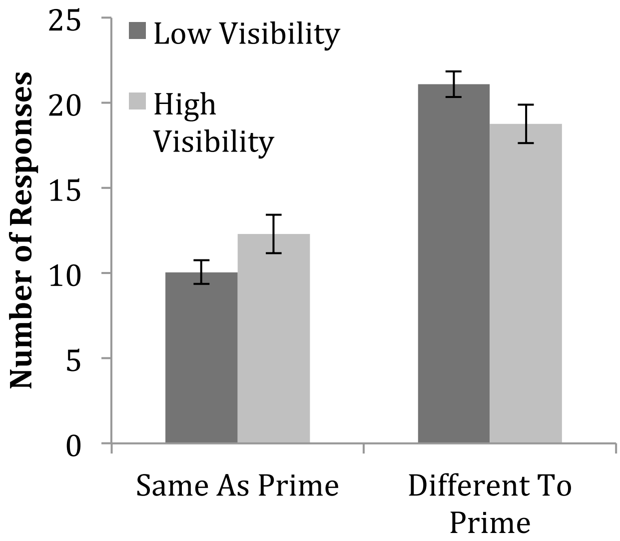
Results

Response time outliers were removed from the analysis. There were 428 in total. Inaccurate responses (179) were also removed from the analysis. On lie trials, there were 20 inaccurate responses in the correct prime condition, 36 in the incorrect prime condition and 37 in the no-prime condition. On truth trials, there were 27 in the correct prime condition, 24 in the incorrect prime condition and 35 in the no-prime condition. In total, 607 out of 7,560 data points were removed from the analysis, amounting to 8% of all trials.

Response Choice

Trials where individuals were instructed to lie and were provided with a correct prime were analysed separately to examine whether participants used the prime as their lie response. A repeated-measures ANOVA was conducted with response choice (same as the prime vs. different to the prime) and prime visibility (high vs. low) as the within-subject factors and the number of responses as the dependent measure. This resulted in 4 conditions; (1) participants chose the same answer as the high visibility prime (HV-S; *M*: 12.29, *SD*: 5.16), (2) participants chose a different answer to the high visibility prime (HV-D; *M*: 18.76, *SD*: 5.17), (3) participants chose the same answer as the low visibility prime (LV-S; *M*: 10.05, *SD*: 3.23), (4) participants chose a different answer to the low visibility prime (LV-D; *M*: 21.09, *SD*: 3.42). These 4 conditions are highlighted in Figure 18.

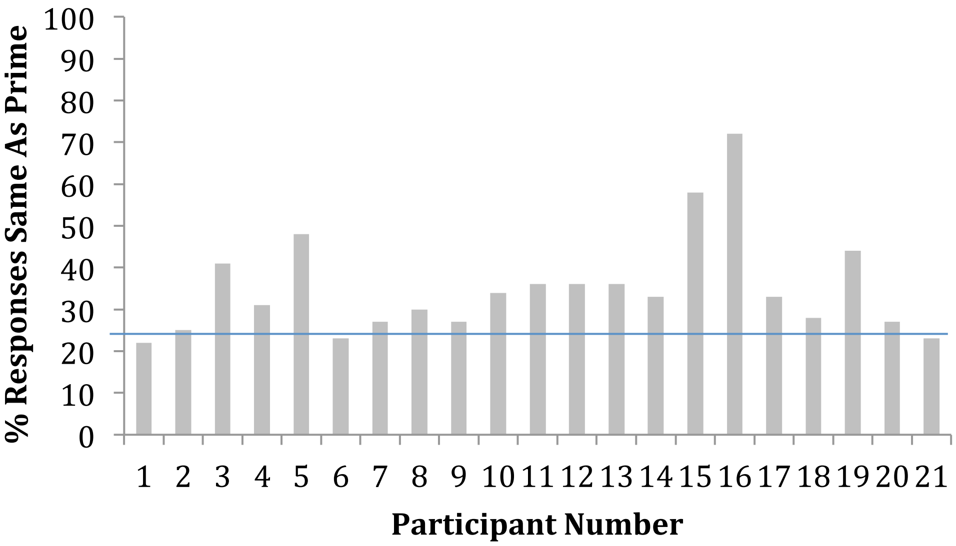
Figure 18. Number of responses for correct prime lie trials in Experiment 8 as a function of prime visibility and response choice. Note: Error bars are standard error.



Results demonstrated a main effect of response choice, with participants using a response different to the prime more often than the same as the prime, $F(1,20) = 25.49$, $p < .001$, $\eta^2 = 0.56$. No significant effect of prime visibility was shown, $F(1,20) = 0.96$, $p = .76$, $\eta^2 = 0.005$, $CI = [-0.273, 0.369]$, but the interaction between the two factors was significant, $F(1,20) = 10.14$, $p < .005$, $\eta^2 = 0.34$. Simple effects tests demonstrated that participants used the same response as the prime to a greater degree on high visibility prime trials compared to low visibility prime trials, $F(1,20) = 8.63$, $p < .01$, $\eta^2 = 0.80$, whereas participants used a different response to the prime more often on low visibility prime trials compared to high visibility prime trials, $F(1,20) = 10.96$, $p < .005$, $\eta^2 = 0.88$. These tests further showed that participants used a response different to the prime more often than the same as the prime on both high visibility, $F(1,20) = 8.36$, $p < .01$, $\eta^2 = 0.29$, and low visibility trials, $F(1,20) = 59.96$, $p < .001$, $\eta^2 = 0.75$. Paired sample t-tests were also conducted to examine whether participants used the prime as their answer more than they used an answer different to the prime. This showed that participants used an answer different to the prime more than the same as the prime in both the low visibility, $t(20) = 7.74$, $p < .001$ and high visibility condition, $t(20) = 2.89$, $p < .01$.

The proportion of responses where individuals used an answer the same as the prime was also calculated according to each participant (Figure 19). Since participants had a choice of four possible lie responses, there was a 25% chance that individuals would use a response the same as the prime by chance alone. A one-sample t-test was conducted to examine whether the proportion of 'same' responses significantly differed from this 25% threshold. It was demonstrated that, overall, individuals used a response the same as the prime significantly more than would be expected by chance, $t(20) = 3.70$, $p < .001$.

Figure 19. Percentage of responses the same as the prime on correct lie trials according to participant in Experiment 8. Note: Error bars are standard error.



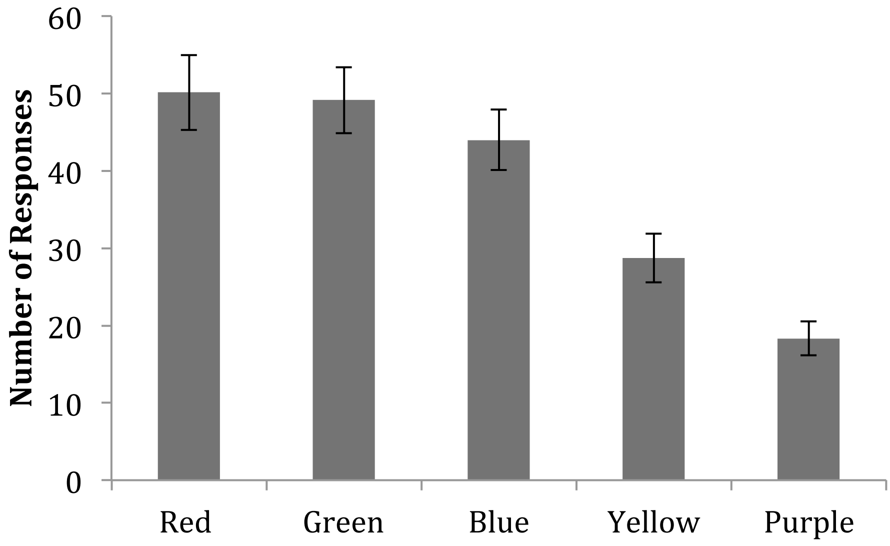
In summary, we found that participants in this experiment used the prime as their lie response more than would be expected by chance alone. The length of time that participants were exposed to the prime was also found to have an effect, with participants more likely to use the prime when it was shown for a longer period of time (100ms).

Previous responses and lie response choice

In addition to the presented primes, the answer that was used in response to a previous trial may also effect the relative activation of particular response possibilities, and hence influence subsequent lie response choice. In order to examine the potential influence of this factor, paired sample t-tests were conducted that compared the actual lie response used with both the colour of the square in the previous trial and the vocal response used in the previous trial. This demonstrated that participants used more lie responses that were different to the colour of the previous square, (M = 157.05, SD = 19.05), than were the same as the colour of the previous square, (M = 33.19, SD = 18.05), *t*(20) = 15.38, $p < 0.005$, and also that participants used more lie responses that were different to the response used in the previous trial, (*M* = 135.43, *SD* = 42.15), than were the same as the response used in the previous trial, (*M* = 54.81, *SD* = 41.84), *t*(20) = 4.40, $p < .005$. This shows that colours encountered and used in the previous trial are no more likely to be used as the lie response.

To further examine how people may choose their lie response, the particular colours that participants used when telling a lie were examined in more detail. Since all five colours were presented as stimuli an equal number of times throughout the task, all colours should be equally active in memory systems. Despite this, participants demonstrated differences in the extent that particular colours were used as a lie response. The mean number of times that each colour was used as a lie response was calculated for the task and demonstrated that red (*M* = 50.14, *SD* = 22.22), blue (*M* = 44.0, *SD* = 17.84) and green (*M* = 49.14, *SD* = 19.59) were most commonly used as a lie response, with yellow (*M* = 28.71, *SD* = 14.51) and purple (*M* = 18.33, *SD* = 10.07) used significantly less, *t*(20) = 2.96, $p < .01$. The mean number of times that each colour was used as the lie response is demonstrated in Figure 20.

Figure 20. Mean number of lie responses as a function of colour used in response for Experiment 8. Note: Error bars are standard error.



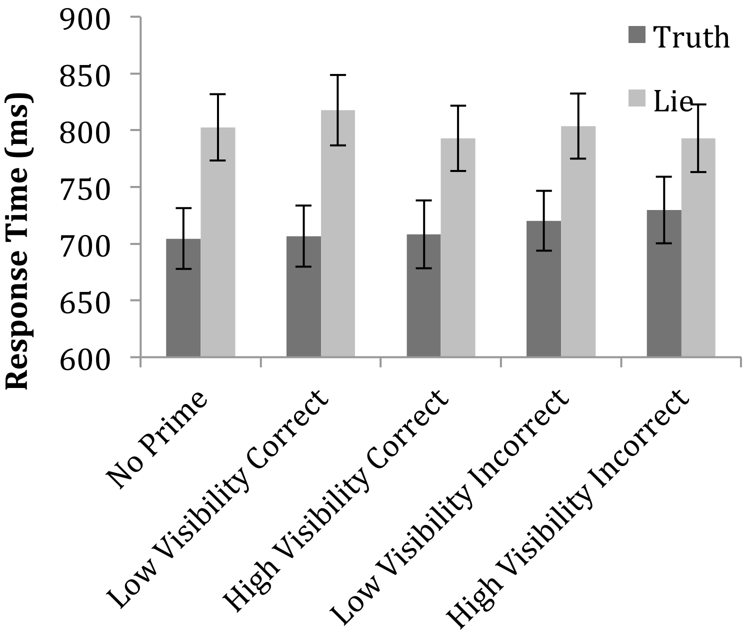
Response Times

To examine whether response times were faster when participants were provided with a correct prime compared to no-prime, a repeated-measures ANOVA was conducted with honesty of response (lie vs. truth) and correct prime type (no-prime vs. low visibility correct prime vs. high visibility correct prime) as within-subject factors. Response time was the dependent measure. This resulted in 6 conditions; (1) no-prime lie trials (NP-L; *M*: 802.64, *SD*: 134.07), (2) low visibility correct prime lie trials (LVC-L; *M*: 817.64, *SD*: 142.66), (3) high visibility correct prime lie trials (HVC-L; *M*: 792.99, *SD*: 132.53), (4) no-prime truth trials (NP-T; *M*: 704.53, *SD*: 122.63), (5) low visibility correct prime truth trials (LVC-T; *M*: 706.87, *SD*: 124.11), (6) high visibility correct prime truth trials (HVC-T; *M*: 708.36, *SD*: 137.88). A main effect of honesty of response was found, with telling a lie taking longer than telling the truth, $F(1,20) = 36.67$, $p < .001$, $\eta^2 = 0.65$. There was no significant effect of correct prime type however, $F(2,19) = 0.97$, $p = .39$, $\eta^2 = 0.09$, *CI* =

[-28.78, 5.62], or any interaction between the two factors, $F(2,19) = 1.12$, $p = .35$, $\eta^2 = 0.10$. Figure 21 shows the mean response times in all possible cells.

To examine whether response times were significantly longer when participants were provided with an incorrect prime compared to no-prime, a repeated-measures ANOVA was also conducted with honesty of response (lie vs. truth) and incorrect prime type (no-prime vs. low visibility incorrect prime vs. high visibility incorrect prime) as within-subject factors. This resulted in 6 conditions; (1) no-prime lie trials (NP-L; *M*: 802.64, *SD*: 134.07), (2) low visibility incorrect prime lie trials (LVI-L; *M*: 803.64, *SD*: 131.21), (3) high visibility incorrect prime lie trials (HVI-L; *M*: 792.99, *SD*: 136.55), (4) no-prime truth trials (NP-T; *M*: 704.53, *SD*: 122.64), (5) low visibility incorrect prime truth trials (LVI-T; *M*: 720.38, *SD*: 121.40), (6) high visibility incorrect prime truth trials (HVI-T; *M*: 729.66, *SD*: 135.05). Figure 21 shows the mean response time in all possible cells. Once again, a main effect of honesty of response was shown, with telling a lie taking longer than telling truth, $F(1,20) = 22.22$, $p < .001$, $\eta^2 = 0.53$. There was no significant effect of incorrect prime type, $F(2,19) = 0.94$, $p = .41$, $\eta^2 = 0.09$, $CI = [-20.49, 19.12]$, but a significant interaction was found between the two factors, $F(2,19) = 3.56$, $p < .05$, $\eta^2 = 0.27$. Simple effects tests demonstrated that lying took longer than telling the truth in the no-prime condition, $F(1,20) = 26.55$, $p < .001$, $\eta^2 = 0.57$, the low visibility incorrect prime condition, $F(1,20) = 17.87$, $p < .001$, $\eta^2 = 0.47$, and the high visibility incorrect prime condition, $F(1,20) = 10.27$, $p < .005$, $\eta^2 = 0.34$. These tests also demonstrated that response times were longer on high visibility incorrect prime trials compared to no-prime trials, but only when participants told the truth, $F(2,19) = 3.68$, $p < .05$, $\eta^2 = 0.28$.

Figure 21. Response times for Experiment 8 as a function of prime condition and honesty. Note: Error bars are standard error.



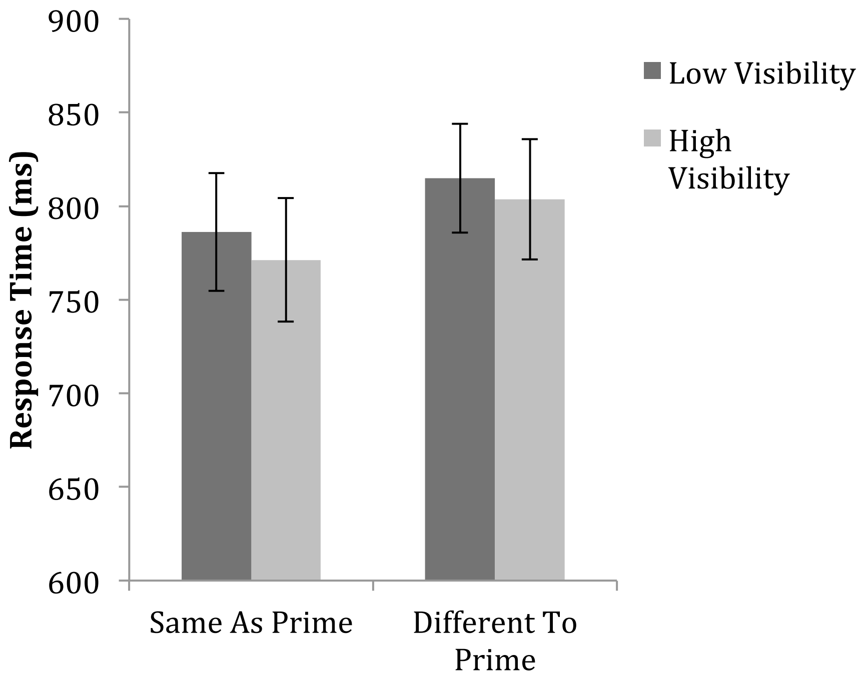
In summary, we found that response time differences between prime conditions in this experiment were not as large as in Experiment 7. The only significant finding was of longer response times when participants responded truthfully on high visibility incorrect prime trials compared to no-prime trials. This lends further support to the suggestion that the presentation of incorrect information interferes with the production of a truthful response.

Response times on correct prime lie trials

Response times were further examined according to whether individuals used the same response as the prime compared to a different response to the prime on correct prime lie trials. A repeated-measures ANOVA was conducted with response choice (same as prime vs. different to prime) and prime visibility (low vs. high) as the within-subject factors and response time as the dependent measure. This resulted in 4 conditions; (1)

participants chose the same answer as the high visibility prime (HV-S; *M*: 771.33, *SD*: 151.30, (2) participants chose a different answer to the high visibility prime (HV-D; *M*: 803.59, *SD*: 146.88), (3) participants chose the same answer as the low visibility prime (LV-S; *M*: 786.08, *SD*: 144.22), (4) participants chose a different answer to the low visibility prime (LV-D; *M*: 814.89, *SD*: 133.34). Figure 22 shows the mean response time for all possible cells. There was no significant effect of prime visibility, $F(1,20) = 1.10$, $p = .31$, $\eta^2 = 0.05$, $CI = [-12.87, 38.92]$, but contrary to the findings of Experiment 7, a significant effect of response choice was shown in the opposite direction, with longer response times when participants chose a response different to the prime compared to the same as the prime, $F(1,20) = 4.17$, $p = .05$, $\eta^2 = 0.17$. There was no significant interaction between the two factors however, $F(1,20) = 0.009$, $p = .93$, $\eta^2 < 0.001$.

Figure 22. Response times for Experiment 8 as a function of response choice and prime visibility. Note: Error bars are standard error.



In summary, our findings contrast with those of Experiment 7 that using the prime as your lie response takes longer than using a response different to the prime. Instead, we found the opposite, namely that using a response different to the prime leads to longer response times, suggesting that the prime aids in the production of a lie response.

Discussion

Experiment 8 was conducted to examine whether a greater number of response options increased the likelihood that participants would use the correct prime as their lie response. It was considered that, if the failure to use the prime when telling a lie in Experiment 7 was due to the task not being sufficiently demanding, increasing the number of response options may increase the difficulty of the task. This would lead to participants paying greater attention to, and having a greater reliance on, previously primed information. On first examination, the results of this experiment do not support this possibility, since increasing the number of response options from two to four did not lead to participants using the same response as the prime more than a response different to the prime when telling a lie.

Contrary to the findings of Experiment 7 however, it was also shown that participants used the same response as the prime significantly more than would be expected by chance, suggesting that the correct prime is influencing the lie response chosen to a certain degree. The hypothesis that providing a correct prime reduces the increased cognitive difficulty associated with telling lies was also supported in this experiment, since response times were shown to be faster when participants chose a response the same as the prime compared to different to the prime. Despite this however, response times remained longer in all conditions when participants told a lie compared to when they told the truth.

The length of time that the prime was presented for was also shown to have an effect on whether participants used the prime as their response. When correct primes were shown for a longer period of time, i.e., on high visibility prime trials, participants used the prime as their response more often than they did on low visibility prime trials. When correct primes were shown for a shorter period of time however, i.e., on low visibility prime trials, participants used a response different to the prime more often than on high visibility prime trials, suggesting that when the prime is noticeably visible to participants they are more likely to use it in their response. This may be due to participants paying greater attention to the prime on high visibility trials (due to an increased level of exposure) and therefore receiving a greater degree of activation relative to other response possibilities, thus increasing the likelihood that it will be used as the lie response.

If high visibility primes increase the activation level of primed lie responses relative to low visibility primes, this suggests that consideration of the lie response involves active, rather than passive, processing choices, especially when combined with findings of faster response times when participants use the prime as their lie response. Indeed, if the activation and choice of response possibilities was a passive process, with participants just producing the most active lie response at that time, then externally increasing the relative activation of one response may not affect response times, since the most active lie in that moment would be used regardless of the presence of an external prompt. If response choice is a more active process, however, then possible lie responses may ordinarily be carefully considered and evaluated, regardless of relative activation levels. The need to provide a response as quickly as possible, which was required in our task, may negate this choice between potential lie responses when a prime has already been provided, leading to a reduction in response times.

General Discussion

Our experiments examined whether cognitive processing differences between lies and truths are reduced when individuals are provided with a plausible response possibility. Both of these points were examined in relation to the claims of the ADCM, which considers that it is the most active lies in memory systems that are used as the response when individuals tell a lie. A priming methodology was used that allowed for the external activation of possible lie responses when participants lied and told the truth regarding the colour of a square.

Our first hypothesis concerned lie response choice, and considered that if the lie response used is the most active response following the truth, then participants would use the prime as their lie response when primed with a correct lie possibility more than would be expected by chance. This hypothesis was partially supported. Although in Experiment 7, participants did not use the correct prime as their lie response more than chance, when the number of overall response possibilities was increased in Experiment 8, participants did use the prime as their response at greater than chance levels. In relation to our second hypothesis, response times were examined when individuals lied using the same response as the prime compared to using a different response to the prime. This allowed us to examine whether using the prime as a lie response reduced the cognitive processes required to tell a lie relative to telling the truth. Since choosing a lie response out of multiple possibilities has been shown to contribute to the longer response times required to tell a lie (see Chapter 2), we hypothesised that priming a particular lie response may negate, or at least reduce, the cognitive processing required when lying. From this, we would expect faster response times when participants use the prime as their lie response compared to when they use a different response. Once again, this hypothesis was partially supported, although converse findings were demonstrated across our experiments. In

Experiment 7, contrary to our hypothesis, response times were shown to be longer when participants used the prime as their lie response, whereas in Experiment 8, response times were shown to be faster when participants used the prime as their lie response compared to when they used a different response.

Lie response choice and task difficulty

The results of our experiments demonstrate that externally activating a particular lie response does not necessarily lead to this lie being used as the question answer. This finding conflicts with the claim of the ADCM that it is the most active, plausible lie that is used as a response. If this were the case, we would expect participants to consistently use the same lie response as the prime significantly more than using a different response, since this colour should be the most active following the truth. Our finding that participants use the prime as their response more than chance in Experiment 8, but not in Experiment 7, suggests that prime utilisation is related to the number of response options that are available to use when lying.

One possibility that explains our response choice results is that an increased number of response options increases the difficulty of the task, since there are more response options that can be considered. When participants are primed with correct lie responses in the first experiment, there is only one other alternative lie response available in addition to the prime, whereas in Experiment 8, there are multiple alternative possibilities. If participants initially link the prime with truthful information (since it is shown prior to the actual colour of the square) and suppress it accordingly, the only remaining response possibility in Experiment 7 is likely to be actively considered. If participants choose to use this alternative colour as their response, they must simply produce their answer. If, however, the participant considers that the prime word can also be used as a lie response and subsequently decides to use it as their answer, the initial suppression that was instigated when this response was linked to truthful information has to be over-ridden. This additional process would explain the longer response times in Experiment 7 when participants use the prime as their lie. Additionally, the response time cost incurred also explains why participants do not use the prime as their response more than chance, since it is less efficient to do so. In Experiment 8, however, the increased number of response options may result in a more active and careful consideration of lie possibilities when choosing how to respond, thus increasing the cognitive demand associated with lying in this task. In order to reduce this demand, it may be more efficient for participants to over-ride any association that the prime has with truthful information, than to choose between the multiple lie possibilities that are permitted, resulting in participants utilising the primed lie response. This would explain why participants show faster response times when they use the same response as the prime compared to a different response in Experiment 8, since using the prime is less cognitively challenging than choosing an alternative lie option. This relative ease would also explain why participants use the prime as their response significantly more than chance, since it is more cognitively efficient to do so when completing a challenging task. If this explanation is indeed correct, then it provides further support for our previous finding that the choice between lie response possibilities independently contributes to the greater time required to lie, even when very simple lie responses are used (see Chapter 2).

Lie response choice and the truth

The possibility that the correct prime is initially considered as truthful information, and hence avoided as such, enables a consideration of what may represent truthful information in such cognitive tasks. Since the prime and the square were presented one following the other, both stimuli may have been processed and stored together as part of a 'truthful response set'. As a result, the prime may not have been considered when individuals generated an alternative answer. This process could be considered as 'truth by association.' In order to be more efficient in their response, participants may have suppressed the most active colours in working memory and chosen the least active alternative, since this may have been less likely to be considered as truthful information. Consequently, participants in this task may be defining the truth as one of the most active responses. This seems a plausible explanation considering that some of our primes related to correct possible responses whereas others related to incorrect responses (i.e., the truth on lie trials and potential lies on truth trials). From this, participants may not expect all primes to provide a correct lie response on lie trials. Conversely, it should also be considered that incoming information provided by external sources may be stored as truthful by default, since we more often encounter truthful information than false information in daily life. This could result in any externally cued information being neglected when participants generate the simple lies required in our experiments.

If an individual's lie response is not affected by external cues from the environment, how exactly do people generate a lie response? One possibility is that the level of activation of a particular lie response is determined by factors internal to individual participants. In this way, an individual may utilise a specific schema to create their lie. This schema may have been activated when the truthful response was retrieved. Indeed, the ADCM claims that when the truth is activated in long-term memory, additional information linked to this memory also becomes active. When considering lie-telling in more applied paradigms, researchers such as Vrij (2008) suggest that lies are often embedded in truthful information, with individuals manipulating details of true experiences when deceiving others. If deceptive answers are indeed developed from already known information, this suggests that lie responses are likely to differ more according to individual differences in the internal activation of information compared to information presented in the wider environment.

Conclusion

In conclusion, this chapter aimed to further explore the processes involved in lie response choice. The ADCM claims that possible lie responses are activated in long-term memory and implausible answers then inhibited. It is the most active lie following this process that is used in response to the question. By priming participants with both correct and incorrect potential responses, we were able to manipulate the relative activation of possible lie responses. Although the ADCM does not consider the role of externally cued response possibilities, the results of our experiments show that externally prompting, and hence activating, lie responses does not necessarily result in these responses being used. This finding is not inconsistent with the construction component of the ADCM, since it is possible that lie responses are only generated and processed internally via long-term memory systems, but it suggests that further work must be undertaken to specify precisely which information is considered when generating lie responses, and how such evaluations are made.

CHAPTER 5

Individual Differences and Deception Detection

Deception and lie-telling is a common occurrence in everyday life (DePaulo et al, 1996; Serota et al, 2010), ranging from the minor ‘white lies’ we tell the people around us, to lies concerning major transgressions, such as denial of involvement in a crime. Given the apparent widespread incidence of deception in society, it is surprising that the majority of us are unable to accurately differentiate between truthful statements and lies, with a recent meta-analysis calculating an overall accuracy rate of around 55% (Bond & DePaulo, 2008). To explore possible reasons for this low judgement accuracy, research has focused on three main areas of deception detection. Firstly, whether manipulating situational aspects of a judgement session can increase accuracy rates, for example, varying the modality of message presentation (Kassin, Meissner & Norwick, 2005). Secondly, whether certain populations or groups are more accurate than others, for example, looking at group differences according to occupation (Kassin et al, 2005; Vrij & Graham, 1997), age (Stanley & Blanchard-Fields, 2008) and gender (Porter et al, 2007). Finally, a limited number of researchers have examined potential individual differences in the ability to detect deceit (O’Sullivan, 2005; Porter, Campbell, Stapleton & Birt, 2002; Vrij, Harden, Terry, Edward & Bull, 2001), specifically in relation to certain personality characteristics, such as social anxiety (DePaulo & Tang, 1994) and self-awareness (Johnson, Barnacz, Constantino, Triano, Shackelford & Keenan, 2004). Although all three areas remain a worthy topic of study, the possible existence of individual differences in detection ability is currently of particular debate (Bond & DePaulo, 2008; Bond & Uysal, 2007; O’Sullivan, 2005). The aim of this chapter, therefore, is to focus on the latter research area and examine individual differences in lie detection ability and truth bias in relation to a number of personality traits.

Individual differences and deception detection

The current interest regarding the existence of individual differences in deception detection ability has been triggered by findings of large variations in judgement accuracy across individuals, with accuracy levels as low as 20% (against a chance level of 50%) and as high as 90% shown in some studies (O'Sullivan & Ekman, 2004; Vrij & Graham, 1997; Vrij, Mann, Robbins & Robinson, 2006). Alternative explanations for these variations, however, have been put forward by a number of researchers (Bond & DePaulo, 2008; Bond & Uysal, 2007; Levine et al, 2005; Levine, 2010). These include suggestions that judgement accuracy varies according to chance patterns. Further, it is suggested that accuracy is influenced by additional factors other than the characteristics of the judge. For example, it has been claimed that accuracy ratings are related more to the skill and demeanour of particular liars than to differences in people's ability as judges (Bond & DePaulo, 2008): Aspects such as demeanour and social skill may lead to particular individuals being consistently judged as dishonest even when they are telling the truth (Bond & DePaulo, 2008; Kraut, 1980; Zebrowitz, Voinescu & Collins, 1996). This could result in accuracy ratings being more affected by the extent of stereotype use than by stable differences in ability (Bodenhausen, 1990).

The number of messages that people judge has also been suggested to affect the pattern of accuracy ratings (Bond & DePaulo, 2008; Bond & Uysal, 2007), with smaller accuracy differences shown amongst judges who make a large number of truth/lie judgements compared to those who make a small number of judgements. Finally, the tendency of lay people to judge statements as truthful, a phenomenon known as truth bias

(Pronin, Lin & Ross, 2002; Zuckerman, DeFrank, Hall, Larrance & Rosenthal, 1979), has been suggested to affect accuracy ratings. In particular, Levine et al (2006) showed that judgement accuracy has a positive linear relationship with the number of truthful messages judged, so it may be that people differ more in their tendency to judge statements as truthful, than in their ability to detect lies.

Truth bias and deception detection

The existence of a truth bias in the general population is well documented. Bond and DePaulo (2006) observed that judges rated 56% of messages as truthful and 44% as deceptive, when an equal number of both were presented. However, such biases have been shown to be context dependent, with participants actually showing a lie bias when judging contexts where deception is more often encountered. For instance, when judging the statements of salespersons (DePaulo & DePaulo, 1989) or when an element of suspicion is introduced (DePaulo et al, 2003).

Possible explanations for the presence of an overall truth bias have been related to the existence of learned rule systems, termed heuristics, which allow us to make efficient decisions when dealing with complex environments. An example of one of these rule systems is the availability heuristic (O'Sullivan et al, 1988), which suggests that individuals are more often presented with truthful information than false information in daily life, and as such, are more likely to judge messages as truths than lies. A second possibility has been based on the anchoring heuristic (Tversky & Kahneman, 1974), which suggests that people make insufficient adjustments from an initial value, resulting in a bias towards that value when making decisions. If truthful information is considered the norm, or default, social behaviour then extra effort will be required to make sufficient judgements away from this default setting and correctly identify deceptive messages

(Elaad, 2003; Gilbert, 1991). A third explanation of the truth bias relates directly to social conventions and rules. Toris and DePaulo (1984) suggest that social convention prevents us from regularly challenging the truthfulness of information we are given. Indeed, such a conversation would not only be extremely time consuming, but also considered impolite by others, therefore jeopardising the formation and continuation of positive social relationships (DePaulo et al, 1982). Although the above suggestions may contribute to the presence of a truth bias, the precise processes affecting this social judgement remain unclear. Since the presence of such biases impacts on lie detection ability, however, examination of individual differences related to this allows for further investigation of the mechanisms involved in both social judgement bias and lie-detection ability. This represents an area of research that has been neglected in the past and provides a second focus of examination for this chapter.

Personality and lie detection

If individual differences in lie detection do exist we would expect the following two conditions to be supported. First, that consistency in judgement accuracy is shown over repeated tests and, second, that particular characteristics relate to either increased or decreased ability levels. In relation to the former, the possibility that judgement accuracy is consistent over time has been supported by a small number of researchers, with certain individuals consistently demonstrating high accuracy ratings. For example, Bond (2008) examined the detection accuracy of 112 people from the law enforcement sector and identified 2 individuals who demonstrated accuracy rates over 80% in two separate tests. Indirect support of this possibility also comes from findings of a positive relationship between an individuals' ability to detect the lies of adults and to detect those of children (Edelstein, Luten, Ekman & Goodman, 2006), and also a relationship between the cues that individuals believe are indicative of deception and judgement accuracy (Forrest, Feldman & Tyler, 2004). Unfortunately, however, reliability in lie-detection performance has failed to be consistently supported by some researchers (e.g., Leach, Lindsay, Koehler, Beaudry, Bala, Lee & Talwar, 2009). The existence of a response bias, on the other hand, has been consistently shown over repeated studies (Köhnken, 1989). Unless situational conditions are set to increase the suspicion of judges (DePaulo et al, 2003), the general population consistently demonstrates a truth bias. Specific populations who are more likely to encounter deception in their daily lives, such as police officers (Garrido, Masip & Herrero, 2004) and prisoners (Hartwig, Granhag, Strömwall & Andersson, 2004), have been shown to demonstrate the opposite, with a greater tendency to judge information as deceptive rather than truthful. Whether individual participants consistently demonstrate the same degree of response bias over multiple tests, however, has, to our knowledge, yet to be examined.

Some research has also addressed the second condition through the examination of the relationship between accuracy and different personality characteristics. In particular, they have focused on traits related to social anxiety and shyness (DePaulo & Tang, 1994; Vrij & Baxter, 1999), self-awareness (Johnson et al, 2004; Malcolm & Keenan, 2003) and extraversion or introversion (Peace, Porter & Almon, 2012; Porter et al, 2002; Vrij et al, 2001). Despite this work, however, consensus remains to be found on whether particular characteristics are associated with lie detection accuracy. For example, whereas DePaulo and Tang (1994) found that individuals low in social anxiety were better at discriminating truths from lies, this finding was not supported in further studies (Vrij & Baxter, 1999; Vrij et al, 2001). Similarly for truth bias, whereas individuals with a more positive view of others, such as extraverts, have been suggested to rate others as more credible (Cole, Leets & Bradac, 2002; Cramer, Brodsky & DeCoster, 2009), a recent study found that extraversion negatively correlated with accuracy when detecting truthful sexual assault claims, suggesting that a truth bias may not be present in all scenarios (Peace et al, 2011).

Despite such inconsistencies, there are several reasons why we would expect some individuals to be intrinsically better lie detectors than others. The awareness of one's own mind that characterises traits such as self-awareness and introversion, for instance, may increase awareness for the internal states of others. In general support of this, O'Sullivan (2005) commented that the majority of people she interviewed who had previously been identified as exceptional lie detectors seemed to have introverted personalities. Such suggestions are unsurprising, since it is intuitive that lie detection involves the ability to accurately identify other peoples' mental states. This is supported by findings of better lie-detection ability in individuals who can adequately identify emotional expressions (Stanley & Blanchard-Fields, 2008; Warren, Schertler & Bull, 2009). If such awareness of mental and emotional states is a key factor involved in lie detection, however, then detection ability could be directly linked to specific measurable traits, such as emotional intelligence (Riggio, Tucker & Throckmorton, 1987).

In contrast to suggestions that a greater degree of internal focus and awareness improves lie detection ability, Vrij et al (2001) failed to show a relationship between lie detection ability and introversion (as measured by subscales of the Fenigstein, Scheier & Buss, 1975, Self-Consciousness Scale). In their study, 61 participants judged 30 short video clips of different individuals, 10 of these were truthful answers to questions regarding a staged theft and 20 were lie responses to the same questions. Half of the lies presented were low stake and half were high stake, where motivation to try hard to deceive was instructionally manipulated. Using a similar paradigm, Vrij and Baxter

(1999) also failed to find a link between deception detection and introversion (as measured by the Briggs, Cheek & Buss, 1990, scale).

Although arguments have been made above for possible reasons why introverts could make better lie detectors, we now consider possible reasons that would suggest the opposite. Firstly, since extraverts have demonstrated enhanced skill at decoding nonverbal behaviour in complex tasks (Ackert & Panter, 1988; Lieberman & Rosenthal, 2001), this may result in an enhanced ability to detect subtle behavioural cues to deception in social situations. Secondly, in comparison to introverts, extraverts actively seek out social stimulation and interaction, spending more time in social situations (Depue & Collins, 1999; Gray, 1970; 1981; Nettle, 2007) and experiencing higher levels of positive affect in such situations than introverts (Costa & McCrae, 1980; Lucas & Baird, 2004; Watson & Clark, 1992). This increased sociability of extraverts could provide a mechanism for enhanced lie detection ability, since greater exposure to other people may enhance learning opportunities to associate particular behaviours with particular intentions. This could explain the findings of DePaulo and Tang (1994) that individuals low in social anxiety are better at discriminating truths from lies than those high in social anxiety. Finally, innate cognitive mechanisms could also increase the lie detection ability of individuals high in extraversion. For example, extraversion has been associated with increased central executive efficiency (Lieberman & Rosenthal, 2001), as well as improved task-focused self-control and discrepancy detection when completing an oddball task (Eisenberger, Lieberman & Satpute, 2005). Taken together, the above findings suggest that extraverts may indeed show an increased ability in discriminating lies and truths.

Cross-cultural lie detection

In order to further understand the mechanisms involved in credibility judgements, through both the extent of truth bias and differences in accuracy levels, variation in judging the honesty of individuals from different cultures can be examined. Whereas some nonverbal behaviour has been found to be universal across different cultures, such as facial expressions of basic emotions (Ekman, 1972, 1973; Ekman & Friesen, 1971), others are more culturally specific. For instance, cross-cultural differences have been found in the meaning and use of emblematic gestures (Ekman, 1976; Friesen, Ekman & Wallbott, 1979; Morris, Collett, Marsh & O'Shaughnessy, 1980), as well as in patterns of eye contact and interpersonal distance (Exline, Jones & Maciorowski, 1977; Hall, 1963; Vrij, Dragt & Koppellar, 1992; Watson, 1970) in Western, Asian and Arab cultures. Differences even occur in the manipulation of universal emotional expressions in social situations, with Japanese participants more likely to mask negative emotions than American participants in the presence of a second individual (Friesen, 1972). Such a different pattern of behaviour across cultures is not surprising when the definition of culture is considered. Matsumoto (2006) defines culture as a "shared system of socially transmitted behaviour that describes, defines, and guides people's ways of life, communicated from one generation to the next." (p.220). As such, an individual from one culture will have learnt to associate particular behaviours with particular social situations and intentions, and will use these associations to guide their own social interactions, decisions and communication. This is seen in suggestions of more accurate emotion recognition for individuals from the same cultural group compared to a different cultural group (Elfenbein & Ambady, 2002).

Since we increasingly interact in a global society, this has resulted in a growth in the number of situations where an individual from one culture has to judge the honesty of an individual from a different culture. One particular example of this can be seen in the judgements of immigration control officers at border crossings, who have to determine whether individuals from a variety of countries are legitimate immigrants to the UK (Home Office, 2011). As such it should be considered that differences in nonverbal behaviour due to different cultural backgrounds may be confused with behaviour indicative of deception, which in turn may affect credibility judgements. This is particularly likely when a judge is not familiar with the behavioural norms of a specific culture. For instance, behaving in an anxious and avoidant manner has been linked with deception (DePaulo et al, 2003) and yet, individuals from Asian cultures have been characterised as anxious, passive and non-assertive in social situations (Okazaki, Liu, Longworth & Min, 2002). Similarly, Vrij and Winkel (1992; 1994) demonstrated that behaviour typical of Surinamese individuals was judged as more suspicious by Dutch Caucasian police officers than the typical behaviour of Dutch Caucasian individuals. In their studies, Surinamese behaviour was associated with increased gaze aversion, speech disturbances, smiling and use of illustrators, which may have contributed to the suspicion of the judging police officers (Vrij & Winkel, 1991). Thus it seems that such differences in cultural behavioural norms are likely to impact on both the degree of truth bias and lie detection accuracy.

Although past research on cultural issues related to deception has focused primarily on differences in motivations to deceive and the acceptance of deception (Aune & Waters, 1994; Lewis & George, 2008; Mealy, Stephan & Urrutia, 2007; Park & Ahn, 2007; Seiter, Bruschke & Bai, 2002), a limited number of studies have examined differences in lie detection ability. This work was conducted by Bond, Omar, Mahmoud and Bonser (1990) and Bond and Atoum (2000), who specifically explored the impact of culture on deception detection accuracy by examining differences between the honesty judgements of Americans, Jordanians and Indians when judging the statements of other Americans, Jordanians and Indians. Initially Bond et al (1990) found that Jordanian and American students could significantly detect lies of individuals from the same cultural background, but were unable to detect the lies of individuals from a different culture. This study, however, used video messages that were presented without sound, and as such, a second study was conducted by Bond and Atoum (2000) to further investigate these findings. Overall, findings of the second study suggested that deception judgements were more accurate within cultures than across cultures. Interestingly, Americans also showed a greater truth bias when judging senders from a different culture compared to when judging other Americans, whereas Jordanians showed no differences between the two. This suggests that an element of overcompensation may be involved in preventing the use of stereotypes when judging individuals from a different cultural group.

A final point to be considered in international deception detection is the issue of language. Conversing in a non-native, second language is likely to induce greater cognitive load than conversing in a native language, resulting in second language speakers demonstrating more cues that are traditionally associated with deception, such as longer response times and fewer details (DePaulo et al, 2003; Walczyk et al, 2003; Williams et al, in prep). In line with this possibility, Da Silva and Leach (in prep) found judges were more likely to exhibit a lie-bias when viewing second-language speakers and a truth-bias when observing native-language speakers. Such findings can also be considered in relation to previous research demonstrating that difficulties in understanding foreign accents and processing less fluent information can impact on the perception of credibility of a speaker (Dixon, Mahoney, & Cocks, 2002; Lev-Ari & Keysar, 2010; Reber & Schwarz, 1999; Smith & Bond, 1994).

The Current Study

We conducted two experiments to examine the role of individual differences in response bias and judgement accuracy in a deception detection task. In Experiment 9, 76 participants viewed 32 messages and judged the honesty of each one, as well as completing a variety of self-report individual difference measures. This allowed us to examine potential relationships between personality traits and both the degree of truth bias demonstrated and judgement accuracy. Experiment 10 was designed to extend this work by comparing honesty judgements for individuals of the same culture (UK) compared to a different culture (South East Asian) to the judge. This enabled an exploration of the potential role of social mechanisms in maintaining the truth bias, since individuals are likely to have less social experience of interacting with individuals of a different cultural background to their own, as well as potential differences in judgement accuracy. Through the consideration of previously discussed findings, a more in-depth examination of the potential factors influencing response bias and judgement accuracy than has previously been conducted is possible.

Experiment 9

The aim of Experiment 9 was to examine whether certain personality characteristics are related to individual differences in lie detection ability and truth bias. Participants assessed a number of videos as to whether the person was being truthful or not. In addition to judging each clip, our participants also filled out several self-report personality measures. These measured traits related to the ability to effectively identify and infer information from wider behaviours, in particular, emotional intelligence, extraversion and autism spectrum characteristics.

There were three hypotheses regarding detection ability. Judges who demonstrate higher scores on the extraversion subscale of the Eysenck Personality Questionnaire-Revised Short Scale (Eysenck & Eysenck, 1991) will show higher discrimination accuracy. Judges who score higher on the Trait Emotional Intelligence Questionnaire – Short Form (Petrides & Furnham, 2006) will also show enhanced discrimination accuracy. Similarly, since autism spectrum traits are characterised by problems attributing mental states to others we would expect judges who score higher on the Adult Autism Spectrum Quotient (Baron-Cohen, Wheelwright, Skinner, Martin & Clubley, 2001) to have lower discrimination accuracy.

In addition to detection ability, we also consider the following hypotheses regarding the possible relationship between these measures and degree of truth bias. Firstly, if truth bias is directly related to the availability heuristic, then a positive relationship between extraversion and truth bias may be demonstrated due to the enhanced social experience and exposure of extraverts. Equally, a positive relationship between extraversion and truth bias may also be related to the higher levels of positive affect experienced by extraverts, which may result in evaluating the messages of individuals as more positive, and hence, trustworthy (Cole et al, 2002; Cramer et al, 2009). Secondly, since autism spectrum traits are related to a lack of understanding of acceptable social behaviour (Baron-Cohen et al, 2001), if truth bias is a product of social norms that encourage us to regard information as truthful, a negative relationship may be shown between degree of truth bias and autism spectrum traits.

Method

Creation of Sender Messages

Participants

The video data used in this study was a subsample of data collected at Cardiff University specifically to examine the ability to detect deceit. Fifteen individuals from the community were originally recruited via the Cardiff University Community Panel. Eight of these individuals were then used to create the final stimulus set, referred to as the Deception Detection Assessment Tool (DDAT). Four of these individuals were males. These individuals will be referred to as senders. All senders identified their nationality as either British or Welsh and spoke English as a first language. Sender age fell into the following categories: 29 and under = 12.5%; 30-39 = 37.5%; 50-59 = 25%; Over 60 = 25%.

Message Generation Task

The task for the creation of messages involved senders both truthfully and falsely describing an image presented on a computer screen. The computer task began with the presentation of the word READY in the centre of the screen for a 1 second period. This was then replaced with a photographic image taken from the International Affective Picture Stimuli set (IAPS; Lang, Bradley & Cuthbert, 2001). These images involved a variety of different categories, and concerned subjects such as a street riot scene and a scene from a wedding. This image was shown for a 10 second period and was then replaced with either the word LIE or the word TRUTH presented in the centre of the screen. When senders saw the word, they had to turn and face the experimenter (who was unable to see the screen) and had to either truthfully describe the image or lie about the content of the image in as much detail as possible to the experimenter, according to the instruction. When senders had finished their description, they pressed any key on the keyboard and the next trial began. All senders viewed the same lie images, but different truth images (to prevent message similarity across senders). In total, senders viewed 24 images and had to truthfully describe half of these images and falsely describe the other half. The order of lie and truth trials was randomised. The experimenter was blind to the honesty instruction of particular trials. Senders were recorded using a Canon HD camera in a quiet room at the School of Psychology. The room contained a table with a laptop adjacent to the sender and two chairs, one for the sender and one for the experimenter. Participants were provided with both written and spoken instructions regarding the experimental task. Participants were asked in particular to try and remember as many details from each image as possible. When lying, participants were instructed that their descriptions should be sufficiently different from the original picture so that an observer would not be able to guess which picture they had viewed if shown a series of alternatives. They were informed that this was part of a larger project to examine individual differences in ability to detect deceit, and as such, future participants would be watching their recorded statements to try and differentiate when they were lying and when they were telling the truth. Therefore, they were asked to be as convincing as possible, both when they were lying and when they were telling the truth. Following completion of the recording session, participants completed a short demographics questionnaire and were then fully debriefed.

Creation of the DDAT

Four statements each were included from eight of the senders. These 32 statements were chosen on the basis that they were of similar duration (no longer than 1 minute), were of sufficient technical quality and were from a similar time point in the task. These time points were two statements taken from the middle of the first half of the task (trials 4-9) and two statements from the middle of the second half of the task (trials 16-21). The ratio of truths/lies of these 4 statements varied for each individual, ranging between 1 lie and 3 truths to 3 lies and 1 truth. However, the combined total of lie statements was equal to the combined total of truth statements, with 16 of each presented. Overall, the statements that were presented to participants ranged in duration between approximately 20 and 60 seconds.

Judgment Study

Participants

Seventy-six Cardiff University students volunteered for this study in exchange for payment. Of these, 21 were male and 68 identified their nationality as British or Welsh. These participants will henceforth be referred to as judges. Judges had a mean age of 22.44 (*SD* = 2.12; *Range* = 18-49) and spoke fluent English.

Design and Procedure

A correlational design was used, whereby judgement accuracy ratings were compared with the questionnaire data provided by the personality measures. Judges were tested in groups of between 2 and 20 individuals in a lecture theatre and were informed that they would view a series of 32 video clips of different individuals describing an image that they have previously viewed on a computer screen. On some of these clips, individuals would be truthfully describing the image and on others they may be lying about the image that they saw. Participants were informed that their task was to identify which clips were true and which were lies. Once all participants were seated, the video clips were presented via a projector. The task was divided into 4 blocks, with each sender being presented once in each block. The order of presentation of senders in each block was randomised prior to the first testing session, with the only limiting factor being that no single sender was displayed consecutively in the following block. The order of presentation of video clips was then identical for each of the judgement sessions. Prior to each video clip, the word READY was presented in the centre of the screen for a 3 second period. Following each clip, the sentence ENTER YOUR RATINGS NOW was presented in the centre of the screen until the experimenter pressed the spacebar to begin the next clip. Following the presentation of each clip, participants were asked to indicate their lie/truth judgement, confidence and trustworthiness rating on the rating sheet provided. Once all participants had done this, the experimenter began the next clip. Following completion of the judgement session, participants completed the questionnaire measures and were then fully debriefed.

Questionnaire Measures

Judges were given a questionnaire pack containing a number of questionnaire measures. These included the Eysenck Personality Questionnaire-Revised Short Scale (EPQ-R SS; Eysenck & Eysenck, 1991), the Trait Emotional Intelligence Questionnaire Short Form (TEIQue-SF; Petrides & Furnham, 2004), the Autism-Spectrum Quotient (AQ; Baron-Cohen et al, 2001) and a demographics questionnaire. These measures are described in detail below.

The EPQ-R SS is a 48-item self-report measure divided into 4 subscales. Three of these subscales measure the personality dimensions of neuroticism, extraversion and psychoticism and the fourth is a lie scale for the revelation of falsehoods. The items included in this short form questionnaire were taken from the Eysenck Personality

Questionnaire-Revised, with 12 items being chosen from each of the separate scales. Participants respond either ‘yes’ or ‘no’ to each question.

The TEIQue-SF is a 30-item self-report measure designed to measure trait emotional intelligence. Two items were taken from each of the 15 subscales of the TEIQue, based on their correlations with the total subscale scores. Participants respond on a 7-point likert scale.

The AQ is a 50-item self-report measure divided into 5 main areas: social skill, attention to detail, imagination, communication and attention switching. Participants choose one of four responses: definitely agree, slightly agree, slightly disagree, definitely disagree; and these responses relate to whether participants display autistic-like characteristics.

A demographics questionnaire was created which included questions related to participants educational level, occupation, age, sex and nationality. In addition, participants completed 4 questions related to perceived lie/truth detection ability using a 7-point likert scale. In addition, a rating sheet was also created to be used during the presentation of video statements for participants to record their judgements. Space was provided for participants to provide a binary judgement of whether they considered each clip to be a lie or a truth, as well as to rate their confidence in their decision (using a 7-point likert scale) and the trustworthiness of the individual (using a 7-point likert scale). The following two open-ended questions were included at the bottom of the rating sheet: What factors made you think that someone was lying? What factors made you think that someone was telling the truth?

Results

Descriptive statistics were computed on the questionnaire measures to examine mean, range and standard deviation of scores, shown in Table 1. To examine the relationship between our separate questionnaire measures, bivariate correlations were computed. These showed a positive relationship between the extraversion subscale of the EPQ-SS and the TEIQue, $r = .502$, $p < .001$, and a negative relationship between the AQ and both the TEIQue, $r = -.601$, $p < .001$ and the extraversion subscale, $r = -.638$, $p < .001$.

Accuracy of lie-detection

The overall percentage accuracy for honesty judgements was then calculated for each participant. This revealed a mean accuracy rating of 54.98% (*Minimum*: 37.50%; *Maximum*: 71.90%), with 61.59% for truths and 48.44% for lies. A one-sample t-test showed that total accuracy was significantly above chance, $t(75) = 5.45$, $p<.001$. No relationship was found between lie detection accuracy and any of the 4 self-report questions regarding ability to detect truths and lies and ability to deceive others, all *r's* < .15, all *p*'s > .21. This suggests that self-reported detection ability is not related to actual ability levels. Paired sample t-tests of the overall number of statements judged as truths compared to lies demonstrated the presence of a truth bias, with more statements judged as truths ($M = 18.04$; $SD = 4.06$) than as lies ($M = 13.96$; $SD = 4.06$), $t(75) = 4.37$, $p<.001$.

Table 1. Descriptive statistics of questionnaire measures for Experiment 9.

	Extraversion	**Emotional Intelligence**	**Autism Spectrum**
Minimum	0.00	89.00	4.00
Maximum	12.00	192.00	30.00
Mean	8.60	148.54	15.08
Standard Deviation	3.60	18.45	6.46

Personality traits and accuracy

Bivariate correlations were computed to examine the relationship between the personality measures of interest and percentage judgement accuracy. A significant positive correlation was found between the extraversion scale of the EPQ-R SS and percentage accuracy, r = .315, p = .006, showing that higher scores on the extraversion scale were related to higher accuracy levels. The AQ, however, did show a trend for a negative relationship, r = -.205, p = .076. Table 2 shows r values for all correlations.

Table 2. Correlations (r values) between personality measures and percentage accuracy, *d'* and *c* for Experiment 9.

	Extraversion	**Emotional Intelligence**	**Autism Spectrum**
Percentage Accuracy	**.315***	.013	-.205
d'	**.296***	.073	-.248
C	.241	.224	-.207

*. Correlation is significant at the .05 level (two-tailed).

In accordance with signal detection theory (Swets, 1964), the proportion of hits (H), misses (M), correct rejections (CR) and false alarms (FA) were calculated for each participant. A hit was defined as a correct lie judgement, a miss was defined as a participant judging a lie statement as a truth, a correct rejection was defined as a correct truth judgement and a false alarm was defined as a participant judging a truthful statement as a lie. These values were used to measure *d'* for each participant. The *d'* statistic provides a measure of detection sensitivity and is computed using the following equation:

$$d' = z(\mathrm{H}) - z(\mathrm{FA})$$

with z being the transformation of the proportion into a probability score based on a normal distribution. Bivariate correlations were then computed to examine the relationship between *d'* and the questionnaire measures. These are shown in Table 2. The only significant correlation was a positive relationship with the extraversion scale of the EPQ-R SS measure, demonstrating that participants who scored higher on the extraversion scale were more accurate at discriminating truths and lies, $r = .296$, $p = .009$. The AQ this time showed a significant negative relationship with discrimination accuracy, $r = -.248$, $p = .031$, but this did not survive corrections for multiple comparisons. To examine the extent that extraversion accounted for variance in *d'*, a multiple regression was computed with age, sex and the questionnaire measures as predictors and *d'* as the dependent variable. Only the extraversion score was significantly related to *d'*, $t = 2.483$, $p = .015$. The model summary from this regression shows that extraversion scores account for 8.7% of the total variance in *d'* ($R^2 = .087$). Finally, the relationship between discrimination accuracy and mean confidence was also examined. Although the overall correlation between *d'* and confidence was not significant, $r = .131$, $p > .10$, there was a significant positive correlation between mean confidence and trait emotional intelligence, $r = .307$, $p = .007$, such that participants who scored higher in emotional intelligence were more confident in their judgements, despite being no more accurate. None of the other questionnaire measures significantly correlated with confidence. Correlations are shown in Table 3.

Table 3. Correlations (*r* values) between personality measures, *d*', *c* and mean confidence for Experiment 9.

	d'	***c***	**Extraversion**	**Emotional Intelligence**	**Autism Spectrum**
Mean Confidence	.131	-.019	.070	**.307***	-.088

*. Correlation is significant at the .01 level (two-tailed).

Since the AQ showed a trend towards a negative relationship with detection ability, overall AQ scores were broken down into 5 separate subscales to examine the nature of this relationship in more detail. These subscales were taken from Hoekstra, Bartels, Cath and Boomsma (2008) and included social skill, communication, attention switching, imagination and attention to detail. Bivariate correlations were then computed between *d'* and the subscale scores. Significant negative correlations were found between *d'* and three of these subscales: the social skill subscale, $r = -.266$, $p = .020$, the communication subscale, $r = -.259$, $p = .024$ and the attention to detail subscale, $r = -.232$, $p = .044$.

Personality traits and bias

A measure of response bias (criterion; *c*) was computed to examine whether certain personality characteristics are related to the tendency to judge a greater number of messages as truths than as lies (*truth bias*). Criterion (*c*) was calculated using the following equation (Macmillan & Creelman, 1991):

$$c = -0.5*(z(\mathrm{H})+z(\mathrm{FA}))$$

A positive relationship was shown between the extraversion scale and *c*, $r = .241$, $p = .031$, suggesting an inclination for extraverts to have a greater truth bias. This relationship, however, was no longer significant following adjustments for multiple comparisons. A trend towards a positive relationship was also found between the TEIQue and *c*, $r = .224$, $p = .052$ and towards a negative relationship between the AQ and *c*, $r = -.207$, $p = .072$. No significant correlations were found between any of the AQ subscales and *c*. Table 2 shows *r* values for all correlations.

Discussion

The aim of Experiment 9 was to investigate possible individual differences in relation to degree of truth bias and the ability to detect deception. In particular, the personality traits of extraversion, emotional intelligence and autism spectrum characteristics were examined. Overall, we found that total judgement accuracy was significantly greater than chance, but in accordance with previous findings (Bond & DePaulo, 2008) the accuracy rate remained low at 55%. We also found an overall truth bias, which is consistent with previous studies of lay populations (Levine et al, 2006; Levine, Park & McCornack, 1999). In terms of personality characteristics, the only self-report measure that was found to have a significant relationship with discrimination accuracy was the extraversion scale of the EPQ-R SS, with higher scores in extraversion associated with higher judgement accuracy. Following regressions analyses, it was shown that extraversion was the only significant predictor of discrimination accuracy, accounting for 8.7% of the total variance.

Personality and lie detection

Our original hypotheses that extraversion would be associated with higher judgement accuracy, whereas autism spectrum characteristics would be associated with lower judgement accuracy, were supported, highlighting the presence of individual differences in discrimination accuracy in our sample. The predicted positive relationship between emotional intelligence and discrimination accuracy, however, was not supported. Regression analyses also demonstrated that extraversion was the only significant predictor of discrimination accuracy in our study, accounting for 8.7% of the total variance.

When introducing the Chapter, we highlighted several possible reasons why extraverts may show increased accuracy at discriminating truths from lies. These included enhanced skill at decoding nonverbal behaviour (Ackert & Panter, 1988; Lieberman & Rosenthal, 2001), greater social experience from increased time spent in social activities (Nettle, 2007), increased central executive efficiency (Lieberman & Rosenthal, 2001), and improved discrepancy detection (Eisenberger et al, 2005). It is possible that these factors singularly, or in combination, contribute to the increased discrimination accuracy shown by extraverts. Since we failed to replicate this finding in Experiment 10, however, we delay discussion of these possibilities until the General Discussion.

In our introduction we also highlighted that the ability to interpret the emotional and mental state of others has been suggested to increase lie detection ability (Johnson et al, 2004; Stanley & Blanchard-Fields, 2008) Our findings failed to support this hypothesis, however, since the TEIQue failed to show a significant relationship with discrimination accuracy. Of particular interest, however, is the finding of a trend towards a negative relationship with the AQ and lie detection, but no such finding in the opposite direction for the TEIQue. Since autism spectrum characteristics have been associated with a deficit in understanding the mental states of others, termed *theory of mind* (Baron-Cohen, 1989), it was expected that this would provide an opposite measure to the TEIQue. Indeed, a significant negative correlation was found between the two measures. Further examination in relation to the subscales of the AQ also showed that the negative trend with detection ability was present in both the communication and social skills domain, both of which relate to theory of mind deficits (Frith, 1989). Since both overall AQ scores and subscale scores were negatively correlated with scores on the TEIQue, the predicted relationship between the two measures was found in our study, which makes the lack of a similar pattern in relation to lie detection particularly surprising. One possible explanation is that a deficit in the ability to interpret emotional and mental states decreases lie detection ability, but an enhanced ability to understand such states has no further effect. Alternatively, since scores on the AQ are negatively correlated with extraversion scores, it may be that individuals who score higher on the AQ spend less time in social situations. This may result in less social experience, which could negatively affect lie detection ability (as discussed previously). This seems an unlikely explanation for the results, however, given our finding of a positive correlation between extraversion and emotional intelligence.

Personality and truth bias

We presented two hypotheses regarding the relationship between personality and truth bias. Firstly, that a positive relationship would be found between extraversion and truth bias, resulting from increased social experience or higher levels of positive affect. Secondly, that a negative relationship would be shown between autism spectrum traits and truth bias, due to a lack of understanding of social communication rules. Although none of these relationships were found to be significant, the above hypotheses were partially supported by findings of a positive relationship between extraversion and truth bias, and a negative trend between autism spectrum traits and truth bias. Although the precise mechanisms responsible for such biases cannot be fully determined, we suggest that these findings can be considered in relation to previous explanations of the truth bias affect, namely the availability heuristic and the influence of social conventions that encourage us to evaluate the majority of information as trustworthy. This social mechanism can explain why extraverts demonstrate a higher truth bias, namely because they are more concerned with, and have greater exposure to, positive social interactions (Nettle, 2007). Since individuals who scored higher in autism spectrum traits also demonstrated a reduced truth bias, this further highlights the role of social learning processes in explaining the existence of the truth bias. The lack of understanding of social conventions and behavioural norms that characterises autism spectrum disorders (Baron-Cohen, 2008) may result in a failure to acquire a 'socially-learned' truth bias.

Additionally to the above findings, we also found a positive trend between emotional intelligence and truth bias. This was not considered in our original hypotheses, but could be related to the drive to maintain positive social relationships in individuals higher in emotional intelligence. Indeed, Goleman (2006) suggests that optimism and the ability to relate positively to others may be a reflection of specific emotional intelligence competencies. Similarly, Bar-On (2000) highlights the ability to be aware of, understand, and relate to others as one of an array of emotional intelligence abilities. If the truth bias is related to the maintenance of positive social relationships according to accepted social interaction and communication rules, then individuals who are more adept at, or concerned with, the maintenance of positive relationships may demonstrate a stronger truth bias.

Experiment 10

Experiment 9 demonstrated that individual differences in the ability to detect deceit exist, and that these differences are strongest in relation to the personality trait of extraversion. As discussed previously, however, the mechanisms responsible for this require further examination. The aims of Experiment 10 were twofold. First, to examine whether the higher accuracy shown by extraverts is due to learnt associations resulting from greater social experience (Allport, 1924; Nettle, 2007), or whether this ability is an inherent cognitive trait of extraverted individuals (Eisenberger et al, 2005; Lieberman & Rosenthal, 2001). Second, to examine whether the use of senders from different cultures results in further individual differences related to both judgement accuracy and bias. In order to investigate these questions, judgements by United Kingdom nationals for two separate sender samples were compared: one collected in Singapore and one collected in the United Kingdom.

The comparison of judgements for two different cultural groups allows us to consider the following hypotheses. If the higher accuracy previously shown by extraverts was predominantly due to increased social experience, then extraversion should be positively related to detection accuracy when judging senders from the same cultural group (UK senders), but not when judging senders from a different cultural group (South East Asian senders). This would be due to a greater familiarity with the behavioural norms of UK senders in deceptive and honest interactions. If, however, ability differences are singularly due to extraverts' greater cognitive efficiency at decoding behaviour in complex situations, then extraversion should be positively related to detection accuracy for judgements of both UK and South East Asian senders. In relation to truth bias, if the higher truth bias previously shown by extraverts was predominantly due to increased social experience, then extraversion should be positively related to truth bias when judging senders from the same cultural group (UK senders), but not when judging senders from a different cultural group (South East Asian senders). This would be due to a greater familiarity with the behavioural norms and expectations of UK senders. If, however, ability differences are singularly due to the greater positive affect experienced by extraverts' overall, then extraversion should be positively related to truth bias for judgements of both UK and South East Asian senders.

In relation to cross-cultural judgement accuracy, previous literature suggests the following hypotheses for our experiment. Firstly, that discrimination accuracy would be greater when judging UK senders compared to South East Asian senders. Secondly, if judges view individuals from a different cultural background as less credible than those from the same cultural background, a truth bias would be shown for UK senders (as shown in Experiment 9) and a lie bias shown for South East Asian senders. If judges overcompensate for possible cultural difference stereotypes, however, findings may be similar to those of Bond and Atoum (2000), with judges demonstrating a greater truth bias for South East Asian senders compared to UK senders. Excepting the previously discussed hypotheses regarding the relationship of extraversion to judgement accuracy, due to a lack of research regarding individual differences and cross-cultural deception detection, no further hypotheses were considered regarding our individual difference measures and differences in detection accuracy and/or bias.

Method

Creation of Sender Messages

Participants

The video data used in this study was made up of two separate samples. Sample 1 was collected in Singapore through poster and e-mail advertisements to businesses and colleges/universities. Sample 2 was collected in the UK through the School of Psychology Experiment Management System. There were 7 male participants in each sample, and these made up our senders. Six senders in sample 1 were students, and 1 was a researcher. All identified their nationalities as Malaysian (1), Indian (2), Vietnamese (3) or Sri Lankan (1), spoke English as a second language and reported their age as 29 or under. All senders in sample 2 were students, identified their nationality as either British (5) or Welsh (2) and spoke English as a first language. The messages were generated in the same way as described in Experiment 1. Six senders reported their age as 29 or under, whereas 1 reported their age as 30-39. The video data was combined to create the Deception Detection Cultural Assessment Tool (DDCAT).

Creation of the DDCAT

Four statements were included from each sender, 2 lies and 2 truths. This differed to Experiment 9 because we planned to analyse individual sender effects in this experiment. In total, 56 statements (half lies and half truths) were included in the DDCAT. Statements were chosen on the basis that they did not exceed 1 minute, were of sufficient technical quality and were from a similar time point in the task.

Judgment Study

Participants

Seventy-seven Cardiff University students volunteered for this study in exchange for payment. Of these, 16 were male. All identified themselves as UK nationals and spoke English as a first language. 71 reported their ethnicity as being of a White background, 2 as a Mixed background and 4 as an Asian background. Participant age data was gathered categorically, with 74 participants reporting their age as between 20-29 and the remaining 3 reporting an age of 30-39.

Design and Procedure

A correlational design was used, whereby judgement accuracy ratings were compared with the questionnaire data provided by the personality measures. Participants viewed the DDCAT (described above) and judged a total of 56 video clips. The task was divided into 4 blocks, with each individual being presented once in each block. The order of presentation of individuals in each block was randomised prior to the first testing session, with the only limiting factor being that no single individual was displayed consecutively in the following block. The order of presentation of video clips was then identical for each of the judgement sessions. The questionnaire measures were identical to those in Experiment 9, except for the inclusion of an additional question asking participants to rate their degree of familiarity and interaction with individuals from Asian cultures on a scale of 1-7. In all other aspects, the design and procedure of the study were identical to Experiment 9.

Results

Descriptive statistics were computed on the questionnaire measures to examine mean, range and standard deviation of scores, shown in Table 4. An adequate range of scores was demonstrated for all questionnaires. To examine the relationship between our separate questionnaire measures, bivariate correlations were computed. These showed a positive relationship between the extraversion subscale of the EPQ-SS and the TEIQue, $r = .491$, $p < .001$, and a negative relationship between the AQ and both the TEIQue, $r = -.590$, $p < .001$ and the extraversion subscale, $r = -.425$, $p < .001$.

Table 4. Descriptive statistics of questionnaire measures for Experiment 10.

	Extraversion	**Emotional Intelligence**	**Autism Spectrum**
Minimum	0.00	85.00	3.00
Maximum	12.00	181.00	31.00
Mean	8.65	144.77	15.68
Standard Deviation	3.53	21.28	6.32

Asian experience and judgment accuracy

Since a primary interest in this study was the examination of cultural differences in deception detection, participants were asked to rate their degree of familiarity and interaction with individuals from Asian cultures on a scale of 1-7 (1 being no familiarity/interaction and 7 being a very high degree of familiarity/interaction). Prior to the main analysis, participants were divided into two groups. Group 1 consisted of participants who rated their experience between 1 and 4 and group 2 consisted of participants who rated their experience between 5 and 7. Of the 77 participants, 23 were in group 2. *d'* and bias were then calculated for judgements related to the South East Asian senders and UK senders independently for each group. We compared these measures using independent samples t-tests. There was no significant difference between the two groups for *d'* for either the UK senders, $t(74) = .63$, $p=.533$, or the South East Asian senders, $t(74) = 1.53$, $p=.130$. Similarly, there was no significant difference between the two groups for bias for either the UK senders, $t(74) = -.85$, $p=.397$, or the South East Asian senders, $t(74) = -.14$, $p=.892$. For each group, paired sample t-tests were also conducted to compare accuracy and bias for the UK and South East Asian senders. For both groups, *d'* was found to be higher for UK senders compared to South East Asian senders (Group 1: $t(53) = 2.94$, $p<.01$; Group 2: $t(23) = 2.57$, $p<.02$). Similarly, truth bias was also found to be higher for UK senders compared to South East Asian senders (Group 1: $t(53) = 2.58$, $p<.02$; Group 2: $t(23) = 4.66$, $p<.001$). Since no significant differences in judgement accuracy or bias were demonstrated across the two groups, the groups were combined for all further analyses.

Cross-cultural judgment accuracy

The overall percentage accuracy for honesty judgements was then calculated for each participant. This revealed a mean accuracy rating of 56.49% (*Minimum*: 41.07%; *Maximum*: 69.64%). Mean truth detection accuracy was 54.85% for South East Asian senders and 60.39% for UK senders, and lie detection accuracy was 24.74% for South East Asian senders and 39.61% for UK senders. A one-sample t-test showed that total accuracy was significantly above chance, $t(76) = 9.22$, $p<.001$. As mentioned above, *d'* was calculated both overall and separately for South East Asian and UK senders. One sample t-tests were conducted on these *d'* measures to examine whether discrimination accuracy was above chance. The general *d'* ($M = .36$, $SD = .34$) was significantly above chance, $t(76) = 9.30$, $p<.001$, as was the UK *d'* ($M = .34$, $SD = .32$), $t(76) = 9.38$, $p<.001$ and the South East Asian *d'* ($M = .16$, $SD = .32$), $t(76) = 4.36$, $p<.001$. To compare the discrimination accuracy for South East Asian senders and UK senders, paired sample t-tests were conducted. As predicted, it was found that discrimination accuracy for UK senders was significantly higher than for South East Asian senders, $t(76) = 3.85$, $p<.001$. Additionally, bivariate correlations were conducted to examine whether there was a significant relationship between *d'* for South East Asian senders and UK senders. The correlation was not significant, $r = .180$, $p = .12$. As in Experiment 9, no relationship was found between lie detection accuracy and any of the 4 self-report questions regarding ability to detect truths and lies and ability to deceive others, all *r*'s < .13, all *p*'s > .26.

To examine possible differences in truth bias according to sender culture, the degree of truth bias was calculated using criterion (*c*) from Signal Detection Theory. Although a truth bias was shown towards both South East Asian senders, $t(76) = 26.22$, $p<.001$, and UK senders overall, $t(76) = 28.88$, $p<.001$, paired sample t-tests demonstrated that a greater truth bias was present when judging UK senders ($M = .91$, $SD = .27$) compared to South East Asian senders ($M = .79$, $SD = .26$), $t(76) = 3.94$, $p<.001$). Bivariate correlations demonstrated a positive relationship between *c* for South East Asian senders and UK senders, $r = .545$, $p < .001$.

Bivariate correlations were computed between general *d'* and mean confidence. No significant relationship between the two measures was found, $r = .040$, $p = .129$. Bivariate correlations were also computed between ratings of sender trustworthiness and confidence ratings. A positive relationship was found between mean trustworthiness and mean confidence, $r = .499$, such that the more trustworthy participants rated a sender to be, the more confident they were in the accuracy of their judgement. Finally, paired samples t-tests were conducted to examine whether participant confidence ratings and ratings of sender trustworthiness differed across the two sender samples. Participants were found to be more confident when judging UK senders compared to South East Asian senders, $t(76) = 5.26$, $p<.001$, and rated UK senders as more trustworthy than South East Asian senders, $t(76) = 5.51$, $p<.001$.

Personality and judgment accuracy

Bivariate correlations were computed to examine the relationship between the personality measures of interest and *d'*. Correlations were computed both for general *d'* collapsed across sender type, and for South East Asian and UK *d'* independently. No significant correlations were found when general *d'* was examined. When *d'* was examined specific to sender type, a positive relationship was shown between the TEI and South East Asian *d'*, $r = .225$, $p = .05$. This correlation did not remain significant following bonferroni corrections, however. Similar to Experiment 9, the AQ also showed a trend for a negative relationship with the South East Asian *d'*, $r = -.194$, $p = .09$, but not with UK *d'*, $r = -.041$, $p = .73$. The increased discrimination accuracy shown for individuals higher in extraversion in Experiment 9 was not replicated for either general *d'*, $r = .122$, $p = .30$, South East Asian *d'*, $r = .078$, $p = .51$, or UK *d'*, $r = .030$, $p = .80$. Tables 5 and 6 shows *r* values for all correlations.

In line with Experiment 9, overall AQ scores were once again broken down into 5 separate subscales (Hoekstra et al, 2008). Bivariate correlations were then computed between *d'* and these subscale scores. Similar to the findings of Experiment 9, a trend towards a negative relationship was once again found between *d'* and the social skill subscale, $r = -.213$, $p = .06$ and the communication subscale, $r = -.204$, $p = .08$. This time, a significant negative correlation was also shown between *c* and the imagination subscale, $r = -.257$, $p = .02$. No other correlations between the subscales and *d'* and *c* reached significance. Bivariate correlations were then computed between the AQ subscales and *d'* and *c* according to sender type. The only significant correlations were between South East Asian *d'* and the attention switching subscale, $r = -.305$, $p = .007$, and UK *c* and the imagination subscale, $r = -.257$, $p = .025$.

Personality and truth bias

To examine the possible relationship between personality and degree of truth bias (*c*), bivariate correlations were also computed between the personality measures and both general *c,* South East Asian *c* and UK *c*. No significant correlations were demonstrated between general *c* and any of the questionnaire measures. Of particular interest is the finding of a positive correlation between the EPQ-E and UK *c,* $r = .315$, $p < .01$, but no positive correlation between the EPQ-E and South East Asian *c,* $r = -.009$, $p = .94$, suggesting that extraverts only show a truth bias when judging individuals of their own culture and not when judging individuals of a different cultural background. To examine whether these two *r* values significantly differed from each other (i.e., that the relationship between extraversion and UK *c* was significantly stronger than between extraversion and South East Asian *c*), the *t* difference statistic was calculated for the comparison of dependent *r*'s. Results demonstrated that the relationship between extraversion and UK *c* was significantly stronger than between extraversion and South East Asian *c,* $t(72) = 3.12$, $p<.0.01$. No other significant relationships were found between the questionnaire measures and either South East Asian *c* or UK *c*.

Table 5. Correlations (*r* values) between personality measures and general *d*' and *c* for Experiment 10.

	Extraversion	**Emotional Intelligence**	**Autism Spectrum**
d'	.122	.160	-.117
c	.000	.156	-.079

*. Correlation is significant at the .05 level following bonferroni corrections (two-tailed).

Table 6. Correlations (*r* values) between personality measures and *d*' and *c* according to sender type for Experiment 10.

	Extraversion		**Emotional Intelligence**		**Autism Spectrum**	
	UK	**South East Asian**	**UK**	**South East Asian**	**UK**	**South East Asian**
d'	.030	.078	.059	.225	-.041	-.194
C	**.315***	-.009	.104	.130	-.108	-.005

*. Correlation is significant at the .05 level following bonferroni corrections (two-tailed).

Discussion

We presented two main aims for Experiment 10. Firstly, to further examine the relationship between extraversion and judgement accuracy and truth bias demonstrated in Experiment 9 and secondly, to explore possible individual differences in judgement accuracy and bias when judging senders from different cultural backgrounds. In relation to the first of these aims, we considered two competing hypotheses for judgement accuracy. If the enhanced judgement accuracy of extraverts relates to their enhanced social experience, a positive relationship would be shown when judging individuals of the same cultural background, but not when judging individuals from a different cultural background. If, however, the enhanced judgement accuracy is related to inherent cognitive skills in decoding communicative behaviour, this increased accuracy should be shown when judging all senders, regardless of cultural background. Our results did not support either of these hypotheses, since no significant relationship was found between extraversion and judgement accuracy for either the UK or South East Asian senders. We also considered two competing hypotheses for truth bias. If the enhanced truth bias displayed by extraverts relates to enhanced social experience, a positive relationship would be shown when judging individuals of the same cultural background, but not when judging individuals from a different cultural background. If, however, the enhanced truth bias is related to greater positive affect, an increased truth bias would be shown when judging all senders, regardless of cultural background. Our results supported the first of these hypotheses, since higher scores in extraversion were significantly related to an increased tendency to judge messages as truthful, but only when those messages were delivered by senders from the same cultural background. In relation to our second aim, our initial hypothesis that participants would demonstrate significantly enhanced accuracy and truth bias when judging UK senders compared to South East Asian senders was supported.

Cross-cultural lie detection

In accordance with Bond and Atoum (2000), our findings further support the suggestion that individuals are more accurate at discriminating the truths and lies of individuals from the same cultural background as themselves compared to a different cultural background. The cross-cultural differences in nonverbal communication previously mentioned (Ekman, 1976; Exline et al, 1977; Friesen et al, 1979; Vrij et al, 1992) are likely to result in difficulties in accurately interpreting the communicative behaviour of other cultural groups. For instance, Elfenbein and Ambady (2002) and Friesen (1972) highlighted differences in how emotions are expressed, and therefore recognised, across different cultural groups (Elfenbein & Ambady, 2002; Friesen, 1972). In line with such findings, we are likely to be more accurate in evaluating the communicative intentions of individuals from our own cultural group, not only because we have more social experience of such behaviour, but also because we use similar actions and rules when communicating ourselves.

Contrasting the findings of Bond and Atoum (2000), however, we found a greater truth bias when judging individuals from the same cultural group compared to a different cultural group, whereas Bond and Atoum demonstrated the opposite. This difference could be due to the study design used, since the biases shown by the participants in Bond and Atoum's study emerged when individuals were communicating in an unfamiliar language to the judges. The authors considered this finding in relation to how judges attribute a cause to a communication failure. For instance, when judges are unable to understand the communication of an individual from a different cultural group, they may overcompensate for this misunderstanding by giving senders the benefit of the doubt and judging them as truthful (Smith & Bond, 1994). Since our senders all communicated in English, this effect may not have been present. Instead, our judges may have attributed any differences in communicative behaviour to deception rather than cultural background. This is supported by findings of Vrij and Winkel (1991) that judges were more suspicious of behaviour typical to individuals from a Surinamese culture compared to individuals from their own culture.

The fact that our South East Asian senders communicated in a second language, rather than their native languages, may also have contributed to our findings of a decreased truth bias. The increased difficulty that individuals may show when communicating in a second language, such as less fluent speech, greater errors and longer response times, could be interpreted by judges as indicators of deceit. This is seen in the findings of Da Silva and Leach (in prep), who compared detection accuracy for foreign individuals speaking in their native language compared to a second language. Overall, a lie bias was shown when individuals judged second language speakers, compared to a truth bias when judging native language speakers. Our findings of a greater truth bias for individuals of the same culture, therefore, could be due to judges attributing behavioural differences resulting from communicating in a second-language to deception. It should be considered, however, that in our study such judgement differences did not negate the presence of a truth bias completely, or lead to a lie bias, but merely reduced the extent of truth bias displayed. It is only when the truth bias displayed for South East Asian senders is compared to that of UK senders that the differences in level of bias emerge.

General Discussion and Conclusions

The primary aim of the current study was to examine individual differences in the ability to detect deceit, in relation to both judgement accuracy and response bias. To do this, Experiment 9 examined judgement accuracy and response bias according to a variety of individual difference measures, including extraversion, emotional intelligence and autism spectrum traits. Experiment 10 then extended this work by examining these measures in relation to cross-cultural deception detection, i.e., accuracy and bias when judging individuals from the same cultural background compared to a different cultural background. As highlighted previously, the presence of individual differences in the ability to detect deceit remains a topic of much controversy, with some researchers supporting the existence of stable individual differences (O'Sullivan, 2005; O'Sullivan & Ekman, 2004) and others arguing against this (Bond & DePaulo, 2008; Levine, 2010).

Our findings suggest that individual differences in judgement accuracy do exist and that these can be related to both judgement bias and overall accuracy rating. In Experiment 9, we found a positive relationship between emotional intelligence and degree of truth bias, and also between extraversion and degree of truth bias. Although the correlation between emotional intelligence and bias was not replicated in Experiment 10, we were able to replicate our extraversion finding, but only when participants judged senders from the same cultural background as their own (UK senders) and not when judging those from a different cultural background (South East Asian senders). Since this relationship was not shown when participants judged South East Asian senders, however, this suggests that the truth bias demonstrated by extraverts may relate to socially learned information. If this is the case, this would explain why such biases are not shown when judging individuals with whom we have less social experience, i.e., individuals from a different cultural background to our own. These findings suggest that the existence of a truth bias could be due to the use of heuristic processes, such as the anchoring or availability heuristic, and that the extent of heuristic use differs according to the context in which an individual is operating. For example, when judging individuals from a different cultural background to our own with whom we are less familiar, the heuristics that usually guide our credibility judgements may be overridden by more deliberate processes. If considered in this way, the truth bias can be viewed as a socially learned heuristic which operates in a particular cultural context and allows us to deal efficiently with the large number of communications that we engage in over the course of any given day. When placed outside of this particular context, the truth bias is diminished by the requirement to consider more carefully the validity of information provided to us from individuals with whom we have less social experience and who may be from a different cultural 'group' to our own.

In relation to individual differences in judgement accuracy, both autism spectrum characteristics and extraversion were found to be significantly related to *d'* in Experiment 9. Although we failed to replicate these findings in Experiment 10, it is possible that this may be due to the senders that were used in this experiment. Since both the UK senders and the South East Asian senders were made up of a different sample to that used in

Experiment 9, judgement accuracy may have been affected to a greater degree in this sample by the particular traits of the senders. For example, Bond and DePaulo (2008) suggested that judgement accuracy is affected more by the demeanour of the liar than by the ability of the judge. Similarly, characteristics such as facial appearance and social skills have been shown to affect credibility judgements (Kraut, 1980; Levine et al, 2009; Zebrowitz et al, 1996). It may be, therefore, that the sender sample used in Experiment 10 was more difficult to accurately judge, and that any advantage extraverts had in Experiment 9 was lost due to these factors in Experiment 10. Because of these possibilities, we discuss reasons behind our significant findings in Experiment 9 below.

Firstly, the decreased ability of individuals high in autism spectrum characteristics to accurately discriminate between truths and lies could be a result of decreased theory of mind abilities, since such deficits affect an individual's ability to determine the intentions of others (Baron-Cohen, Leslie & Frith, 1985). Such deficits have been linked to an impaired capacity of autistic children to deceive others (Baron-Cohen, 1992), and thus, may similarly be linked to an impaired ability to correctly identify deception in others. Since theory of mind deficits have been suggested to negatively affect the formation of successful social relationships, through difficulties in understanding social reciprocity or the impact of behaviour on others (Baker, 2003), the contribution of such deficits to decreased detection accuracy is further supported by our findings of a negative relationship between both the social skill and communication AQ subscales and discrimination accuracy. Secondly, our finding of a positive relationship between extraversion and the ability to detect deceit can be considered in relation to a number of possible explanations. These include enhanced skill at decoding nonverbal behaviour (Ackert & Panter, 1988; Lieberman & Rosenthal, 2001), greater social experience from increased time spent in social activities (Nettle, 2007), increased central executive efficiency (Lieberman & Rosenthal, 2001), and improved discrepancy detection (Eisenberger, Lieberman & Satpute, 2005). It is possible that these factors singularly, or in combination, contribute to the increased discrimination accuracy shown by extraverts in Experiment 9.

The precise mechanisms responsible for the enhanced skill of extraverts in decoding nonverbal behaviour, however, are currently unknown. Ackert and Panter (1988) suggest that increased decoding ability could be due to superior attentional and perceptual abilities. This would allow extraverts to gain more information from complex social interactions than introverts, either through passive information gathering or greater motivation to seek information out. Alternatively, the greater social experience of extraverts may provide them with more opportunities to associate particular behaviours with particular outcomes or intentions. This idea was suggested as early as 1924 when Floyd Henry Allport proposed that individuals who avoid social interactions will miss out on opportunities to learn the vocabulary of facial expression. This could be reflected in more recent evidence that extraverts show enhanced ability on tasks that involve both the decoding of posed emotional expressions (Funder & Harris, 1986; Mill, 1984) and the attribution of conversation topics to visually presented ambiguous social situations (Ackert & Panter, 1988). Lieberman and Rosenthal (2001), however, found that extraverts displayed enhanced nonverbal sensitivity only when a secondary task was introduced, leading to the requirement of efficient multitasking processes. This is logical when considered with findings of greater central executive efficiency for extraverts (Lieberman & Rosenthal, 2001). Therefore, differences in detection ability are likely to be influenced by a combination of differences in social exposure and innate cognitive ability. Since conflicting findings have also been put forward by other researchers in the field, however, who have proposed that introverted individuals are more accurate at detecting deceit (O'Sullivan, 2005; Peace et al, 2011), further work is required to disentangle the particular circumstances in which certain personality characteristics may be advantageous in detecting deceit.

CHAPTER 6

General Discussion

The present thesis had two main aims. Firstly, to examine the additional cognitive processes involved in telling a lie compared to telling the truth and secondly, to examine the factors that impact on the ability of others to accurately detect deception. In relation to the first aim, our experiments support the general supposition that lying is more cognitively demanding than telling the truth due to the additional processes involved (Christ et al, 2009; Spence et al, 2001; Vendemia et al, 2009; Walczyk et al, 2003). We found these additional processes to include: the suppression of competing responses, including both truthful and false information; choosing between alternative lie possibilities; and switching between truth and lie task-sets. In relation to the second aim, the increased cognitive load that liars experience when telling unprepared lies did not result in the accurate identification of deception by human observers. Overall, human ability to detect lies was shown to be poor. However, variability in both accuracy levels and truth bias was found to be related to individual and cultural difference factors.

Experimental summary: Cognitive processes and deception

Experiments 1 and 2 specifically examined the decision to lie and demonstrated that the response time difference between lying and telling the truth was smaller when participants chose whether to lie or tell the truth compared to when they were directed to do so. In particular, participants were slower to respond with the truth when they chose the response compared to when they were directed to do so, whereas lying was much less affected by the choice manipulation.

Experiments 3, 4 and 5 examined lie response choice and demonstrated longer response times for lies when there is a choice of multiple lie response options compared to having only one lie possibility. The number of lie possibilities did not interfere with response time when participants told the truth. Furthermore, the findings of Experiment 5 also suggest that when choosing a lie response, implausible lies are inhibited prior to any decision process.

Experiment 6 examined whether switching between telling a lie and telling the truth incurs a response time cost compared to consistently responding in one manner. It was found that switching between these two processes does increase response time compared to trials where no switch is required, indicating that the two response types involve the use of different task-sets. This difference was greater when participants switched from telling a lie to telling the truth rather than vice versa, suggesting that telling the truth is a more dominant cognitive task than telling a lie (i.e., Allport et al, 1994).

Experiments 7 and 8 examined the influence of priming techniques on lie construction processes. On certain trials, participants were primed with a potential lie response. The results of Experiment 7 demonstrated that participants do not use these primes as their lie response any more than would be expected by chance. When the number of potential lie response options was increased however (Experiment 8), this resulted in participants using the same response as the prime to a greater degree, suggesting that the correct prime influences the lie response chosen in certain situations.

Cognitive processes when telling lies

We previously discussed a number of research studies that have suggested that telling a lie involves additional processes compared to telling the truth (Christ et al, 2009; Spence et al, 2001; Vendemia et al, 2005; Walczyk et al, 2003). This additional cognitive load results in discernible behavioural differences between liars and truth tellers, including differential brain activity patterns (Christ et al, 2009), increased speech hesitations (Vrij et al, 2008) and longer response times to questions (Walczyk et al, 2003; 2005; 2009). Although researchers have suggested potential explanations for such processing differences, including the necessity to suppress the truthful response (Spence et al, 2001) and the decision of when to lie and when to tell the truth (Walczyk et al, 2003), we were interested in disentangling the potential processes that may contribute to the cognitive difficulty associated with lying. In accordance with the current literature, we organised our experiments around three main factors: suppressing the truthful response; the decision to lie; and the construction of a lie.

Suppression of the alternative response

The nature of our experimental design meant that, in all of our response time experiments, participants were required to tell a simple lie regarding the colour of a square. It was not necessary for participants to construct a sophisticated lie response, and their lie response options were minimal (in Experiments 1 and 2, only one possible lie response was available). In all but Experiments 1 and 2, the decision process was also absent. Despite this reduction in the necessary processes required to lie, we still consistently demonstrated longer response times when individuals lied compared to when they told the truth. According to models such as the ADCM Revised (Walczyk et al, 2009), the only process left to explain longer lie response times is that the truthful response needs to be suppressed. Our experiments therefore provide direct evidence that suppression of the truthful response is a contributing factor to longer lie response times.

Although suppression processes have been traditionally associated with truthful information, it is also possible that such processes are required to suppress alternative responses in general, regardless of the honesty of information. Since uttering the truth has been suggested to be our default communicative stance (Gilbert, 1991), it is intuitive that when telling a lie, truthful information will have to be suppressed. If we are placed in a context where the relative strength of a truthful response is reduced through an increased necessity to lie, however, then the reverse may also be required, i.e., suppression of the lie response. In Experiment 6, we demonstrated that switching between telling a lie and telling the truth incurred a response time cost, and that this cost was greatest when participants switched from telling a lie to telling the truth. In accordance with task switching theorists (Allport et al, 1994; Rogers & Monsell, 1995), this greater cost is likely due to the increased cognitive effort required to reinstate the task-set associated with telling the truth. In addition to such processes, potential lie responses are also likely to require suppression. If individuals have previously lied to a question, then this task-set will remain active when faced with a second response requirement, potentially resulting in the automatic activation of possible lie responses. When individuals must then revert to responding truthfully, it will be necessary to take time to suppress this lie response, a task that will increase cognitive demand when telling the truth.

The decision to lie

Telling a spontaneous lie requires two overarching decisions: choosing to lie rather than to tell the truth, and choosing how to lie. If telling the truth is our default communicative stance, then deciding to lie in response to a question represents a departure from the normal communicative state. This departure will invoke additional processes, since an active choice to lie would be required, whereas no such choice should be required when telling the truth (Walczyk et al, 2003). In Experiments 1 and 2, we compared response times in trials in which participants chose to lie with trials in which they were directed to lie. While we found effects of deciding to lie, we discovered that there was a much greater cost to deciding to tell the truth than deciding to lie, relative to the cost of being directed in the response. Thus, the decision process does not singularly impact on lie response times. We consider therefore that it is not deciding to lie *per se* that incurs a response time cost, but instead choosing to depart from the norm for that context and the resultant suppression of the alternative response. Individuals who engage in deception and lying on a more regular basis, such as pathological liars (Yang, Raine, Lencz, Bihrle, Lacasse & Colletti, 2005), may not invoke a decision process when responding deceptively to a question. Instead, it may take them longer to respond to a question truthfully, since any natural propensity to lie must be overcome.

Our work suggests that the effect of choosing how to respond also impacts on necessary suppression processes. We found a greater response time difference between directed and choice trials when participants told the truth compared to when they lied (Experiments 1 and 2). This suggests that there is a greater processing difference between being directed to tell the truth and choosing to tell the truth, than being directed to lie and choosing to lie. This greater difference can be considered in relation to suppression processes. When participants are directed to lie, they must suppress the truthful response and produce an alternative, whereas when participants are directed to tell the truth, only truthful information should be activated and thus, no suppression of alternative responses should be required. In contrast, when participants choose to tell the truth, the evaluation of how to respond may diminish the relative strength of the default truthful state. This may lead to both potential lie responses and truth responses becoming active, with the lie response then requiring suppression. This evaluation process will have less effect on lie trials, since participants are already suppressing the alternative response type when they are directed to lie. Thus, choosing whether to lie or tell the truth was found to enhance the cognitive processes required to tell the truth, thereby diminishing the processing difference between truths and lies.

The construction of a lie

In 1997, McCornack highlighted a number of myths of deception research, one of which included the assumption that constructing a lie response is more difficult, and requires more active processing, than constructing a truthful response. Indeed, although it has been suggested that constructing a plausible and consistent lie is more cognitively demanding than telling the truth (Zuckerman et al, 1981), a comprehensive understanding regarding why, or even whether, this is the case is considerably lacking.

Lie construction processes involve the consideration of how to respond to any question, i.e., how to lie. When telling the truth, we have particular knowledge which represents our consideration of an accurate and honest response to a question. Although we can vary how we present this truthful information to others, such as the amount of detail we provide, an honest response should have basic, factual elements that remain constant with our own prior knowledge and recollection. This will provide the basis against which we will construct an honest response. When we tell a lie, however, we have more variability in the information that we can provide, with the only constraint for success being that our response is plausible to others, even if we know it to be false ourselves. This will inevitably lead to a greater choice of response options when lying than when telling the truth.

We found in Experiments 3 and 4 that having to make a choice regarding which lie to use from many, arbitrary possibilities is difficult and incurs a response time cost. When participants had a choice of multiple lie response options, compared to only one lie possibility, they took longer to respond and demonstrated a greater difference between response times for lies and truths. Even after hundreds of trials, and with only two choices, participants experienced difficulty in making an arbitrary choice when they were forced to lie. Therefore, when choosing between lie possibilities that are equally plausible, deciding which false response to use contributes to the additional processing required when telling a lie. Although it could be considered that we are often constrained by the information we use when lying, since we have to ensure that our stories remain plausible and hence go undetected, the consideration of plausibility may not be a major contributor to longer response times for lies. When we introduced a constraint on the particular lie response that participants could use, we found that lie response times were faster than when no constraint was provided and hence a decision between plausible lie responses required. This suggests that responses known to be implausible are not considered in the response decision process, but are suppressed prior to this.

The process of choosing a lie response is considered by the ADCM. In this model, possible lie responses are activated in long-term memory and implausible answers are inhibited. It is the most active lie following this process that is used in response to the question. Our experiments support the idea that implausible lies are inhibited prior to any response decision processes between plausible possibilities. How participants then choose between plausible responses, however, is unclear, with the ADCM claiming that the most active lie following the truth is ultimately used in response. This appears to suggest that an active consideration of potential alternatives is not undertaken. This possibility contrasts with our findings that lie response times increase when participants are provided with multiple responses to choose between compared to having only one response alternative, since if this were the case, we would expect no response time difference between these two conditions. Our work also shows that enhancing the relative activation level of a particular lie response does not decrease the cognitive processes involved in lie-telling (Experiments 7 and 8), since participants do not necessarily use the lie response prime as their answer even though it should be the most active response following the truth.

Limitations and future directions

The paradigm that we used appears quite different to the usual methods of investigating how people lie (e.g., Abe et al, 2007; Vrij et al, 2008). For example, participants were not asked to lie about personal information, nor was there an interlocutor present asking questions. The method we employed is a powerful technique without which we would not have been able to address the detailed processing questions discussed above. It is important, however, to consider the relationship between our task and lying outside of the laboratory.

Similar to many cognitive experiments (Johnson et al, 2005; Mameli et al, 2010; Spence et al, 2008; Vendemia et al, 2005), our paradigm did not require participants to engage in the direct deception of another individual. They were producing verbal responses recorded by a computer, and there was no human "addressee" to fool. While this procedure means that participants may have felt that the task was different to lying in everyday life, they were performing operations that must necessarily be present in even the most simple of lies independently of both the intention and motivation to deceive. What is important is that participants in our study intentionally and knowingly produced falsehoods. While there are situations in which a person can knowingly produce falsehoods without lying (e.g., when both parties are aware of the falsehood) there are very few situations when lies are produced without falsehoods (see Meibauer, 2005, for a discussion). Clearly, however, it is possible that the effects found in our experiments may interact or be overshadowed by the affective components of lying, such as guilt, stress or negative emotions in general. Future studies may be able to test these interactions by, for example, inducing negative moods in participants in the laboratory (e.g., Kirschbaum, Pirke & Hellhammer, 1993; Philippot, 1993).

Atypically for research in deception, participants in the current study had to lie when a representation of the truth was in front of them. For example, participants had to lie, "red" when the truth, a yellow square, was present on the screen (compare this with a study such as Fullam et al, 2009, in which participants are asked to lie about having performed an everyday act). One likely effect of having the visual stimulus on the screen would be to make it more difficult to suppress the truthful response when lying. This design, therefore, maximised the suppression effect so we could manipulate particular components of the lie process. Despite the likelihood of larger effects, however, there is no reason why the overall difficulty should have interacted with any of the differences found in our experiments. Both lying about a visual stimulus and lying about the content of memory involve suppression of the truthful response and the experiments reported here investigated this suppression. Furthermore, participants were not being presented with the colour name, i.e., a possible response, only a coloured square. This meant that the truthful response still needed to be recalled from memory, just as if we had asked them what they were up to the night before last.

Human ability to detect deception

In Chapters 2, 3, and 4, we supported previous findings that telling unrehearsed lies is more cognitively demanding than telling the truth. Even simple lies regarding the colour of a square require additional processing, such as the suppression of alternative responses and choosing how to lie. This increased difficulty was evidenced in observable behavioural differences of longer response times to questions. Previous work has suggested that this increased cognitive load is also reflected in a wider range of behavioural differences, including increased blink rate (Vrij et al, 2008) and increased speech disturbances (DePaulo et al, 2003). Accordingly, such behavioural differences between lies and truths may aid in the accurate detection of deception. Although human observers have been shown to identify that liars appear to be thinking harder when producing their messages (Caso et al, 2005; Vrij et al, 2010), human ability to detect deception is generally poor and thus, the second aim of this thesis was to examine whether such difficulty can be detected by human observers, and the potential factors that may affect this.

Experiments 9 and 10 examined the relationship between lie detection ability, truth bias and personality characteristics when judging individuals from the same vs. a different cultural background to the judge. Our judges demonstrated both poor discrimination accuracy between truths and lies (approximately 55%) and a truth bias, findings which are in accordance with previous deception detection research (Bond & DePaulo, 2008). Our finding that both truth bias and accuracy levels decrease when judging individuals from a different cultural background to our own (South East Asian), has only been shown in a limited number of studies examining international deception detection (Bond & DePaulo, 2000; Bond et al, 1990). Where our work surpasses previous research is in the analysis of individual differences in both the degree of truth bias demonstrated, and the relative accuracy shown, when judging individuals from different cultural groups.

Individual differences and deception detection

We have previously highlighted that the potential existence of individual differences in the ability to detect deception is an issue of contention (Aamodt & Custer, 2006; Bond & DePaulo, 2008; Bond & Uysal, 2007). While some researchers have demonstrated findings that support the supposition that some people are intrinsically better lie-detectors than others (Bond, 2008), the majority argue against such conclusions (Bond & DePaulo, 2008). A lack of research examining potential individual differences, especially the effect that they may have on wider factors relating to deception detection such as response bias, has made it difficult to draw any firm conclusions regarding this area. We found that individual differences in deception judgements exist, and that these relate to both accuracy and truth bias, when judging the statements of individuals from the same compared to a different cultural background.

In relation to the ability to detect deception, both extraversion and autism spectrum characteristics were found to be related to the discrimination of truths and lies in Experiment 9, with extraversion positively related, and autism spectrum traits negatively related, to discrimination accuracy. As discussed in Chapter 5, the decreased judgement ability of individuals high in autism spectrum characteristics may result from impairments in theory of mind capability, since such deficits impact on an individual's ability to determine the intentions of others (Baker, 2003; Baron-Cohen, 1992; Baron-Cohen et al, 1985). Since theory of mind deficits may negatively affect the formation of successful social relationships, through difficulties in understanding social reciprocity or the impact of behaviour on others (Baker, 2003), it may also lead to a reduction in general social experience. This reduced social experience contrasts with individuals who score highly in extraversion traits, since they traditionally seek out and more readily engage in social situations (Nettle, 2007). This enhanced social experience may explain the increased discrimination accuracy shown by those high in extraversion. These findings should be considered with caution however, since they failed to replicate in Experiment 10.

Individual differences and truth bias

The propensity that an individual has to consider incoming information as truthful, termed a truth bias, has also been shown to contribute to deception detection accuracy (Levine et al, 2006). The extent that people differ in this propensity has not been examined according to specific individual differences when judging deception. We found that particular individual characteristics are related to the degree of truth bias that people experience when judging potentially deceptive messages. In Experiment 9, we found a positive relationship between both emotional intelligence and extraversion, and the degree of truth bias. Although the correlation between emotional intelligence and truth bias was not replicated in Experiment 10, we were able to replicate our finding of an enhanced truth bias for those high in extraversion. Of particular interest was the fact that the enhanced truth bias shown by extraverts effectively disappeared when judging individuals from a different cultural background to their own.

If the truth bias is due to the use of intrinsic heuristic processes when judging deception (Fiske & Taylor, 2008; Kahneman & Tversky, 1972), it may be that such heuristics are only relied upon when dealing with individuals with whom we have more social experience. When judging individuals from a different cultural background to our own with whom we are less familiar, the heuristics that usually guide our credibility judgements may be overridden by more deliberate processes. Alternatively, as discussed in Chapter 5, our findings could be explained by factors relating to a generic suspicion of individuals from different cultural groups to our own, which reduces our propensity to consider them as honest. Since the typical behaviour demonstrated by South East Asian cultures, such as increased gaze aversion (Okazaki et al, 2002), reflects behaviours that people traditionally associate with deception (Global Deception Team, 2006), it may also be that our judges identified such behavioural differences and used them to guide their judgements. If this were the case, however, we would expect that not only would the relative truth bias be reduced, but that our judges would actually demonstrate a lie-bias.

Limitations and future directions

A number of further questions remain to be addressed following this study. Firstly, the further exploration of the mechanisms behind the truth bias, and the particular situations and populations in which it occurs. For example, it is important to investigate whether the relative differences in truth bias that were shown by extraverts in Experiment 10 would also be found in populations that have been found to be lie-biased, such as prisoners (Bond, Malloy, Arias, Nunn, & Thompson, 2005) and police officers (Garrido, Masip & Herrero, 2004). Indeed, if the lie bias generally shown by police officers is further enhanced when dealing with individuals from a different cultural background, then it is important to address such biases in future training programmes.

Secondly, since we only used one cultural group for our sender comparison (South East Asian), it would be pertinent to include a wider range of cultural backgrounds in future work. For example, judgement biases and accuracy may be influenced by current social stereotypes regarding particular cultural groups. Such work would not only provide further information regarding the mechanisms involved in credibility judgement biases overall, but is also of practical importance. The global nature of current society means that we interact with a large variety of cultural groups, and it is important to identify any differences that may be present in how we evaluate and judge the credibility of individuals from these different groups in both security, and wider social, settings.

Lastly, in Experiment 10 we only examined individual differences in the judgements of UK participants. To understand the effects of individual differences more fully, particularly in relation to cross-cultural judgements, it would be useful to examine the judgements of individuals from other cultural groups. Since individuals from different cultural groups have been shown to view the acceptability and motivations behind deception differently (Aune & Waters, 1994; Lewis & George, 2008; Mealy et al, 2007; Park & Ahn, 2007; Seiter et al, 2002), the mechanisms involved in the actual identification and judgement of deception may differ accordingly and would therefore be a worthy target of future research work.

Conclusions

Despite the wealth of research investigating lying in general, such as lie detection (e.g., Vrij et al, 2007), the social psychology of lying (e.g., Cole, 2001; DePaulo & Kashy, 1998) and the linguistics and philosophy of lying (e.g., Meibauer, 2005), very little work has been conducted on how we lie. The present thesis has tried to address the imbalance by investigating why people take longer to lie than to tell the truth. We come to three conclusions. First, lying involves suppressing information, primarily the truth, and suppressing or rejecting a default response will increase response time. Second, there can be costs associated with choosing to tell the truth, just as there can be with choosing to lie. We therefore maintain that the decision to depart from the normal type of communication can be costly, and while this will often be a cost associated with a decision to lie, it is not an obligatory component of lying. Lastly, lying often requires more choice in generating a response than telling the truth. There is typically only one truth but there are many possible lie options. Choosing between these additional options is a difficult job and contributes directly to the longer time needed to tell a lie.

In accordance with the difficulty that people experience when telling a lie, the present thesis has also tried to examine possible factors that impact on human ability to accurately detect this deception. From our work, we conclude that variation in deception judgements exist and that these relate to measurable individual difference characteristics, specifically extraversion, emotional intelligence and autism spectrum traits. Such variation is not restricted solely to discrimination accuracy, but also relates to the degree of truth bias that an individual experiences. Individual differences in credibility judgements were further shown to interact with wider factors, namely the cultural background of the sender. From this, we suggest that further consideration is therefore necessary regarding the interaction between personal and situational factors on accurate deception detection.

REFERENCES

Aamodt, M. G., & Custer, H. (2006). Who can best catch a liar? A meta-analysis of individual differences in detecting deception. *The Forensic Examiner, Spring,* 7-11.

Abe, N., Fujii, T., Hirayama, K., Takeda, A., Hosokai, Y., Ishioka, T., Nishio, Y., Suzuki, K., Itoyama, Y., Takahashi, S., Fukuda, H., & Mori, E. (2009). Do parkinsonian patients have trouble telling lies? The neurobiological basis of deceptive behaviour. *Brain, 132, 5,* 1386-1395.

Abe, N., Okuda, J., Suzuki, M., Sasaki, H., Matsuda, T., Mori, E., Tsukada, M., & Fujii, T. (2008). Neural correlates of true memory, false memory, and deception. *Cerebral Cortex, 18, 12,* 2811-2819.

Abe, N., Suzuki, M., Mori, E., Itoh, M., & Fujii, T. (2007). Deceiving others: Distinct neural responses of the prefrontal cortex and amygdala in simple fabrication and deception with social interactions. *Journal of Cognitive Neuroscience, 19,* 287-295.

Abe, N., Suzuki, M., Tsukiura, T., Mori, E., Yamaguchi, K., Itoh, M., & Fujii, T. (2006). Dissociable roles of prefrontal and anterior cingulate cortices in deception. *Cerebral Cortex, 16, 2,* 192-199.

Ackert, R. M., & Panter, A. T. (1988). Extraversion and the ability to decode nonverbal communication. *Personality and Individual Differences, 9, 6,* 965-972.

Akehurst, L., & Vrij, A. (1999). Creating suspects in police interviews. *Journal of Applied Social Psychology, 29,* 192-210.

Ali, M., & Levine, T. R. (2008). The language of truthful and deceptive denials and confessions. *Communication Reports*, *21*, 82-91.

Allport, G. W. (1924). The study of the undivided personality. *Journal of Abnormal and Social Psychology, 19,* 132-141.

Allport A., Styles E. A., & Hsieh S. (1994). Shifting intentional set: Exploring the dynamic control of tasks. In C. Umilta & M. Moscovitch (Eds.), *Attention and performance XV* (pp.421–452). Cambridge, MA: MIT Press.

Allport, A., & Wylie, G. (2000). Task-switching, stimulus-response bindings, and negative priming. In S. Monsell & J. S. Driver (Eds.), *Control of cognitive processes: Attention and Performance XVIII* (pp. 35-70). Cambridge, MA: MIT press.

Altmann, E. M. (2002). Functional decay of memory for tasks. *Psychological Research*, *66,* 287-297.

Ansari, T. L., Derakshan, N., & Richards, A. (2008). Effects of anxiety on task-switching: Evidence from the mixed antisaccade task. *Cognitive, Affective, and Behavioural Neuroscience, 8,* 229-238.

Appelbaum, P. S. (2007). The new lie detectors: Neuroscience, deception, and the courts. *Psychiatric Services, 58,* 460-462.

Aune, R. K., & Waters, L. L. (1994). Cultural differences in deception: Motivations to deceive in Samoans and North Americans. *International Journal of Intercultural Relations, 18, 2,* 159-172.

Baker, J. (2003). *Social Skills Training: for children and adolescents with Asperger Syndrome and Social-Communication Problems*. Mission, KS: Autism Asperger Publishing Company.

Bar-On, R. (2000). Emotional and social intelligence: Insights from the Emotional Quotient Inventory (EQ-i). In R. Bar-On, & J. D. A. Parker (Eds.), *Handbook of emotional intelligence* (pp. 363–388). San Francisco, CA: Jossey-Bass.

Baron-Cohen, S. (1989). The autistic child's theory of mind: a case of specific developmental delay. *Journal of Child Psychology and Psychiatry, 30,* 285-298.

Baron-Cohen, S. (1992). Out of sight or out of mind: another look at deception in autism. *Journal of Child Psychology and Psychiatry, 33,* 1141-1155.

Baron-Cohen, S. (2008). *Autism and Asperger Syndrome: The facts.* Oxford: Oxford University Press.

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a `theory of mind'? *Cognition, 21,* 37-46.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The Autism-Spectrum Quotient (AQ): Evidence from Asperger Syndrome/High-Functioning Autism, Males and Females, Scientists and Mathematicians. *Journal of Autism and Developmental Disorders, 31, 1,* 5-17.

Ben-Shakhar, G., & Elaad, E. (2002). The guilty knowledge test (GKT) as an application of psychophysiology : Future prospects and obstacles. In M. Kleiner (Ed.), *Handbook of polygraph testing* (pp. 87-102). San Diego, CA: Academic Press.

Ben-Shakhar, G., & Elaad, E. (2003). The validity of psychophysiological detection of information with the guilty knowledge test: A meta-analytic review. *Journal of Applied Psychology, 88,* 131-151.

Ben-Shakhar, G., & Furedy, J. J. (1990). *Theories and applications in the detection of deception.* New York: Springer-Verlag.

Bodenhausen, G. V. (1990). Stereotypes as judgemental heuristics: Evidence of circadian variations in discrimination. *Psychological Science, 1, 5,* 319-322.

Bond, G. D. (2008). Deception Detection Expertise. *Law and Human Behavior, 32,* 339-351.

Bond, C. F., & Atoum, A. O. (2000). International deception. *Personality and Social Psychology Bulletin, 26,* 385-395.

Bond, C. F., & DePaulo, B. M. (2006). Accuracy of deception judgments. *Personality and Social Psychology Review, 10,* 214-234.

Bond, C. F., & DePaulo, B. M. (2008). Individual differences in judging deception: Accuracy and bias. *Psychological Bulletin, 134, 4,* 477-492.

Bond, C. F., Kahler, K. N., & Paolicelli, L. M. (1985). The miscommunication of deception: An adaptive perspective. *Journal of Experimental Social Psychology, 21,* 331-345.

Bond, G. D., & Lee, A. Y. (2005). Language of lies in prison: linguistic classification of prisoners' truthful and deceptive natural language. *Applied Cognitive Psychology, 19, 3,* 313-329.

Bond, G., Malloy, D. M., Arias, E., Nunn, S., & Thompson, L. A. (2005). Lie-biased decision making in a prison context. *Communication Reports, 18,* 9-19.

Bond, C. F., Omar, A., Mahmoud, A., & Bonser, R. N. (1990). Lie detection across cultures. *Journal of Nonverbal Behavior, 14,* 189-205.

Bond, C. F., & Robinson, M. (1988). The evolution of deception. *Journal of Nonverbal Behavior, 12,* 295-307.

Bond, C. F., & Uysal, A. (2007). On lie detection "wizards". *Law and Human Behavior, 31, 1,* 109-115.

Bressler, S. L. (2002). Event-Related Potentials. In M. A. Arbib (Ed.), *The Handbook of Brain Theory and Neural Networks,* (pp. 412-415) MIT Press, Cambridge MA.

Briggs, S. R., Cheek, J. M., & Buss, A. H. (1980). An analysis of the Self-Monitoring Scale. *Journal of Personality and Social Psychology, 38,* 679-686.

British Psychological Society (2004). *A review of the current scientific status and fields of application of polygraphic deception detection. Final report from the BPS Working Party.* Leicester, England: British Psychological Society.

Bull, R. (1988). What is the lie-detection test? In A. Gale (Ed.), *The polygraph test: Lies, truth and science* (pp. 10-19). London: Sage.

Buller, D. B., Comstock, J., Aune, R. K., & Strzyewski, K. D. (1989). The effect of probing on deceivers and truthtellers. *Journal of Nonverbal Behavior, 13,* 155-170.

Carrión, R. E., Keenan, J. P., & Sebanz, N. (2010). A truth that's told with bad intent: An ERP study of deception. *Cognition, 114,* 105-110.

Caso, L., Gnisci, A., Vrij, A., & Mann, S. (2005). Processes underlying deception: An empirical analysis of truths and lies when manipulating the stakes. *Journal of Interviewing and Offender Profiling, 2,* 195-202.

Caso, L., Maricchiolo, F., Bonaiuto, M., Vrij, A., & Mann, S. (2006). The impact of deception and suspicion on different hand movements. *Journal of Nonverbal Behavior, 30,* 1-19.

Caso, L., Vrij, A., Mann, S., & DeLeo, G. (2006). Deceptive responses: The impact of verbal and nonverbal countermeasures. *Legal and Criminological Psychology, 11,* 99-111.

Cheng, K. H., & Broadhurst, R. G. (2005). Detection of deception: the effects of language on detection ability among Hong Kong Chinese. *Psychiatry, Psychology and Law, 12, 1,* 107-118.

Christ, S. E., Van Essen, D. C., Watson, J. M., Brubaker, L. E., & McDermott, K. B. (2009). The contributions of prefrontal cortex and executive control to deception: Evidence from activation likelihood estimate meta-analyses. *Cerebral Cortex, 19,* 1557-1566.

Clemens, F., Granhag, P.A., & Strömwall, L.A. (2011). Eliciting cues to false intent: A new application of strategic interviewing. *Law and Human Behavior, 35,* 512–522.

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

Cole, T., Leets, L., & Bradac, J. J. (2002). Deceptive message processing: The role of attachment style and verbal intimacy markers in deceptive message judgments. *Communication Studies, 53,* 74-89.

Costa, P. T., Jr., & McCrae, R. R. (1980). Still stable after all these years: Personality as a key to some issues in adulthood and old age. In P. B. Baltes & O. G. Brim, Jr. (Eds.), *Life span development and behavior* (Vol. 3, pp. 65-102). New York: Academic Press.

Cramer, R. J., Brodsky, S. L., & DeCoster, J. (2009). Expert witness confidence and juror personality: Their impact on credibility and persuasion in the courtroom. *Journal of the American Academy of Psychiatry and Law, 37,* 63-74.

Da Silva, C. S., & Leach, A. (manuscript in prep). *Detecting deception in second-language speakers.*

Darwin, C. (1872). *The expression of the emotions in man and animals.* Chicago: University of Chicago Press.

Daubert v. Merrel Dow Pharmaceuticals, Inc, 113 S. Ct. 2786, 1993.

Davis, M., Markus, K. A., Walters, S. B., Vorus, N., & Connors, B. (2005). Behavioral cues to deception vs. topic incriminating potential in criminal confessions. *Law and Human Behaviour, 29,* 683-704.

De Jong, R. (2000). An intention-activation account of residual switch costs. In S. Monsell & J. Driver (Eds.), *Control of cognitive processes: Attention and performance XVIII* (pp. 357-376). Cambridge, MA: MIT Press.

Dehaene, S., & Naccache, L. (2001). Towards a cognitive neuroscience of consciousness: basic evidence and a workspace framework. *Cognition, 79,* 1-37.

DePaulo, B. M., & Bell, K. L. (1996). Truth and investment: Lies are told to those who care. *Journal of Personality and Social Psychology, 70,* 703-716.

DePaulo, P. J., & DePaulo, B. M. (1989). Can attempted deception by salespersons and customers be detected through nonverbal behavioural cues? *Journal of Applied Social Psychology, 19,* 1552-1577.

DePaulo, B. M., Jordan, A., Irvine, A., & Laser, P. S. (1982). Age changes in the detection of deception. *Child Development, 53,* 701-709.

DePaulo, B. M., & Kashy, D. A. (1998). Everyday lies in close and casual relationships. *Journal of Personality and Social Psychology, 74,* 63-79.

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,* 979-995.

DePaulo, B. M., & Kirkendol, S. E. (1989). The motivational impairment effect in the communication of deception. In J. C. Yuille (Ed.), *Credibility assessment* (p.51-70). Dordrecht, the Netherlands: Kluwer.

DePaulo, B. M., Lindsay, J., Malone, B., Muhlenbruck, L., Charlton, K., & Cooper, H. (2003). Cues to Deception. *Psychological Bulletin, 129, 1,* 74-118.

DePaulo, B. M., & Tang, J. (1994) Social anxiety and social judgement: The example of detecting deception. *Journal of Research in Personality, 28*, 142-153.

Depue, R. A., & Collins, P. F. (1999). Neurobiology of the structure of personality: Dopamine, facilitation of incentive motivation, and extraversion. *Behavioural and Brain Sciences, 22,* 491-517.

Dionisio, D. P., Granholm, E., Hillix, W. A., & Perrine, W. F. (2001). Differentiation of deception using pupillary responses as an index of cognitive processing. *Psychophysiology, 38, 2,* 205-211.

Dixon, J. A., Mahoney, B., & Cocks, R. (2002). Accents of guilt? Effects of regional accent, 'race' and crime type on attributions of guilt. *Journal of Language and Social Psychology, 21,* 162-168.

Driskell, J. E. (2011, published online). Effectiveness of deception detection training: A meta-analysis. *Psychology, Crime, & Law*.

Duchenne, G. B. (1862/1990). *The mechanism of human facial expression.* New York: Cambridge University Press.

Duran, N. D., Dale, R., & McNamara, D. S. (2010). The action dynamics of overcoming the truth. *Psychonomic Bulletin and Review, 17,* 486-491.

Edelstein, R. S., Luten, T. L., Ekman, P., & Goodman, G. S. (2006). Detecting lies in children and adults. *Law and Human Behavior, 30,* 1-10.

Eisenberger, N. I., Lieberman, M. D., & Satpute, A. B. (2005). Personality from a controlled processing perspective: An fMRI study of neuroticism, extraversion, and self-consciousness. *Cognitive, Affective, & Behavioral Neuroscience, 5, 2,* 169-181.

Elfenbein, H. A., & Ambady, N. (2002). On the universality and cultural specificity of emotion recognition: A meta-analysis. *Psychological Bulletin, 128,* 205-235.

Ekman, P. (1972). Universal and cultural differences in facial expression of emotion. In J. R. Cole (Ed.), *Nebraska symposium on motivation, 1971* (pp. 207-283). Lincoln: Nebraska University Press.

Ekman, P. (1973). *Darwin and facial expression; A century of research in review.* New York: Academic Press.

Ekman, P. (1976). Movements with precise meanings. *Journal of Communication, 26, 3,* 14-26.

Ekman, P. (1988). Lying and nonverbal behaviour: Theoretical issues and new findings. *Journal of Nonverbal Behavior, 12,* 163-176.

Ekman, P. (1997). Deception, lying and demeanor. In *States of Mind: American and Post-Soviet Perspectives on Contemporary Issues in Psychology*. D. F. Halpern and A. E. Voiskounsky (Eds.), pp. 93-105. New York: Oxford University Press.

Ekman, P., Davidson, R. J., & Friesen, W. V. (1990). The Duchenne smile: Emotional expression and brain physiology II. *Journal of Personality and Social Psychology, 58,* 342-353.

Ekman, P., & Friesen, W. V. (1969). Nonverbal leakage and clues to deception. *Psychiatry, 32,* 88-106.

Ekman, P., & Friesen, W. (1971). Constants across culture in the face and emotion. *Journal of Personality and Social Psychology, 17,* 124-129.

Ekman, P., & Friesen, W. V. (1974). Detecting deception from body or face. *Journal of Personality and Social Psychology, 29,* 288-298.

Ekman, P., & Friesen, W. V. (1978). *Facial Action Coding System: A Technique for the Measurement of Facial Movement.* Palo Alto: Consulting Psychologists Press.

Ekman, P. & Friesen, W. V. (1982). Felt, false, and miserable smiles. *Journal of Nonverbal Behavior, 6,* 238-253.

Ekman, P., Friesen, W. V., & O'Sullivan, M. (1988). Smiles when lying. *Journal of Personality and Social Psychology, 54,* 414-420.

Ekman, P., O'Sullivan, M., & Frank, M. G. (1999). A few can catch a liar. *Psychological Science, 10,* 263-266.

Ekman, P., Roper, G., & Hager, J. C. (1980). Deliberate facial movement. *Child Development, 51,* 886-891.

Elaad, E. (2003). Effects of feedback on the overestimated capacity to detect lies and the underestimated ability to tell lies. *Applied Cognitive Psychology, 17,* 349-363.

Engelhard, I. M., Merckelbach, H., & van den Hout, M. A. (2003). The guilty knowledge test and the modified stroop task in the detection of deception: An exploratory study. *Psychological Reports, 92,* 683-691.

Ericsson, K. A., & Kintsch, W. (1995). Long-term working memory. *Psychological Review, 102,* 211-245.

Exline, R. V., Jones, P., & Maciorowski, K. (1977, August). *Race, affiliative-conflict theory and mutual visual attention during conversation.* Paper presented at the American Psychological Association Annual Convention, San Francisco.

Eysenck, H. J., & Eysenck, S. B. G. (1991). *Manual of the Eysenck Personality Scales (EPS Adult).* London: Hodder & Stoughton.

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

Farwell, L. A., & Smith, S. S. (2001). Using brain MERMER testing to detect knowledge despite efforts to conceal. *Journal of Forensic Sciences, 46,* 135-143.

Fenigstein, A., Scheier, M. F., & Buss, A. H. (1975). Public and private self-consciousness: Assessment and theory. *Journal of Consulting and Clinical Psychology, 43, 4,* 522-527.

Fiske, S.T., & Taylor, S.E. (1991). *Social cognition* (2nd ed.). New York: McGraw-Hill.

Fiske, S.T. & Taylor, S. E. (2008). *Social Cognition: From Brains to Culture*. New York: McGraw-Hill.

Forrest, J. A., Feldman, R. S., & Tyler, J. M. (2004). When accurate beliefs lead to better lie detection. *Journal of Applied Social Psychology, 34, 4,* 764-780.

Friesen, W. V. (1972). *Cultural differences in facial expressions in a social situation: An experimental test of the concept of display rules.* Unpublished doctoral dissertation, University of California, San Francisco.

Friesen, W. V., Ekman, P., & Wallbott, H. (1979). Measuring hand movements. *Journal of Nonverbal Behavior, 4,* 97-112.

Frost, P., Adie, M., Denomme, R., Lahaie, A., Sibley, A., & Smith, E. (2010). Application of the implicit association test to a study on deception. *American Journal of Psychology, 123,* 221-230.

Frueh, B. C., Elhai, J. D., Grubaugh, A. L., Monnier, J., Kasdan, T. B., Sauvageot, J. A., et al. (2005). Documented combat exposure of US veterans seeking treatment for combat-related posttraumatic stress disorder. *British Journal of Psychiatry, 186,* 467-472.

Frith, U. (1989). *Autism: explaining the enigma.* Oxford: Basil Blackwell.

Fukuda, K. (2001). Eye blinks: New indices for the detection of deception. *International Journal of Psychophysiology, 40,* 239-245.

Fullam, R. S., McKie, S., & Dolan, M. C. (2009). Psychopathic traits and deception: A functional magnetic resonance imaging study. *The British Journal of Psychiatry, 194,* 229-235.

Funder, D. C., & Harris, M. J. (1986). On the several facets of personality assessment: The case of social acuity. *Journal of Personality, 54,* 528-550.

Gamer, M., Bauermann, T., Stoeter, P., & Vossel, G. (2007). Covariations among fMRI, skin conductance, and behavioral data during processing of concealed information. *Human Brain Mapping, 28, 12,* 1287-1301.

Ganis, G., Kosslyn, S. M., Stose, S., Thompson, W. L., & Yurgelun-Todd, D. A. (2003). Neural correlates of different types of deception: An fMRI investigation. *Cerebral Cortex, 13,* 830-836.

Ganis, G., Rosenfeld, J. P., Meixner, J., Kievit, R. A., & Schendan, H. E. (2011). Lying in the scanner: covert countermeasures disrupt deception detection by functional magnetic resonance imaging. *NeuroImage, 55,* 312-319.

Garrido, E., Masip, J., & Herrero, C. (2004). Police officers, credibility judgements: Accuracy and estimated ability. *International Journal of Psychology, 39,* 254-275.

Geraerts, E., Kozaric-Kovacic, D., Merckelbach, H., Peraica, T., Jelicic, M., & Candel, I. (2009). Detecting deception of war-related posttraumatic stress disorder. *The Journal of Forensic Psychiatry and Psychology, 20,* 278-285.

Gibbs, R. W., Jr. (1980). Spilling the bean on understanding and memory for idioms in conversation. *Memory & Cognition, 8,* 449-456.

Gibbs, R. W., Jr. (1994). *The poetics of mind*. Cambridge, England: Cambridge University Press.

Gilbert, D.T. (1991). How mental systems believe. *American Psychologist, 46,* 107–119.

Gilbert, S. J., & Shallice, T. (2002). Task switching: A PDP model. *Cognitive Psychology, 44,* 297-337.

Godert, H. W., Gamer, M., Rill, H. G., & Vossel, G. (2005). Statement validity assessment: Inter-rater reliability of criteria-based content analysis in the mock-crime paradigm. *Legal and Criminological Psychology, 10,* 225-245.

Goldstein, E. R. (1923). Reaction times and the consciousness of deception. *American Journal of Psychology, 34,* 562-581.

Goleman, D. (2006). *Emotional Intelligence: Why it can matter more than IQ.* (10th Edition). New York: Bantam Books.

Granhag, P. A., & Hartwig, M. (2008). A new theoretical perspective on deception detection: On the psychology of instrumental mindreading. *Psychology, Crime & Law*, *14*, 189-200.

Granhag, P. A., & Strömwall, L.A. (2002). Repeated interrogations: Verbal and nonverbal cues to deception. *Applied Cognitive Psychology, 16,* 243-257.

Gray, J. A. (1970). The psychophysiological basis of introversion-extraversion. *Behaviour Research and Therapy, 8, 3,* 249-266.

Gray, J. A. (1981). A critique of Eysenck's theory of personality. In H. J. Eysenck (Ed.), *A Model for Personality* (pp. 246-276). New York: Springer.

Greene, J. O., O'Hair, D., Cody, M. J., & Yen, C. (1985). Planning and control of behavior during deception. *Human Communication Research, 11,* 335-364.

Greene, J. D., & Paxton, J. M. (2009). Patterns of neural activity associated with honest and dishonest moral decisions. *Proceedings of the National Academy of Sciences, 106, 30,* 12506-12511.

Gregg, A. (2007). When vying reveals lying: The Timed Antagonistic Response Alethiometer. *Applied Cognitive Psychology, 21, 5,* 621-647.

Grice, H. P. (1989). *Studies in the way of words.* Harvard University Press: Cambridge, Massachusetts.

Gronau, N., Ben-Shakhar, G., & Cohen, A. (2005). Behavioral and physiological measures in the detection of concealed information. *Journal of Applied Psychology, 90, 1,* 147-158.

Hall, E. T. (1963). A system for the notation of proxemic behaviours. *American Anthropologist, 65,* 1003-1026.

Hartwig, M., & Bond, C. F. (2011). Why do lie-catchers fail? A lens model meta-analysis of human lie judgments. *Psychological Bulletin, 137, 4,* 643-659.

Hartwig, M., Granhag, P. A., Strömwall, L., & Andersson, L. O. (2004). Suspicious minds: Criminals' ability to detect deception. *Psychology, Crime, & Law, 10,* 83-95.

Hartwig, M., Granhag, P. A., Strömwall, L., & Kronkvist, O. (2006). Strategic use of evidence during police interrogations: When training to detect deception works. *Law and Human Behavior, 30,* 603-619.

Hewes, D. E., & Planalp, S. (1987). The individual's place in communication science. In C. Berger & S. Chaffee (Eds.), *Handbook of communication science* (pp. 146-183). Beverly Hills, CA: Sage.

Hoekstra, R. A., Bartels, M., Cath, D. C., & Boomsma, D. I. (2008). Factor structure, reliability and criterion validity of the Autism-Spectrum Quotient (AQ): A study in Dutch population and patient groups. *Journal of Autism and Developmental Disorders, 38, 8,* 1555–1566.

Holden, R. R. (1998). Detecting fakers on a personnel test: Response latencies versus a standard validity scale. *Journal of Social Behavior and Personality, 13,* 387-398.

Home Office (2005). *Making provision in the Management of offenders and Sentencing Bill for the mandatory Polygraph Testing of certain Sexual Offenders.* London, England: National Probation Directorate. Retrieved May 29th 2009, from http://www.homeoffice.gov.uk/documents/ria-manage-offenders-bill-060105/ria-offender-polygraphy-060105?view=Binary

Home Office (2011). *Control of immigration: Quarterly statistical summary.* Retrieved 13th November 2011, from http://www.homeoffice.gov.uk/publications/science-research-statistics/research-statistics/immigration-asylum-research/control-immigration-q1-2011-t/

Honts, C. R. (2004). The psychophysiological detection of deception. In P. A. Granhag & L. A. Stromwall (Eds.), *Deception detection in forensic contexts* (pp. 103-123). Cambridge, England: Cambridge University Press.

Honts, C. R., Hartwig, M., Kleinman, S. M., & Meissner, C. A. (2009). *Credibility assessment at portals: Portals committee report*. Final report of the Portals Committee to the Defense Academy for Credibility Assessment / U. S. Defense Intelligence Agency.

Honts, C. R., Kircher, J. C., & Raskin, D. C. (2002). The scientific status of research on polygraph techniques: The case for polygraph tests. In D. L. Faigman, D. Kaye, M. J. Saks, & J. Sanders (Eds.), *Modern scientific evidence: The law and science of expert testimony (Volume 2)* (pp. 446-483). St Paul, MN: West Law.

Horvath, F. (1973). Verbal and nonverbal cues to truth and deception during polygraph examinations. *Journal of Police Science and Administration, 1,* 138-152.

Horvath, F., Blair, J. P., & Buckley, J. P. (2008). The behavioural analysis interview: clarifying the practice, theory and understanding of its use and effectiveness. *International Journal of Police Science and Management, 10, 1,* 101-118.

Horvath, F., Jayne, B., & Buckley, J. (1994). Differentiation of truthful and deceptive criminal suspects in behavioral analysis interviews. *Journal of Forensic Sciences, 39,* 793-807.

Hsu, L.M., Santelli, J., & Hsu, J.R. (1989). Faking detection validity and incremental validity of response latencies to MMPI Subtle and Obvious item. *Journal of Personality Assessment, 53,* 278-295.

Hurley, C. M., & Frank, M. G. (2011). Executing facial control during deception situations. *Journal of Nonverbal Behavior, 35,* 119-131.

Iacono, W. G. (2000). The detection of deception. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology, 2nd edition* (pp.772-793). Cambridge, England: Cambridge University Press.

Iacono, W. G., & Lykken, D. T. (1997). The validity of the lie detector: Two surveys of scientific opinion. *Journal of Applied Psychology, 82,* 426-433.

Ikehara, C. S., & Crosby, M. E. (2009). Detecting intentional errors using the pressures applied to a computer mouse. *HCI, 16,* 248-253.

Inbau, F. E., Reid, J. E., & Buckley, J. P. (1986). *Criminal interrogation and confessions* (3rd ed). Baltimore, MD: Williams & Wilkins.

Inbau, F. E., Reid, J. E., Buckley, J. P., & Jayne, B. C. (2001). *Criminal interrogation and confessions, fourth edition.* Gaithersburg, Maryland: Aspen.

Johnson, A. K., Barnacz, A., Constantino, P., Triano, J., Schackelford, T. K., & Keenan, J. P. (2004). Female deception detection as a function of commitment and self-awareness. *Personality and Individual Differences, 37,* 1417-1424.

Johnson Jr, R., Barnhardt, J., & Zhu, J. (2004). The contribution of executive processes to deceptive responding. *Neuropsychologia, 42,* 878-901.

Johnson Jr, R., Barnhardt, J., & Zhu, J. (2005). Differential effects of practice on the executive processes used for truthful and deceptive responses: An event-related brain potential study. *Cognitive Brain Research, 24,* 386-404.

Johnson Jr, R., Henkell, H., Simon, E. J., & Zhu, J. (2008). The self in conflict: The role of executive processes during truthful and deceptive responses about attitudes. *NeuroImage, 39,* 469-482.

Johnson, M. K., & Raye, C. L. (1981). Reality Monitoring. *Psychological Review, 88,* 67-85.

Kahneman, D., & Tversky, A. (1972). Subjective probability: A judgment of representativeness. *Cognitive Psychology, 3*, 430-454.

Kalma, A., Witte, M., & Zaalberg, R. (1996). Authenticity: operationalization, manipulation, and behavioural components: An exploration. *Medium Psychologie, 8,* 49-65.

Karim, A. A., Schneider, M., Lotze, M., Veit, R., Sauseng, P., Braun, C., & Birbaumer, N. (2010). The truth about lying: Inhibition of the anterior prefrontal cortex improves deceptive behavior. *Cerebral Cortex, 20,* 205-213.

Kassin, S. M., & Fong, C. T. (1999). "I'm innocent!": Effects of training on judgements of truth and deception in the interrogation room. *Law and Human Behavior, 23,* 499-516.

Kassin, S. M., Meissner, C. A., & Norwick, R. J. (2005). "I'd know a false confession if I saw one": A comparative study of college students and police investigators. *Law and Human Behavior, 29,* 211-227.

Kintsch, W. (1998). *Comprehension: A paradigm for cognition.* Cambridge, England: Cambridge University Press.

Kireev, M. W., Pakhomov, S. V., & Medvedev, S. V. (2008). Cerebral mechanisms of error detection during deceptive responses in the normal state and under the influence of alcohol. *Human Physiology, 34, 2,* 141-149.

Kirschbaum, C., Pirke, K. M., & Hellhammer, D. H. (1993). The Trier Social Stress Test: A tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology, 28,* 76-81.

Klaver, J. R., Lee, Z., & Hart, S. D. (2007). Psychopathy and nonverbal indicators of deception in offenders. *Law and Human Behavior, 31, 4,* 337-351.

Koechlin, E., & Hyafil, A. (2007). Anterior prefrontal function and the limits of human decision-making. *Science, 318, 5850,* 594-598.

Köhnken, G. (1989). Behavioral correlates of statement credibility: Theories, paradigms and results. In H. Wegener, F. Lösel, & J. Haisch (Eds.), *Criminal behavior and the justice system: Psychological perspectives* (pp. 271-289). New York: Springer-Verlag.

Köhnken, G., & Steller, M. (1988). The evaluation of the credibility of child witness statements in German procedural system. In G. Davies & J. Drinkwater (Eds.), *The child witness: Do the courts abuse children?* (Issues in Criminological and Legal Psychology, no. 13) (pp. 37-45). Leicester, England: British Psychological Society.

Kozaric-Kovacic, D., Bais, M., Vidosic, S., Maltic, A., Alegic, K. A., & Peraica, T. (2004). Change of diagnosis of posttraumatic stress disorder related to compensation-seeking. *Croatian Medical Journal, 45,* 427-433.

Krapohl, D, J. (2002). The polygraph in personnel screening. In M. Kleiner (Ed.), *Handbook of polygraph testing* (pp. 217-236). San Diego, CA: Academic Press.

Kraut, R. E. (1980). Humans as lie detectors: Some second thoughts. *Journal of Communication, 30,* 209-216.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2001). *International Affective Picture System (IAPS): Instruction manual and affective ratings* (Tech. Rep. No. A-5). Gainesville: The Center for Research in Psychophysiology, University of Florida.

Langleben, D. D. (2008). Detection of deception with fMRI: Are we there yet? *Legal and Criminological Psychology, 13,* 1-9.

Leach, A. M., Lindsay, R. C., Koehler, R., Beaudry, J. L., Bala, N. C., Lee, K., & Talwar, V. (2009). The reliability of lie detection performance. *Law and Human Behavior, 33, 1,* 96-109.

Leal, S., & Vrij, A. (2008). Blinking during and after lying. *Journal of Nonverbal Behavior, 32, 4,* 187-194.

Lee, T. M. C., Liu, H. L., Chan, C. C. H., Ng, Y. B., Fox, P. T., & Gao, J. H. (2005). Neural correlates of feigned memory impairment. *NeuroImage, 28,* 305-313.

Leins, D., Fisher, R. P., Vrij, A., Leal, S., & Mann, S. (2011). Using sketch drawing to induce inconsistency in liars. *Legal and Criminological Psychology, 16,* 253-265.

Lev-Ari, S., & Keysar, B. (2010). Why don't we believe non-native speakers? The influence of accent on credibility. *Journal of Experimental Social Psychology, 46,* 1093-1.

Levine, T. (2010). A few transparent liars. In C. Salmon (Ed.), *Communication Yearbook, 34* (pp. 40–61). Thousand Oaks, CA: Sage.

Levine, T. R., Feeley, T. H., McCornack, S. A., Hughes, M., & Harms, C. M. (2005). Testing the effects of nonverbal behaviour training on accuracy in deception detection with the inclusion of a bogus training control group. *Western Journal of Communication, 69,* 203-217.

Levine, T. R., Kim, R. K., Park, H. S., & Hughes, M. (2006). Deception detection accuracy is a predictable linear function of message veracity base-rate: A formal test of Park and Levine's probability model. *Communication Monographs, 73,* 243-260.

Levine, T. R., Park, H. S., & McCornack, S. A. (1999). Accuracy in detecting truths and lies: Documenting the "Veracity Effect". *Communication Monographs, 66,* 125-14.

Lewis, C. C., & George, J. F. (2008). Cross-cultural deception in social networking sites and face-to-face communication. *Computers in Human Behavior, 24, 6,* 2945-2964.

Lieberman, M. D., & Rosenthal, R. (2001). Why introverts can't always tell who likes them: Multitasking and nonverbal decoding. *Journal of Personality and Social Psychology, 80, 2,* 294-310.

Logan, G. D., & Bundesen, C. (2003). Clever homunculus: Is there an endogenous act of control in the explicit task-cuing procedure? *Journal of Experimental Psychology: Human Perception and Performance, 29*, 575-599.

Lubow, R. E., & Fein, O. (1996). Pupillary size in response to a visual guilty knowledge test: new technique for the detection of deception. *Journal of Experimental Psychology: Applied, 2,* 164-177.

Lucas, R. E., & Baird, B. M. (2004). Extraversion and emotional reactivity. *Journal of Personality and Social Psychology, 86, 3,* 473-485.

Lui, M., & Rosenfeld, J. P. (2008). Detection of deception about multiple, concealed, mock crime items, based on a spatial-temporal analysis of ERP amplitude and scalp distribution. *Psychophysiology, 45, 5,* 721-730.

Lui, M., & Rosenfeld, J. P. (2009). The application of subliminal priming in lie detection: Scenario for identification of members of a terrorist ring. *Psychophysiology, 46,* 889-903.

Lykken, D. T. (1959). The GSR in the detection of guilt. *Journal of Applied Psychology, 43,* 385-388.

Lykken, D. T. (1974). Psychology and the lie detector industry. *American Psychologist, 29,* 725-739.

Macmillan, N. A., & Creelman, C. D. (1991). *Detection theory: A user's guide*. Cambridge, England: Cambridge University Press.

Malcolm, S. R., & Keenan, J. P. (2003). My right I: Deception detection and hemispheric differences in self-awareness. *Social Behavior and Personality, 31,* 767-772.

Mameli, F., Mrakic-Sposta, S., Vergari, M., Fumagelli, M., Macis, M., Ferrucci, R., Nordio, F., Consomni, D., Sartori, G., & Priori, A. (2010). Dorsolateral prefrontal cortex specifically processes general-but not personal-knowledge deception: Multiple brain networks for lying. *Behavioural Brain Research, 211, 2,* 164-168.

Mann, S., Vrij, A., & Bull, R. (2002). Suspects, lies, and videotape: An analysis of authentic high-stakes liars. *Law and Human Behavior, 26,* 365-376.

Mann, S., Vrij, A., Fisher, R., & Robinson, M. (2007). See no lies, hear no lies: Differences in discrimination accuracy and response bias when watching or listening to police suspect interviews. *Applied Cognitive Psychology, 22,* 1062-1071.

Marston, W. M. (1920). Reaction time symptoms of deception. *Lancet, 60,* 72-87.

Marston, W. M. (1925). Negative type reaction-time symptoms of deception. *Psychological Review, 32,* 241-247.

Masip, J., Bethencourt, M., Lucas, G., Segundo, M., & Herrero, C. (2012). Deception detection from written accounts. *Scandinavian Journal of Psychology, 53,* 103-111.

Masip, J., Garrido, E., & Herrero, C. (2004). Facial appearance and impressions of credibility: The effects of facial babyishness and age on person perception. *International Journal of Psychology, 39,* 276-289.

Matsumoto, D. (2006). Culture and nonverbal behavior. In V. Manusov & M. Patterson (eds.), *Handbook of nonverbal communication* (pp. 219-235). Thousand Oaks, CA: Sage.

Mayr, U., & Keele, S. (2000). Changing internal constraints on action: The role of backward inhibition. *Journal of Experimental Psychology: General, 129,* 4-26.

Mayr, U., & Kliegl, R. (2000). Task-set switching and long-term memory retrieval. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26,* 1124-1140.

McCabe, D. P., Castel, A. D., & Rhodes, M. G. (2011). The influence of fMRI lie detection evidence on juror decision making. *Behavioral Sciences & the Law*, *29*, 566-577.

McCornack, S. A. (1997). The generation of deceptive messages: Laying the groundwork for a viable theory of interpersonal deception. In J. O. Greene (ed.), *Message production: Advances in communication theory.* (pp. 91-126). Mahway, NJ: Erlbaum.

Mealy, M., Stephan, W., & Urrutia, I. C. (2007). The acceptability of lies in the United States and Ecuador. *International Journal of Intercultural Relations, 31, 6,* 689-702.

Mehrabian, A. (1971). Nonverbal betrayal of feeling. *Journal of Experimental Research in Personality, 5,* 64-73.

Mehrabian, A. (1972). *Nonverbal Communication.* Chicago, IL: Aldine-Atherton.

Meibauer, J. (2005). Lying and falsely implicating. *Journal of Pragmatics, 37,* 1373-1399.

Meijer, E. H., Verschuere, B., Vrij, A., Merckelbach, H. L. G. J., Smulders, F. T. Y., Leal, S., et al. (2009). A call for evidence-based security tools. *Open Access Journal of Forensic Psychology, 1,* 1-14.

Meiran, N. (1996). Reconfiguration of processing mode prior to task performance. *Journal of Experimental Psychology: Learning, Memory & Cognition, 22,* 1423–1442.

Memon, A., Fraser, J., Colwell, K., Odinot, G., & Mastroberardino, S. (2010). Distinguishing truthful from invented accounts using reality monitoring criteria. *Legal & Criminological Psychology, 15,* 177-194.

Metts, S. (1989). An exploratory investigation of deception in close relationships. *Journal of Social and Personal Relationships, 6,* 159-179.

Mill, J. (1984). High and low self-monitoring individuals: Their decoding and empathic expression. *Journal of Personality, 52,* 372-388.

Monsell, S. (2003). Task switching. *Trends in Cognitive Sciences, 7, 3,* 134-140.

Morgan, C. J., LeSage, J. B., & Kosslyn, S. M. (2009). Types of deception revealed by individual differences in cognitive abilities. *Social Neuroscience, 4,* 554-569.

Morris, D., Collett, P., Marsh, P., & O'Shaughnessy, M. (1980). *Gestures: their origins and distribution.* New York: Scarborough.

Nakayama, M. (2002). Practical use of the concealed information test for criminal investigation in Japan. In M. Kleiner (Ed.). *Handbook of polygraph testing* (pp.49-86.). San Diego, CA: Academic Press.

National Research Council (2003). *The polygraph and lie detection. Committee to Review the Scientific Evidence on the Polygraph.* Washington, DC: The National Academic Press.

Nettle, D. (2007). An evolutionary approach to the extraversion continuum. *Evolution and Human Behavior, 26,* 363-373.

Newman, M. L., Pennebaker, J. W., Berry, D. S., & Richards, J. N. (2003). Lying words: Predicting deception from linguistic styles. *Personality and Social Psychology Bulletin, 29,* 665-675.

Nunez, J. M., Casey, B. J., Egner, T., Hare, T., & Hirsch, J. (2005). Intentional false responding shares neural substrates with response conflict and cognitive control. *NeuroImage, 25, 1,* 267-277.

Okazaki, S., Liu, J. F., Longworth, S. L., & Minn, J. Y. (2002). Asian american-white american differences in expressions of social anxiety: a replication and extension. *Cultural Diversity and Ethnic Minority Psychology, 8, 3,* 234-247.

Ollian, J. (2003). *Resume fraud in the corner office*. Available at http://www.smeal.psu.edu/news/latest-news/nov02/resume.html

Oorsouw, K. V., & Merckelbach, H. (2010). Detecting malingered memory problems in the civil and criminal arena. *Legal and Criminological Psychology, 15, 1,* 97-114.

Osman, M., Channon, S., & Fitzpatrick, S. (2009). Does the truth interfere with our ability to deceive? *Psychonomic Bulletin and Review, 16, 5,* 901-906.

O'Sullivan, M. (2005). Emotional intelligence and deception detection: Why most people can't "read" others, but a few can. In R. E. Riggio & R. S. Feldman (Eds.), *Applications of nonverbal communication* (pp. 215-253). Mahwah, NJ: Erlbaum.

O'Sullivan, M. (2007). Unicorns or Tiger Woods: Are lie detection experts myths or rarities? A response to on lie detection "wizards" by Bond and Uysal. *Law and Human Behavior, 31,* 117-123.

O'Sullivan, M. (2008). Home runs and humbugs: Comment on Bond and DePaulo. *Psychological Bulletin, 134, 4,* 493-497.

O'Sullivan, M., & Ekman, P. (2004). The wizards of deception detection. In P. A. Granhag & L. A. Strömwall (Eds.), *Deception detection in forensic contexts* (pp. 269-286). Cambridge, England: Cambridge University Press.

O'Sullivan, M., Ekman, P., & Friesen, W. V. (1988). The effect of comparisons on detecting deceit. *Journal of Nonverbal Behavior, 12,* 203-216.

Park, H. S., & Ahn, J. Y. (2007). Cultural differences in judgment of truthful and deceptive messages. *Western Journal of Communication, 71, 4,* 294-315.

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

Peace, K. A., Porter, S., & Almon, D. F. (2012, in press). Sidetracked by emotion: Observers' ability to discriminate genuine and fabricated sexual assault allegations. *Legal and Criminological Psychology.*

Petrides, K. V., & Furnham, A. (2006). The role of trait emotional intelligence in a gender-specific model of organizational variables. *Journal of Applied Social Psychology*, *36,* 552-569.

Phan, K. L., Magalhaes, A., Ziemlewicvz, T. J., Fitzgerald, D. A., Green, C., & Smith, W. (2005). Neural correlates of telling lies: A functional magnetic resonance imaging study at 4 Tesla. *Academic Radiology, 12,* 164-172.

Philipp, A.M., Gade M., & Koch I. (2007). Inhibitory processes in language switching? Evidence from switching language-defined response-sets. *European Journal of Cognitive Psychology, 19*, 395-416.

Philippot, P. (1993). Inducing and assessing differentiated emotion-feeling states in the laboratory. *Cognition & Emotion, 7,* 171-193.

Pollina, D. A., & Ryan, A. H. (2002). *The relationship between facial skin surface temperature reactivity and traditional polygraph measures used in the psychophysiological detection of deception: A preliminary investigation.* (Source code 437720). Fort Jackson, US: Department of Defense Polygraph Institute.

Porter, S., Camp, M. A., Stapleton, J., & Birt, A. R. (2002). The influence of judge, target, and stimulus characteristics on the accuracy of detecting deceit. *Canadian Journal of Behavioural Science, 34,* 172-185.

Porter, S., Doucette, N. L., Woodworth, M., Earle, J., & MacNeil, B. (2008). Halfe the world knows not how the other halfe lies: Investigation of verbal and non-verbal signs of deception exhibited by criminal offenders and non-offenders. *Legal and Criminological Psychology, 13,* 27-38.

Porter, S., Juodis, M., ten Brinke, L., Klein, R., & Wilson, K. (2010). Evaluation of a brief deception detection training program. *Journal of Forensic Psychiatry & Psychology, 21,* 66-76.

Porter, S., & ten Brinke, L. (2008). Reading between the lies: Identifying concealed and falsified emotions in universal facial expressions. *Psychological Science, 19,* 508-514.

Porter, S., & ten Brinke, L. (2009). Dangerous decisions: A theoretical framework for understanding how judges assess credibility in the courtroom. *Legal and Criminological Psychology, 14,* 119-134.

Porter, S., ten Brinke, L., & Wallace, B. (2012). Secrets and lies: Involuntary leakage in deceptive facial expressions as a function of emotional intensity. *Journal of Nonverbal Behavior, 36,* 23-37.

Porter, S., Woodworth, M., & Birt, A. R. (2000). Truth, lies, and videotape: An investigation of the ability of federal parole officers to detect deception. *Law and Human Behavior, 24, 6,* 643-658.

Porter, S., Woodworth, M., McCabe, S., & Peace, K. A. (2007). "Genius is 1% inspiration and 99% perspiration"...or is it? An investigation of the impact of motivation and feedback on deception detection. *Legal and Criminological Psychology, 12,* 297-310.

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind. *Behavioral and Brain Sciences, 1, 4,* 515-526.

Priori, A., Mameli, F., Cogiamanian, F., Marceglia, S., Tiriticco, M., Mrakic-Sposta, S., et al. (2008). Lie-specific involvement of dorsolateral prefrontal cortex in deception. *Cerebral Cortex, 18,* 451-455.

Pronin, E., Lin, D. Y., & Ross, L. (2002). The bias blind spot: Perceptions of bias in self versus others. *Personality and Social Psychology Bulletin, 28, 3,* 369-381.

Raskin, D. C., & Esplin, P. W. (1991). Assessment of children's statements of sexual abuse. In J. Doris (Ed.), *The suggestibility of children's statements recollections* (pp. 153-165). Washington DC: American Psychological Association.

Reber, R., & Schwarz, N. (1999). Effects of perceptual fluency on judgments of truth. *Consciousness and Cognition, 8, 3,* 338-342.

Reid, J. E. (1947). A revised questioning technique in lie detection tests. *Journal of Criminal Law, Criminology, and Police Science, 37,* 542-547.

Riggio, R. E., Tucker, J., & Throckmorton, B. (1987). Social skills and deception ability. *Personality and Social Psychology Bulletin, 13, 4,* 568-577.

Robie, C., Curtin, P. J., Foster, T. C., Phillips, H. L. I. V., Zbylut, M., & Tetrick, L. E. (2000). The effects of coaching on the utility of response latencies in detecting fakers on a personality measure. *Canadian Journal of Behavioural Science/Revue canadienne des sciences du comportement, 32, 4*, 226-233.

Robinson, W. P., Shepherd, A., & Heywood, J. (1998). Truth equivocation/concealment and lies in job applications and doctor/patient communication. *Journal of Language and Social Psychology, 17, 2,* 149-164.

Rogers R. D., & Monsell S. (1995). The cost of a predictable switch between simple cognitive tasks. *Journal of Experimental Psychology: General, 124,* 207–231.

Rosenfeld, J. P., Soskins, M., Bosh, G., & Ryan, A. (2004). Simple, effective countermeasures to P300-based tests of detection of concealed information. *Psychophysiology, 41,* 205-219.

Rossini, N. (2010). Deception cues in political speeches: Verbal and non-verbal traits of prevarication. *COST 2102 Conference 2010,* 406-418

Rothwell, J., Bandar, Z., O'Shea, J., & McLean, D. (2006). Silent Talker: A new computer-based system for the analysis of facial cues to deception. *Applied Cognitive Psychology, 20,* 757-777.

Rubenstein, J. S., Meyer, D. E., & Evans, J. E. (2001). Executive control of cognitive processes in task switching. *Journal of Experimental Psychology: Human Perception and Performance, 27,* 763-797.

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

Saxe, L. (1994). Detection of deception: Polygraph and integrity tests. *Current Directions in Psychological Science, 3,* 69-73.

Schelleman-Offermans, K., & Merckelbach, H. L. G. J. (2010). Fantasy proneness as a confounder of verbal lie detection tools. *Journal of Investigative Psychology and Offender Profiling, 7,* 247-260.

Sedivy, J. C., Tanenhaus, M. K., Chambers, C. G., & Carlson, G. N. (1999). Achieving incremental semantic interpretation through contextual representation. *Cognition, 71,* 109-147.

Seiter, J. S., Bruschke, J., & Bai, C. (2002). The acceptability of deception as a function of perceivers' culture, deceiver's intention, and deceiver-deceived relationship. *Western Journal of Communication, 66,* 158-180.

Serota, K. B., Levine, T. R., & Boster, F. J. (2010). The prevalence of lying in America: Three studies of reported deception. *Human Communication Research, 36*, 1-24.

Seymour, T. L., Seifert, C. M., Shafto, M. G., & Mossman, A. L. (2000). Using response time measures to assess 'guilty knowledge.' *Journal of Applied Psychology, 85,* 30-37.

Sip, K. E., Lynge, M., Wallentin, M., McGregor, W. B., Frith, C. D., & Roepstorff, A. (2010). The production and detection of deception in an interactive game. *Neuropsychologia, 48, 12,* 3619-3626.

Sip, K. E., Roepstorff, A., McGregor, W., & Frith, C. D. (2008). Detecting deception: the scope and limits. *Trends in Cognitive Sciences, 12, 2,* 48-53.

Sitton, S. C., & Griffin, S. T. (1981). Detection of deception from clients' eye contact patterns. *Journal of Counseling Psychology, 28,* 269-271.

Smith, P. B., & Bond, M. H. (1994). *Social psychology across cultures.* Boston: Allyn and Bacon.

Sokolov, A. N. (1963). *Perception and the conditioned reflex.* Oxford, England: Pergamon Press.

Spence, S. A., Farrow, T. F., Herford, A. E., Wilkinson, I. D., Zheng, Y., & Woodruff, P. W. (2001). Behavioral and functional anatomical correlates of deception in humans. *Neuroreport, 12,* 2849-2853.

Spence, S. A., Hunter, M. D., Farrow, T. F. D., Green, R. D., Leung, D. H., & Hughes, C. J. (2004). A cognitive neurobiological account of deception: Evidence from functional neuroimaging. *Philosophical Transactions of the Royal Society of London, 359,* 1755-1762.

Spence, S. A., Kaylor-Hughes, C., Farrow, T. F. D., & Wilkinson, I. D. (2008). Speaking of secrets and lies: The contribution of ventrolateral prefrontal cortex to vocal deception. *NeuroImage, 40,* 1411-1418.

Spinney, L. (2011). Truth or dare: How to spot a liar. *New Scientist*, 2818.

Sporer, S. L., & Schwandt, B. (2006) Paraverbal Indicators of Deception: A Meta-Analytic Synthesis. *Applied Cognitive Psychology, 20, 4,* 421-446.

Sporer, S. L., & Schwandt, B. (2007). Moderators of Nonverbal Indicators of Deception: A Meta-Analytic Synthesis. *Psychology, Public Policy and Law, 13, 1,* 1-34.

Sporer, S. L., & Sharman, S. J. (2006). Should I believe this? Reality Monitoring of accounts of self-experiences and invented recent and distant autobiographical events. *Applied Cognitive Psychology, 20,* 837-854.

Stanley, J. T., & Blanchard-Fields, F. (2008). Challenges older adults face in detecting deceit: The role of emotion recognition. *Psychology and Aging, 23, 1,* 24-32.

Stern, J. A., Walrath, L. C., & Goldstein, R. (1984). The endogenous eyeblink. *Psychophysiology, 21,* 22-33.

Strömwall, L. A., Hartwig, M., & Granhag, P.A. (2006). To act truthfully: Nonverbal behaviour and strategies during a police interrogation. *Psychology, Crime and Law, 12,* 207-219.

Tarlovsky, Y., Yechiam, E., Ofek, E., & Grunwald, A. (2008). Peripheral Arterial Tone: A Missing Channel in Polygraph Examination. *American Journal of Forensic Psychology, 26, 2,* 45-60.

ten Brinke, L., McDonald, S., Porter, S., & O'Connor, B. (2012). Crocodile Tears: Facial, verbal and body language behaviour associated with genuine and fabricated remorse. *Law and Human Behavior, 36,* 51-59.

The Global Deception Team (2006). A world of lies. *Journal of Cross-Cultural Psychology, 37,* 60-74.

Thonney, J., Kanachi, M., Sasaki, H., & Hatayama, T. (2005). Eye Blinking as a Lie – Detection Index in an Emotionally Arousing Context. *Tohoku Psychologica Folia, 64,* 58-67.

Toris, C., & DePaulo, B. M. (1984). Effects of actual deception and suspiciousness of deception on interpersonal perceptions. *Journal of Personality and Social Psychology, 47,* 1063-1073.

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,* 197-214.

Tulving, E., Schacter, D. L., & Stark, H. A. (1982). Priming effects in word fragment completion are independent of recognition memory. *Journal of Experimental Psychology: Learning, Memory and Cognition, 8, 4,* 336-342.

Tversky, A., & Kahneman, D. (1974). Judgement under uncertainty: Heuristics and biases. *Science, 185,* 1124-1134.

Tyler, J. M., Feldman, R. S., & Reichert, A. (2006). The price of deceptive behavior: Disliking and lying to people who lie to us. *Journal of Experimental Social Psychology, 42,* 69-77.

United States Government Accountability Office (2010). *Aviation Security*. Retrieved on 14th December 2011 from http://www.gao.gov/new.items/d10484t.pdf

United States Government Accountability Office (2011). *Aviation Security*. Retrieved on 14th December 2011 from http://www.gao.gov/new.items/d11740.pdf

Vandierendonck, A., Liefooghe, B., & Verbruggen, F. (2010). Task switching: Interplay of reconfiguration and interference control. *Psychological Bulletin, 136,* 601-626.

Vendemia, J. M. C., Buzan, R. F., & Green, E. P. (2005). Practice effects, workload, and reaction time in deception, *American Journal of Psychology, 118,* 413-428.

Vendemia, J. M. C., Buzan, R. F., & Simon-Dack, S. L. (2005). Reaction time of motor responses in two-stimulus paradigms involving deception and congruity with varying levels of difficulty. *Behavioural Neurology, 16,* 25-36.

Vendemia, J. M. C., Schillaci, M. J., Buzan, R. F., Green, E. P., & Meek, S. W. (2009). Alternate technologies for the detection of deception. In D. T. Wilcox (ed.), *The use of the polygraph in assessing, treating and supervising sex offenders* (pp. 267-296). West Sussex, UK: Wiley-Blackwell.

Verbruggen, F., Liefooghe, B., & Vandierendonck, A. (2006). Selective stopping in task switching: The role of response selection and response execution. *Experimental Psychology, 53,* 48-57.

Verbruggen, F., Liefooghe, B., Vandierendonck, A., & Demanet, J. (2007). Short cue presentations encourage advance task preparation: a recipe to diminish the residual switch cost. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33*, 342-356.

Verschuere, B., Crombez, G., Declercq, A., & Koster, E. (2004). Autonomic and behavioral responding to concealed information: Differentiating defensive and orienting responses. *Psychophysiology, 41,* 461-466.

Verschuere, B., Meijer, E., De Clercq, A. (2011). Concealed information under stress: A test of the orienting theory in real-life police interrogations. *Legal and Criminological Psychology, 16, 2,* 348-356.

Verschuere, B., Spruyt, A., Meijer, E. H., & Otgaar, H. (2011). The ease of lying. *Consciousness and Cognition, 20,* 908-911.

Vrij, A. (2006). Challenging interviewees during interviews: The potential effects on lie detection. *Psychology, Crime and Law, 12, 2,* 193-206.

Vrij, A. (2008). *Detecting lies and deceit: pitfalls and opportunities.* West Sussex, England: John Wiley & Sons.

Vrij, A. (2008a). Nonverbal dominance versus verbal accuracy in lie detection: A plea to change police practice. *Criminal Justice and Behaviour, 35,* 1323-1336.

Vrij, A., Akehurst, L., Soukara, S., & Bull, R. (2004). Detecting deceit via analyses of verbal and nonverbal behavior in children and adults. *Human Communication Research, 30, 1,* 8-41.

Vrij, A., & Baxter, M. (1999). Accuracy and confidence in detecting truths and lies in elaborations and denials: Truth bias, lie bias and individual differences. *Expert Evidence, 7,* 25-36.

Vrij, A., Dragt, A. W., & Koppelaar, L. (1992). Interviews with ethnic interviewees: Nonverbal communication errors in impression formation. *Journal of Community and Applied Social Psychology, 2,* 199-209.

Vrij, A., Edward, K., & Bull, R. (2001). Stereotypical verbal and nonverbal responses while deceiving others. *Personality and Social Psychology Bulletin, 27,* 899-909.

Vrij, A., Edward, K., Roberts, K. P., & Bull, R. (2000). Detecting deceit via analyses of verbal and nonverbal behavior. *Journal of Nonverbal Behavior, 24,* 239-263.

Vrij, A., Ennis, E., Farman, S., & Mann, S. (2010). People's perceptions of their truthful and deceptive interactions in daily life. *Open Access Journal of Forensic Psychology, 2,* 6-42.

Vrij, A., & Graham, S. (1997). Individual differences between liars and the ability to detect lies. *Expert Evidence, 5,* 144-148.

Vrij, A., & Granhag, P. A. (in press). Eliciting cues to deception and truth: What matters are the questions asked. *Journal of Applied Research in Memory and Cognition.*

Vrij, A., Granhag, P. A., Mann, S., & Leal, S. (2011). Outsmarting the liars: Towards a cognitive lie detection approach. *Current Directions in Psychological Science, 20,* 28-32.

Vrij, A., Harden, F., Terry, J., Edward, K., & Bull, R. (2001). The influence of personal characteristics, stakes and lie complexity on the accuracy and confidence to detect deceit. In R. Roaesch, R. R. Corrado, & R. J. Dempster (Eds.), *Psychology in the courts: International advances in knowledge* (pp. 289-304). London: Routledge.

Vrij, A., & Heaven, S. (1999). Vocal and verbal indicators of deception as a function of lie complexity. *Psychology, Crime and Law, 5,* 203-215.

Vrij, A., Leal, S., Granhag, P. A., Mann, S., Fisher, R. P., Hillman, J., & Sperry, K. (2009). Outsmarting the liars: The benefit of asking unanticipated questions. *Law and Human Behavior, 33,* 159-166.

Vrij, A., & Mann, S. (2001). Telling and detecting lies in a high-stake situation: The case of a convicted murderer. *Applied Cognitive Psychology, 15,* 187-203.

Vrij, A., Mann, S., & Fisher, R. (2006a). Information-gathering vs. accusatory interview style: Individual differences in respondents experiences. *Personality and Individual Differences, 41,* 589-599.

Vrij, A., Mann, S., & Fisher, R. (2006b). An empirical test of the Behaviour Analysis Interview. *Law and Human Behavior, 30,* 329-345.

Vrij, A., Mann, S., Fisher, R. P., Leal, S., Milne, R., & Bull, R. (2008). Increasing cognitive load to facilitate lie detection: The benefit of recalling an event in reverse order. *Law and Human Behavior, 32,* 253-265.

Vrij, A., Mann, S., Kristen, S., & Fisher, R. (2007). Cues to deception and ability to detect lies as a function of police interview styles. *Law and Human Behavior, 31,* 499-518.

Vrij, A., Semin, G. R., & Bull, R. (1996). Insight into behavior displayed during deception. *Human Communication Research, 22,* 544-562.

Vrij, A., & Winkel, F. W. (1991). Cultural patterns in Dutch and Surinam nonverbal behaviour: An analysis of simulated police/citizen encounters. *Journal of Nonverbal Behavior, 15,* 169-184.

Vrij, A., & Winkel, F. W. (1992). Cross-cultural police-citizen interactions: The influence of race, beliefs, and nonverbal communication on impression formation. *Journal of Applied Social Psychology, 22,* 1546-1559.

Vrij, A., & Winkel, F. W. (1994). Perceptual distortions in cross-cultural interrogations: The impact of skin color, accent, speech style and spoken fluency on impression formation. *Journal of Cross-Cultural Psychology, 25,* 284-296.

Walczyk, J. J., Mahoney, K. T., Doverspike, D., & Griffith-Ross, D. A. (2009). Cognitive lie detection: Response time and consistency of answers as cues to deception. *Journal of Business and Psychology, 24,* 33-49.

Walczyk, J. J., Roper, K. S., Seemann, E., & Humphrey, A. M. (2003). Cognitive mechanisms underlying lying to questions: Response time as a cue to deception. *Applied Cognitive Psychology, 17,* 755-774.

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

Warmelink, L., Vrij, A., Mann, S., Leal, S., Forrester, D., & Fisher, R. (in press). Thermal imaging as a lie detection tool at airports. *Law & Human Behavior, 35,* 40-48.

Warren, G., Schertler, E., & Bull, P. (2009). Detecting deception from emotional and unemotional cues. *Journal of Nonverbal Behavior, 33, 1,* 59-69.

Watson, O. M. (1970). *Proxemic behavior: A cross-cultural study.* The Hague, The Netherlands: Mouton.

Watson, D., & Clark, L. A. (1992). On traits and temperament: General and specific factors of emotional experience and their relation to the Five-factor Model. *Journal of Personality, 60, 2,* 441-476.

Weinberger, S. (2010). Airport security: Intent to deceive? *Nature, 465,* 412-415.

Whiten, A., & Byrne, R. W. (1997). *Machiavellian Intelligence II: Extensions and Evaluations.* Cambridge: Cambridge University Press.

Williams, E. J., Bott, L. A., Lewis, M. B., & Patrick, J. (submitted). *Telling lies: The irrepressible truth.*

Wilson, D. (2003). Intentional deception and lies. *British Journal of Forensic Practice, 5, 4,* 29-37.

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

Yang, Y., Raine, A., Lencz, T., Bihrle, S., Lacasse, L., & Colletti, P. (2005). Prefrontal white matter in pathological liars. *British Journal of Psychiatry, 187,* 320-325.

Yeung, N., & Monsell, S. (2003). The effects of recent practice on task switching. *Journal of Experimental Psychology: Human Perception and Performance*, *29*, 919-936.

Zebrowitz, L. A., Voinescu, L., & Collins, M. A. (1996). "Wide-Eyed" and "Crooked-Faced": Determinants of perceived and real honesty across the life span. *Personality and Social Psychology Bulletin, 22, 12,* 1258-1269.

Zuckerman, M., DeFrank, R. S., Hall, J. A., Larrance, D. T., & Rosenthal, R. (1979). Facial and vocal cues of deception and honesty. *Journal of Experimental Social Psychology, 15,* 378-396.

Zuckerman, M., DePaulo, B. M., & Rosenthal, R. (1981). Verbal and nonverbal communication of deception. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 14, pp. 1-59). New York, NY: Academic Press.