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An Investigation of the Factors Related to Deception Processing

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Copyright Statement

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Contents

Abstract

Models of deception processing suggest the use and manipulation of truthful and context relevant schema information to construct a lie. Debate exists, however, between a greater cognitive cost associated with lying compared to truth telling. Lying is proposed to be no more difficult than truth telling related to a path of least effort in processing, where lies are provided in contexts that truth telling would be difficult or resource demanding. Related to a working memory approach, however, lying will be more demanding than truth telling due to the additional processing steps in processing and the associated resource consumption of this. The role of additional factors upon processing is largely absent from current models despite a large body of work highlighting the impact these have. The work of this thesis investigated further into the processing of lies, their associated load, and the impact upon processing of factors of applied cognitive load and rehearsal. Facial stimuli were utilised with response time and response accuracy measured to provide a focus upon the cognitive mechanisms involved within processing as suggested in literature. Findings overall indicated a greater difficulty in the processing of lies compared to truth telling, a negative effect of applied load at the same magnitude for both truth and lie responses, a positive effect of truth rehearsal and no effect of lie rehearsal. A model of the processing of truths and lies is offered, with explanations of how each factor affects this processing expanding upon current deception processing models.

Introduction

Deception Processing

Deception is defined as an act of withholding and manipulating information with the intent to convince another that the information being provided to them is true (McCornack, Morrison, Paik, Wisner, & Zhu, 2014; Zuckerman, DePaulo, & Rosenthal, 1981). Several theoretical models of the processing of deception currently exist, suggesting the use of truthful information and manipulation of this, along with context related schema information, to construct a lie (McCornack et al., 2014; Sporer, 2016; Walczyk, Harris, Duck, & Mulay, 2014). Debate exists, however, surrounding the difficulty of lying in comparison to truth telling, with some processing models proposing the same or lower difficulty within lying as truth telling (McCornack et al., 2014; Walczyk et al., 2014) related to a path of least effort in deception processing (McCornack et al., 2014; Zipf, 2016) and incremental construction of information (Baars & Franklin, 2007; Hovy, 1990). Other models argue a greater difficulty within deception processing (Sporer, 2016) related to additional processing steps within lying consuming cognitive resources and inducing a higher cognitive load (Sweller, 1988). Such a proposal relates to the working memory model (Baddeley, 2007) where limited cognitive resources are consumed by additional tasks (Morrison, Burnham, & Morrison, 2015; Sweller, 1988) of schema recall and information manipulation not present in truth telling (Sporer, 2016).

Factors including additional applied cognitive load, such as reversed recall of events and dual tasking (Vrij, Mann, et al., 2008), and rehearsal of lie information before it is reported (Lykken, 1998) are evidenced to impact upon our ability to lie (Lykken, 1998; Vrij, Blank, & Fisher, 2018; Vrij, Fisher, Mann, & Leal, 2006; Vrij, Mann, et al., 2008; Walczyk, Igou, Dixon, & Tcholakian, 2013). A direct link of the impact of these factors upon the processing of deception is not elaborated upon within models, however, with only small predictions of the effects of some factors (Walczyk et al., 2014). Processing models can, therefore, be expanded upon through the incorporation of the predicted processing differences as a result of extraneous factors upon our ability to lie. Debate also exists as to the impact of certain factors, such as the effect of truth rehearsal upon our ability to lie (Debey, De Houwer, & Verschuere, 2014; Walczyk et al., 2014) warranting further research into these factors to establish their impact upon deception processing. This section will provide an overview of the key theories related to deception processing, as well as an explanation of factors which may impact upon this.

Four Factor Theory

One of the first influential theories of deception processing is the four factor theory (Zuckerman et al., 1981) which includes four different but related factors suggested to be present during deceptive behaviour. These factors contribute to the processing of deception and to the ability of others to detect when a lie is being told. This work defines deception as an act that is intended to convince an individual that information presented to them is true, while the sender of such information believes it to be false (Zuckerman et al., 1981). This holds the implication that the information provided does not necessarily need to be false, only that the sender of such information believes it to be false and is actively attempting to convince others that the presented information is true. Furthermore, the four factor theory only considers behaviour to be classified as deception when it is intentional, conscious and directed at another person (Siegman & Feldstein, 1985). This omits actions such as self-deception and intentionally transparent lies, such as sarcasm. This model only considers deception when information is willingly and intentionally manipulated by the sender in an effort to have the receiver believe the information presented to them is true.

The first factor related to the processing of deception described by this model is physiological arousal; the act of deception causes anxiety in the individual resulting in various behavioural cues to the deception. This anxiety and related physiological arousal is related to feelings of guilt at being deceptive or the fear of being caught when lying (Zuckerman et al., 1981). Such feelings in relation to lies do have some literature support, with self-reported feelings of anxiety in relation to a deception task and increased activation in all prefrontal cortex areas (Phan et al., 2005), a brain area related to the moderation of social behaviour and implicated within deception (Karim et al., 2010; Priori et al., 2008). Certain behavioural cues associated with the physiological arousal of lying are considered within contemporary deception detection research, such as dilation of the pupil (Walczyk et al., 2012) and an increased number of speech errors (Vrij et al., 2009). Such cues related to arousal are used as a method to detect deception (Feeley & deTurck, 1998; Vrij et al., 2006, 2009) though they do not provide detail upon how deception is processed in comparison to truth telling, only that such physiological features relate to anxiety within deception.

Anxiety in relation to the fear of being caught when lying within the physiological arousal factor (Zuckerman et al., 1981) may be an early link to a cost benefit analysis of deception that is elaborated upon in modern deception processing theories. Within such modern theories, the decision to lie is based upon the potential punishment of being truthful and the benefit of lying in comparison (McCornack et al., 2014; Walczyk et al., 2014). Anxiety related to lying within the physiological arousal factor and the fear of being caught is reflective of the punishment of being truthful combined with the additional punishment of being caught lying. This fear associated with lying then relates to the greater levels of arousal, manifesting as physiological cues to deception. The potential processing steps taken in deception are, therefore, alluded to within this first factor, but are not elaborated upon further until contemporary deception processing theory.

In relation to the first factor and the associated behavioural cues that manifest as a result of increased arousal in deception (Feeley & deTurck, 1998; Jeon & Lee, 2016; Vrij et al., 2009) is the second factor, behavioural control. Attempts made to control body language and physiological cues related to deception may result in further arousal due to the additional level of cognitive processing implemented in trying to prevent behavioural cues (Zuckerman et al., 1981) as additional tasks consume further cognitive resources (Sweller, 1988). Additionally, in an attempt to appear as believable as possible, deceivers exert greater control over processes related to their current deceptive actions. For verbal deception, this may cause information to appear to be planned or more persuasive than normal speech, providing further cues to the deception (Siegman & Feldstein, 1985). This factor, again, relates to modern literature utilising greater levels of cognitive load to increase the difficulty of processing of deception (Vrij et al., 2018, 2006). As greater behavioural control is exerted by the individual, cognitive resources are consumed, leaving fewer resources to process the deception. The consumption of these resources results in further cues to deception becoming present, or the act of deception becoming more difficult due to fewer resources remaining to process the behaviour.

The third factor, emotion, suggests that the emotional state of the individual changes during the production of deception, and that these changes can result in further behavioural cues such as minute facial expressions (Zuckerman et al., 1981). Such emotional changes are evidenced by expressions of negativity following deceptive actions, a reduction of smiling reported, though this effect was marginal, and a significant increase in negative statements provided verbally (Siegman & Feldstein, 1985). These emotional changes may relate to factors such as feelings of guilt and anxiety related to increased arousal in deception. While emotion may relate to the processing of deception, modern theory does not focus upon this as a factor, relying more upon deception as a goal-oriented behaviour to maximise gain and limit cognitive consumption (McCornack et al., 2014; Walczyk et al., 2014). Furthermore, literature investigating the brain areas involved within deception processing do not list any area involved within emotional processing as having a high level of involvement within deceptive responses (Bhatt et al., 2009; Sun, Lee, & Chan, 2015). Focus within research is oriented away from emotional control associated with lying and towards the use of response time differences (Walczyk, Roper, Seemann, & Humphrey, 2003) or other behavioural cues such as speech errors (DePaulo et al., 2003; Feeley & deTurck, 1998). These factors are considered to be more reflective of differences as a result of deception processing, and more reliable indicators of deception (Debey, Verschuere, & Crombez, 2012; DePaulo et al., 2003; Sporer & Schwandt, 2006; Vrij et al., 2009).

The final factor, thinking, suggests that liars require a greater effort in their thought process to create and produce a lie (Zuckerman et al., 1981). As with arousal, this is an early concept of deception processing which has been expanded upon greatly in more modern research, specifically work related to cognitive load (Vrij et al., 2018, 2006; Vrij, Mann, et al., 2008) and working memory (Sporer, 2016). These suggest that lying requires a greater amount of cognitive cost in its processing than truth telling due to a combined effort of retrieval of information relevant to the lie, and the processing of this information to create a lie (Debey, Liefooghe, De Houwer, & Verschuere, 2015; Sporer, 2016; Sporer & Schwandt, 2006; Suchotzki, Crombez, Smulders, Meijer, & Verschuere, 2015). Specific to the thinking stage of the four factor theory, a greater level of thinking required in deception processing can be related to the use of the working memory, and to the greater required control of action within deception (Baddeley, 2007). This in turn may be related back to the behavioural cues suggested as being associated with deception, and the consumption of cognitive resources making deception more difficult to process. Related to thinking, it is also suggested that individuals with a greater level of intelligence are better liars, those who can think quicker experience less load when lying (Vrij, Granhag, & Mann, 2010). Fewer cognitive resources are consumed within the processing of lie information in individuals of higher intelligence (Vrij et al., 2010) and so the associated demand within the thinking factor is lessened.

The thinking stage within the four factor theory (Zuckerman et al., 1981) seems to be the factor grounded to the greatest extent within modern cognitive theory associated with deception processing. Modern work on deception processing theory has expanded upon this factor with relations to cognitive load (Debey et al., 2015, 2012; Suchotzki et al., 2015) and the use of the working memory in deception processing (Sporer, 2016). While aspects of some contemporary theory can be related to other factors in this model, most can be explained through a relation to thinking associated with deception. The four factor theory provides an overview of the factors that may be related to the production of deceptive responses but lacks explanatory detail of how deception is processed in comparison to truth telling, relying upon factors that manifest behavioural cues to deception. Modern deception theory has built upon this foundation of deception processing theory, providing further detail into the reasons why an individual would lie, and how this deception is processed at the cognitive level.

Information Manipulation Theory 2

Information manipulation theory 2 (IMT2) (McCornack et al., 2014) is a theory of deception processing, concerned specifically with the production of verbal deception. This theory shares a similar definition of deception to that of the four factor theory, in that individuals covertly manipulate information with the intent of misleading listeners into believing what has been said is true. Unlike the four factor theory, this definition holds the implication that the sender knows the presented information is false, as the truthful information has been recalled and manipulated in such a way as to avoid detection and is presented to be as believable as possible.

IMT2 proposes that lying is processed based upon a system of punishment and reward, whereby the decision to lie is based upon the potential punishment of being truthful vs. the potential reward of withholding this truth and manipulating the information to create a lie (McCornack et al., 2014). Furthermore, this system follows a path of least effort (Zipf, 2016) in its processing whereby the decision to lie is also based upon which response type is the most efficient choice based upon the induced load. Should a truth invoke a high level of cognitive load, either through difficult recall or through stress associated with negative consequences, a lie is more likely to be chosen as a response due to the comparatively lesser associated load (McCornack et al., 2014). This idea of a path of least resistance in cognitive processing fits well with the propositions within the working memory model (Baddeley, 2007) where information relevant to a specific event is stored in chunks for greater ease of later retrieval.

Following the decision to lie or be truthful, a response must be constructed, and this response is constructed 'on the go' using relevant available information. Information is presented incrementally, that is to say our response, whether a truth or lie, is not entirely constructed beforehand, but is constructed during discourse as information is retrieved (Hovy, 1990; McCornack et al., 2014). As information is recalled, a decision is made whether to disclose this information or not, based upon the previously discussed punishment/reward system. If the choice is to not disclose, this information is either omitted or manipulated in the moment using the working memory to fill the gaps. Manipulated information relates to memory schemas, where information relevant to the truthful context is recalled and used to manipulate the known truth in an effort to make this as convincing as possible (McCornack et al., 2014). Through the provision of information that is strongly related to the truth, a more convincing lie can be constructed and is, therefore, more likely to achieve the perceived goal associated with being deceptive.

When applied to the working memory model (Baddeley, 2007), a lie requires use of the working memory to recall truthful information from long term memory, further use of the working memory to recall relevant schema information related to the truth, and then manipulation of this to construct a lie, all in an amount of time that would sustain discourse. Such a level of processing should entail a high amount of cognitive load, and possible behavioural or physiological cues to this load, and is acknowledged within IMT2 (McCornack et al., 2014). However, when related back to a path of least effort approach in lying, this load may not be as great as expected. It is suggested that when lying, the first available schema information will be used to construct the lie, possibly a method of creating a more convincing lie as a longer period of time before responding would indicate the presence of a lie (McCornack et al., 2014). The first available information is used in construction and so should not result in a greater load being applied to lying because time and cognitive effort and not expended in the retrieval of information (McCornack et al., 2014).

Despite the high load associated with the construction of a lie related to the associated steps in working memory processes (Baddeley, 2007; Sporer, 2016), IMT2 proposes that lying does not necessarily invoke a greater load than truth telling related to the two main reasons discussed. First, in a context where we would make the decision to lie, truth telling would be very load demanding by comparison due to the consequence associated with telling the truth (McCornack et al., 2014). While lying requires a greater effort on the part of the working memory systems to construct, the decision to lie is made based upon a path of least resistance (Zipf, 2016) and so should still be less demanding upon resources than being truthful in the same context (McCornack et al., 2014). Second, we do not fully construct our discourse before we say it, rather we construct both truth and lie responses in the moment, accessing and presenting relevant information from memory as it is communicated (Hovy, 1990). We incrementally recall information and decide whether to disclose this or not, either omitting the information or using additional information in working memory to fill in the gaps. Lying, therefore, should not induce much, if any, additional load as both truth telling and lying use the same systems within their processing, with only small changes made to recalled information (McCornack et al., 2014).

IMT2 makes several theoretical claims in relation to the processing of lies as a summary of the propositions of lie processing within the model. First, both truth and lies share the same speech production systems within their processing, with both truth and lie following the same steps, with small changes made, based upon schema information, to lies (Mohamed et al., 2006; Walczyk et al., 2014).

Second, the production of both truth and lie involves the use of parallel-distributed-processing, both truth and lie are processed together at the same time with the decision to deceive often not being made prior to the production of discourse (Baars & Franklin, 2007). As with the first claim, truth and lie are processed at the same time in the same way, with only small changes being made to construct a lie.

Third, the processing of truth and lie is related to the desire to maximise efficiency of this processing based upon information within long term and working memory (McCornack et al., 2014). Whether truth or lie information is provided is based upon an effort to reduce cognitive load and create a path of least resistance within processing, this path being based upon problem solving behaviour and ease of access to schema information in working memory. Whichever response is decided upon is likely the easiest response type to provide in that context.

Fourth, the production of truth and lie happens incrementally, with small bursts of attention as information is accessed and/or manipulated within the working memory (Baars & Franklin, 2007; Dell, Chang, & Griffin, 1999). As with the second claim, deception is not constructed beforehand with the intention of being deceptive, rather it is constructed on the go using relevant information and small bursts of attention to manipulate required information.

Fifth, modification of information during recall is normal and to be expected, changing back and forth between truth and lie and the manipulation of information mid-sentence is part of the standard deception process (McCornack et al., 2014). This is a key reason that lying should not be more load inducing than truth telling. If information manipulation is common and changing back and forth between truth and lie to be expected, then lying is unlikely to produce more load, if any, and not for a sustained length of time (McCornack et al., 2014).

Overall, IMT2 suggests that in the processing of lies, additional processing steps must be taken on the part of the working memory in order to recall truthful and schema information (Baddeley, 2007), and then manipulate this to construct a convincing lie (McCornack et al., 2014). This, however, should not result in a greater level of cognitive load than truth telling as deception is constructed on the go as part of normal discourse, sharing the same processing steps as truth telling. Additionally, lying is used in an effort to reduce the level of load induced upon the working memory, fulfilling a path of least effort in processing.

Truth Default Theory

Closely related to IMT2, the truth default theory (Levine, 2014) also proposes that deception functions upon a basis of reward/punishment, and decisions to lie are based upon goal oriented behaviour. Truth default theory suggests that individuals typically believe what they are being told is the truth, and that the majority of the time this is the case (Levine, 2014). This expectation of the truth is related to either no expectation of deception in the context of discourse, or a baseline state of acceptance related to a failure to gather a sufficient amount of information to indicate a lie was told (Levine, 2014).

In addition to typically believing what we are being told is truthful, truth default theory also suggests that what individuals say typically is truthful. Reasons for why a lie would be provided are compatible with those proposed within IMT2, we lie only in certain situations related to goal oriented behaviour, where lying is the preferable behavioural choice to avoid the potential consequences of being truthful, achieve a benefit of being deceptive, and reduce system load, or when being truthful could be considered ineffective (Levine, 2014).

This theory provides support to IMT2, and support for the use of deception as an effective behavioural strategy for personal gain. If individuals typically expect to be presented truthful information, and truthful information is presented the majority of the time, to lie without consequence is easier, reducing the risk of lying in the cost benefit analysis.

Activation Decision Construction Action Theory

The activation-decision-construction-action-theory (ADCAT) (Walczyk et al., 2014) provides a framework of the processing of deception, proposing the cognitive processing steps taken by an individual during a lie. Similar to IMT2 (McCornack et al., 2014), ADCAT suggests deception functions upon a process of cognitive economics, where reward and punishment possibilities of truth telling and lying are used within a decision making process.

Additionally, a stage of construction of the lie is suggested, where a combination of truthful and schema relevant information are used to create a lie. Specifically, ADCAT and the associated processing steps are related to 'high stakes' deception, defined within the model as lying in a social context where truth telling would be very costly to the individual in meeting their desired goals (Walczyk et al., 2014). Though meta-analysis data suggests no difference in the ability to detect high and low stakes deception (Hartwig & Bond, 2014), and so any difference in the processing of these subtypes of deception could be debated.

In line with the theoretical claims of IMT2, ADCAT proposes little to no load difference between truth and lie responses, and that contexts exist where truth telling would be comparatively high load to lying (Walczyk et al., 2014). A context in which the truth is difficult to recall, or would result in consequence if divulged would illicit a high cognitive load, and following a path of least resistance in processing (McCornack et al., 2014) will result in a higher likelihood of lying. Furthermore, this lie should have lower than or equal to cognitive load as truth telling related to the desire to reduce load in responses (Walczyk et al., 2014).

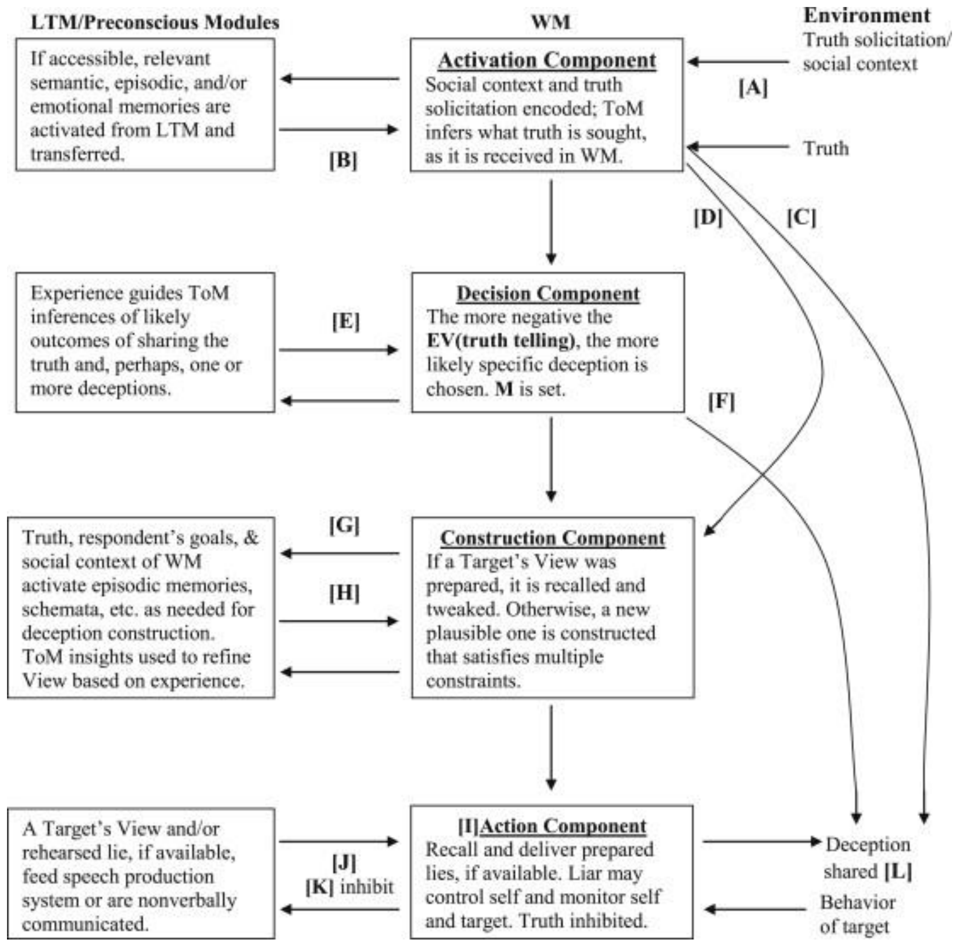

Figure 1. The flow of information and processing of the four ADCAT components, Reprinted from 'A social-cognitive framework for understanding serious lies: Activation-decision-construction-action theory' by J. J. Walczyk, L. L. Harris, T. K. Duck, and D. Mulay, 2014, New Ideas in Psychology, 34, p.22.

The information in figure 1. illustrates the processing steps involved in deception processing, and how working memory systems access and use information stored within long-term memory (Walczyk et al., 2014). The initial stage of activation in the ADCAT processing model involves the activation of truthful information, and the recall of this from long-term memory through the use of the working memory. This step is present in both truth telling and lying as information is primed to be appraised by the second step. Such a stage is supported by the working memory model (Baddeley, 2007) which states retrieval from memory requires the use of the working memory to take information from the long-term memory via the episodic buffer and to the central executive whereby it can be processed (Baddeley, 2007; Sporer, 2016). In the processing of lies, the truth must be activated, and is done so through the use of the working memory systems.

A decision is then made as to whether to be truthful or provide deception. This step, as with other models of deception processing, functions based upon a cognitive economics approach to decision making. The decision to be truthful or to lie depends upon the calculated punishment of being truthful compared to the potential reward of lying. This stage is dependent upon the recalled truthful information, as well as other recalled information relevant to the social context, which then guides the process of a cost/benefit analysis (Walczyk, Tcholakian, Newman, & Duck, 2016). Negative expectations associated with being truthful and positive expectations of lying are found to be the largest factors in making a decision to lie (Walczyk et al., 2016). As with IMT2 (McCornack et al., 2014) if within the given context lying is easier or has more potential for reward, this behaviour is more likely to occur.

Should a lie be chosen as the course of action, this must then be constructed involving the manipulation of known information. This, again, can be related to IMT2 where relevant schema information is used in order to construct a lie that would be believable in the context (McCornack et al., 2014). Again, this can be applied to the working memory model, requiring the recall of further context relevant schema information and additional manipulation of this within working memory (Baddeley, 2007; Sporer, 2016). This process is likely to use a high amount of cognitive resources to process (Walczyk et al., 2014) due to the high level of use of working memory systems within the recall and manipulation of information. Finally, action is provided, where the truth is inhibited and deceptive information provided in its place (Walczyk et al., 2014). ADCAT, therefore, assumes that truth telling and lying do not differ in their basic cognitive processing mechanics, only that lying requires an additional stage where construction must take place, and that this stage is formed based upon problem solving behaviour in an attempt to avoid the potential consequence of being truthful.

While the ADCAT model predicts that lying should not have a higher cognitive cost than truth telling (Walczyk et al., 2014), research evidence does suggest that both the decision process involved within lying, and the construction of a lie add significant amounts to the average response time of lies (Walczyk et al., 2003). When applying the ADCAT processing steps to the working memory model, the reasons for this increase in response time become clear. Within the activation stage, working memory resources are used to recall truthful information (Baddeley, 2007; Sporer, 2016). The level of resources is the same for both truth and lie responses as a decision of whether or not to lie has yet to be made, assuming we lie on the go (McCornack et al., 2014) after appraisal of the information in a decision making stage (Walczyk et al., 2014). The decision stage of processing then adds additional load, as the working memory is once again used within the decision-making process. For truthful responses, this decision appears to be an easy process requiring little load as decision does not add to the average response time of truth (Walczyk et al., 2003), while for lies more load is required, represented by an increase in response times (Walczyk et al., 2003). A greater level of load appears to be present during the decision stage if a lie response is chosen. Further load is then added to lie responses during the construction stage as schema information is recalled and manipulated within the working memory (Sporer, 2016). As with the decision stage, an increase in response time is representative of the additional load incurred (Walczyk et al., 2003). This additional load at construction should not be present within truth telling as no further recall, or manipulation, of information is required in truthful responses. Following the ADCAT processing steps and related working memory processes involved within each step, it seems to be the case that lying would incur a much higher cognitive cost than truth telling, though the model itself states that this is not the case (Walczyk et al., 2014).

Overall, the ADCAT processing stages seem unclear about a greater difficulty in the processing of lies compared to truth. The model considers that lying should be no more difficult than truth telling, and that in certain contexts truth telling would be more load demanding than lying (Walczyk et al., 2014). These assumptions can be related to the theoretical claims in IMT2 (McCornack et al., 2014) where truth and lie share the same processing systems, and lying occurs in contexts that truth would have a high associated cognitive cost. At the same time, the model predicts processing steps involved in lying that are not present in truth telling which when applied to models of working memory processes would predict a much higher associated cognitive load from lying (Baddeley, 2007; Morrison et al., 2015; Sweller, 1988). Research also provides evidence of the cumulative effect present upon response time of applying a decision and construction stage to lie processing (Walczyk et al., 2003) that does not affect truth telling. While this does not refute the claim that lying should be no more demanding than truth telling, when considering the working memory model, the associated load of truth telling would have to be very large indeed for the additional processing steps of decision and construction within lying to be the path of least resistance in cognitive processing.

Two-Step Processing

A commonality shared amongst deception processing theory is the notion of a first step of truth recall in deceptive responses, whereby the truthful information must be known and recalled before a deceptive response can be provided in its place. This is seen within ADCAT (Walczyk et al., 2014) as the activation stage of processing where truthful information is retrieved from long term memory through use of the working memory, and in IMT2 (McCornack et al., 2014) as the recall and manipulation of known information on the go with the intent to deceive. Research evidence also supports the existence of a first step of truth recall, as when truthful distractors are placed at the point of recall when a deceptive response was to be expected, lie responses were facilitated in their response time in comparison to an irrelevant distractor (Debey et al., 2014). The placement of the truthful distractor primed the first step of truth recall within lie responses, making lying easier as a result (Debey et al., 2014). When applied to the ADCAT model (Walczyk et al., 2014), it can be inferred that the presence of the truthful information at the point of response allows for the activation stage to be fulfilled without consuming cognitive resources to recall this information from long-term memory as the required information is already provided. This allows the following processes of decision and construction to occur without the recall of truth adding to the processing time of the lie.

Evidence of a first step of truth recall within lying is also provided via neurological research. Data indicates brain activity in relation to the recognition of stimuli during processing 270ms after presentation, followed by further activation, between 300-1000ms after presentation, related to the frontal cortices and premotor cortex areas after stimuli recognition (Sun et al., 2015). This activity is proposed as being representative of the initial activation of truthful information, followed by the manipulation of this to construct a lie response (Sun et al., 2015) providing support to both ADCAT and IMT2 processing models. Different fMRI activations are documented for truth and lie responses though (Sun et al., 2015; Sun, Lee, Wang, & Chan, 2016), suggesting differences in the way in which each response type is processed while processing theory proposes the same steps for both truth and lie (McCornack et al., 2014; Walczyk et al., 2014). Neurological evidence suggests that these two response types begin their processing in the same way with an activation of truthful information, though differences in processing may be present following this initial step (Sun et al., 2015, 2016).

Other Factors in Deception Processing

Several other factors related to deception are investigated within literature, but do not have an explicit link to the discussed processing theories. Factors such as motivation to lie may be related to a cost/benefit analysis in deception processing, as a greater motivation to deceive an individual would indicate a greater reward for being deceptive and a greater punishment for being truthful. Two arguments are made towards the effect of motivation upon lie processing: the motivational effort hypothesis, whereby the motivation to lie increases effort and improves task performance (Horvath, Jayne, & Buckley, 1994) and the motivational impairment hypothesis, whereby a greater motivation to deceive may have the paradoxical effect of being detrimental to lying (DePaulo, Kirkendol, Tang, & O'Brien, 1988). Meta-analysis data upon the effects of motivation on lie processing conclude either a negative effect of motivation (DePaulo et al., 2003) or no difference between high and low motivation deception (Hartwig & Bond, 2014; Kleinberg & Verschuere, 2016).

This effect of motivation may be a saliency effect (Kleinberg & Verschuere, 2016) whereby the more meaningful the lie is to an individual, the harder this would make it to lie about. Motivation increases the saliency of the lie information, and has at best no effect upon ability to lie (Hartwig & Bond, 2014; Kleinberg & Verschuere, 2016) and at worst a negative effect upon ability to lie (DePaulo et al., 2003). A negative effect of saliency of lie information is also evidenced, as the more important this was to an individual, in this case favourite colour (low) vs. name (high), the harder it was to lie about (Verschuere, Kleinberg, & Theocharidou, 2015). When related to cognitive processing theory, it may be suggested that information saliency induces a greater cognitive load during lie processing, or a greater difficulty in the suppression of the truth due to its high importance. This, therefore, results in a more difficult to process deceptive response during high motivation or high saliency lies.

Instructed and Spontaneous Deception

An important distinction to make within deception processing research is the difference between instructed and spontaneous deception, with instructed lies being told by participants of research who are asked to lie, while spontaneous lies are told willingly and out of choice by individuals. Spontaneous deception is more difficult to control in a research setting and is the more likely version of real-life deception where individuals choose whether to tell the truth or provide a lie. Neurological research provides evidence of differences in activation across several brain areas between instructed and spontaneous deception (Yin, Reuter, & Weber, 2016). Furthermore, truth activation patterns elicited differences in activity for each type of lie (Yin et al., 2016) suggesting activity differences at the very first step of deception processing depending on the type of lie provided. Additional research highlights a difference in alpha frequency between truth and spontaneous lie responses that is not present between truth and instructed lie responses (Kim, Jung, & Lee, 2012) suggesting a higher associated cognitive load for spontaneous lies that instructed lies do not possess. Research also highlights basic behavioural differences between instructed and spontaneous lie responses, with fewer speech errors, hesitations and gaze avoidance within spontaneous lies compared to instructed lies (Feeley & deTurck, 1998).

These differences between lie types may be explained by the decision stage of deception processing. When a lie is instructed, a decision is not required, and so a cost/benefit analysis of whether to lie or not may not take place. This likely reduces the overall level of associated load within instructed lies as a processing step required within spontaneous lies is now absent (McCornack et al., 2014; Walczyk et al., 2014) eliminating the load associated with this step (Walczyk et al., 2003). While the other stages of activation and construction should remain present in instructed lies, it is important that research is clear as to which type of lie is being investigated, as clear differences between instructed and spontaneous lies are present (Yin et al., 2016) and such differences may be reflected within processing models.

Next Steps in Deception Processing

Much of the literature on deception, including the processing models themselves, are focused upon the ability to detect deception, generally using interview methodologies as their theoretical support and focus. This is understandable, as realistically most lies are presented verbally and spontaneously constructed on the go (McCornack et al., 2014) or constructed beforehand to be presented in an interview (Lykken, 1998). Literature suggests, however, that theoretical analysis of the processing of deception take place outside of an interview design (Blandón-Gitlin et al., 2014; Sporer, 2016) to provide further detail as to how we process deception. Experimentation within a different context of lying than verbally or in an interview will allow aspects of deception theory to be tested, either adding strength to their theoretical claims, or suggesting areas of refinement.

Cognitive Load in Deception

Deception processing theory remains divided as to the role of cognitive load within the processing of lies, with suggestions of both the induction of additional cognitive load when lying (Debey et al., 2014, 2012; Suchotzki et al., 2015), and no greater cognitive demand from lying than truth telling (DePaulo et al., 2003; McCornack et al., 2014; Walczyk et al., 2014). Both of these propositions can be explained through relation to the working memory model (Baddeley, 2007); lying will induce additional load through the use of additional steps in its processing (McCornack et al., 2014; Walczyk et al., 2014), involving the retrieval and manipulation of information (McCornack et al., 2014), as well as the construction of new information (Walczyk et al., 2014). A greater load in lying may not be the case though, if truth telling in the context would be highly load inducing (McCornack et al., 2014; Walczyk et al., 2014) and a path of least resistance is taken within cognitive processing of the response (McCornack et al., 2014). As can be seen, both IMT2 and ADCAT models can be used as support to both possibilities, though both models predict no difference in cognitive load within deception processing.

Despite the uncertainty of the differences within cognitive load in deception processing theory, a great deal of research evidence exists indicating a greater cognitive cost associated with lying compared to truth telling. A possible explanation of a greater cognitive cost of lying may be a lesser memory retrieval ability during high load tasks as a result of fewer cognitive resources being available (Barrouillet, Bernardin, Portrat, Vergauwe, & Camos, 2007). When applied to deception processing models, less memory retrieval ability creates a greater difficulty in the first step of truth recall (Debey et al., 2014; Walczyk et al., 2014) as well as the retrieval of further information required in the construction of a lie (McCornack et al., 2014; Walczyk et al., 2014), which in turn creates an overall greater load in lying, should lying be a more demanding cognitive task than truth telling. This greater cost of lying is documented through slower response times and lower response accuracy within lies (Debey et al., 2015; Suchotzki et al., 2015), greater complexity associated with lie responses (Duran, Dale, & McNamara, 2010), a greater level of executive control required when lying (Bhatt et al., 2009; Debey et al., 2012), and differences in brain activity related to deception (Bhatt et al., 2009; Chun et al., 2014; Suchotzki et al., 2015). All of these factors are suggested as being related to a greater level of cognitive cost associated with lying and are representative of a greater amount of effort required to process lie responses as compared to truth responses.

Research evidence also points towards the proposition that lying does not require a greater cognitive cost than truth telling. As previously explained, this can be related to the similarity in processing of truth and lie (Walczyk, 2014), a path of least effort approach to the processing of truth and lies (McCornack et al., 2014) and the routine practice of lie behaviour making it easy to process (DePaulo et al., 2003). Some EEG evidence also provides evidence of no greater cognitive cost associated with lying (Panasiti et al., 2014) despite a decreased motor readiness in lying associated with facing a moral dilemma, possibly related to a decision stage of deception processing. Other EEG data illustrates that a difference in the associated load of truth telling and lying is evident, however, (Sun et al., 2015, 2016).

Application of Cognitive Load

While the cognitive load associated with deception processing remains a matter of debate between deception theory and processing research, literature provides evidence of the use of cognitive load application as a method of enhancing deception detection ability. While this thesis is not specifically concerned with methods of deception detection, such methods are telling of the underlying processing related to deception through the proposition that application of cognitive load builds upon an already loaded process (Vrij et al., 2018, 2006). If lie processing is a high load process, in comparison to truth telling, and so is more difficult than truth telling (Debey et al., 2012; Suchotzki et al., 2015), application of further load will make this behaviour still more difficult resulting in an improvement of the ability to detect lies (Vrij et al., 2018). Research into the use of cognitive load as a deception detection method, therefore, provides further support of a greater level of cognitive load associated with lying, and a greater difficulty in the processing of lies in comparison to truth telling.

To elaborate, application of load during truth and lie responses consumes cognitive resources that would be required for the processing of this response (Baddeley, 2007) therefore making this response more difficult to process (Craik, Eftekhari, & Binns, 2018; Morrison et al., 2015; Sweller, 1988). Related to the four factor theory (Zuckerman et al., 1981) less resources would then be left to control for behavioural cues to deception and as a result, deception becomes easier to detect when a high load is placed upon the individual. The applied load would, however, affect both truth and lie responses, as fewer cognitive resources are left to process both response types, making both more difficult to process (Sweller, 1988). If lying requires a greater amount of cognitive resources than truth telling at its baseline level, lies should be affected to a greater extent than truth by the application of more load (Vrij et al., 2006; Vrij, Mann, et al., 2008), as a greater amount of cognitive resources are consumed in this response type than truth telling.

While such research does suggest a higher level of cognitive load within the processing of lies related to a greater effect of applied load upon lie responses than truth telling, alternate explanations of such findings are offered. For example, reverse order recall is a commonly used load inducing method within verbal deception which claims to increase the ability to detect deception (Vrij, Mann, et al., 2008). Considering the effect of cognitive load application, the reverse order recall applies more load upon the recall of required information, making the associated processing more difficult (Morrison et al., 2015; Sweller, 1988). If lying is already higher in its load demand than truth telling (Debey et al., 2012; Suchotzki et al., 2015), applied load will impact lie responses to a greater extent than truth responses (Vrij et al., 2006; Vrij, Mann, et al., 2008). Evidence suggests, however, that such techniques naturally incur a greater number of errors (Dando, Ormerod, Wilcock, & Milne, 2011; Sporer, 2016) which may not be related to the processing of lies. It is possible, therefore, that load inducing techniques are related to extraneous cognitive factors, and not to an application of additional load upon lie processing.

Cognitive Load in Lie Detection

Multiple questioning methods and behavioural cues are related to deception detection, and such methods and cues can be applied to deception processing theory to provide further detail of the processing involved within deception. Methods of intrinsic and extraneous load application techniques are identified as making the detection of deception easier through a higher associated cognitive load within lying (Walczyk, Igou, Dixon, & Tcholakian, 2013). Intrinsic cognitive load is the load already associated with the task and ability to lie, such as the maintenance of attention and use of working memory resources (van Merriënboer & Sweller, 2005; Walczyk et al., 2013). The application of further intrinsic load involves the use of surprising test items, such as a fast response requirement, inducing a higher load as memories must be accessed and information manipulated quickly (Walczyk et al., 2013). Application of this type of cognitive load results in deception being easier to detect as the associated processing steps of recall and information manipulation (McCornack et al., 2014; Walczyk, 2014) are placed under additional strain.

Extraneous cognitive load relates to any external factors which result in the consumption of cognitive resources, making lying more difficult (van Merriënboer & Sweller, 2005; Walczyk et al., 2013). Application of extraneous load may include methods such as dual tasking, where further resources are required to achieve both tasks (Walczyk et al., 2013). Application of this type of cognitive load results in deception being easier to detect via the consumption of further cognitive resources, applying additional cognitive load to an already loaded process (Vrij et al., 2018, 2006). Resources are consumed in resolving the demand of the extraneous factors, leaving fewer resources to process the deception. Each of these techniques have advantages in the detection of deception, and it is suggested that application of both techniques gains the advantages of each (Walczyk et al., 2013). Methods of applying additional load to the processing of lies appear to create greater difficulty in the processing of lies, by both making the existing processing steps more difficult and through the consumption of cognitive resources (Sweller, 1988).

Other methods of questioning are also shown to provide a benefit to lie detection ability due to the impact they have on lie processing. Open ended questions are found to facilitate lie detection, with a higher rate of gaze avoidance and lower GSR levels in comparison to truthful responses to the same questions (Jeon & Lee, 2016). It is suggested that open ended questions create a higher cognitive load in processing (Jeon & Lee, 2016), and as with other methods of inducing cognitive load, this facilitates the ability to detect deception due to the greater consumption of cognitive resources (Sweller, 1988) and so greater difficulty in the processing of the deceptive responses is evidenced. Reverse order recall is also proposed as a load inducing technique which enhances deception detection ability through making the processing of deception more difficult (Vrij, Mann, et al., 2008), though as previously discussed, such a technique may naturally create a greater number of errors which are unrelated to lie processing (Dando et al., 2011; Sporer, 2016).

The application of pressure in an interview context is also proposed as a method by which lie detection can be facilitated (ten Brinke, Khambatta, & Carney, 2015). Factors such as sterile environments are suggested to increase feelings of powerlessness and discomfort, making it more difficult to lie (ten Brinke et al., 2015). Such a method is argued against, however, with a distinction drawn between application of additional cognitive load and an application of pressure (Verschuere, Meijer, & Vrij, 2016). Application of additional load in questioning impacts the processing of deception, as cognitive resources are consumed increasing the difficulty of lie processing (Morrison et al., 2015; Sweller, 1988); application of pressure does not achieve the same effect and should have little to no impact upon the cognitive processing of the lie (Verschuere et al., 2016). Research evidence finds that making people feel powerless is not an effective method of impacting deception processing, while application of additional load is due to the effect application of load has upon the processing of lies (Verschuere et al., 2016).

Behavioural Cues of Deception

Deception literature lists a wide variety of potential behavioural cues to deception including pitch of speech, number of errors and response latency (Sporer & Schwandt, 2006). These cues are proposed as being related to cognitive processing, emotional control and physiological arousal (Zuckerman et al., 1981). It is acknowledged that no single behavioural cue is related specifically to deception though, and alternative explanations of each response are possible (DePaulo et al., 2003). Differences in the details of reported events are present within lies, with the reporting of fewer details when lying being a reliable indicator (DePaulo et al., 2003; Gawrylowicz et al., 2016). When applied to deception processing theory, the reporting of fewer details may be related to creating a path of least resistance when lying, reporting the first schema information that comes to mind (McCornack et al., 2014). A greater number of speech errors are also reported in deceptive responses, with pitch of speech, number of errors, and response latency all occurring more frequently in deception (Sporer & Schwandt, 2006). Again, it is proposed that these cues are related to greater cognitive load associated with the processing of lie responses (Vrij, Mann, et al., 2008), as a greater number of resources are required for the recall of schema information held in long term memory (Baddeley, 2007) within the construction of a lie (Sporer, 2016).

In consideration of the reporting of details when lying, liars are found to be less consistent in their responses than truth tellers, suggesting a lower level of cognitive flexibility within this response type (Leins, Fisher, & Vrij, 2012). Lack of consistency provides support for deception processing theory, where schema information is required to be recalled to aid in the construction of a lie (McCornack et al., 2014; Walczyk et al., 2014). Inconsistencies within the recalled schema information may lead to inconsistencies with the constructed deception, as slightly different information packages are used in order to construct this, especially if the first available information that comes to mind is used (McCornack et al., 2014). Conflicting evidence suggests, however, that liars are in fact more consistent in their responses, specifically multiple liars, due to the ability to consolidate and rehearse the lie (Granhag, Strömwall, & Jonsson, 2003; Vrij et al., 2009). Liars pre-emptively construct their response and rehearse this, resulting in a greater level of consistency than truth tellers (Granhag et al., 2003; Vrij et al., 2009), related to the goal oriented desire of lying to convince others that the provided information is true (McCornack et al., 2014; Walczyk et al., 2014).

It is widely acknowledged that many of the behavioural cues associated with deception may be related to other factors, such as anxiety in relation to the situation (DePaulo et al., 2003), and methods by which these factors can be differentiated are needed. In response to this, the strategic use of evidence technique was outlined (Vrij & Granhag, 2012), which suggests that the way in which questions are asked, and when certain information is disclosed to individuals, can aid in identifying which cues are related specifically to deception. Truth tellers are typically more open about information while liars are avoidant (Vrij & Granhag, 2012) and probing further or disclosing additional information during an interview elicits a higher load resulting in deception being more difficult to process. Related to processing theory, truth tellers are more open in their responses as information only needs to be recalled and provided (Walczyk et al., 2014), probing further in truth telling will then only require further recall of remembered information. Liars are typically avoidant (Vrij & Granhag, 2012) as each probing question requires effort on the part of the working memory to recall relevant information and manipulate this to create a lie (McCornack et al., 2014; Walczyk et al., 2014), as well as the maintenance of consistency in response, requiring further effort (McCornack et al., 2014). Probing for further information will, therefore, elicit a greater load in processing lies, hence the avoidant nature of providing further information. Additionally, the more lie information that is divulged, the greater the chance of inconsistency in response and the detection of this.

As previously explained, the processing steps involved within deception are likely to lead to longer response times in the processing of lies compared to truth (Walczyk et al., 2003). This can be related to additional processing steps required in the production of lies (Walczyk et al., 2014) and to a greater effort on the part of the working memory in the recall and manipulation of information (Sporer, 2016). This difference as a result of processing has led to the use of response time analysis within the detection of deception with models such as Tri-Con (Walczyk et al., 2005). However, other research suggests no difference in response time between truth and lie, while neurological differences between response types are evidenced (Bhatt et al., 2009).

Overall, in the investigation of multiples cues to deception, response time analysis is found to be the most consistent measure of deception (Walczyk et al., 2012). This may be related to additional processing steps within lying (McCornack et al., 2014; Walczyk et al., 2014) and a greater amount of cognitive effort required to process lie responses (Debey et al., 2015, 2012; Suchotzki et al., 2015; Vrij et al., 2018, 2006). No difference, however, is reported in response time analysis between rehearsed lies and truth (Walczyk et al., 2012), possibly related to only having to recall the rehearsed lie in the same way truth would be recalled, therefore lacking the additional stages hence no difference in response time, and supporting the claim that the additional stages in processing result in a greater response time within lies.

Working Memory Model of Deception Processing

The working memory model of deception processing (Sporer, 2016) expands upon a cognitive load approach to deception processing by applying the working memory, long-term memory and action to be linked together, whereby deception relies upon the working memory for recall of known information, schema information and the provision of a response (Baddeley, 2007; Sporer, 2016). Use of the working memory in the recall and manipulation of required information is similar to the stages proposed within IMT2

(McCornack et al., 2014) and ADCAT (Walczyk et al., 2014), with the ADCAT processing stages specifically related to working memory processes. Unlike these models, however, the working memory model suggests that this processing procedure will tax the working memory systems, making lying more difficult to process than truth telling (Sporer, 2016).

Working memory is strongly related to the ability to maintain attention to goal oriented behaviour (Shipstead, Redick, & Engle, 2012), and with the clear links provided to goal oriented behaviour outlined within deception processing theory (Levine, 2014; McCornack et al., 2014; Walczyk et al., 2014) the role of the working memory within deception processing is also made clear. The claim is also made that working memory lacks a specific capacity, and that the amount of information that can be stored in it is related to the amount of attention paid to the information (Emrich, Lockhart, & Al-Aidroos, 2017). When applied to deception processing, the more attention that is paid to the lie information, the easier it should be to process (Jehee, Brady, & Tong, 2011), evidence of which can be seen in experiments applying cognitive load (Vrij, Mann, et al., 2008). Applied load divides the attention of the working memory, resulting in fewer resources dedicated to the processing of a lie.

Individuals with a higher level of executive functioning ability are found to produce more sophisticated lies (Evans & Lee, 2011). Additionally, individuals who performed better at a verbal working memory task are found to be better verbal liars, with no difference reported upon a visuo-spatial task (Alloway, McCallum, Alloway, & Hoicka, 2015). These results suggest the benefit of better working memory, and the role this system plays, within the production of deception.

Overall, the working memory seems to play an important role within the processing of deception, related to the recall of truth and schema information, as well as the manipulation of this information to construct a lie (Baddeley, 2007; Sporer, 2016). Whether this additional processing leads to a greater difficulty in the production of lies is, however, a matter of debate within deception processing theory. Both IMT2 and ADCAT state that this should not create greater difficulty due to a path of least resistance in processing to avoid a high load associated with truth telling (McCornack et al., 2014; Walczyk et al., 2014) and the routine practice of deception (DePaulo et al., 2003). The working memory model (Sporer, 2016) and a large body of research evidence (Debey et al., 2015, 2012; Suchotzki et al., 2015; Vrij et al., 2018, 2006) suggest that lying does in fact entail a greater effort within its processing, and this can be linked to the extra processing steps involved within the working memory.

Further investigation into the associated load of deception processing is, therefore, important to establish. The work of this thesis aims to provide this information, and investigate into the debate established within deception literature between a higher associated load within deception processing (Debey et al., 2015, 2012; Sporer, 2016; Suchotzki et al., 2015; Vrij et al., 2018, 2006) and equal to or lesser than truthful load within lying (DePaulo et al., 2003; McCornack et al., 2014; Walczyk et al., 2014).

Rehearsal and Memory

Within interview research upon deception, the ability to rehearse the deceptive information before it is provided is acknowledged as a possibility, with rehearsal claimed as being a frequently used behaviour when lying (Vrij et al., 2009). The act of rehearsal has the potential of skipping the construction stage of deception processing as a response is provided by performing this step before provision of a response, meaning that only the deceptive information needs to be recalled. Rehearsal of a lie is used as a load reducing technique to make lying easier (Lykken, 1998). If a lie is constructed beforehand, memorised, and rehearsed, any load inducing cognitive processing associated with recall of information and manipulation of this information does not have to take place when a lie is provided. This can be countered, however, through the use of unexpected questions which are unlikely to have been rehearsed and will therefore still incur additional cognitive processes (Vrij et al., 2009).

A distinct difference is presented between rehearsed and unrehearsed lies within literature, with no difference in response time compared to truth for rehearsed lies (Walczyk et al., 2012), suggesting the lack of a construction stage, with rehearsed lies requiring only the recall of information. Rehearsal is also found to reduce or eliminate behavioural cues related to deception, suggesting the reduction of associated cognitive load with deception processing (Foerster, Wirth, Herbort, Kunde, & Pfister, 2017). Again, this can be related to the construction stage of deception processing being skipped during questioning as this stage has taken place beforehand, and only the rehearsed information needs to be recalled. Due to the possibility of potential differences in processing caused by the rehearsal of information, rehearsal is a factor that needs to be controlled for within deception research and the effects upon the processing of truths and lies applied to deception processing models. Such an investigation of the effect of rehearsal upon the processing of truth and lie responses will be addressed within this thesis with suggestions of differences in truth and lie processing offered and applied to processing models.

Warrington & Weiskrantz, (1968, 1970) identify two separate types of memory, implicit memory which is procedural and related to automatic, unconscious, retrieval of information on how to complete a task, and explicit memory which is declarative, related to factual knowledge, requiring a conscious recall of encoded information (Rovee-Collier, Hayne, & Colombo, 2000). These two systems are distinctly different in terms of both their processing and purpose, including the neural systems and development associated with each (Finn et al., 2016), with manipulations that affect one typically not affecting the other (Graf & Schacter, 1985). This difference between memory types was identified by amnesic patients displaying impaired ability for the retention of information, but no impairment upon a priming task, suggesting the use of two different memory systems for information and procedure (Warrington & Weiskrantz, 1968, 1970). Memory systems can be broken down further to episodic and semantic memory, derived from the explicit memory (Tulving, 1983) though such a level of detail is not required for this thesis. Lying and truth telling should rely upon the explicit memory, as these response types require known truthful and schema information to be recalled from long term memory (McCornack et al., 2014; Walczyk et al., 2014). Such factual information is related to the explicit memory system (Rovee-Collier et al., 2000; Warrington & Weiskrantz, 1968, 1970).

Rehearsal is described as one of the six stages of memory (MacLeod, 2013) with its purpose being the review and strengthening of encoded information (Baddeley, 2007; MacLeod, 2013); defined as being the recitation of to be remembered information during the encoding, storage or retrieval of this information from memory (Pashler, 2013). This would suggest rehearsal may take place at any point within memory processing, as long as information is being reviewed to strengthen the memory. The combination of different and multiple rehearsal methods, visual, auditory etc. are also found to enhance the effects of rehearsal (Do & Moreland, 2014) with better encoding and retrieval as more rehearsal occurs. The act of rehearsal seems to be as simple as the repeated recall of information, which has the effect of enhancing the encoding, and later retrieval, of stored information (Baddeley, 2007; Pashler, 2013; Pyc & Rawson, 2009).

Rehearsal can be related to explicit memory, as this memory system has the potential to only partially be recalled (Rovee-Collier et al., 2000), in that known information may be only partly remembered and partly recalled. This is in contrast to the all-or-none retrieval of implicit memory (Rovee-Collier et al., 2000) where procedural memories are either entirely recalled or not at all. Rehearsal allows for a better encoding of information, and so more explicit information may be recalled following rehearsal resulting in a greater accuracy. Rehearsal may also be related to working memory systems, in that better encoded information will require fewer resources to access (Lykken, 1998).

Additionally, evidence is provided that difficult to recall memories result in facilitated rehearsal in comparison to easy to recall memories (Pyc & Rawson, 2009). A difficult to recall memory will provide more benefit to the encoding of this information due to the related retrieval effort of this rehearsal (Pyc & Rawson, 2009). Effectively, a greater amount of attention needs to be paid, and effort required, to the information being rehearsed, providing benefit to this rehearsal (Block, 2009; Jehee et al., 2011). An alternative explanation, however, is that easy to recall information is already well encoded, and so rehearsal of this information has a lesser effect than poorly encoded information that would require a greater effort to enhance.

Methods of rehearsal can be grouped into active forms of rehearsal, and passive forms of rehearsal (Staniland, Colombo, & Scarf, 2015). Passive rehearsal involves simply the recall of encoded information, while active rehearsal involves both a recall and use of the encoded information (Staniland et al., 2015). For example, repeatedly viewing a face would classify as passive rehearsal, as recognition information is being accessed and encoded repeatedly. Repeatedly viewing a face and providing a recognition response would classify as active rehearsal, as information is being both accessed and used in order to respond. Active forms of rehearsal are found to be a more effective method of enhancing the encoding of information (Staniland et al., 2015), possibly due to a greater effort to the act of encoding (Block, 2009) or an enhanced level of attention (Jehee et al., 2011).

While the act of rehearsal is typically used to facilitate encoded memories and their recall, there is evidence to suggest rehearsal can provide the opposite effect and inhibit recall in certain circumstances. Periods of extensive rehearsal reduced individual ability to access encoded information in comparison to short periods of rehearsal (Kuhl & Anderson, 2011). Within this research, a single word was repeated multiple times followed by a free association task where sentences could be completed with either the repeated word or with a semantically similar word. Periods of brief rehearsal (5-10 seconds) provided facilitated priming, with responses becoming faster, periods of long rehearsal (20-40 seconds) inhibited priming. Further evidence of a paradoxical effect of rehearsal is illustrated within facial identification, where slight changes to the stimuli resulted in a negative effect of rehearsal (Read, Hammersley, Cross-Calvert, & McFadzen, 1989). After witnessing a staged event, rehearsal took place either immediately, or following a 10-minute delay; immediate rehearsal improved recognition accuracy, but reduced accuracy if there was a slight change in the appearance of the stimuli in comparison to a no rehearsal control. With a 10-minute delay, rehearsal improved recognition accuracy regardless of any changes made to the stimuli. While the typical effect of rehearsal is facilitated encoding of information (Pyc & Rawson, 2009; Staniland et al., 2015) factors do appear to exist where rehearsal provides a paradoxical negative effect upon the encoding of information (Kuhl & Anderson, 2011; Read et al., 1989) though the exact reasons for this are unclear.

Rehearsal in Deception Processing

Due to the effect rehearsal of information has on its level of encoding and the later ability to retrieve this information, rehearsed lies can be considered a different form of deception to spontaneous lies, and differences in their processing are documented (Morgan, LeSage, & Kosslyn, 2009). Deception processing theory tends to focus on spontaneous lies, constructing lies on the go (McCornack et al., 2014; Walczyk et al., 2014), with little suggested as to the effect of rehearsal upon the processing of truth and lie responses. Processing theory can, therefore, be expanded upon through the integration of rehearsal and the effect this has on truth and lie processing. Rehearsal within deception may involve rehearsal of the truthful information or lie information and can affect either truth or lie responses; each of these combinations are to be investigated in order to gain a full understanding of the effects of rehearsal on deception processing.

In terms of the effect of rehearsal of the truth upon the ability to provide the truth, rehearsal literature suggests that this will facilitate the ability to tell the truth. Rehearsal of information enhances the encoding of this stored information (Pyc & Rawson, 2009; Staniland et al., 2015) and facilitates its later recall as a result. In cognitive processing, rehearsal of truthful information should make it easier to provide the truthful information due to a lesser required effort on the part of the working memory in the retrieval of information (Baddeley, 2007).

Debate exists as to the effect of rehearsal of the truth upon the ability to provide a lie. A faciliatory effect may be expected due to an easier to process first step of truth recall (Debey et al., 2014) and the greater ease at which working memory systems can access and use this information within lying (Sporer, 2016). Alternatively, an inhibitory effect is proposed due to proactive interference and a more difficult to supress truth (Flicker, Ferris, Crook, & Bartus, 1989; Walczyk et al., 2014). A facilitated effect of rehearsal of the truth upon a lie is based upon the first step of truth recall involved within deception processing (Debey et al., 2014; McCornack et al., 2014; Walczyk et al., 2014). If the truthful information is better encoded due to rehearsal (Pashler, 2013; Pyc & Rawson, 2009; Staniland et al., 2015) a first step of truth recall within lying is made easier and so an overall improvement in lie processing should be seen as a result.

As an example of the effect of easier truth recall positively impacting lie processing, a distractor of the truthful information placed at the point of recall facilitated the ability to provide a lie response (Debey et al., 2014). This is suggested as being related to the first step of truth recall as truthful information was primed by the presented information (Debey et al., 2014). While this is not explicitly rehearsal of the lie, predictions of the effect of rehearsal can be made from this work. When the truth was made easier to recall lying also became easier which may be applied to an easier to process first step of truth recall and a lesser demand upon working memory systems due to this easier recall (Baddeley, 2007; Sporer, 2016). If truthful information is better encoded and made easier to recall through rehearsal, lying should become easier to process as the information required to lie is made easier to recall. This facilitated effect of truth rehearsal is made clear when applied to the ADCAT model (Walczyk et al., 2014) and the working memory model of deception processing (Sporer, 2016). Within the ADCAT processing steps, truthful information is better encoded by rehearsal and so easier to recall in the activation stage, facilitating this step for both truth and lie responses. This may have no effect upon the following decision and construction stages, but an overall faster response time could be expected between lies with a rehearsed truth and lies without a rehearsed truth if the first step of truth telling is processed faster. Applied to the working memory model, truthful information will require a lesser amount of cognitive effort to be retrieved due to the stronger encoding granted by rehearsal (Pyc & Rawson, 2009; Staniland et al., 2015). A facilitatory effect may, therefore, be expected due to the greater ease of access to information required within the processing of lies.

While the ADCAT model may be used to explain the effect of an easier to recall truth upon deception processing, within the model the explicit prediction that truth rehearsal will have a negative effect upon lie processing is made, and that this is related to an effect of proactive interference of the truth (Walczyk et al., 2014). Proactive interference is seen when earlier stimuli or information interferes with later information, making this more difficult to recall or encode (Flicker et al., 1989). In terms of lie processing, a better remembered truth is easier to recall and harder to supress, resulting in a greater difficulty during the construction of a lie (Walczyk et al., 2014). As a truthful memory is made stronger through rehearsal, a lie is then made more difficult to process as further cognitive resources must be applied to supress this easily recalled truthful information (Walczyk et al., 2014). This concept may also apply to IMT2 (McCornack et al., 2014) as it can be proposed that truth rehearsal will reduce the associated load of truth telling, possibly making this the path of least resistance over lying, even in a context where lying may be expected. Lying, therefore, may incur more load to overcome the use of the first available information that would be the truth. It is important to note, though, that IMT2 does not make any explicit predictions as to the effect of truth rehearsal upon lie processing.

In terms of the effect of rehearsal of a lie upon the ability to provide a lie, previously encoded lie information should make lying easier to process and provide a lie response (Walczyk et al., 2014). Rehearsal of the lie is used as a load reducing technique (Lykken, 1998) to make lying easier. As previously explained, methods exist to exploit this such as asking unanticipated questions (Vrij et al., 2009) though this is used within the detection of lies. In terms of the processing of lies, rehearsal of the lie lessens the associated load through commitment of the lie information to long term memory (Walczyk et al., 2014) which puts the recall of lie information equal to or easier than truth telling in terms of associated load (Walczyk et al., 2014). It can be suggested that this commitment of lie information to long term memory will negate the need for a construction stage of deception when the lie is later provided. Lie information simply needs to be recalled, and so should be similar in cognitive demand and processing steps as truth telling as only the load associated with retrieval is placed upon the cognitive systems (Baddeley, 2007).

Behavioural differences are also documented within rehearsed lies compared to unrehearsed lies, such as the provision of wordier answers, in comparison to unrehearsed lies, in an attempt to convince listeners they are being truthful (Walczyk, Igou, et al., 2013). This would suggest some level of difference in their processing, though as frequent an occurrence rehearsal is predicted to be in verbal deception (Vrij et al., 2009) an understanding of the effect of rehearsal upon lie processing has yet to be established within current processing models.

In terms of the effect of rehearsal of the lie upon the ability to provide truth, predictions are unclear, as no literature seems to have considered the effect of lie rehearsal upon the ability to provide the truth. The effect of rehearsal in general is an area which is in need of further research, as too few studies exist to provide a meaningful comparison in meta-analysis (Sporer & Schwandt, 2007) though no research, to my knowledge, exists to investigate the effect of lie rehearsal upon truth processing. Predictions can be made as to this effect, however, based upon a first step of truth telling within lying, if lying requires a first step of truth telling within its processing (Debey et al., 2014; McCornack et al., 2014; Walczyk et al., 2014) then rehearsal of the lie should also involve a stage of truth recall. Construction of the lie involves the manipulation of recalled truthful information (McCornack et al., 2014; Walczyk et al., 2014) with this truthful recall potentially resulting in enhanced encoding of the truthful information (Pyc & Rawson, 2009; Staniland et al., 2015). It may, therefore, be predicted that upon rehearsing the lie, the truth is also being rehearsed, and so lie rehearsal will facilitate the provision of a truthful response.

Face Processing

The use of facial stimuli within deception processing is an overlooked area of research, with most literature focusing upon lying in an interrogation or interview context and verbal deception. This is understandable due to the practical application of this work to interrogation methods and to identification of lies within interviews (Walczyk et al., 2005). While limited, some research has been conducted upon lying in response to facial stimuli, suggesting a greater effort on the part of cognitive processes (Sun et al., 2015, 2016), though interestingly no difference in response time between truth and lie (Bhatt et al., 2009) listed as the most reliable indicator of deception for verbal responses (Walczyk et al., 2012). A combination of fMRI and EEG evidence suggests that lying to facial stimuli still involves the recall of truthful information and manipulation of this to construct a lie (Sun et al., 2015) following the processing steps proposed within the previously discussed models.

The investigation of deception to facial stimuli holds the practical application of an understanding of lying in response to a line up, or recognition within an interrogation context. Additionally, research upon such stimuli using simple responses will allow for further study of the cognitive mechanisms involved within deception processing to be investigated without potential interference from other factors related to telling a story (Blandón-Gitlin et al., 2014; Sporer, 2016).

The ability to accurately recognise faces is suggested to develop early, between the ages of 5-7 when controlled against other developing cognitive abilities (Crookes & McKone, 2009). This results in humans being very good at the recognition of faces in comparison to non-expert populations, such as animals or prosopagnosia cases (Rossion, 2018), likely related to the length of time we can be considered experts (Crookes & McKone, 2009) and the high level of exposure we have to facial stimuli (Burton, Schweinberger, Jenkins, & Kaufmann, 2015; Curby & Gauthier, 2007). Research evidence of our ability to recognise faces finds accuracy rates of 80% after a short exposure of four seconds, repeated three times, and with distractors present (Haxby et al., 1996). Contemporary research debates this high accuracy rate, however, with individuals displaying limited expertise at unfamiliar face recognition, but high accuracy recognition for familiar faces (Wiese et al., 2019; Young & Burton, 2018). Identification accuracy is, however, likely to differ between individuals and experiments related to several factors such as recognition bias (Herlitz & Lovén, 2013; Tanaka, Heptonstall, & Hagen, 2013).

Several propositions are made as to how individuals process faces, such as configural processing which relies on the spatial relation between various facial features (Haig, 2013). Burton et al., (2015) argue against this processing method, as when large changes were made to configural information within the face, no difference in recognition was found, while non-configural changes did reduce accuracy. Literature also suggests the use of a holistic method within face processing, whereby an individual encodes as much information as possible about all aspects of the face, with the magnitude of recognition being related to how holistically the face was processed (Boutet, Gentes-Hawn, & Chaudhuri, 2002; Wang, Li, Fang, Tian, & Liu, 2012). This method of processing differs from that used for other types of visual stimuli and is directly related to face processing, not other cognitive aspects such as intelligence or attention (Boutet et al., 2002; Wang et al., 2012).

A further suggestion of face processing is that faces are broken down into multiple cells of data and codes are applied to each data package (Chang & Tsao, 2017). Faces are broken down in such a way that each package contains unique and simple information, with distinctive faces being easier to remember (Bainbridge, Isola, & Oliva, 2013), while for other visual information the information remains large and complex (Chang & Tsao, 2017). Such a method may relate to holistic processing, as all aspects of the face are encoded, being broken down into simpler forms of information which can be easily accessed.

Faces are found to be easier to encode than other complex visual stimuli (Wang et al., 2012) and more faces can be stored within visual short term memory than other complex non-face items (Curby & Gauthier, 2007). While a holistic processing method appears to be unique to facial processing (Wang et al., 2012) there appears to be no special trick involved in the encoding of faces (Sporer, 1991). Several different methods of encoding facial stimuli were found to be no more effective than simply being able to see the face for long enough to encode all of the needed information (Sporer, 1991). Exposure time long enough to holistically encode facial features is enough to enhance recognition, with longer exposure times increasing recognition accuracy (Memon, Hope, & Bull, 2003).

Within the processing of faces, differences are found between the processing of familiar and unfamiliar stimuli, with unfamiliar faces resulting in higher error rates (Jenkins & Burton, 2011). Such differences in processing may reflect within experimental data, and so must be considered in work utilising facial stimuli. Differences in brain activity are identified within the processing of familiar and unfamiliar faces, with a greater amount of activity reported within the processing of familiar faces (Benton, 1980; Hanso, Bachmann, & Murd, 2010; Ramon, Vizioli, Liu-Shuang, & Rossion, 2015). This activity is found outside of the occipital areas, specifically the medial temporal lobe and anterior inferior temporal cortex (Ramon et al., 2015), suggesting the processing of familiar faces involves factors outside of simple recognition of the stimuli and visual processing. The same facial features are used to identify both familiar and unfamiliar faces, suggesting the same processing steps are used for each (Abudarham, Shkiller, & Yovel, 2019), differences in the processing of familiar and unfamiliar stimuli, therefore, are related to factors outside of the recognition of stimuli. Such a claim is supported by evidence finding individuals gaze at a familiar face for significantly longer than an unfamiliar face (Devue, Van der Stigchel, Brédart, & Theeuwes, 2009) suggesting additional processing steps on top of the analysis of stimuli.

As it seems that familiar and unfamiliar faces are processed in different ways (Benton, 1980; Hanso et al., 2010; Ramon et al., 2015), the factors that cause a face to become familiar must be understood and considered within research. Individuals gain familiarity with a face through extensive exposure to the face (Devue, Wride, & Grimshaw, 2018) in a variety of different angles and facial expressions (Burton, Kramer, Ritchie, & Jenkins, 2016). It is possible, therefore, that during experimentation a face never truly becomes familiar as the high level of exposure and variety of appearances required to achieve familiarity are not met. While a potential difference in the processing of familiar and unfamiliar faces is possible, and a factor that should be considered within experimentation using facial stimuli, the criteria required to achieve familiarity may not be met, and so should not result in extraneous factors.

Finally, within face processing exist several forms of bias related to the presented stimuli and personal factors of the individual which can cause encoding and recognition of face information to become easier or more difficult. Such biases are: own race bias, where individuals are more proficient at recognition of their own race suggested as being related to a greater perceptual expertise of exposure to the facial type of your own race (Tanaka et al., 2013). Own age bias, where individuals are better at recognising the faces of others in their own age group, suggested as being related to recent extensive experience with one's own age group as individuals who were once part of another group (adults were once young adults) lack expertise for other groups (Rhodes & Anastasi, 2012). There is also some evidence of an own sex bias in females, whom are better at a recognition of their own sex face and outperform males in face recognition in general, though males do not show an own sex bias (Herlitz & Lovén, 2013). Such factors also need to be considered within face recognition research, as bias may provide additional factors within processing, making recognition easier or more difficult.

Current research upon deception processing related to facial stimuli suggests stages of truth recall and construction of a lie (Sun et al., 2015) and a greater cognitive effort required within processing related to greater activation in several brain areas during deception (Bhatt et al., 2009). Such research offers support to deception processing models in terms of the steps involved within lie processing, though a greater load associated with lying contrasts with both IMT2 and ADCAT models (McCornack et al., 2014; Walczyk et al., 2014). Additionally, the lack of a difference in response time between truth and lies to facial stimuli (Bhatt et al., 2009) is in contrast to the majority of literature listing this as a reliable factor of detecting verbal deception (Walczyk et al., 2012). Further investigation into the use of facial stimuli upon lie processing will allow for deception processing models to be tested in a different context than the typically applied interview or interrogation design (Vrij et al., 2006; Vrij, Mann, et al., 2008; Walczyk et al., 2003). This will allow for the rigidity of the proposed processing steps to be tested, investigating whether lie processing is similar for other forms of lying. Additionally, such an investigation will allow for a greater focus on the cognitive factors within processing without potential interference from other factors related to the production of verbal deception (Blandón-Gitlin et al., 2014; Sporer, 2016).

Previous Methodologies

Several methodological paradigms are frequently used throughout research in the study of the processing, and detection, of deception. One such methodology is an interview design, with participants taking part in, or witnessing, a staged event, then reporting details verbally in an interview setting either truthfully, deceptively, or both (Feeley & deTurck, 1998; Gawrylowicz et al., 2016; Jeon & Lee, 2016; Leins et al., 2012; Vrij et al., 2006, 2009; Vrij, Mann, et al., 2008). Such methodologies may apply additional cognitive load to the interview, such as reverse recall (Vrij, Mann, et al., 2008), in order to make lying more difficult to process, and so easier to detect (Vrij et al., 2006; Vrij, Mann, et al., 2008). An interview paradigm relies upon the recall of encoded information and reconstruction of this information through the use of schemas, relating directly to the processing outline offered in the working memory model of deception processing (Sporer, 2016) and the stages proposed within IMT2 where verbal deception is constructed on the go, using further recall of schema information to fill in the blanks of memory, constructing a lie as similar to the truthful context as possible (McCornack et al., 2014).

Also frequently used are response time analysis based paradigms, these relate to a greater cognitive cost associated with deception in comparison to truth telling (Debey et al., 2014, 2012; Suchotzki et al., 2015). The concealed information task (CIT) is one such method applied to a response time based methodology, where the same question asked multiple times in different ways provides an average response time, which compared to known truthful responses may be used to indicate concealed information (Kleinberg & Verschuere, 2016). This methodology can be used with either a word based or image based design, and relies upon a greater cognitive cost of lying in comparison to truth telling, with the more difficult lie responses taking longer on average than truth responses (Debey et al., 2014; Kleinberg & Verschuere, 2016; Verschuere et al., 2015). Response time based designs may employ either recall of encoded information or simple recognition of stimuli, depending on the stimuli and methodological design used and still be indicative of deceptive responses in relation to a greater cognitive cost of providing this response type.

Other methodologies include gambling tasks, where lies are provided in order to increase the reward outcome (Panasiti et al., 2014; Yin et al., 2016). Such designs relate to the goal oriented nature of deception (McCornack et al., 2014; Walczyk et al., 2014) where lies are provided in a context where doing so will be beneficial over being truthful. In the context of a gambling design, lies as to the outcome of the task are provided for greater financial reward from doing so (Panasiti et al., 2014; Yin et al., 2016). The monitoring of physiological cues within a polygraph test is also used as a method of deception detection in research, with questioning methods such as the guilty knowledge task showing increased stress and anxiety levels (Phan et al., 2005).

Deception literature has shown some focus upon facial recognition and lying in relation to this, though this is an area of research which requires further development. Current research demonstrates similarity in the processing of lies in comparison to interview context, but potential differences between the processing of familiar and unfamiliar stimuli (Bhatt et al., 2009; Sun et al., 2015, 2016). The proposal may be made that the use of facial stimuli may be similar to the use of images during the CIT using a response time based design. However, due to potential differences between the processing of familiar and unfamiliar facial stimuli (Sun et al., 2015, 2016) further work is required to consider if a response time based paradigm is appropriate for use within face stimuli deception research.

Thesis Aims

Much of the current theory on deception processing focuses only on the processing of lies with little elaboration on how truth is processed in comparison. Some proposals are made that truth and lie do not differ in their basic cognitive processes (McCornack et al., 2014; Walczyk et al., 2014) with such models providing the same processing steps for both truth and lie responses. Evidence is provided, however, of differences within the processing of truth and lie responses following the initial truth recall stage (Sun et al., 2015, 2016). Consideration of the processing of both truth and lie responses is important in establishing which stages of each response type are similar and different to each other. Such an investigation will allow for the assumption of the same basic processing steps involved within lying as are used in truth telling (McCornack et al., 2014; Walczyk et al., 2014) to be tested. This thesis, therefore, aims to provide an overview of the processing steps of both truth and lie responses, allowing for a comparison of these steps.

The associated cognitive demand of lying in comparison to truth telling remains an area of debate within deception processing literature. Both IMT2 (McCornack et al., 2014) and ADCAT (Walczyk et al., 2014) models of deception processing state that lying should not induce a greater cognitive demand than truth telling within its processing related to a path of least resistance in processing, an incremental recall of information, and the routine practice of lying reducing any associated load (DePaulo et al., 2003; McCornack et al., 2014; Walczyk et al., 2014). Alternative theory, and a large body of research evidence, suggest that lying and its associated processing do induce a greater cognitive load within processing related to working memory processes of recalling and manipulating information, additional stages within the processing of deception, and control of potential behavioural cues consuming further cognitive resources (Debey et al., 2015, 2012; Sporer, 2016; Suchotzki et al., 2015; Vrij et al., 2018, 2006). This thesis aims to investigate further into this debate, to determine if lying requires a greater cognitive cost than truth telling. In addition, if a greater load is found, explanations will be offered as to where in processing this load occurs and why a greater difficulty is caused. If no greater load is found, explanations will be offered as to why lying is no more difficult in its processing than truth telling. Both potential explanations will aim to expand upon the deception processing models.

Application of additional load is a commonly practiced method within lie detection research which claims to make lies easier to detect (Verschuere et al., 2016; Vrij et al., 2018, 2006; Vrij, Mann, et al., 2008). In addition, the proposal is made that load application should impact lie responses more so than truth responses, by applying more load to an already loaded process (Vrij et al., 2006; Vrij, Mann, et al., 2008). While such methods do seem to increase the ability to detect lies, their impact upon the processing of lie responses is not elaborated on. The work of this thesis aims to provide this elaboration, applying the factor of applied load to deception processing models to explain how and why applied load impacts the processing of both truth and lie responses. In addition, an investigation of a greater impact of applied load upon lie responses will be conducted, again applying this information to processing models should a greater effect be found.

Various theories of deception processing suggest the cognitive steps involved within lying. Many of these stages are similar such as a recall of truthful information, a decision of whether to be truthful or lie, and manipulation of information to construct a lie (McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014). While research evidence is provided for the existence of each of these stages within deception processing (Debey et al., 2014; Walczyk et al., 2003) this work aims to consider these processing steps and provide further support for their existence and role within deception processing.

Blandón-Gitlin et al., (2014) and Sporer, (2016) recommend further research upon the processing of deception should focus on the cognitive aspects of processing and controlling for potential extraneous factors related to interview designs such as rehearsal of information. Findings of such experimentation will work in conjunction with previous evidence from interview designs, providing a focus upon how lies are processed at the cognitive level. Such an investigation will allow for the cognitive processing steps involved within deception to be provided, while offering suggestion as to which factors may be related more to the context of an interview. As an example, anxiety in an interview may result in behavioural cues (DePaulo et al., 2003) which are not related to the actual processing of deception. With potential extraneous factors of interview research, such as rehearsal of lie information (Granhag et al., 2003; Vrij et al., 2009), and methodological factors related to other cognitive processes (Dando et al., 2011; Sporer, 2016) controlled for, focus on the cognitive factors of deception processing can be achieved. This thesis aims to utilise methodological designs which achieve this cognitive focus, controlling for extraneous factors that are possibly present within interview designs, to elaborate upon which factors are specifically related to the processing of lies.

Research highlights some of the effects of rehearsal upon truth and lie responses, such as truth rehearsal facilitating truth recall (Pyc & Rawson, 2009; Staniland et al., 2015), and lie rehearsal facilitating lie recall (Granhag et al., 2003; Vrij et al., 2009). Certain areas of processing and the influence of rehearsal are, however, unresearched, with the effect of truth rehearsal upon lie processing debated between a facilitated effect related to an enhanced ability to recall truthful information (Debey et al., 2014) and possible effects of proactive interference and difficulty in the suppression of the truth (Walczyk et al., 2014). Additionally, no research evidence currently exists to suggest the effect of lie rehearsal upon truth processing, though related to a first step of truth recall within lying a facilitated effect may be expected from this. Models of deception processing are also limited in terms of their explanations of the effect of rehearsal of information upon the processing of truth and lie. The work of this thesis, therefore, aims to investigate further the effect of rehearsal of both truth and lie information and the impact this has upon the processing of both response types. Such an investigation will allow for an expansion of processing models by offering suggestion of the processing steps of truth and lie under the influence of the factor of rehearsal.

Current deception research typically focuses on verbal deception and interview designs. This is understandable due to the clear practical application this research has to interrogation or interview scenarios where lying may be expected. How lies are processed in other contexts, however, is still largely under researched, and further work outside of interview contexts should be considered to investigate the cognitive aspects of deception processing (Blandón-Gitlin et al., 2014; Sporer, 2016). Some research upon lying about facial stimuli does exist, and suggests similar processing systems to other forms of deception (Bhatt et al., 2009; Sun et al., 2015), though some differences, such as a lack of response time difference (Bhatt et al., 2009) are present and warrant further investigation. Despite the identified similarities, facial stimuli within deception processing is still an under researched area, and with the possible application to lying in a line up context or to presented visual information within an interrogation, further investigation into lie processing within this context should be conducted. If differences in processing are noted, understanding of why this is the case must be identified so current deception processing models can be built upon to aid in explaining deception in other contexts. If no differences in processing are found, further support can be provided to processing models, as the systems proposed within remain reliable in explaining deception in contexts outside of the interview contexts they are designed to explain. This thesis aims to investigate the processing of truth telling and lying about facial stimuli, such a design will allow for a focus upon the cognitive aspects of deception processing.

- To investigate further the cognitive processing of both truth telling and lie responses.
- To investigate the level of cognitive demand associated with lying and lie processing in comparison to that of truth telling.
- To investigate the impact of applied cognitive load on the processing of truth and lie responses.
- To investigate further the existence and role of the proposed processing steps involved within deception.

- To investigate truth telling and lying in a context outside of an interview design with a focus on the cognitive aspects of deception processing.
- To investigate the effect of rehearsal on the processing of both truth and lie responses, specifically the rehearsal of both truth and lie information on each response type.
- To investigate the processing of truth and lie responses to facial stimuli.

Implications of Work

The work of this thesis will allow for further investigation of the role of cognitive load within lying. Debate exists in the literature as to a greater cognitive cost of lying in comparison to truth telling with the prominent ADCAT (Walczyk et al., 2014) and IMT2 (McCornack et al., 2014) theories proposing no greater cost of lying. This is in contrast to the working memory model of deception processing (Sporer, 2016) and the majority of experimental literature (Debey et al., 2015, 2012; Suchotzki et al., 2015; Vrij et al., 2018, 2006) which proposes that lying does incur a greater cognitive cost than truth telling within its processing. This work will provide further evidence towards this debate, recommending whether processing models should account for a greater cognitive cost of lying or not.

In addition to an investigation of the processing steps involved within lying, this work will also provide the steps involved within truth telling. The current models focus on the processing of deception, with little elaboration upon how truth is processed by comparison outside of the claim that both truth and lie are processed in a similar way (McCornack et al., 2014; Walczyk et al., 2014) though this similarity in processing too is debated in experimental literature (Sun et al., 2015, 2016). This work will provide a framework of both truth and lie processing to allow for a comparison of which processing steps are similar and which are different between the two response types. This will allow for a greater understanding of the cognitive processes involved within each response type to be established.

The work of this thesis will also expand upon the current models of deception processing by explaining how external factors, such as applied cognitive load and rehearsal of information, impact the processing of both response types. The current models explain how deception is processed in an ideal situation, with no external factors influencing processing. Some information is provided as to the expected effects of factors such as rehearsal (Walczyk et al., 2014) though this is somewhat limited in the current theory. It is recognised within experimental literature that factors such as applied cognitive load (Vrij et al., 2006; Vrij, Mann, et al., 2008) and rehearsal of information (Lykken, 1998; Vrij, Mann, et al., 2008; Walczyk, Igou, et al., 2013) affect the ability to lie, but no direct link is made as to how these factors impact processing within the current models. This work will incorporate these factors into a processing model, offering an explanation of how truth and lie are processed both on their own, with no external factors influencing their processing, and how each response type is processed differently due to the impact of additional factors.

Such an investigation will also offer further insight into the role these factors play within truth and lie processing. Debate exists as to the role these factors play upon the ability to process information, such as a positive or negative effect of truth rehearsal upon lie processing (Walczyk et al., 2014) and a greater effect of applied load upon lying than truth telling (Vrij et al., 2006; Vrij, Mann, et al., 2008). This work will determine what impact each of these factors has upon our ability to tell the truth and to tell a lie, then incorporate this into the processing stages of truth telling and lying. This will allow for a model which both explains how each response type is processed and provides the expectations of how processing will differ in both response types due to the impact of external factors.

Experimental Chapter One: The processing of truths and lies with cognitive load applied at encoding.

Introduction

In the processing of deception, a two-step model is suggested in its production whereby lying requires a first step of truthful recall (Debey et al., 2014); the known truthful response must first be recalled before a deceptive response can be purposefully provided in place of this truth. Such a model suggests that lying is more cognitively demanding than truth telling (Debey et al., 2012; Suchotzki et al., 2015) and requires additional steps in its processing with additional stages of creating the deceptive response following the truthful recall (McCornack et al., 2014; Walczyk et al., 2014). Current deception processing theory debates any greater cognitive demand within lying compared to truth telling, with the proposal that deception occurs within contexts where truth telling is cognitively demanding, and lies are used as a method of reducing this load (McCornack et al., 2014; Walczyk et al., 2014). Current cognitive research, however, highlights an increasing amount of evidence in support of the hypothesis that lying requires a greater amount of cognitive demand than truth telling (Vrij et al., 2006; Vrij, Fisher, Mann, & Leal, 2008; Vrij, Mann, et al., 2008).

It is suggested that a difference in the cognitive processing of truth and lie accounts for the greater length of response time documented within deception (Debey et al., 2014; Suchotzki et al., 2015; Verschuere et al., 2015). Additional stages required within the processing of lies build upon each other, resulting in measurable differences in response time as more stages are required (Walczyk et al., 2003). Therefore, potential differences in the processing of truth and lie responses may be assessed through response time analysis, as differences represent greater cognitive effort required within processing and can be related to additional processing steps (Debey et al., 2014; Suchotzki et al., 2015).

The Activation Decision Construction Action Theory (ADCAT) (Walczyk et al., 2014) provides a framework of what the proposed additional steps within deception processing may be. It is suggested that deception begins with a stage of truth activation followed by a decision of whether to be truthful or deceptive in response, construction of the lie, and finally provision of a response (Walczyk et al., 2014). In comparison, truthful responses begin with a truthful recall, a decision of which response type to provide, and provision of response, lacking the construction aspect of deception. These processing steps are in tandem with those proposed within Information Manipulation Theory 2 (IMT2) (McCornack et al., 2014) which also offers the proposition that truth and lie processing do not differ in their basic cognitive processes.

Regarding a working memory model, it is proposed that truth telling relies only on recall from memory while deception requires recall and further effort from the working memory during its construction (Sporer, 2016). While literature does suggest that retrieval from memory requires the use of the working memory to take information from long-term memory via the episodic buffer and to the central executive whereby it can be processed

(Baddeley, 2007; Sporer, 2016); if lying requires both recall and construction, and truth requires only recall, it can be expected that the working memory load of lying will outweigh that of truth. This is due to the combined effect of the cognitive load related to the recall of information, the suppression of this information, and the construction of new information (Sporer, 2016) with each additional cognitive process consuming and depleting limited cognitive resources (Morrison et al., 2015; Sweller, 1988). The construction stage of deception could, therefore, be suggested as the cause of the greater difficulty in the processing of a lie response due to the cognitive demand of this extra processing step that is not present within truth telling.

IMT2 acknowledges the use of further information recall within deceptive processing (McCornack et al., 2014) which, ordinarily, would induce a greater load within processing (Baddeley, 2007; Sporer, 2016; Sweller, 1988). An explanation is offered as to why this additional processing within lying does not induce a higher load when lying within the IMT2 model. Lying does not incur a greater cognitive demand than truth due to the on the go nature of discourse and deception production, where information is not entirely constructed beforehand but is recalled and manipulated as needed with an effort on the part of the working memory filling in the gaps of truth information to construct a lie (McCornack et al., 2014). Related to a path of least resistance approach in deception processing (McCornack et al., 2014; Walczyk et al., 2014), the first available schema information is used to fill in these blanks, and deception constructed based upon these (McCornack et al., 2014). As the first available information is used in construction, time and cognitive effort are not expended in the retrieval of information and so should not result in a greater load being applied to lying (McCornack et al., 2014).

Much of the literature on deception, including the deception processing models themselves, generally focus on the ability to detect deception, often using interview methodologies as their theoretical support and focus. This is understandable, as realistically most lies are presented verbally and spontaneously constructed on the go (McCornack et al., 2014) or constructed beforehand to be presented in an interview (Lykken, 1998). There is also the practical application of detecting lies within an interview context, as most lies are presented verbally. Recommendation is provided, however, that theoretical analysis of the processing of deception take place outside of an interview design (Blandón-Gitlin et al., 2014; Sporer, 2016) to provide further detail as to how we process deception. Experimentation within a different context of lying than verbally or in an interview will allow aspects of deception theory to be tested, either adding strength to their theoretical claims, or suggesting areas of refinement.

Related to a proposed greater cognitive cost of the processing of deception, is the application of additional load during deception. Such methods are often implemented in deception detection literature and are telling of the underlying cognitive processes of lying through the proposition that application of cognitive load builds upon an already loaded process (Vrij et al., 2018, 2006). All tasks require a consumption of cognitive resources within their processing (Morrison et al., 2015; Sweller, 1988). If lie processing is a high load process, in comparison to truth telling, and so is more difficult than truth telling, application of further load will make this behaviour still more difficult resulting in an improvement of the ability to detect lies (Vrij et al., 2018). To elaborate, application of further load leads to the consumption of a greater number of cognitive resources within processing as working memory systems must be allocated to process additional factors (Baddeley, 2007). Fewer remaining resources will, therefore, make both truth and lie more difficult to process

(Zuckerman et al., 1981), and assuming that lying requires a greater number of resources than truth telling, will impact this response type to a greater extent (Vrij et al., 2006; Vrij, Fisher, et al., 2008). Discussed research on the use of cognitive load as a deception detection method, therefore, provides further support to a greater level of cognitive load associated with lying, and more difficulty in lie processing than truth telling.

Alternate explanations of the findings of load inducing literature are, however, proposed. For example, reverse order recall is one such load inducing method within verbal deception which claims to increase the ability to detect deception through cognitive resource consumption (Vrij, Mann, et al., 2008). Evidence suggests, however, that such techniques naturally incur a greater number of errors (Dando, Ormerod, Wilcock, & Milne, 2011; Sporer, 2016) which may not be related to the processing of lies. It is possible, therefore, that load inducing techniques are related to extraneous cognitive factors, and not to an application of additional load upon lie processing. Further research is, therefore, recommended regarding the impact of factors such as load application, and their effect on the processing of both truth and lies at the cognitive level.

Additionally, techniques of applying additional cognitive load work on the assumption that lying has a greater cognitive cost than truth telling, hence there is a greater effect of applied load on lying than truth. Prominent theory states, however, that lying should not induce a greater cognitive cost than truth telling (McCornack et al., 2014) and that contexts exist where truth telling will be more load demanding than lying (Walczyk et al., 2014). It must, therefore, be considered why there appears to be a greater effect of applied load on lie responses than truth responses (Vrij et al., 2018, 2006) if it is the case that lying is no more difficult than truth telling. Such an investigation is the aim of this work, to examine the processing involved within truth telling and lying, assess the associated cognitive cost of these processes, and determine the impact of application of load upon these.

To achieve this, facial stimuli are to be used as research upon such stimuli using simple responses will allow for further study of the cognitive mechanisms involved within deception processing without potential interference from other factors related to telling a story (Blandón-Gitlin et al., 2014; Sporer, 2016). Current research on the use of face stimuli within deception processing is somewhat limited. Existing literature provides evidence of a similarity in processing to the provided processing models with stages of truth activation and construction (Sun et al., 2015) though evidence of key differences in other aspects such as response time differences are documented (Bhatt et al., 2009). Important to consider with the use of face stimuli, however, is the difference between responses and cognitive processing of familiar and unfamiliar faces (Jenkins & Burton, 2011) with a greater amount of brain activity reported within the processing of familiar faces (Benton, 1980; Hanso et al., 2010; Ramon et al., 2015). The possibility exists of differences between responses to previously seen facial stimuli and never before seen unfamiliar stimuli which must be considered within research, though the extensive exposure required for a face to become familiar (Burton, Kramer, Ritchie, & Jenkins, 2016; Devue, Wride, & Grimshaw, 2018) may not be fulfilled in a short exposure time.

The use of facial stimuli within this work differs from the commonly used interview paradigm in deception literature (Feeley & deTurck, 1998; Leins et al., 2012; Vrij et al., 2006, 2009; Vrij, Fisher, et al., 2008) through the use of simple responses to the recognition of the stimuli, not a recall of known information and verbalisation of this. Such a design allows for a greater level of control over factors such as stress involved in an interview which may impact responses by applying further load to the task (DePaulo et al., 2003). A potential limitation of such a method, however, is that the recognition of facial stimuli may differ from the recall of encoded information and context relevant schema information required for verbal deception (McCornack et al., 2014; Sporer, 2016). This may, therefore, mean that findings of such work are incompatible with established research findings and theory relating to an interview paradigm. Current research upon facial stimuli used within a deception research design does, however, find similarities in processing between a facial recognition design and processing theory based upon verbal deception (Sun et al., 2015, 2016) holding the implication that face recognition paradigm research upon deception processing may be compatible with recall paradigm interview methodology.

As stated, this work aims to investigate the processing of truth and lie responses and the associated cognitive cost of each of these responses. Current deception processing theory states that there should be no difference in cognitive cost between truth and lie processing (McCornack et al., 2014; Walczyk et al., 2014) while a vast amount of experimental evidence suggests that lying does in fact have a greater cognitive cost than truth telling (Debey et al., 2014, 2012; Sporer, 2016; Suchotzki et al., 2015; Vrij et al., 2018, 2006). Additionally, the effect on processing of application of additional load will be investigated. Literature provides evidence of the effectiveness of this technique within deception detection (Vrij et al., 2018, 2006) proposed as being a result of applying additional load to an already loaded process. The impact of this upon the actual cognitive processing stages requires further elaboration, however, and if lying is found to be no more load inducing than truth telling, as proposed within theory (McCornack et al., 2014; Walczyk et al., 2014) alternative explanations of the effects of applied load must be considered.

Within this research, additional cognitive load will be applied at the encoding stage of memory when information is first presented, impacting the magnitude of encoding of presented information. This will allow for an investigation of the first step of truth recall within deception processing, and the degree to which truthful information is important in the construction of a lie. This first step of truth recall is suggested within processing theory (McCornack et al., 2014; Walczyk et al., 2014) and has received experimental support towards its existence (Debey et al., 2014; Sun et al., 2015). Also explained, however, is the proposal that lies are constructed with the first available recalled information and it is the intention to lie that is important (McCornack et al., 2014). In this case, while a lie is intended to be provided an accurate recall of the truth may not be required and the first available information will be used in place. Load applied at the encoding stage of memory will result in a poor encoding of truthful information related to divided attention (Morrison et al., 2015; Sweller, 1988), making this information more difficult to recall. If lying requires a first step of truth recall (Debey et al., 2014; McCornack et al., 2014; Walczyk et al., 2014), whereby the truth must be recalled before deception can be constructed, this poor encoding should result in a more difficult to process lie. If lying does not require a first step of an accurate truth recall, where a lie can just be made up with the first available information if the lie is intended, poor encoding of the truthful information may make no difference to lie processing, as the truthful information is not required.

Based upon the discussed theory, the following research hypotheses will be tested. Lie responses will be significantly slower in their response time and lower in their response accuracy than truthful responses; this will test literature suggesting a greater difficulty in the processing of deception related to a greater cognitive demand within lie processing (Debey et al., 2014; Suchotzki et al., 2015).

In relation to literature suggesting the effectiveness of application of load (Vrij et al., 2018, 2006), both response types will be significantly slower in their response time and lower in their response accuracy in the high load condition. If it is found that lying has a greater associated cognitive cost through the analysis for hypothesis one, it may also be expected that lies are affected more so by application of load related to the application of load to an already loaded process.

Additional analysis will also be conducted upon a potential difference of responses to previously seen facial stimuli and never before seen unfamiliar facial stimuli. If these stimuli types are found to be different, data must be split further to account for this. If they are not found to be different, then responses to each stimuli type can be considered the same as exposure to stimuli was not extensive enough to achieve familiarity.

Method

Design

This experiment utilised a repeated measures design. All participants took part in both low cognitive load and high cognitive load conditions, were presented with both male and female faces, and were instructed to be truthful and deceptive. The block order of these variables was randomised for each participant to counter any order effects of the design.

The first independent variable was the instructed response type with two levels of an instructed truthful response or an instructed lie response; instruction provided by the word ‘truth’ or ‘lie’ on screen. The second independent variable was the applied cognitive load with two levels of low applied cognitive load (identifying the colour of the letter string) and high applied cognitive load (identifying a specific target letter within a presented letter string). A within subjects design was utilised with all participants responding both truthfully and deceptively, as well as taking part in low and high load conditions.

The first dependent variable was the response time to the presented faces, measured in milliseconds (ms) to respond between stimulus onset and response provided. Only correct responses, hit or correct rejection, were included within analysis. The second dependent variable was the number of correct responses provided. For truthful responses this was measured as a ‘yes’ response to target stimuli and a ‘no’ response to foil stimuli, correctly identifying the stimuli. For lie responses this was measured as a ‘no’ response to target stimuli and a ‘yes’ response to foil stimuli, correctly lying about identification of the stimuli.

Participants

Thirty-six undergraduate students at the University of Huddersfield (eight male, M-age=23 years, SD=7.9 years) were recruited as a volunteer sample via the SONA recruitment system at the University of Huddersfield; an online recruitment software containing details of the experiment and opportunity for participants to book a time most convenient to them. Participation via this system is voluntary, though a certain number of credits are required as part of the course of each student, with one credit equalling 30 minutes of research time. All participants had normal, or corrected to normal, vision and were fluent in English.

Apparatus

Facial stimuli were created using Facegen Modeller 3.5, a tool used to generate face images via manipulation of sliders to change aspects of facial features (such as nose size small-large) or create randomly generated faces within set parameters. Sliders for each facial structure aspect were locked between a certain threshold to ensure average faces were generated, avoiding the 'monster' settings the software is capable of, and then randomised in their generation to create many distinct face stimuli. No hair or facial hair was present in any stimuli. To counterbalance effects of a potential own sex bias in facial recognition (Herlitz & Lovén, 2013) both distinctive male and female faces were created for use by manipulating the sex slider to 75% or above male or female facial features. Only white European faces were selected for use as the inclusion of multiple ethnicities would have created difficulty in counterbalancing all possible options of sex and ethnicity across all participants. This facial type was selected due to the geographical location of the experiment ensuring a high level of perceptual expertise of identification of white European faces (Tanaka et al., 2013).

In total 200 male and 200 female faces were generated. 50 of each sex were designated as target faces and 150 of each sex designated as foil faces. The designation of which stimuli were target and which were foil was randomised once before use in experimentation to create a group of target faces and a group of foil faces. Faces designated as target remained target stimuli in all subsequent experimentation, and likewise for foil stimuli. Designation was random to maximise potential of a wide range of differing facial features in both stimuli types and so that faces of one group could not be identified more easily than the other group.

The experiment used a 15.5 inch LCD monitor to view the experiment, a standard laptop pc running Windows 10, with a standard keyboard for participants to respond. The experiment was programmed using e-Prime 2.0 and software was programmed to record both response time from stimulus onset to response provided, and the accuracy of this response in relation to the correct response.

Procedure

Participants were first verbally briefed on the task, instructed that they would be asked to respond both truthfully and deceptively to stimuli and take part in both low and high applied cognitive load trials. After the opportunity to ask for further information or greater clarity, informed consent was provided.

Each trial block of the experiment contained two stages, first a stage of encoding where facial stimuli were presented in the centre of the screen with a letter string superimposed over the focal point of the face. Participants were instructed to encode the facial stimuli to the best of their ability as they would later be tested upon their recognition, while responding to the letter string task. These letter strings were six letters long and contained angular letters (H, K, M, W, Z, X, N) randomly selected and placed in a random location within the string. Every letter string contained only one target letter (X or N), and this was placed in a random location within the string. These letter strings functioned as a distractor task to induce cognitive load during the encoding of facial stimuli based upon the Jenkins, Lavie, & Driver, (2005) research design where identification of letter string colour induced a low cognitive load upon the task and target letter identification induced an overall higher cognitive load.

Low load task: participants were required to identify the colour of the letter string presented, pressing button '1' if the letters were blue and '0' if the letters were red.

High load task: participants were required to search for a target letter within the letter string, pressing button '1' if the target letter was an 'X' and '0' if the target letter was an 'N'.

Faces and letter strings were presented for 400ms before participants were asked to respond to the string colour or target letter. Within the original research design (Jenkins et al., 2005) a 200ms exposure time was implemented, this was increased to 400ms in the current design in an attempt to increase the level of encoding of facial information. Feedback was provided as to whether the response was correct, incorrect or no response was detected. A 200ms inter stimulus interval between each feedback display and new stimuli was present. A total of five to be remembered target faces were presented in a random order ten times each. Stimuli sexes were not mixed within each trial block to prevent the possibility of an own sex bias influencing recognition, stimuli were either exclusive male or female for each block.

The second stage, recognition, presented ten faces in a random order, five of which were the previously seen target stimuli which participants were instructed to encode to the best of their ability, and five were never before seen foil stimuli. Participants were required to identify recognition of these stimuli as quickly as possible, pressing ‘1’ for a ‘yes’ response, recognition of stimuli, or ‘0’ for a ‘no’ response, no recognition of stimuli. Following each response an inter stimulus interval of 500ms occurred before presenting the next random face. At this stage, the word ‘truth’ or ‘lie’ was superimposed at the focal point of the face, providing instruction as to the response type required, with lie responses requiring a change in response recognition. Ten truthful responses were requested followed by ten lie responses, or vice versa. No foil stimuli were seen more than once throughout the experiment. Instructions were provided before each stage to ensure clarity of the task.

The experimenter was present throughout the task to offer further clarity to participants if required, and to ensure engagement with the task. Data was visually inspected before analysis with instances of complacency and lack of task engagement, usually a repeated pressing of only one response button, were removed from analysis.

Following completion, a new trial block began using the opposite cognitive load and new stimuli, following the same design. In total eight trial blocks were completed by each participant, with four blocks for each cognitive load. Each trial block contained ten truthful and ten deceptive responses, equating to one hundred and sixty responses in total, eighty lie and eighty truth, forty low load lie, forty high load lie, forty low load truth and forty high load truth.

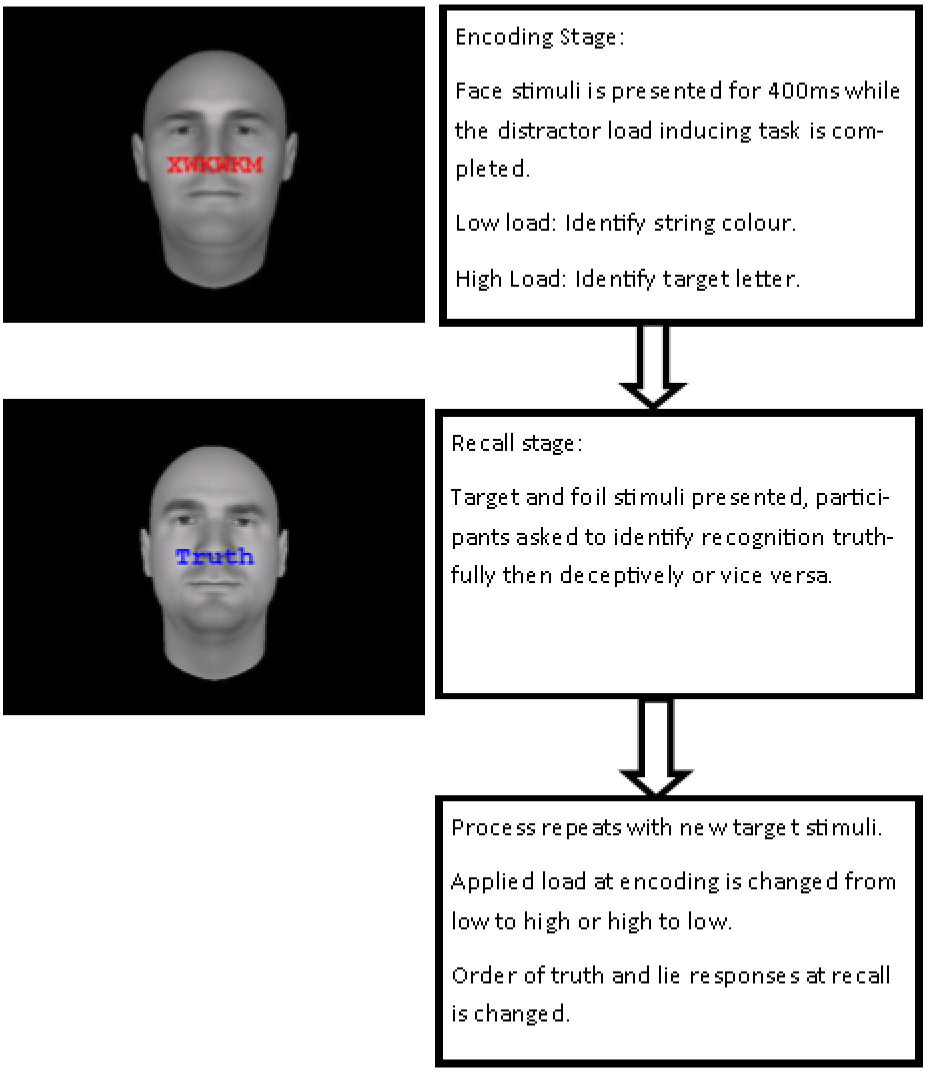

Figure 2. Flow of a single trial block in experiment 1.

Results

Response Time

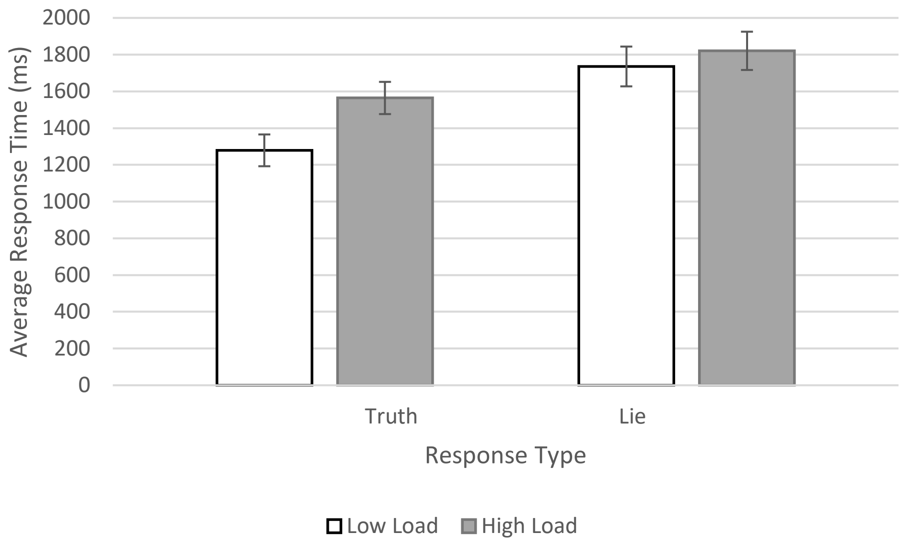

Figure 3. Average response time of truth and lie responses in high and low cognitive load, error bars represent one standard error.

Mean values in figure 3. were analysed using a 2x2 repeated measures ANOVA with the alpha level set at 0.05 with response type (truth vs. lie) and cognitive load (low load vs. high load) as the within subjects variables. The aim of which was to test for a difference in response time due to these variables.

An interaction effect was reported between response type and applied cognitive load $F(1,35)=11.492$, $p=0.002$, partial eta squared=0.247, indicating that the effect of applied load on response time depends upon the response type provided. A main effect of response type was found $F(1,35)=25.39$, $p<0.01$, partial eta squared=0.42, indicating significantly slower lie responses (M=1778.22, SD=637.45) than truth responses (M=1421.55, SD=522.78) and a main effect of applied load $F(1,35)=38.47$, $p<0.01$, partial eta squared=0.52, indicating significantly slower high load responses (M=1692.42, SD=587.97) than low load responses (M=1507.35, SD=584.27).

Post hoc data used a Bonferroni adjusted alpha level of 0.025. Simple main effect analysis indicated a significant difference between low load truth (M=1279.03, SD=519.09) and low load lie (M=1735.68, SD=649.46) responses, $t(35)=5.909$, $p<0.001$, $d=0.78$ and a significant difference between high load truth (M=1564.06, SD=526.48) and high load lie (M=1820.77, SD=625.43) responses, $t(35)=3.375$, $p=0.002$, $d=0.44$. Lie responses are, therefore, found to be slower on average than truth responses regardless of applied cognitive load.

Further post hoc data regarding cognitive load indicated a significant difference in truthful responses between the high (M=1564.06, SD=526.48) and low (M=1279.03, SD=519.09) load condition, $t(35)=8.114$, $p<0.001$, $d=0.55$. However, no difference is found in lie responses between the high (M=1820.77, SD=625.43) and low (M=1735.68, SD=649.46) load condition $t(35)=1.780$, $p=0.084$, $d=0.13$. Truth responses were found to significantly increase in their response time between low and high cognitive load conditions, while such an effect was not seen for lie responses. This explains the interaction effect found, as truth responses were affected to a greater extent by the application of load at encoding than lie responses.

Response Accuracy

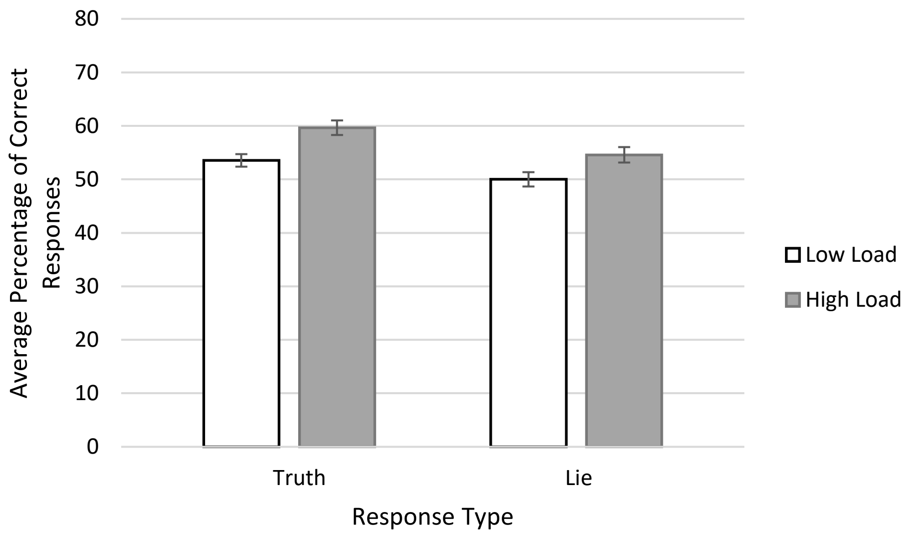

Figure 4. Average response accuracy of truth and lie responses in low and high cognitive load, presented as a percentage, error bars represent one standard error.

Mean values in figure 4. were analysed using a 2x2 repeated measures ANOVA with the alpha level set at 0.05 with response type (truth vs. lie) and cognitive load (low load vs. high load) as the within subjects variables. The aim of which was to test for a difference in response accuracy due to these variables.

No interaction effect was reported between response type and applied cognitive load $F(1,35)=0.39$, $p=0.54$, partial eta squared=0.01. A main effect of response type was found $F(1,35)=14.31$, $p<0.01$, partial eta squared=0.29, indicating significantly less accurate lie responses (M=20.92, SD=3.34) in comparison to truth responses (M=22.64, SD=3.04). This suggests a greater difficulty in the processing of deception in comparison to the processing of truth. A main effect of applied cognitive load was also found $F(1,35)=18.40$, $p<0.01$, partial eta squared=0.35, indicating significantly higher accuracy in the high cognitive load condition (M=22.85, SD=3.37) in comparison to the low cognitive load condition (M=20.71, SD=3.01). This suggests an accurate recognition of information was easier within the high load condition.

Target and Foil Responses

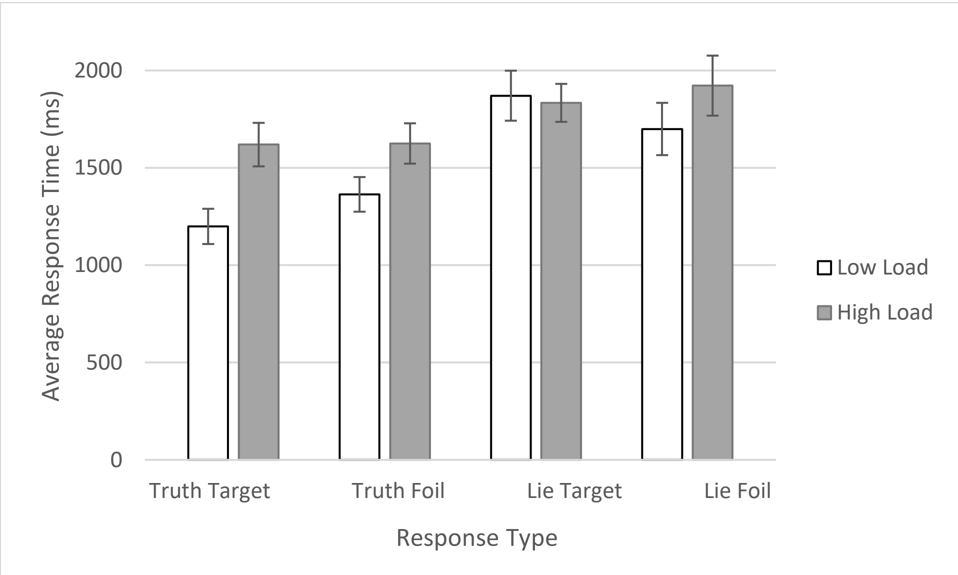

Figure 5. Average response time of truth and lie responses to target and foil stimuli in low and high cognitive load, error bars represent one standard error.

Additional analysis was conducted upon responses to target and foil faces; these were hypothesised as potentially different types of response, to a previously seen (target) stimulus, and to a never seen (foil) stimulus. Establishing if such a difference in responses existed was vital to analysis as a difference would create another level of variables which must be controlled for within analysis. Mean values in figure 5. were analysed using a 2x2x2 repeated measures ANOVA with the alpha level set at 0.05 with response type (truth vs. lie), cognitive load (low load vs. high load), and stimulus type (target vs. foil) as the within subjects variables. The aim of which was to test for a potential difference in response time due to these variables.

A main effect of stimuli type was found $F(1,35)=24.28$, $p<0.01$, partial eta squared=0.41, indicating significantly slower lie responses (M=1831.40, SD=771.56) than truth responses (M=1451.69, SD=592.31). A main effect of applied load was also found $F(1,35)=31.72$, $p<0.01$, partial eta squared=0.48, indicating significantly slower high load responses (M=1749.97, SD=700.61) than low load responses (M=1533.12, SD=663.26). No main effect of stimuli type was found $F(1,35)=0.11$, $p=0.74$, partial eta squared<0.01, indicating no difference in response time between target and foil stimuli.

No interaction effect was reported between response type and stimuli type $F(1,35)=1.74$, $p=0.20$, partial eta squared=0.05, nor was an interaction effect present between applied cognitive load and stimuli type $F(1,35)=0.30$, $p=0.59$, partial eta squared=0.01. An interaction effect was however reported between response type and applied cognitive load $F(1,35)=10.49$, $p<0.01$, partial eta squared=0.23 indicating the effect of applied load was dependent upon the response type.

Post hoc data used a Bonferroni adjusted alpha level of 0.025. Simple main effect analysis indicated a significant difference between truth responses in the low load condition (M=1279.03, SD=519.09) and lie responses in the low load condition (M=1735.68, SD=649.46) $t(35)=-5.91$, $p<0.01$, $d=0.78$ and a significant difference between truth responses at high load (M=1564.06, SD=526.48) and lie responses at high load (M=1820.77, SD=625.43) $t(35)=-3.38$, $p<0.01$, $d=0.44$. This data, therefore, provides support to the previous analysis upon response time, indicating a difference between truth and lie in terms of their response time, with lie responses being slower on average.

An interaction effect was also reported between response type, applied cognitive load and stimuli type $F(1,35)=6.50$, $p=0.02$, partial eta squared=0.16. Post hoc data used a Bonferroni adjusted alpha level of 0.0125. Simple main effect analysis indicated no difference between lie responses at high load to target stimuli (M=1833.63, SD=584.87) and lie responses at high load to foil stimuli (M=1922.06, SD=925.39) $t(35)=0.75$, $p=0.46$, $d=0.11$, no difference between lie responses at low load to target stimuli (M=1870.40, SD=770.52) and lie responses at low load to foil stimuli (M=1699.50, SD=805.47) $t(35)=1.30$, $p=0.20$, $d=0.22$, and no difference between truth responses at high load to target stimuli (M=1619.16, SD=670.08) and truth responses at high load to foil stimuli (M=1625.05, SD=622.08) $t(35)=0.07$, $p=0.95$, $d=0.01$. A significant difference was, however, reported between truth responses at low load to target stimuli (M=1199.04, SD=543.01) and truth responses at low load to foil stimuli (M=1363.53, SD=534.07) $t(35)=3.09$, $p<0.01$, $d=0.31$. This indicated that the type of stimuli seen within the recognition stage, be it a previously seen before target face or a never before seen foil face, had no impact upon the response time of participants. A difference was reported for truthful responses at low load, though considering the lie response type at both low and high load as well as truth responses in the high load condition indicated no difference, responses to stimuli type are to be considered the same. For the purposes of this analysis, responses to both target and foil stimuli can be considered the same type of response and no further modification is required to the data. Analysis conducted regarding hypothesis 1 and 2 does not need to be split further between target and foil stimuli. Hypothesis 3 is therefore rejected.

Discussion

The current research aimed to investigate further into the processing of truth and lie responses and potential differences between these two response types. Specifically, an investigation of the load associated with each response type was conducted due to differences between theoretical propositions and experimental evidence. This research also aimed to investigate the effects of application of factors such as additional cognitive load upon truth and deception processing. This will allow for further investigation of associated load within truth and lie processing, as research suggests a greater effect of applied load upon lies related to adding more load to an already loaded process (Vrij et al., 2006). Furthermore, application of load at the encoding stage of memory will allow for a first step of truth recall within deception processing to be investigated. If lies require a recall of the truth within their processing (Debey et al., 2014), a poorly encoded truth memory should result in a greater difficulty within this processing, while if the truth does not have to be recalled a poorly encoded truth should not impact lie processing.

A potential difference between the processing of previously seen before target stimuli and never before seen foil stimuli was identified related to differences in the processing of familiar and unfamiliar faces (Benton, 1980; Hanso et al., 2010; Ramon et al., 2015). Such a difference in the processing of faces may have created another variable to be considered within analysis. This difference may not be fulfilled, however, due to the extensive exposure required for a face to become familiar (Burton et al., 2016; Devue et al., 2018). No difference was reported between target and foil stimuli within this research, and so responses to both previously seen and never before seen faces can be considered the same in terms of their processing and do not need to be split as another variable level during analysis.

In terms of a difference between truth and lie processing, support was provided towards experimental literature suggesting a greater level of cognitive effort required within the processing of lies in comparison to truth (Debey et al., 2014, 2012; Sporer, 2016; Suchotzki et al., 2015; Vrij et al., 2018, 2006). Lie responses were found to be both slower in their response time, and lower in their response accuracy than truthful responses. It is suggested that this reflects a difference between the processing of truth and lie responses which results in a greater associated load for lie responses. Applied to theory, this greater difficulty is possibly associated with the extra step of construction present within lie responses (McCornack et al., 2014; Walczyk et al., 2014) as this stage would account for the slower response time and greater difficulty within processing. Though both the ADCAT (Walczyk et al., 2014) and IMT2 (McCornack et al., 2014) theories state that this stage should not result in a greater difficulty in the processing of lies, evidence exists to suggest that a construction stage does apply a greater amount of load within processing (Walczyk et al., 2003) and that in general every cognitive task engaged with requires further resources within processing (Morrison et al., 2015; Sweller, 1988). From the results of this experiment, however, exactly what the cause of this greater difficulty in deception processing is, is unclear. It is only clear that deceptive responses were more difficult and required a greater level of cognitive effort in comparison to truth responses. Hypothesis one related to a greater difficulty in the processing of lies in comparison to truth is, therefore, accepted as lie responses do appear to require a greater level of cognitive effort in their processing.

In terms of the application of additional cognitive load, truth responses were impacted in terms of their response time, indicating that poorer encoding of truthful information resulted in greater difficulty in the recognition and use of this information. Lie responses were, however, unaffected by the application of load in terms of their response time, suggesting that a stage of truth recall within lying may not be required. No change in response time data between applied cognitive loads, in lie responses, indicates the same level of processing for both low and high applied load, and considering the difference evidenced within truthful responses, suggests that truth information was not required in lie processing. Truth responses rely on an accurate recognition of the truth within their responses, you must remember the truth to provide the truth, hence a greater difficulty in processing of the truth as load was increased. If lie responses do not rely on an accurate truth recognition and can just be made up, a greater difficulty in truth recognition will make no difference to this response type, as truthful information is not required and a greater difficulty in the recognition of this information (Baddeley, 2007; Craik, Eftekhari, & Binns, 2018; Sporer, 2016) was not required within the processing of lies.

An alternative explanation of this finding is an effect of task difficulty. Lie response are more difficult than truth responses (Debey et al., 2014, 2012; Suchotzki et al., 2015), as evidenced by the findings related to hypothesis one, and so at baseline require a greater level of cognitive effort within their processing than truth responses. As a result of this, findings may reflect a ceiling effect, where lie responses were already at maximum difficulty, and so application of additional load had no effect upon this response type. Truth responses, with their lesser associated cognitive load, were impacted by an increase in cognitive load as their associated load within processing is lesser than that of lie responses. Further research is, therefore, required investigating at different levels of task difficulty to fully assess the impact of applied cognitive load upon truth and lie responses and the importance of an accurate truth recall within lie responses.

Further findings related to the impact of applied load upon truth and lie responses indicated that both response types became more accurate as load was increased. This suggests that application of load made the task easier, as information was more accurately recognised as load was increased, this being in contrast to findings related to response time which indicate an increase in task difficulty as load was increased. A possible explanation of an increase in response accuracy as applied cognitive load was increased is an increase in the amount of attention that had to be paid to the task. All tasks engaged with require the consumption of cognitive resources, including attention (Morrison et al., 2015; Sweller, 1988). The high load task may have caused participants to pay more attention during the encoding of information while searching for and responding to the target letter, accounting for a greater associated load within this task, and so led to a greater encoding of the provided facial information. This finding may also represent a trade-off effect of cognitive resources, where response accuracy is increased at the cost of response time (Craik et al., 2018). Retrieval of information requires the consumption of cognitive resources (Baddeley, 2007; Craik et al., 2018; Sporer, 2016) and to ensure the accuracy of provided responses, responses must be provided more slowly, balancing out the required cognitive resources.

The findings related to response accuracy may again be investigated further via manipulation of task difficulty. Currently, it may be too difficult to encode enough information for an accurate identification of facial stimuli due to the low exposure time of these stimuli combined with the dual task related to applied load. Within the high load task, more attention was required, and so more information was encoded, leading to a more accurate recognition. Reduction of task difficulty via manipulation of exposure time will allow for a greater encoding of information related to the face, and so a more accurate recognition of this information (Sporer, 1991). This will allow for further investigation of the impact of applied load upon truth and lie responses and is required due to the difference of findings between response time and response accuracy. Response time data indicating an increase in difficulty as load is increased, while response accuracy suggests a reduction of difficulty as load is increased. Manipulation of task difficulty will aid in gaining a better understanding of the role of applied load upon truth and deception processing, as well as the role of a first step of truth recall within deception processing.

Currently, findings related to the effect of applied load upon truth and lie processing are inconclusive, with some data suggesting an increase in difficulty while alternative data suggests a decrease in difficulty. Further investigation is required to determine the role applied load plays within truth and lie processing, and a manipulation of task difficulty is suggested as a way in which to achieve this.

In conclusion, this research provides evidence that lying is more difficult than truth telling, providing support to experimental evidence (Debey et al., 2014, 2012; Sporer, 2016; Suchotzki et al., 2015; Vrij et al., 2018, 2006) and indicates established processing theory should account for a greater difficulty in processing of lies. The cause of this greater difficulty in the processing of lies is unclear from this work, though it is suggested that it may be related to the additional step of construction proposed within theory (McCornack et al., 2014; Walczyk et al., 2014) as previous evidence has highlighted this stage to impact upon response time in processing (Walczyk et al., 2003). Further research is required, however, to determine the cause of this greater difficulty as, while a greater difficulty in processing is apparent from this work, the exact cause is unclear.

The effects of applied load within this work require further investigation. While it appears that lying may not require an accurate recognition of the truth, a ceiling effect is a possible explanation of the findings provided. It is recommended that the effect of applied load upon truth and lie processing be considered again with a manipulation of task difficulty present. This will allow for a better encoding of information, while still measuring the effects of applied load upon processing. Doing so will allow for a more robust assessment of the effects of applied load upon truth and lie processing, as well as a measure of the importance of a first step of truth recall within lie processing.

Experimental Chapter Two: The processing of truths and lies with cognitive load applied at encoding with varying exposure times.

Introduction

Previous research in chapter one provided evidence of a greater difficulty in the processing of lie responses than truth responses, supporting experimental findings (Debey et al., 2014, 2012; Suchotzki et al., 2015; Vrij et al., 2018, 2006) and the proposition of a greater cognitive demand within the working memory model of deception processing (Sporer, 2016). Findings related to the application of additional load, however, were inconclusive with no effect of load upon the response time of lies, and an increase in response accuracy of both truth and lie responses. The finding of no effect of load upon lie responses calls to question the first step of truth telling proposed within lies (Debey et al., 2014; McCornack et al., 2014; Walczyk et al., 2014) as a poorly encoded truthful memory did not seem to impact the ability to provide a lie, while truth was affected. This finding may, however, be explained by task difficulty; a ceiling effect of deception already being difficult and requiring a high cognitive demand within the task resulting in no measurable difference between applied low cognitive load and high cognitive load upon deceptive responses. A difference is still present within truth responses between low and high applied load as the associated load of this response type is lesser than that of lies, resulting in a measurable difference of load application.

To test this research question, and to further investigate the effects of applied load upon deception processing, various difficulty levels are proposed to be used within experimentation. Lower overall task difficulty will result in a better encoding of information as more time is provided to the holistic processing of faces (Boutet et al., 2002; Sporer, 1991; Wang et al., 2012). This will allow for any differences between low and high applied cognitive load to be investigated, while still measuring the effects upon processing of applied load. This will then allow for a more robust assessment of the effects of applied load upon truth and lie processing, as well as a measure of the importance of a first step of truth recall within lie processing.

To facilitate task difficulty in relation to facial stimuli several strategies are proposed including repeated exposure of stimuli, low number of blocks to be stored and exposure time of stimuli (Haxby et al., 1996). The current research design implements both repeated exposure and a low number of blocks, with only five stimuli to be stored at any one time and each presented ten times in total. Manipulation of stimuli exposure time would appear to be a practical way to vary the task difficulty while maintaining consistency in other aspects of the task. Additionally, evidence is provided that encoding strategies specialised for facial stimuli, such as making judgements of the character of the facial stimuli, made no difference over holistic strategies of encoding various aspects of the face and its structure (Sporer, 1991). This, therefore, suggests that sufficient exposure time to the facial stimuli to encode information is enough to facilitate recognition (Memon et al., 2003), again suggesting that manipulation of exposure time is a viable method of varying task difficulty.

In consideration of the difficulty of the stimuli type, more face stimuli are evidenced to be stored within the visual short-term memory than other, similar, complex visual stimuli (Curby & Gauthier, 2007), the example provided being faces compared to cars. It is suggested that this greater ability to store and recognise facial stimuli is related to facial expertise and the holistic processing methods employed for this stimuli type in comparison to other complex visual stimuli (Curby & Gauthier, 2007; Wang et al., 2012). Facial stimuli should, therefore, be a viable stimulus without inadvertently creating too great a task difficulty.

Three exposure times of 400ms, 800ms and 1200ms were proposed for use within this experimental design to assess the effects of task difficulty upon deception processing. Exposure time to stimuli was a key element in the encoding of facial stimuli and a practical way of manipulating task difficulty (Haxby et al., 1996; Sporer, 1991) as longer exposure time allows for more facial stimuli to be stored in visual short-term memory (Curby & Gauthier, 2007). This will allow for further analysis of the effects of applied cognitive load upon deception as a lesser overall cognitive load at higher exposure times will allow for any potential differences due to the applied load to be measured. Additionally, differences between truth and lie responses can still be made at each exposure time.

Based on the discussed theory, the following research hypotheses will be tested. Lie responses will be significantly slower in their response time and lower in their response accuracy than truthful responses. This will test literature suggesting a greater difficulty in the processing of deception related to a greater cognitive demand within lie processing (Debey et al., 2014; Suchotzki et al., 2015) and the findings of chapter one which indicated a greater difficulty in lie responses.

In relation to literature suggesting the effectiveness of application of load (Vrij et al., 2018, 2006), both response types will be significantly slower in their response time and less accurate in their response accuracy in the high load condition. If it is found that lying has a greater associated cognitive cost through the analysis for hypothesis one, it may also be expected that lies are affected more so by application of load related to the application of load to an already loaded process.

Concerning a reduction of task difficulty, greater exposure time will significantly increase response accuracy and reduce response time as information will be better encoded with a longer exposure time and so easier to recognise (Curby & Gauthier, 2007; Haxby et al., 1996; Sporer, 1991). Additionally, such a change based on exposure time will provide evidence of a first step of truth recall within deception processing. If a better encoded truth facilitates lie responses, evidence is provided of the use of this information during lie processing.

Method

Design

A repeated measures design was utilised within this experiment. All participants took part in the high and low cognitive load conditions, were presented with both male and female faces, were instructed to be truthful and deceptive, and were exposed to three exposure times of stimuli. The block order of these variables was randomised for each participant to counter any order effects of the design.

The first independent variable was the cognitive load of the task. This was split between two levels: high cognitive load (identifying a specific target letter within a presented letter string) and low cognitive load (identifying the colour of the letter string). The second independent variable was the instructed response type split between two levels of an instructed truthful response or an instructed lie response; instruction provided by the word ‘truth’ or ‘lie’ onscreen. The third independent variable was the exposure time of each individual stimulus split between three levels of 400ms, 800ms and 1200ms. A within subjects design was utilised with all participants responding both truthfully and deceptively, taking part in low and high load conditions, and subject to all three exposure times.

The first dependent variable was the response time to the presented faces, measured in milliseconds (ms) to respond between stimulus onset and response provided. Only correct responses, hit or correct rejection, were included in the analysis. The second dependent variable was the number of correct responses provided. For truthful responses this was measured as a ‘yes’ response to target stimuli and a ‘no’ response to foil stimuli, correct identification of the stimuli. For lie responses this was measured as a ‘no’ response to target stimuli and a ‘yes’ response to foil stimuli, correctly lying about identification of the stimuli.

Participants

Twenty-eight undergraduate students at the University of Huddersfield (five male, M-age=22.6 years, SD=7.6 years) were recruited as a volunteer sample via the SONA recruitment system at the University of Huddersfield; an online recruitment software containing details of the experiment and opportunity for participants to book a time most convenient to them. Participation via this system is voluntary, though a certain number of credits are required as part of the course of each student, with one credit equalling 30 minutes of research time. All participants had normal, or corrected to normal, vision and were fluent in English.

Apparatus

Facial stimuli and apparatus used within this experiment remained consistent with those used in chapter one.

Procedure

Participants were first verbally briefed on the task, instructed that they would be asked to respond both truthfully and deceptively to stimuli, take part in both low and high applied cognitive load trials and that they would take part in all three task difficulty levels. After the opportunity to ask for further information or greater clarity, informed consent was provided.

Each trial block of the experiment contained two stages, first a stage of encoding where facial stimuli were presented in the centre of the screen with a letter string superimposed over the focal point of the face. Participants were instructed to encode the facial stimuli to the best of their ability as they would later be tested upon their recognition, while responding to the letter string task. These letter strings were six letters long and contained angular letters (H, K, M, W, Z, X, N) randomly selected and placed in a random location within the string. Every letter string contained only one target letter (X or N), and this was placed in a random location within the string. These letter strings functioned as a distractor task to induce cognitive load during the encoding of facial stimuli.

Low load task: participants were required to identify the colour of the letter string presented, pressing button ‘1’ if the letters were blue and ‘0’ if the letters were red.

High load task: participants were required to search for a target letter within the letter string, pressing button ‘1’ if the target letter was an ‘X’ and ‘0’ if the target letter was an ‘N’.

Faces and letter strings were presented for 400ms, 800ms or 1200ms, depending on the task difficulty level of the trial block, before participants were asked to respond to the string colour or target letter. Feedback was provided as to whether the response was correct, incorrect or no response was detected. A 200ms inter stimulus interval between each feedback display and new stimuli was present. A total of five to be remembered target faces were presented in a random order ten times each. Stimuli sexes were not mixed within each trial block to prevent the possibility of an own sex bias influencing recognition, stimuli were either exclusively male or female for each block.

The second stage, recognition, presented ten faces in a random order, five of which were the previously seen target stimuli which participants were instructed to encode to the best of their ability, and five were never before seen foil stimuli. Participants were required to identify recognition of these stimuli as quickly as possible, pressing '1' for a 'yes' response, recognition of stimuli, or '0' for a 'no' response, no recognition of stimuli. Following each response an inter stimulus interval of 500ms occurred before presenting the next random face. At this stage, the word 'truth' or 'lie' was superimposed at the focal point of the face, providing instruction as to the response type required, with lie responses requiring a change in response recognition. Ten truthful responses were requested followed by ten lie responses, or vice versa. No foil stimuli were seen more than once throughout the experiment. Instructions were provided before each stage to ensure clarity of the task.

The experimenter was present throughout the task to offer further clarity to participants if required, and to ensure engagement with the task. Data was visually inspected before analysis with instances of complacency and lack of task engagement, usually a repeated pressing of only one response button, were removed from analysis.

Following completion, a new trial block began using the opposite cognitive load and new stimuli, following the same design. A total of four trial blocks were completed at each task difficulty level before this was changed. Order of difficulty was random for each participant to balance order effects. In total, twelve trial blocks were completed by each participant, four blocks per difficulty level and six trial blocks for each cognitive load with two low load and two high load blocks per difficulty level. Each block contained ten truthful and ten deceptive responses, equating to two hundred and forty responses in total, twenty of each response type (truth and lie) per cognitive load (high and low) per exposure time (400ms, 800ms, 1200ms).

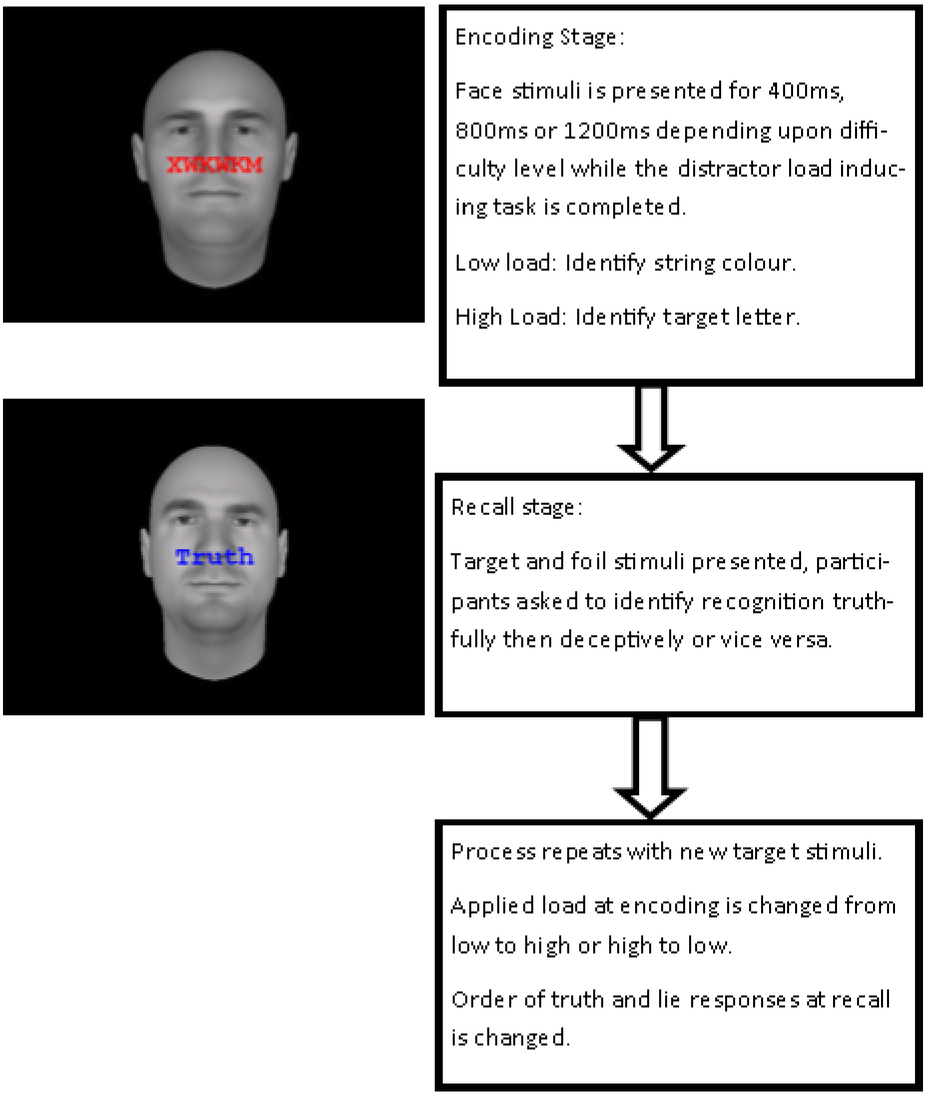

Figure 6. Flow of a single trial block in experiment 2.

Results

Response Time

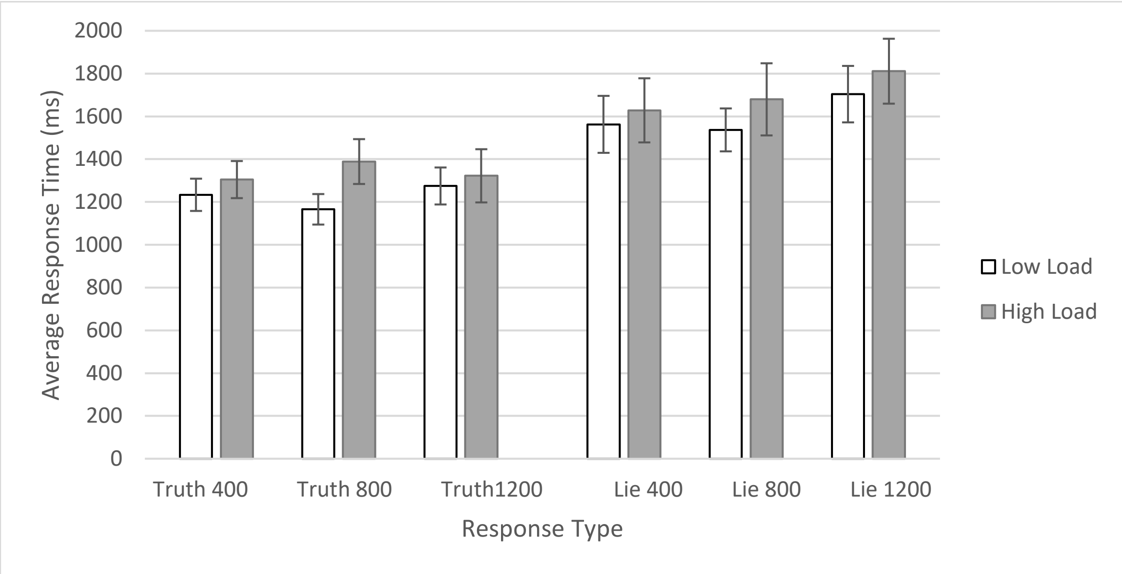

Figure 7. Average response time of truth and lie responses at three exposure times in high and low cognitive load, error bars represent one standard error.

Mean values in figure 7. were analysed using a 2x2x3 repeated measures ANOVA with the alpha level set at 0.05 with response type (truth vs. lie), cognitive load (low load vs. high load), and exposure time (400ms vs. 800ms vs. 1200ms) as the within subjects variables. The aim of which was to test for a difference in response time due to these variables.

No interaction effect was present for any combination of variables: response type by applied load $F(1,27)=0.02$, $p=0.90$, partial eta squared<0.01, response type by exposure time $F(2,54)=1.90$, $p=0.16$, partial eta squared=0.07, applied load by exposure time $F(2,54)=0.93$, $p=0.40$, partial eta squared=0.03, response type by applied load by exposure time $F(2,54)=0.52$, $p=0.60$, partial eta squared=0.02. Though a main effect of response type

F(1,27)=27.48, *p*<0.001, partial eta squared=0.50 was found, indicating significantly slower lie responses (M=1653.66, SD=639.63) compared to truth responses (M=1281.53, SD=353.88). This suggests a greater difficulty in the processing of deception in comparison to the processing of truth. A main effect of load was also found *F*(1,27)=7.66, *p*=0.01, partial eta squared=0.22 indicating significantly slower responses in the high cognitive load condition (M=1522.36, SD=543.30) than in the low cognitive load condition (M=1412.83, SD=436.53). This suggests a greater difficulty in processing within the high load condition. No main effect of exposure time was reported *F*(1,27)=0.76, *p*=0.47, partial eta squared=0.03 indicating no difference in response time as a result of exposure time.

Response Accuracy

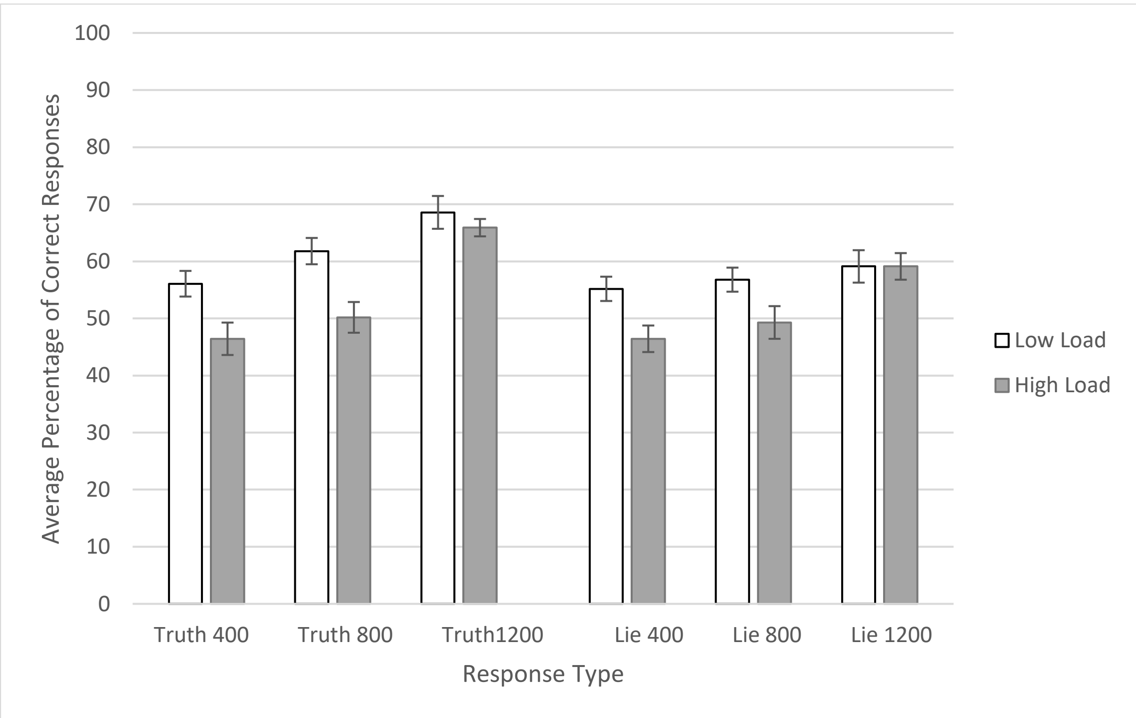

Figure 8. Average response accuracy of truth and lie responses at three exposure times in high and low cognitive load, presented as a percentage, error bars represent one standard error.

Mean values in figure 8. were analysed using a 2x2x3 repeated measures ANOVA with the alpha level set at 0.05 with response type (truth vs. lie), cognitive load (low load vs. high load), and exposure time (400ms vs. 800ms vs. 1200ms) as the within subjects variables. The aim of which was to test for a difference in response accuracy due to these variables.

No interaction effect was found between response type and applied cognitive load $F(1,27)=1.46$, $p=0.24$, partial eta squared=0.05, nor was an interaction effect present between response type, load and exposure time $F(2,54)=0.13$, $p=0.88$, partial eta squared<0.01. An interaction effect was, however, found between response type and exposure time $F(2,54)=4.62$, $p=0.01$ indicating the effect of exposure time upon response accuracy was dependent on the response type provided.

Post hoc data used a Bonferroni adjusted alpha level of 0.017. Simple main effect analysis indicated a significant difference between truth responses at 1200ms exposure time (M=13.45, SD=1.80) and lie responses at 1200ms exposure time (M=11.82, SD=2.41) $t(27)=3.97$, $p<0.01$, $d=0.77$. No difference, however, was present between truth responses at 400ms exposure time (M=10.25, SD=2.07) and lie responses at 400ms exposure time (M=10.17, SD=1.86) $t(27)=0.24$, $p=0.81$, $d=0.04$ or between truth responses at 800ms exposure time (M=11.20, SD=2.10) and lie responses at 800ms exposure time (M=10.61, SD=1.80) $t(27)=1.55$, $p=0.13$, $d=0.30$. Data, therefore, indicated that a difference in response accuracy between truth and lie responses is only seen at high levels of exposure time. This also explains the interaction effect, as the difference in the number of correct responses provided between truth and lie responses depends on the level of exposure to stimuli. It may be assumed that as task difficulty is reduced at the higher exposure times, more of a difference between truth and lie responses can be seen.

Additionally, an interaction effect was found between applied cognitive load and exposure time $F(2,54)=5.03$, $p=0.01$ indicating the effect of exposure time upon response accuracy was dependent on the level of applied cognitive load. Post hoc data used a Bonferroni adjusted alpha level of 0.017. Simple main effect analysis indicated a significant difference between low applied load response accuracy at 400ms (M=11.13, SD=2.04) and high applied load response accuracy at 400ms (M=9.29, SD=2.19) $t(27)=3.91$, $p<0.01$, $d=0.87$ and a significant difference between low load response accuracy at 800ms exposure time (M=11.86, SD=1.90) and high load response accuracy at 800ms exposure time (M=9.95, SD=2.26) $t(27)=4.03$, $p<0.01$, $d=0.92$. No difference was reported between low load response accuracy at 1200ms exposure time (M=12.77, SD=2.64) and high load response accuracy at 1200ms exposure time (M=12.50, SD=1.51) $t(27)=0.63$, $p=0.53$, $d=0.13$. Data, therefore, indicated that a difference in response accuracy between low and high applied load is only seen at lower levels of exposure time. This also explains the interaction effect, as the difference in the number of correct responses provided between low and high applied cognitive load depends on the level of exposure to stimuli. These results may relate to task difficulty, as the highest level of exposure time may have resulted in a high level of encoding of information, negating any effect of applied load to inhibit this.

As only some data combinations provided an interaction effect, main effects of the response accuracy analysis will also be provided to give a full account of the analysis. A main effect of response type was found $F(1,27)=9.77$, $p<0.01$, partial eta squared=0.27 indicating significantly more accurate overall truth responses (M=11.63, SD=1.44) than lie responses

(M=10.86, SD=1.57). A main effect of applied cognitive load was also found $F(1,27)=18.97$, $p<0.01$, partial eta squared=0.41 indicating significantly more accurate responses, overall, within the low load condition (M=11.92, SD=1.74) than within the high load condition (M=10.57, SD=1.41). Finally, a main effect of exposure time was reported $F(2,54)=25.04$, $p<0.01$, partial eta squared=0.48 indicating significantly more accurate responses within the highest level of exposure time of 1200ms (M=12.63, SD=1.83) than at the lower exposure times of 800ms (M=10.90, SD=1.67) and 400ms (M=10.21, SD=1.71). This also provides evidence towards the effectiveness of the exposure time manipulation implemented, as evidence is provided of an increase in response accuracy as exposure time increased, suggesting reduced task difficulty.

Discussion

Findings within chapter one provided evidence of a greater difficulty in the processing of lie responses compared to truth responses, though findings related to the impact of applied cognitive load were inconclusive, providing evidence of both an increase and decrease in difficulty related to applied load. It was suggested that this effect may be related to task difficulty and a ceiling effect within lie responses, and that this factor should be manipulated in order to investigate further the role of load application upon truth and lie processing; this was achieved within the current experiment. The current experiment also aimed to investigate further the first step of truth recall within deception processing reflected by the impact a well or poorly encoded truth has on the ability to process a lie response.

In terms of a difference between truth and lie processing, support was provided towards experimental literature suggesting a greater level of cognitive effort required within the processing of lies, evidenced by longer average response times within lies, in comparison to truth (Debey et al., 2014, 2012; Sporer, 2016; Suchotzki et al., 2015; Vrij et al., 2018, 2006). Support is also provided to the findings of chapter one where lies were concluded to be more difficult to process related to the same factor. Response accuracy, however, was found to only differ between truth and lie responses at the highest level of encoding time, with no difference in response accuracy present at lower encoding times. This suggests that only well encoded truthful information results in a difference between truth and lie response accuracy, though support of a greater difficulty in the processing of lies is still provided from this data. To explain, truth information is better encoded with a greater length of exposure time, evidenced by the main effect of exposure time for response accuracy, and so easier to accurately recognise. Lie accuracy is also increased by this greater exposure time, providing support to a first step of truth recall within lie processing, but the lower accuracy of lies suggests a greater difficulty within their processing (Suchotzki et al., 2015). Truthful information within lying is accessed and used, but due to the additional processing steps involved within lie processing lies were more likely to be wrong than truth responses, hence a greater associated load within lies.

Such a finding may relate to the working memory model of deception processing (Sporer, 2016), stating the use of the working memory in both retrieval of known information and in the construction of new information (Baddeley, 2007; Sporer, 2016). Deception involved both of these processes, while truth telling required only recall (Walczyk et al., 2014). As more processes are involved within a behaviour a greater likelihood of an error being made is created (Morrison et al., 2015; Sweller, 1988) hence the lower response accuracy within lies due to a greater difficulty in their process. A lower response accuracy within lies may also represent a failure to supress the recalled truth within response (Suchotzki et al., 2015). Lies require a recall of the truthful information and suppression of this as false information is provided in its place (McCornack et al., 2014; Walczyk et al., 2014). Lower response accuracy within lies may represent a failure to achieve this suppression. Individuals fail to change their response from the recalled truth to create a lie, which again may reflect a greater difficulty within this behaviour related to lie construction.

Considering the findings related to both response time and response accuracy, lie responses appear to be more difficult than truth responses. Applied to a working memory model, it may be suggested that this greater difficulty is related to a requirement of the changing of recalled information, utilising further working memory resources to create a lie (Baddeley, 2007; Sporer, 2016). This extra step is similar to the proposed construction stage within deception processing (McCornack et al., 2014; Walczyk et al., 2014). Hypothesis one related to a greater difficulty in the processing of lies in comparison to truth is, therefore, accepted as lie responses do appear to require a greater level of cognitive effort in their processing.

In terms of the application of additional load, findings indicated slower response times within the high load condition than in the low load condition. This suggests a greater difficulty within the processing of both response types as additional cognitive load was applied, providing support to the use of additional load as a method of impacting deception processing (Debey et al., 2015, 2012; Vrij et al., 2018, 2006; Vrij, Fisher, et al., 2008). A difference in response accuracy was reported at the lower encoding times, but not within the highest encoding time. It may be the case that at the highest encoding time, sufficient time was given to encode enough detail of the stimuli to ensure an accurate recognition, as length of time of exposure is the strongest factor in relation to accurate face recognition (Sporer, 1991). This explains why applied load did not impact recognition accuracy at this exposure time, as the applied load was not enough to overcome the level of encoding given to the stimuli. An effect of load is seen at the lower levels of encoding as information was successfully disrupted by the additional load applied, resulting in a greater difficulty of recognition of information, adding load to this process (Baddeley, 2007; Craik, Eftekhari, & Binns, 2018; Sporer, 2016).

Interestingly, the findings related to response accuracy and applied cognitive load illustrated the opposite effect as seen in the findings of chapter one, with response accuracy decreasing in the high load condition in the current findings rather than increasing as was previously found. Within chapter one, the findings related to response time and response accuracy contrasted in terms of their implications, with response time indicating a greater difficulty in processing due to applied load and response accuracy indicating a lesser difficulty. This was suggested as being an effect of a greater level of attention being paid to a more difficult task, or a trade-off effect of slower responses with a greater degree of accuracy (Craik et al., 2018). The task difficulty manipulation applied in this research was a method of investigating this effect further, to determine the role applied load plays within the processing of truth and lie responses. With this manipulation in place, findings indicated that applied load does in fact seem to provide a negative effect upon the processing of both response types, increasing response time and reducing response accuracy. Previous findings in chapter one, therefore, are likely due to the high task difficulty of the experiment, as was previously suggested as being the case.

Findings overall indicated a negative effect upon both truth and lie responses, making both more difficult to process as more load is applied to the task. This finding additionally provides evidence of a first step of truth recall within lying, as truthful information poorly encoded due to load applied during its encoding resulted in a more difficult to process lie response. Support is, therefore, provided to deception processing theory including this first step within their models (McCornack et al., 2014; Walczyk et al., 2014).

It was, however, predicted that a greater effect of applied load may be seen upon lie responses than truth responses, related to the concept of applying more load to an already loaded process (Vrij et al., 2006; Vrij, Mann, et al., 2008). If lying is more cognitively demanding than truth telling, application of more load is suggested to impact this response type to a greater extent (Vrij et al., 2006; Vrij, Mann, et al., 2008). Were this the case, an interaction effect would be expected between response type and applied cognitive load, as the effect of load would depend upon the response type provided. This was not found to be the case in either response time or response accuracy analyses. The findings of this research, therefore, provide evidence that both truth and lie responses were impacted to the same extent by the application of additional load. Additional load may be used as a method of making lying more difficult, but it can be expected that this impact would be the same upon truth responses provided in the same context.

The possibility exists, however, that load applied at the encoding stage only impacts the initial truth recall stage within processing and does not affect any additional stages involved within deception processing. The encoding of information is made more difficult by the application of load (Sweller, 1988) and in turn so is the associated recall of this information from long-term memory (Baddeley, 2007). The following stage of construction within lying (Walczyk et al., 2014) may then not be affected by this applied load, as only the recognition of information was made more difficult by the applied load. This may explain the lack of an interaction effect, as load impacted only the truth recall stage of processing, therefore affecting both response types in the same way. Further research is, therefore, required to investigate the effect applied load has at other stages of memory in order to fully assess the role load application has upon truth and lie processing.

Overall, support is provided for hypothesis two, application of additional load does increase the difficulty of both truth and lie responses. No evidence was provided, however, of a greater impact of applied load on lie responses. Partial support is provided for the use of load as a method of increasing the difficulty of lying (Vrij et al., 2018, 2006; Vrij, Fisher, et al., 2008), in that load does increase the difficulty of lies, but impacts the difficulty of truth processing to the same extent.

In terms of the effect of exposure time, findings indicated an increase in response accuracy as exposure time was increased, providing support for a reduction of task difficulty, but no effect upon response time was found. This suggests that information was better encoded and easier to accurately recognise, but this did not seem to impact the ability to better process the information. Applied to a working memory model, information could be accessed with a greater degree of accuracy, but no difference upon the ability to recall this information from the long term memory and transfer it to working memory was made (Baddeley, 2007). Such a finding may relate to a longer gaze effect to a familiar face than an unfamiliar one (Devue et al., 2009) whereby individuals gaze at a familiar face for longer than an unfamiliar one. Within the context of this experiment, therefore, participants increased their response accuracy due to better encoded facial information but did not increase their response time due to a longer gaze length to stimuli as it became more familiar. A trade-off effect may also be an explanation, whereby participants could have increased their response time, but response accuracy would have suffered; in this case response time was maintained while accuracy was increased (Craik et al., 2018). Support is provided to hypothesis three despite the lack of a change in response time. Exposure time reduced task difficulty related to a better encoding of information as information could be more accurately recognised. Additionally, support is provided for a first step of truth recall within deceptive processing, as better encoding of truthful information resulted in more accurate lie responses, suggesting the use of this information within the processing of lies.

In conclusion, the findings of this research indicated that lies are more difficult within their processing than truth telling, represented by slower average response time and lower response accuracy. Support is, therefore, provided for experimental evidence (Debey et al., 2014, 2012; Sporer, 2016; Suchotzki et al., 2015; Vrij et al., 2018, 2006) and for the findings in chapter one, suggesting established processing theory should account for a greater difficulty in processing of lies. Applied to a working memory model (Sporer, 2016), the greater associated load within this processing appears to be related to an additional stage of manipulation of information recalled within lying. Truthful information is evidenced to be recalled and used within the processing of deception, and further manipulation of this information to construct a lie accounts for a greater difficulty within its processing.

Application of additional cognitive load to this processing does seem to make both truth and lie responses more difficult to process. Evidence of a first step of truth recall is also provided by this finding, as poorly encoded truthful information negatively impacts the ability to process a lie. This load, however, does not appear to impact lie responses to a greater extent than truth, suggested in literature as applying more load to an already loaded process (Vrij et al., 2006; Vrij, Mann, et al., 2008). It is possible, within this research, that applied load may only impact the initial truth recall stage, related to a poorly encoded truth memory, therefore leaving following processes of lie construction unloaded. Further investigation is, therefore, required to assess if the findings of this research was load impacting only the first stage of truth recall within lying, or if applied load does indeed impact both response types equally.

Experimental Chapter Three: The processing of truths and lies with cognitive load applied at recognition.

Introduction

Previous research in chapters one and two provided evidence of a greater difficulty in the processing of lie responses than truth responses, supporting experimental findings (Debey et al., 2014, 2012; Suchotzki et al., 2015; Vrij et al., 2018, 2006) and the proposition of a greater cognitive demand within the working memory model of deception processing (Sporer, 2016). Findings also provided support for the method of load application as a means by which the processing of lies can be made more difficult (Vrij et al., 2006; Vrij, Mann, et al., 2008) and a first step of truth recall within lie production (Debey et al., 2014; McCornack et al., 2014; Walczyk et al., 2014). Related to the application of more load to an already loaded process (Vrij et al., 2006; Vrij, Mann, et al., 2008) it was predicted that lies may be impacted more so than truth responses by load application. This, however, was not found to be the case, with both truth and lie responses being impacted to the same magnitude by the application of additional load, suggesting an additive process. It was proposed that applied load may only impact the initial truth recall stage, related to a poorly encoded truth memory, therefore leaving the following processes of lie construction unloaded. It is possible, therefore, that load applied at other processing stages may impact truth and lie processing differently, possibly resulting in a greater effect upon lie responses if the additional stages within lie processing (Walczyk et al., 2014) become loaded in addition to those present in truth responses.

In the testing of this research question, the current research aimed to apply load at the recognition stage of processing, where both a recognition of known truthful information and manipulation of information within lie processing takes place (McCornack et al., 2014; Sporer, 2016). The aim was to test further the role of load application within the processing of truth and lie responses. Load applied at encoding may have only impacted the truth recall stage in both truth and lie processing by making the specific truthful information more difficult to recognise related to a poor encoding of this information. Load applied at recognition allows for information to be well encoded, but more difficult to process at recognition due to the additional processes consuming cognitive resources (Morrison et al., 2015; Sweller, 1988). A greater effect of load application may be expected, therefore, as predicted within literature (Vrij et al., 2006; Vrij, Mann, et al., 2008) as this load may impact both the stages of recognition and information manipulation present within lying (McCornack et al., 2014) while only the stage of truth recognition within truth telling would be impacted.

Applied to the working memory model, the working memory is utilised in the recall of information, and in the construction of additional information (Baddeley, 2007; Sporer, 2016). Application of additional load at this point may, therefore, impact both of these stages as fewer cognitive resources will remain (Morrison et al., 2015; Sweller, 1988). This may potentially explain a greater impact of applied load upon lie processing (Vrij et al., 2006; Vrij, Mann, et al., 2008) as only truth recall will be impacted during truth telling, while both truth recall, related to the first step of truth telling in lie processing (Debey et al., 2014;

Walczyk et al., 2014) and lie construction (McCornack et al., 2014; Walczyk et al., 2014) will be impacted by this additional load within lie processing. It may be expected, therefore, that load applied at the recognition stage may provide a difference in findings to load applied at the encoding stage, where it is possible that only the first stage of truth recall was loaded related to poor encoding of information. Further investigation of this will provide further detail in terms of the impact of load application upon truth and lie processing.

To investigate the impact of additional cognitive load applied at the recognition of information, it was proposed to use a task that specifically loads the visual working memory systems due to the visual nature of the stimuli within the design. Evidence is provided of the use of different mathematical problems to load different aspects of working memory, with multiplication problems using the phonological loop, and subtraction problems using the visuo-spatial sketchpad (Lee & Kang, 2002). The effect of subtraction on the visual working memory was evidenced by a visual image held in mind reducing the response time of subtraction problems (Lee & Kang, 2002). Further evidence of the effect of subtraction upon visual working memory ability is evidenced within a counting backwards task (Rao & Baddeley, 2013). While verbally counting backwards from a three-digit number in two's, and completing the Raven's matrices, an increased load of executive function was reported, with this task having no effect upon the phonological loop (Rao & Baddeley, 2013).

A design similar to that of Rao & Baddeley, (2013) was adopted for the current research; in which individuals count backwards in factors of ones or factors of threes. Such a task should provide load to the executive functions involved within the visual processing of the information within the task (Lee & Kang, 2002; Rao & Baddeley, 2013) allowing for an investigation of the effect of load applied at the recognition of information to take place.

Based on the discussed theory, the following research hypotheses will be tested. Lie responses will be significantly slower in their response time and lower in their response accuracy than truthful responses. This will test literature suggesting a greater difficulty in the processing of deception related to a greater cognitive demand within lie processing (Debey et al., 2014; Suchotzki et al., 2015) and the findings of chapter one and chapter two which indicated a greater difficulty in lie responses.

With regard to literature suggesting the effectiveness of application of load (Vrij et al., 2018, 2006), both response types will be significantly slower in their response time and less accurate in their response accuracy as additional cognitive load is applied. This will reflect a greater difficulty in the processing of responses as load is applied.

In relation to a greater effect of load application upon lie responses than truth responses (Vrij et al., 2006; Vrij, Mann, et al., 2008) related to a consumption of a greater number of working memory resources (Baddeley, 2007; Morrison et al., 2015; Sporer, 2016; Sweller, 1988), applied load will increase response time and lower response accuracy significantly more so in lie responses than in truth responses. This will reflect a greater impact of applied load upon lie responses, as a greater amount of cognitive resources are consumed within the processing of lies.

Method

Design

This experiment utilised a repeated measures design; all participants took part in the three cognitive load conditions, were presented with both male and female faces, and were instructed to be truthful and deceptive. The block order of these variables was randomised for each participant to counter any order effects of the design.

The first independent variable was the instructed response type split between two levels of an instructed truthful response or an instructed lie response; instruction was provided by the word 'truth' or 'lie' onscreen. The second independent variable was the cognitive load of the task split between three levels: no applied load, low load (counting backwards in a factor of 1), high load (counting backwards in a factor of 3). A within subjects design was utilised with all participants responding both truthfully and deceptively, as well as taking part in no load, low load, and high load conditions.

The first dependent variable was the response time to the presented faces, measured in milliseconds (ms) to respond between stimulus onset and response provided. Only correct responses, hit or correct rejection, were included within analysis. The second dependent variable was the number of correct responses provided. For truthful responses this was measured as a 'yes' response to target stimuli and a 'no' response to foil stimuli, correct identification of the stimuli. For lie responses this was measured as a ‘no’ response to target stimuli and a ‘yes’ response to foil stimuli, correctly lying about identification of the stimuli.

Participants

Forty participants (eleven male, M-age=28.1, SD=13.5) were recruited as a volunteer sample via the SONA recruitment system at the University of Huddersfield; an online recruitment software containing details of the experiment and opportunity for participants to book a time most convenient to them. Participation via this system is voluntary, though a certain number of credits are required as part of the course of each student, with one credit equalling 30 minutes of research time. All participants had normal, or corrected to normal, vision and were fluent in English.

Apparatus

Facial stimuli and apparatus used within this experiment remained consistent with those used in chapter one and chapter two.

Procedure

Participants were first verbally briefed on the task, instructed that they would be asked to respond both truthfully and deceptively to stimuli, take part in both low and high applied cognitive load trials and that they would take part in all three task difficulty levels. After the opportunity to ask for further information or greater clarity, informed consent was provided.

Each trial block of the experiment contained two stages, first a stage of encoding where facial stimuli were presented in the centre of the screen for 2000ms with an inter stimulus interval of 500ms between each. Five stimuli were presented ten times each in a random order, participants were instructed to attempt to remember the stimuli presented as they would be tested upon their recognition later. Stimuli sexes were not mixed within each trial block to prevent the possibility of an own sex bias influencing recognition, stimuli were either exclusive male or female for each block.

The second stage, recognition, presented ten faces in a random order, five of which were the previously seen target stimuli which participants were instructed to encode to the best of their ability, and five were never before seen foil stimuli. Participants were required to identify recognition of these stimuli as quickly as possible, pressing '1' for a 'yes' response, recognition of stimuli, or '0' for a 'no' response, no recognition of stimuli. Following each response an inter stimulus interval of 500ms occurred before presenting the next random face. At this stage, the word 'truth' or 'lie' was superimposed at the focal point of the face, providing instruction as to the response type required, with lie responses requiring a change in response recognition. Ten truthful responses were requested followed by ten lie responses, or vice versa. No foil stimuli were seen more than once throughout the experiment. Instructions were provided before each stage to ensure clarity of the task. Cognitive load was applied at this recognition stage in the form of a counting task.

No load task: participants were required only to respond to their recognition of the presented stimuli.

Low load task: participants were required to verbally count backwards in factors of one from a random three-digit number, between 300-999, provided by the experimenter. Each digit of the number was spoken individually, for example three-two-seven as opposed to three hundred and twenty-seven.

High load task: participants were required to verbally count backwards in factors of three from a random three-digit number, between 300-999, provided by the experimenter. Each digit of the number was spoken individually.

The experimenter was present throughout the task to offer further clarity to participants if required, and to ensure engagement with the task. Data was visually inspected before analysis with instances of complacency and lack of task engagement, usually a repeated pressing of only one response button, were removed from analysis.

Following completion, a new trial block began following the same design and with new stimuli. A total of four trial blocks were completed at each applied cognitive load before this was changed. The order of difficulty was random for each participant to balance order effects. In total, twelve trial blocks were completed by each participant, four blocks per applied cognitive load. Each block contained ten truthful and ten deceptive responses, equating to two hundred and forty responses in total, forty of each response type (truth and lie) per cognitive load (no load, low load and high load).

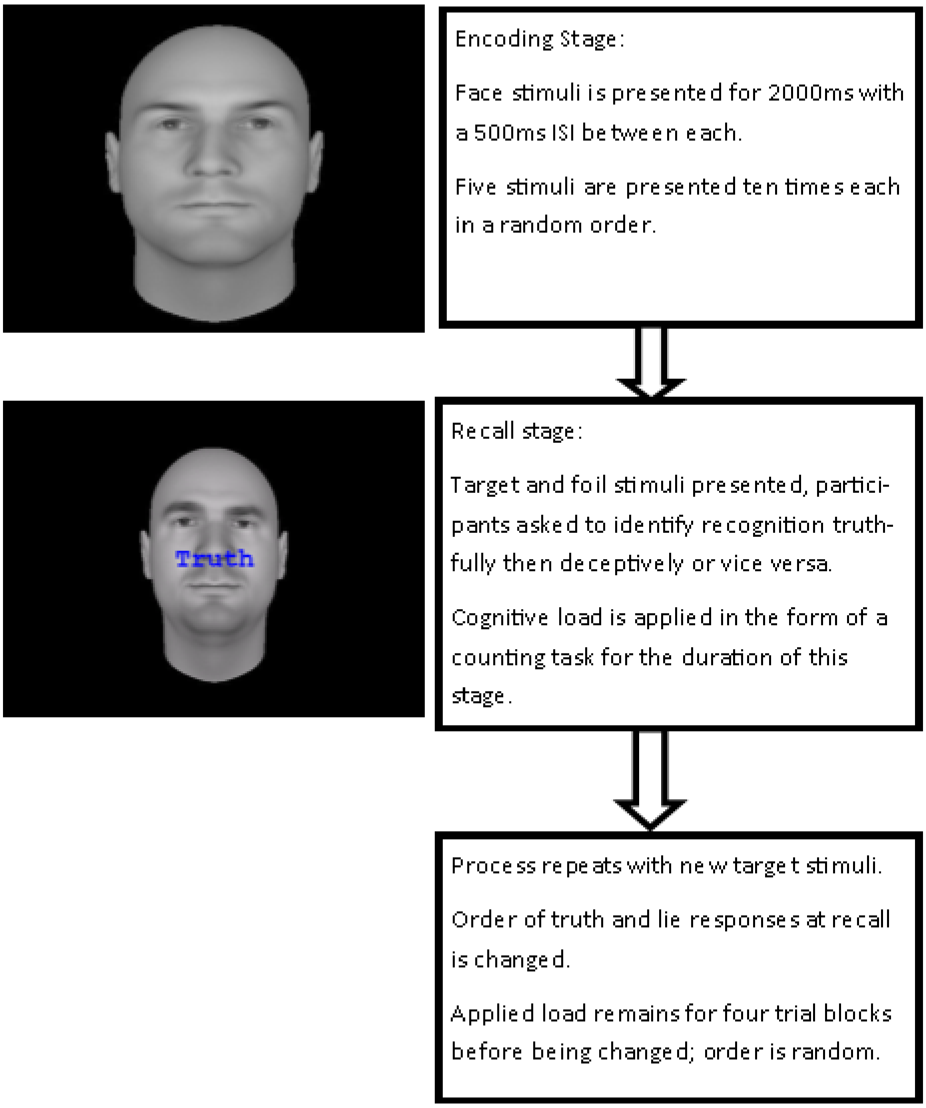

Figure 9. Flow of a single trial block in experiment 3.

Results

Response Time

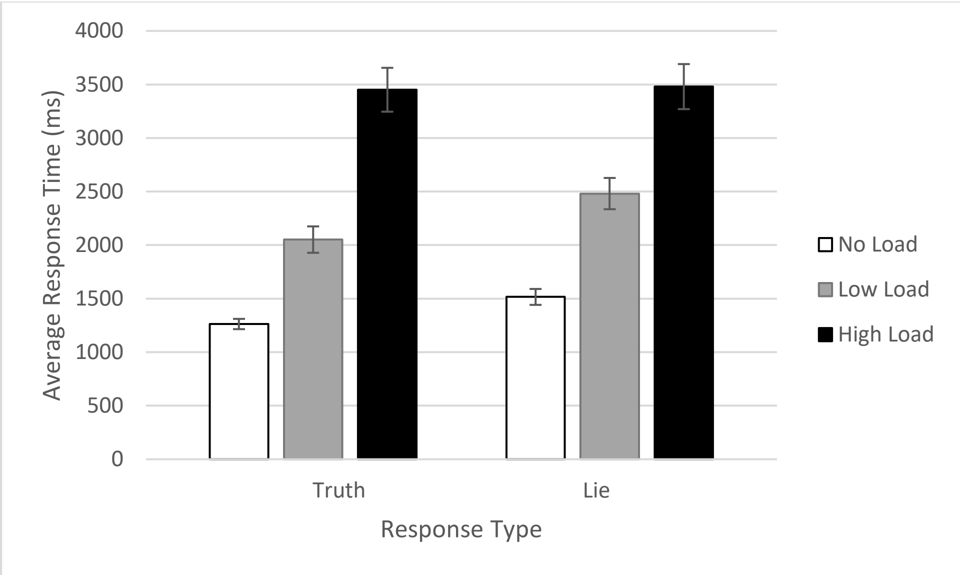

Figure 10. Average response time of truth and lie responses in no, low and high applied cognitive load, error bars represent one standard error.

Mean values in figure 10. were analysed using a 2x3 repeated measures ANOVA with the alpha level set at 0.05 with response type (truth vs. lie) and cognitive load (no load vs. low load vs. high load) as the within subjects variables. The aim of which was to test for a difference in response time due to these variables.

Mauchley's test of sphericity indicated violation within applied cognitive load, $\chi^2(2)=29.11$, $p<0.01$ and a violation within the interaction effect of type and load, $\chi^2(2)=10.68$, $p=0.005$, Greenhouse-Geisser correction was, therefore, used for these analyses. No data is reported for response type from this test as there are only two levels of repeated measures data within it.

No interaction effect was reported between response type and cognitive load, $F(2,78)=3.26$, $p=0.06$, partial eta squared=0.08, though it is of note that there is a trend towards significance within this interaction. In consideration of the power of the analysis, however, the confidence interval of 0.08 is considerably below the calculated required effect size of 0.32 for the sample size of this experiment. Due to both a non-significant p-value and a low confidence interval, a conclusion of no interaction effect between response type and applied load is drawn. A main effect of response type $F(1,39)=8.25$, $p=0.01$, partial eta squared=0.18 was found, indicating significantly slower lie responses (M=2492.25, SD=733.64) compared to truthful responses (M=2254.88, SD=672.83). This suggests a greater difficulty in the processing of lie responses in comparison to truth responses.

Additionally, a main effect of cognitive load $F(1,39)=99.06$, $p<0.01$, partial eta squared=0.72 was found, indicating significantly slower response times in higher cognitive load. As the cognitive load variable had three levels, post hoc data must be considered to determine where the differences between levels were. Post hoc data used a Bonferroni adjusted alpha level of 0.017. Post hoc analysis indicated a significant difference between all combinations of load: no applied cognitive load (M=1389.47, SD=348.26) and low applied cognitive load (M=2266.16, SD=752.38), $t(39)=-7.34$, $p<0.01$, $d=1.50$. No applied cognitive load (M=1389.47, SD=348.26) and high applied cognitive load (M=3465.22, SD=1212.75), $t(39)=-10.66$, $p<0.01$, $d=2.33$. Low applied cognitive load (M=2266.16, SD=752.38) and high applied cognitive load (M=3465.22, SD=1212.75), $t(39)=10.30$, $p<0.01$, $d=1.19$. This suggests a greater difficulty within processing of both response types as load was increased, with a gradual increase in difficulty as more load was applied to the task.

Response Accuracy

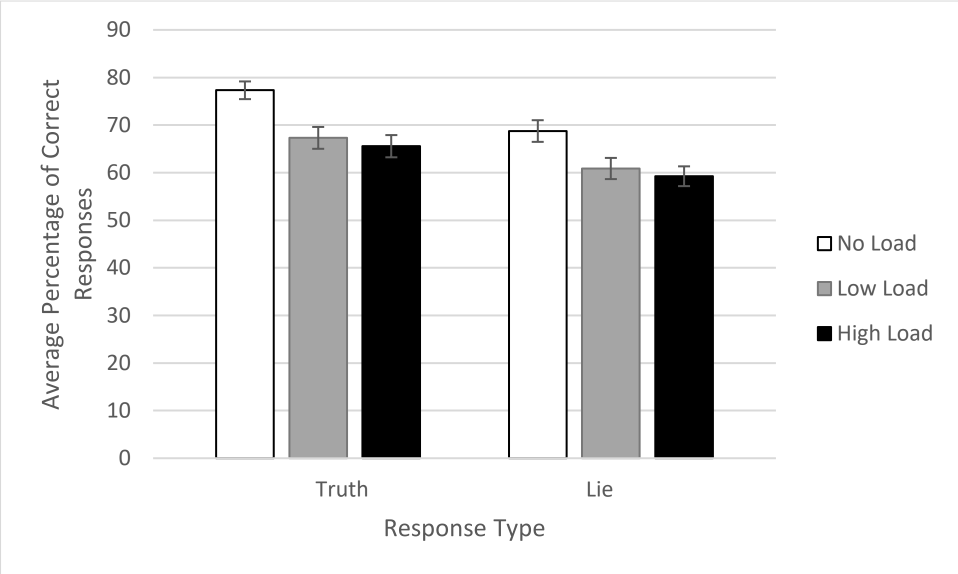

Figure 11. Average response accuracy of truth and lie responses in no, low and high applied cognitive load, presented as a percentage, error bars represent one standard error.

Mean values in figure 11. were analysed using a 2x3 repeated measures ANOVA with the alpha level set at 0.05 with response type (truth vs. lie) and cognitive load (no load vs. low load vs. high load) as the within subjects variables. The aim of which was to test a difference in response accuracy due to these variables.

Mauchley's test of sphericity indicated no violation in both applied cognitive load, $\chi^2(2)=0.85$, $p=0.66$, and within the interaction between response type and cognitive load, $\chi^2(2)=4.78$, $p=0.09$. Standard sphericity assumed data was, therefore, used for these analyses. No data is reported for response type from this test as there are only two levels of repeated measures data within it.

No interaction effect was reported between response type and applied cognitive load, $F(2,78)=0.61$, $p=0.55$, partial eta squared=0.02. A main effect of response type

$F(1,39)=41.93$, $p<0.01$, partial eta squared=0.52 was found, indicating significantly lower accuracy within lie responses (M=25.18, SD=4.73) compared to truthful responses (M=28.03, SD=4.80). This suggests a greater difficulty in the processing of lie responses in comparison to truth responses.

Additionally, a main effect of load $F(1,39)=27.69$, $p<0.01$, partial eta squared=0.42 was found, indicating significantly lower accuracy in higher cognitive loads. Post hoc data used a Bonferroni adjusted alpha level of 0.017. Post hoc analysis indicated a significant difference between no load (M=29.21, SD=4.73) and low load (M=25.64, SD=5.26), $t(39)=5.99$, $p<0.01$, $d=0.71$, and a significant difference between no load (M=29.21, SD=4.73) and high load (M=24.96, SD=5.23), $t(39)=6.47$, $p<0.01$, $d=0.85$. No significant difference was found between low load (M=25.64, SD=5.26) and high load (M=24.96, SD=5.23), $t(39)=1.15$, $p=0.26$, $d=0.13$. This suggests a greater difficulty in the accurate retrieval of information as load is applied, though a difference in retrieval accuracy is not present between low and high applied cognitive load.

Discussion

Findings in chapters one and two provided evidence of a greater difficulty within the processing of lies compared to truth, and that the application of additional load results in an increased difficulty in the processing of both response types. A greater effect of applied load upon lie responses was, however, not evidenced, with data indicating the same impact of load upon both truth and lie responses. This was explained by load applied at the encoding stage of memory only impacting the initial truth recognition stage, as truthful information required in both truth and lie processing (McCornack et al., 2014; Walczyk et al., 2014) was made more difficult to recognise, while the following lie processes were unaffected.

The current experiment aimed to investigate the role of additional load application at the recognition stage, where both the recognition of truthful information and manipulation of this information within lying (McCornack et al., 2014) require resources from the working memory within their processing (Baddeley, 2007; Sporer, 2016). Load at this point may impact lie responses more so than truth responses, as suggested within interview literature (Vrij et al., 2006; Vrij, Mann, et al., 2008) by applying further load to an already loaded process. Each additional cognitive process requires further resources to be consumed (Morrison et al., 2015; Sweller, 1988). With the additional stage of construction within lie responses, load is predicted to impact this response type to a greater extent (Vrij et al., 2006; Vrij, Mann, et al., 2008). Such an investigation will provide further detail of the processing of truth and lie responses, as well as further information related to the impact of applied load on the processing of both response types.

In terms of a difference between truth and lie processing, support was provided towards experimental literature suggesting a greater level of cognitive effort required within the processing of lies, evidenced by longer average response times, and lower average response accuracy, within lies, in comparison to truth (Debey et al., 2014, 2012; Sporer, 2016; Suchotzki et al., 2015; Vrij et al., 2018, 2006). Support was also provided for the findings of chapters one and two where lies were concluded to be more difficult within their cognitive processing than truth related to these factors.

As with previous experimentation, the findings related to both response time and response accuracy provided evidence that lie responses are more difficult than truth responses. Applied to a working memory model, it may be suggested that this greater difficulty is related to a requirement of the changing of recalled information, utilising further working memory resources to create a lie (Baddeley, 2007; Sporer, 2016). This extra step is similar to the proposed construction stage within deception processing (McCornack et al., 2014; Walczyk et al., 2014). Hypothesis one related to a greater difficulty in the processing of lies in comparison to truth is, therefore, accepted as lie responses do appear to require a greater level of cognitive effort in their processing.

In terms of the effect of application of additional load upon truth and lie processing, findings indicated slower average response time and lower average response accuracy as load was increased. Response time was found to incrementally decrease as more load was applied, while response accuracy was found to be no different between low and high applied load, while a difference was seen for the remaining combinations. Overall, application of additional load did impact the processing of both response types, making these more difficult to process supporting the proposal that application of load can be used as a method of increasing the ability to detect lies by increasing the difficulty of their processing (Vrij et al., 2018, 2006; Vrij, Mann, et al., 2008). Findings overall indicated a negative effect on both truth and lie responses, making both more difficult to process as more load is applied to the task. Hypothesis two related to a greater difficulty in the processing of responses related to the application of cognitive load is, therefore, accepted.

In terms of a greater impact of load upon lie responses than truth responses, no interaction effects were present for either response time or response accuracy analysis. Data, therefore, indicates no difference in the magnitude of impact applied load has upon truth and lie responses; both response types were affected in the same way by the application of additional load. This, therefore, indicated that applied load appears to be an additive process, where the additional cognitive cost of the load inducing task adds to the existing processes, rather than creating a greater impact on the response which is already more difficult as hypothesised (Vrij et al., 2006; Vrij, Mann, et al., 2008). Applied to the working memory model, the stages involved within processing are not multiplied in terms of their difficulty, only a greater amount of resources are required to fulfil the extra requirements of the applied load.

Truth responses require working memory resources in the retrieval of information (Sporer, 2016) and in the completion of the applied load task (Morrison et al., 2015; Sweller, 1988). Lie responses require working memory resources in the retrieval of information, manipulation of this information (Sporer, 2016) and then in the completion of the applied load task (Morrison et al., 2015; Sweller, 1988). The presence of the applied load does seem to increase the processing difficulty, evidenced by the findings related to hypothesis two, but does not multiply the difficulty of the existing steps in processing.

Hypothesis three, related to a greater effect of applied load on lie responses is, therefore, rejected. Both response types were impacted by load, but no one response type was impacted to a greater extent than the other. This, therefore, suggests that load can be used as a method to increase the difficulty of lie responses, but truth responses will be impacted to the same magnitude. A possibility exists, therefore, that the number of false positive identifications will increase as well as the hit rate of lie identification with the use of load inducing methods. It is advised that care be taken when applying load as a lie detection method, and that research should consider the false alarm rate of this methodology.

These findings do, however, provide evidence of an extra processing step present within lie responses that is absent within truth responses, as proposed within processing theory (McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014). Lie responses remain both slower and less accurate than truth responses despite the level of applied load. A possible explanation of this is a greater difficulty in their processing related to an additional step, this being the construction of the lie (McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014). The additional load incurred by the presence of this step, as with the impact of applied load, is additive, increasing the processing difficulty of this response type as further resources are depleted by its presence (Morrison et al., 2015; Sweller, 1988).

In conclusion, the findings of this research indicated that lies are more difficult within their processing than truth telling, represented by slower average response time and lower response accuracy. Support is, therefore, provided for experimental evidence (Debey et al., 2014, 2012; Sporer, 2016; Suchotzki et al., 2015; Vrij et al., 2018, 2006) and for the findings in chapters one and two, suggesting established processing theory should account for a greater difficulty in the processing of lies. Applied to a working memory model (Sporer, 2016), the greater associated load within this processing appears to be related to an additional stage of manipulation of information recalled when lying. Truthful information was evidenced to be recalled in the previous chapters and used within the processing of deception, and further manipulation of this information to construct a lie accounts for a greater difficulty within its processing.

Application of additional load does appear to be a valid method of increasing the difficulty of both truth and lie responses, so it may be possible to use this method in the detection of lies. As the processing of responses is made more difficult, fewer resources remain to control for potential behavioural cues to deception, making it easier to detect (Vrij et al., 2018, 2006; Vrij, Mann, et al., 2008). Importantly, however, the effect of applied load is the same for both truth and lie responses, with applied load seeming to be an additive process which does not affect one response type more than the other. It is suggested that care should be taken when using load application as a method of lie detection as, while it is likely that lies become easier to detect in relation to their greater difficulty to process, the same magnitude of this effect will be seen on truthful responses.

Experimental Chapter Four: The processing of truths and lies with rehearsal of the truth.

Introduction

Previous research in chapters one, two and three provided evidence of a greater difficulty in the processing of lie responses than truth responses, supporting experimental findings (Debey et al., 2014, 2012; Suchotzki et al., 2015; Vrij et al., 2018, 2006) and the proposition of a greater cognitive demand within the working memory model of deception processing (Sporer, 2016). Support is provided for the existence of a first step of truth recall within deception processing (Debey et al., 2014; McCornack et al., 2014; Walczyk et al., 2014) as a poorly encoded truthful memory was found to inhibit the processing of lie responses. Additionally, when applied to the working memory model of deception processing (Sporer, 2016) evidence is provided of an additional step within deception processing, accounting for the consistent finding of a slower response time and lower response accuracy.

Findings also provided support for the method of load application as a means by which the processing of lies can be made more difficult (Vrij et al., 2006; Vrij, Mann, et al., 2008). Related to the application of more load to an already loaded process (Vrij et al., 2006; Vrij, Mann, et al., 2008) it was predicted that lies may be impacted more so than truth responses by load application. This, however, was not found to be the case, with both truth and lie responses being impacted to the same magnitude by the application of additional load, suggesting an additive process. Additional cognitive load applied at both the encoding and recognition stages increased the difficulty of processing of both truth and lie responses through the consumption of cognitive resources (Morrison et al., 2015; Sweller, 1988) though it did not impact lie responses to a greater extent.

This thesis has provided evidence of the cognitive processing mechanisms involved in both truth and lie processing as well as the associated cognitive cost of each of these response types. Additionally, insight into the impact upon the processing of these responses by applying additional load has been explored, with explanations of how and why load impacts the processing of each response type offered. To proceed and to provide further information regarding factors that may influence the processing of each response type, research will consider the application of rehearsal of information to assess the impact this has on the processing of both truth and lie responses. Rehearsal within lying is claimed to be a commonly practiced behaviour (Vrij et al., 2009) and is used as a load reducing technique (Lykken, 1998). Related to processing models, it may be suggested that rehearsal allows for a construction stage of lying (Walczyk et al., 2014) to be skipped during the provision of a lie. The information related to the lie has already been constructed and rehearsed before it is required (Granhag et al., 2003; Vrij et al., 2009), meaning this information only requires recall from memory, similar to the cognitive demands of truth telling (Walczyk et al., 2014). An argument can be made, therefore, that rehearsal of information has the ability to limit the cognitive demand of lying to the same level as that of truth telling.

In the investigation of the research question of the effect of rehearsal of information on truth and lie processing, the current research aims to examine the role of rehearsal of the truth on processing of these response types. This investigation relates to the findings of chapter two, and to a first step of truth recall within lie processing (Debey et al., 2014; McCornack et al., 2014; Walczyk et al., 2014). Chapter two indicated that a poor encoding of truthful information related to a greater difficulty in the processing of lie responses. The possibility exists, therefore, that a better encoding of truthful information will facilitate the processing of lie responses, though debate to this claim exists within the ADCAT model (Walczyk et al., 2014) with the claim of an enhanced truthful memory disrupting the ability to process a lie.

Within memory, two distinct types are identified: explicit, the memory for information remembered, and implicit, the procedural memory of how to perform a task (Graf & Schacter, 1985; Warrington & Weiskrantz, 1968, 1970). These two systems are distinctly different in terms of their functioning and processing, and manipulations affecting one typically do not affect the other (Graf & Schacter, 1985). Rehearsal functions to enhance the encoding of information stored within explicit memory, to enhance the remembered information (Pyc & Rawson, 2009; Staniland et al., 2015). Implicit memory of how to perform a task should not be affected by a form of rehearsal designed to enhance encoded information in the explicit memory due to the differences in their functioning (Graf & Schacter, 1985).

Rehearsal is defined as the recitation of to be remembered information during the encoding, storage or retrieval of this information from memory (Pashler, 2013), and described as one of the six stages of memory, its purpose being the review of information with the aim of strengthening the memory (MacLeod, 2013). Evidence of the benefit of rehearsal is provided, with it promoting the better encoding of word-pair information and facilitated recall (Pyc & Rawson, 2009). In addition, memories requiring a greater amount of effort in their recall provided more benefit to the effect of rehearsal in comparison to an easier recall requiring less effort (Pyc & Rawson, 2009). This would suggest that the more effort an individual applies to rehearsal, or the more difficult the information is to rehearse, the greater the benefit of rehearsal upon information recall. In relation to a greater effort of memory recall, evidence is also provided of a greater level of task engagement facilitating recall (Block, 2009). Within this task, facial stimuli were rapidly presented for 0.5-1.5 seconds with no inter stimulus interval. Individuals with a high intent to remember the stimuli performed better than those with a low intent to remember. This indicates that even in a very difficult task, the level of effort applied can positively affect performance.

The act of rehearsal itself can be achieved in a variety of methods. These methods can be grouped into passive rehearsal and active rehearsal; passive rehearsal being accessing the encoded information, and active rehearsal being accessing and using the encoded information (Staniland et al., 2015). Active forms of rehearsal are found to be more effective than passive, leading to enhanced encoding and retrieval of information in comparison to passive rehearsal (Staniland et al., 2015).

While the act of rehearsal is typically used to facilitate encoded memories and their recall, there is evidence to suggest rehearsal can provide the opposite effect and inhibit recall in certain circumstances. Long periods of rehearsal were found to reduce the ability to access encoded information in comparison to short periods of rehearsal (Kuhl & Anderson, 2011). Within this research, a single word was repeated multiple times followed by a free association task where sentences could be completed with either the repeated word or with a semantically similar word. Periods of brief rehearsal (5-10 seconds) provided facilitated priming of information, with responses becoming faster, periods of long rehearsal (20-40 seconds) inhibited priming. This is described as a paradoxical effect, where long periods of rehearsal seem to counterintuitively result in longer response times (Kuhl & Anderson, 2011).

Further evidence of the paradoxical effect of rehearsal is seen specifically in the case of facial stimuli (Read et al., 1989). After witnessing a staged event, rehearsal took place either immediately or following a 10-minute delay. Immediate rehearsal improved recognition accuracy, but reduced accuracy if there was a slight change in the appearance of the stimuli in comparison to a no rehearsal control. With a 10-minute delay, rehearsal improved recognition accuracy regardless of any changes made to the stimuli. While the typical effect of rehearsal is an enhanced recall of encoded information (Pyc & Rawson, 2009; Staniland et al., 2015) literature does offer examples of circumstances where this may not be the case and the act of rehearsal demonstrates a paradoxical effect (Kuhl & Anderson, 2011; Read et al., 1989) though the exact reasons for this effect are still unclear.

Rehearsal within deception is claimed as being a commonly practiced behaviour (Vrij et al., 2009) used in an effort to reduce the cognitive load associated with lying (Lykken, 1998). The impact of rehearsal on the processing of both truth and lie responses remains somewhat unclear, however, with the effects of this particular factor largely absent within the proposed deception processing models (McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014). Considering rehearsal of the truth, literature related to a first step of truth recall within lying may be applied to suggest that rehearsal of the truth should make lying easier (Debey et al., 2014). A truthful distractor placed at the point of a deceptive response was found to facilitate this response type, while an irrelevant distractor had no effect. It is suggested that the truthful distractor primed the first step of truth recall when lying, accounting for this first step within processing and making lying easier as a result (Debey et al., 2014). From this work, it may be predicted that rehearsal of the truth will provide a similar effect, the truthful memory will be primed making the first step of truth recall easier and as a result will make deception easier.

Additionally, literature related to a first step of truth recall within lying may be used in support of an enhanced ability to provide a lie following truth rehearsal when applied to the functioning of the explicit memory system. Rehearsal provides the effect of enhancing the encoding of information in the explicit memory system (Pyc & Rawson, 2009; Staniland et al., 2015) and if this information is required within lie processing, an enhanced ability to recall this information should result in greater success in the production of lie responses following rehearsal of the truth. Applied to the working memory model (Baddeley, 2007; Sporer, 2016), enhanced encoding of information will result in an increased ability to recall this, and a lesser cognitive demand from this behaviour. Truth rehearsal should, therefore, facilitate the processing of the first step of truth recall (Baddeley, 2007; Sporer, 2016), which in turn will facilitate both truth and lie processing as both of these response types rely on the recall of the truth (Debey et al., 2014; McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014).

In contrast, the ADCAT model (Walczyk et al., 2014) predicts that rehearsal of the truth will inhibit the ability to be deceptive due to an effect of proactive interference of information (Walczyk et al., 2014). Proactive interference is an effect of previously seen stimuli negatively impacting the ability to recognise later stimuli (Flicker et al., 1989). Within the context of the current research, proactive interference may cause lower accuracy rates in facial stimuli seen later in the experiment due to interference from the previously seen faces. The ADCAT model suggest that deception involving well-rehearsed truths will cause more proactive interference to a lie as the better remembered truth interferes with the ability to construct a lie (Walczyk et al., 2014). As a truthful memory is made stronger through rehearsal, a lie is then made more difficult as more effort must be applied to supress this information and the well-practiced truth interferes with the construction of the lie (Walczyk et al., 2014).

Based on the discussed theory, the following research hypotheses will be tested. Lie responses will be significantly slower in their response time and lower in their response accuracy than truthful responses. This will test literature suggesting a greater difficulty in the processing of deception related to a greater cognitive demand within lie processing (Debey et al., 2014; Suchotzki et al., 2015) and the findings of chapter one, chapter two and chapter three which indicated a greater difficulty in lie responses.

In relation to literature suggesting facilitated encoding and retrieval of information related to rehearsal (Pyc & Rawson, 2009; Staniland et al., 2015) it is expected that truthful responses will become significantly faster in their response time and greater in their response accuracy following rehearsal. This will indicate a greater ease of access to information within explicit memory as a result of the facilitated encoding provided by rehearsal.

A prediction of the direction of the effect of rehearsal upon lie responses is less clear to make as theory provides arguments for both directions. If a better remembered truth facilitates lie processing (Debey et al., 2014) rehearsal will cause lies to become significantly faster in their response time and greater in response accuracy. If a better remembered truth creates proactive interference within a lie response (Walczyk et al., 2014) rehearsal will cause lies to become significantly slower in their response time and lower in their response accuracy.

Method

Design

This experiment utilised a repeated measures design; all participants took part in both rehearsal and no rehearsal conditions, were presented with both male and female faces, and were instructed to be truthful and deceptive. The block order of these variables was randomised for each participant to counter any order effects of the design.

The first independent variable was the instructed response type split between two levels of an instructed truthful response or an instructed lie response; instruction provided by the word 'truth' or 'lie' onscreen. The second independent variable was the task rehearsal split between two levels of no rehearsal and rehearsal of the truth. A within subjects design was utilised with all participants responding both truthfully and deceptively as well as taking part in no rehearsal and rehearsal conditions.

The first dependent variable was the response time to the presented faces, measured in milliseconds (ms) to respond between stimulus onset and response provided. Only correct responses, hit or correct rejection, were included within analysis. The second dependent variable was the number of correct responses provided. For truthful responses this was measured as a ‘yes’ response to target stimuli and a ‘no’ response to foil stimuli, correct identification of the stimuli. For lie responses this was measured as a ‘no’ response to target stimuli and a ‘yes’ response to foil stimuli, correctly lying about identification of the stimuli.

Participants

Thirty-four participants (two male, M-age=20.9, SD=5.03) were recruited as a volunteer sample via the SONA recruitment system at the University of Huddersfield; an online recruitment software containing details of the experiment and opportunity for participants to book a time most convenient to them. Participation via this system is voluntary, though a certain number of credits are required as part of the course of each student, with one credit equalling 30 minutes of research time. All participants had normal, or corrected to normal, vision and were fluent in English.

Apparatus

Facial stimuli and apparatus used within this experiment remained consistent with those used in chapter one, chapter two and chapter three.

Procedure

Participants were first verbally briefed on the task, instructed that they would be asked to respond both truthfully and deceptively to stimuli and take part in both rehearsal and no rehearsal trials. After the opportunity to ask for further information or greater clarity, informed consent was provided.

Each trial block contained three stages, first a stage of encoding where facial stimuli were presented in the centre of the screen for 800ms with an inter stimulus interval of 500ms between each. Five stimuli were presented ten times each in a random order. Participants were instructed to attempt to remember the stimuli presented as they would be tested upon this recognition later. Stimuli sexes were not mixed within each trial block to prevent the possibility of an own sex bias influencing recognition, stimuli were either exclusive male or female for each block.

The second stage, rehearsal, involved a presentation of the to be remembered target faces as well as never before seen foil faces. The target faces were presented a total of three times each, with fifteen stimuli in total; this was combined with fifteen unique foil stimuli. Participants were asked to respond to the stimuli truthfully, answering yes or no to a recognition of the stimuli, with a 200ms inter stimulus interval following each response. This design allowed for the target stimuli to both be seen more than without rehearsal, and for participants to respond to these stimuli and engage with the task. This design achieved the more effective active form of rehearsal by requiring participants to both access and use stored information (Staniland et al., 2015). Foil stimuli were included in this rehearsal stage to ensure participants engaged with the task, requiring participants to appraise the recognition of the stimuli. Rehearsal stages were only present in half of the trial blocks of this experiment, with the other half acting as no rehearsal controls.

The third stage, recognition, presented ten faces in a random order, five of which were the previously seen target stimuli and five were never before seen foil stimuli. Participants were required to identify recognition of these stimuli as quickly as possible, pressing ‘1’ for a ‘yes’ response, recognition of stimuli, or ‘0’ for a ‘no’ response, no recognition of stimuli. Following each response an inter stimulus interval of 500ms occurred before presenting the next random face. At this stage, the word ‘truth’ or ‘lie’ was superimposed at the focal point of the face, providing instruction as to the response type required, with lie responses requiring a change in response recognition. Ten truthful responses were requested followed by ten lie responses, or vice versa. No foil stimuli were seen more than once throughout the experiment. Instructions were provided before each stage to ensure clarity of the task. Trial blocks were counter balanced for stimuli sex order, response type order, and rehearsal level order.

The experimenter was present throughout the task to offer further clarity to participants if required, and to ensure engagement with the task. Data was visually inspected before analysis with instances of complacency and lack of task engagement, usually a repeated pressing of only one response button, were removed from analysis.

Following completion, a new trial block began following the same design and with new stimuli. In total, twelve trial blocks were completed per participant, six no rehearsal trial blocks and six rehearsal trial blocks. Each block contained ten truthful responses and ten deceptive responses, equating to two hundred and forty responses in total, sixty of each response type (truth and lie) per rehearsal condition (no rehearsal and rehearsal of the truth).

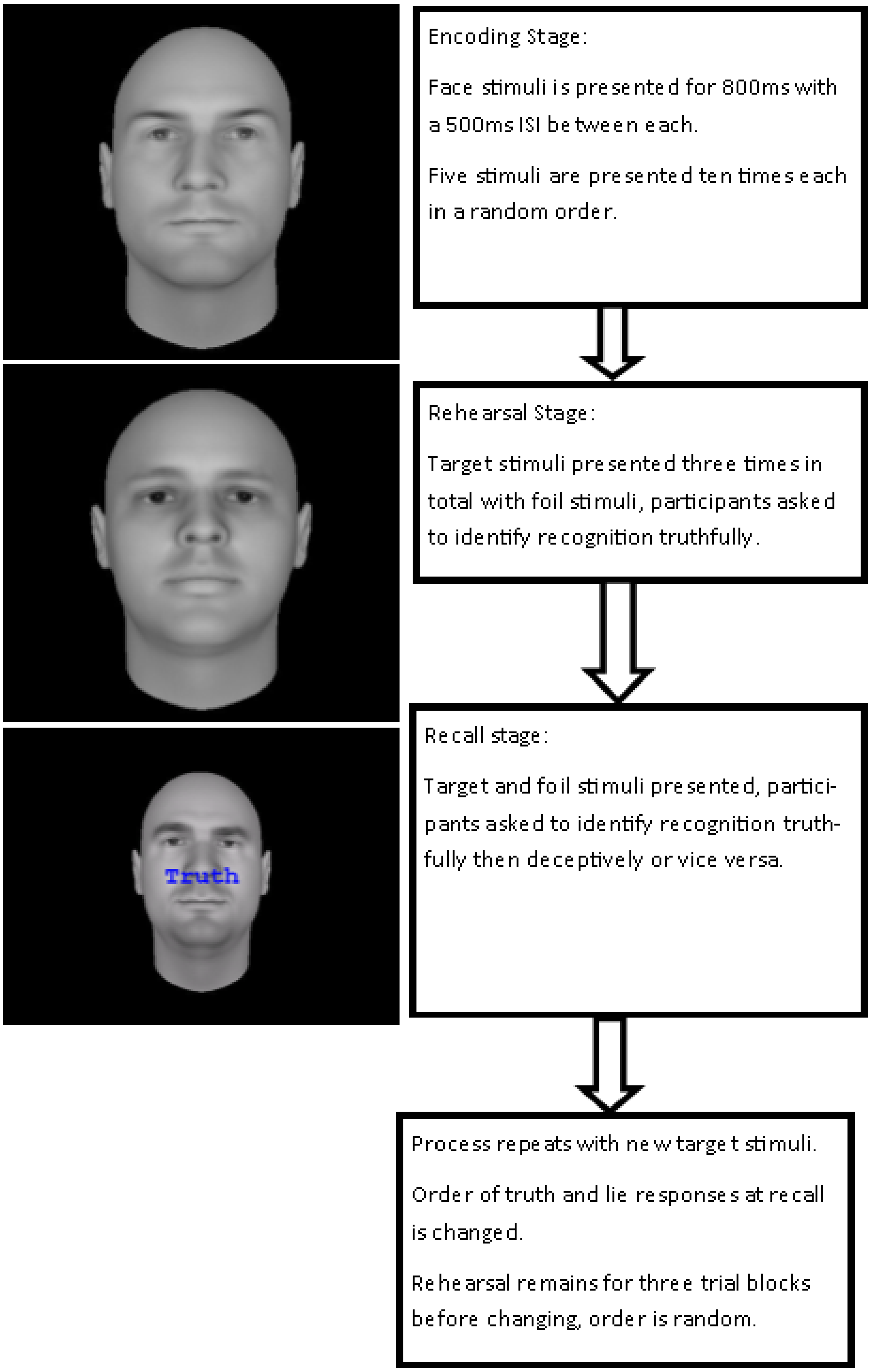

Figure 12. Flow of a single trial block in experiment 4.

Results

Response Time

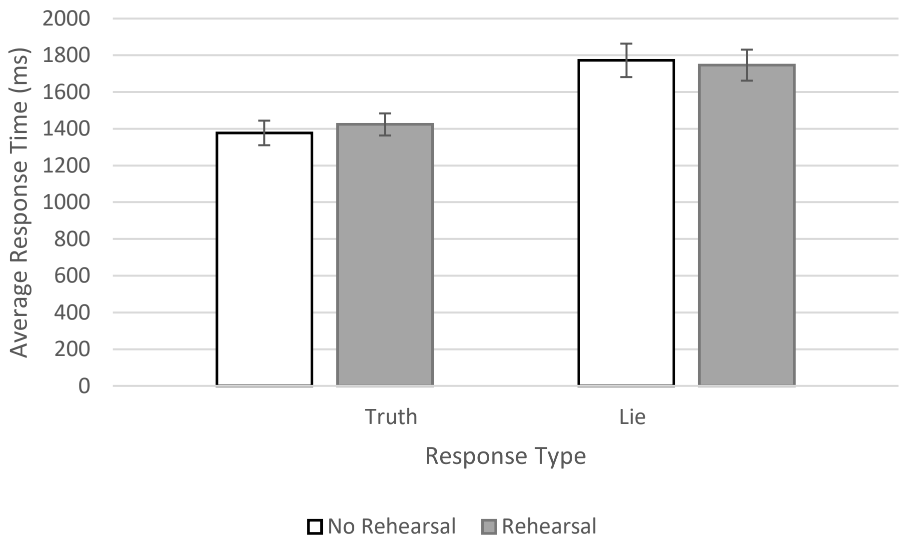

Figure 13. Average response time of truth and lie responses with and without rehearsal, error bars represent one standard error.

Mean values in figure 13. were analysed using a 2x2 repeated measures ANOVA with the alpha level set at 0.05 with response type (truth vs. lie) and rehearsal (no rehearsal vs. truth rehearsal) as the within subjects variables. The aim of which was to test for a difference in response time due to these variables.

No interaction effect was reported between response type and rehearsal $F(1,33)=1.55$, $p=0.22$, partial eta squared=0.05. A main effect of response type was found $F(1,33)=83.14$, $p<0.01$, partial eta squared=0.72, indicating significantly slower lie responses (M=1759.442, SD=511.7341) compared to truthful responses (M=1400.507, SD=370.5152). This may represent a greater difficulty in the processing of deception in comparison to the processing of truth. No main effect of rehearsal was reported $F(1,33)=0.05$, $p=0.82$, partial eta squared<0.01, indicating no effect of rehearsal on response time. A stage of rehearsal did not appear to inhibit or facilitate the processing of either truth or lie responses.

Response Accuracy

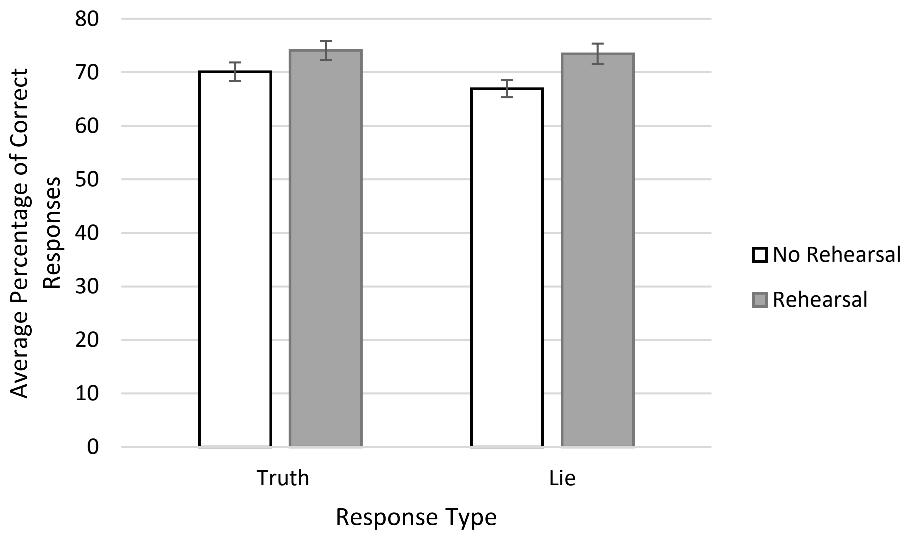

Figure 14. Average response accuracy of truth and lie responses with and without rehearsal, presented as a percentage, error bars represent one standard error.

Mean values in figure 14. were analysed using a 2x2 repeated measures ANOVA with the alpha level set at 0.05 with response type (truth vs. lie) and rehearsal (no rehearsal vs. truth rehearsal) as the within subjects variables. The aim of which was to test for a difference in response accuracy due to these variables.

An interaction effect was reported between response type and rehearsal $F(1,33)=5.31$, $p=0.03$, partial eta squared=0.14, indicating that the effect of rehearsal on response accuracy depends upon the response type provided. A main effect of rehearsal was found *F*(1,33)=18.44, *p*<0.01, partial eta squared=0.36 indicating an increase in response accuracy with a period of rehearsal (M=44.25, SD=6.52) than without a period of rehearsal (M=41.10, SD=5.81). No main effect of response type was found *F*(1,33)=3.48, *p*=0.07, partial eta squared=0.10, indicating no difference in response accuracy between truth responses (M=43.25, SD=6.19) and lie responses (M=42.10, SD=6.14).

Post hoc data used a Bonferroni adjusted alpha level of 0.025. Simple main effect analysis indicated a significant difference between truthful responses with no rehearsal (M=42.06, SD=6.06) and truthful responses with rehearsal (M=44.44, SD=6.33) *t*(33)=-2.95, *p*=0.01, *d*=0.38 and a significant difference between lie responses with no rehearsal (M=40.15, SD=5.56) and lie responses with rehearsal (M=44.06, SD=6.71) *t*(33)=-4.87, *p*<0.01, *d*=0.64. An effect of rehearsal where both truth and lie responses became more accurate following a period of rehearsal of the truth is found. Additionally, a significant difference between truthful responses with no rehearsal (M=42.06, SD=6.06) and lie responses with no rehearsal (M=40.15, SD=5.56) *t*(33)=2.75, *p*=0.01, *d*=0.33 was provided, but no significant difference was found between truthful responses with rehearsal (M=44.44, SD=6.33) and lie responses with rehearsal (M=44.06, SD=6.71) *t*(33)=0.54, *p*=0.59, *d*=0.06. Lie responses were found to be less accurate than truth before a period of rehearsal of the truth, but following this both response types had the same average accuracy rates, having both increased.

Discussion

Findings in chapters one, two and three provide the consistent finding of a greater difficulty in the processing of lie responses, as well as offering insight into the processing steps involved within truth and lie responses. A first step of truth recall within lying was evidenced, in addition to the likelihood of an additional step within the processing of this response type. The effect of applied load was also established, with additional load increasing the difficulty of both response types to an equal magnitude. The current experiment aimed to investigate an additional factor which may influence the processing of truth and lie responses, the role of rehearsal of information. First, the rehearsal of truthful information was examined in order to test the claim made within the ADCAT model (Walczyk et al., 2014) that such an act will inhibit the ability to lie against the possibility of a facilitated effect of an enhanced first step of truth recall.

In terms of a difference between truth and lie responses, further support is provided of a greater difficulty in the processing of lie responses in comparison to truthful responses. Evidence is provided by a slower response time within lie responses and a lower response accuracy before rehearsal in comparison to truthful responses. This, as with the findings in previous chapters, provides evidence of greater difficulty in the processing of deception in comparison to truth telling and to literature suggesting a greater cognitive demand within lying (Debey et al., 2014; Suchotzki et al., 2015). No difference was found within response accuracy between truth and lie responses when a period of rehearsal is provided, however. This lack of a difference following a period of rehearsal is due to an increase in the accuracy of lie responses to be the same average accuracy as truth responses following rehearsal.

This change also explains the interaction effect present in response accuracy analysis as the lie response type was subject to a greater increase in average accuracy than the truth response type. Hypothesis one related to a greater difficulty in the processing of lies in comparison to truth is, therefore, accepted as lie responses do appear to require a greater level of cognitive effort in their processing.

Of additional note, it was found that the response time of lie responses remains greater than that of truth responses after a period of rehearsal, and after both response types are the same in terms of their response accuracy. This provides evidence of additional processing steps within the processing of lies compared to truth responses, as even when each response type was the same in terms of accuracy and in terms of difficulty to recognise information, lie responses still took longer on average than truth telling. Related to the working memory model of deception processing (Sporer, 2016) it is proposed that this additional processing time is related to the manipulation of information to construct a lie following the recall of the truth. This is in tandem with the proposed construction stage within the ADCAT processing steps (Walczyk et al., 2014). Evidence is, therefore, provided of an additional stage of construction within lie responses not present in truth responses, in the context of this research a changing of response in relation to recognition of stimuli. Truth information is recognised to the same degree of accuracy in each response type, and so differences in response time can be related to additional processing in lies, not an effect of greater difficulty in the recognition of information in lies.

In terms of the effect of rehearsal of the truth on the processing of the truth, findings indicated that response accuracy of both response types was increased following rehearsal of the truth, but response time was not. The increase in response accuracy provides evidence that rehearsal enhanced the encoding of information within the explicit memory and as a result caused this information to become easier to recognise with a greater degree of accuracy. Information related to the recognition of stimuli was better encoded within memory and so could be accessed with a greater degree of success. An increase in response accuracy, therefore, supports an effect of rehearsal enhancing the encoding of information (Pyc & Rawson, 2009; Staniland et al., 2015).

The lack of an improvement in response time, however, suggests that while information seemed to be encoded to a greater extent than baseline, this did not improve the ability to process and provide the remembered information during the recognition stage. Participants were more able to provide an accurate response, and accurately identify the stimuli following rehearsal, but this did not facilitate the cognitive processing steps related to providing this information. This may be related to a difference between explicit and implicit memory as these two systems are different in their processing and may not be affected by a manipulation that would affect the other (Graf & Schacter, 1985). Within this research, rehearsal enhanced the remembered information stored in the explicit memory, hence a greater accuracy following rehearsal. It did not, however, enhance the ability to process this information, as the procedure of doing so is related to the implicit memory.

Alternatively, such a finding may represent a floor effect within the response time data. Participants were instructed to respond to stimuli as quickly as possible in both no rehearsal and rehearsal conditions. Response time differences may not be present due to the engagement with the task and the rapid responses provided. A difference is present within response accuracy data due to the better encoding of information provided by rehearsal (Pyc & Rawson, 2009; Staniland et al., 2015). Partial support is provided to hypothesis two, rehearsal of the truth resulted in an increased accuracy of truthful responses, indicating a better encoded truthful memory, but this did not improve the response time of truthful responses.

In terms of the effect of rehearsal of the truth on the processing of a lie, findings indicated that response accuracy was increased following rehearsal, but response time findings provided no difference. As with the effect of rehearsal upon truth responses, the increase in response accuracy may be attributed to an enhanced memory of the required truthful information facilitating the ability to recognise this information during the task. This, therefore, provides further evidence of a first step of truth recall within lying (Debey et al., 2014; McCornack et al., 2014; Walczyk et al., 2014); as the truthful information was encoded to a greater level than at baseline and easier to recognise accurately, this too increased the ability to accurately manipulate this response to construct a lie (McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014).

As with truth responses, response time was unchanged between no rehearsal and rehearsal stages. Again, this may be explained by the rehearsal method applied within this task having no effect on the implicit memory due to differences in the processing of implicit and explicit memory systems (Graf & Schacter, 1985), and therefore having no effect on the ability to process information. The ability to accurately recognise truthful information is still enhanced due to the better encoding of this information in the explicit memory. Findings may also be explained by the possible floor effect elaborated on previously. As with the findings related to truth responses, partial support is provided for a positive effect of truth rehearsal on lie responses within hypothesis three. While response time analysis indicated no difference, the response accuracy of lie responses following a period of rehearsal of the truth increased, providing evidence of a positive effect of truth rehearsal on lie processing. Support is, therefore, provided for a facilitatory effect of enhanced truthful information, and no evidence of a proposed inhibitory effect was indicated (Walczyk et al., 2014).

Contrary to the prediction made within the ADCAT model (Walczyk et al., 2014), an inhibitory effect of enhanced truthful information was not seen in lie responses. No effect on response time was indicated, though a positive effect on response accuracy was. Should an enhanced truth knowledge inhibit lies related to either proactive interference or a greater difficulty in supressing information (Walczyk et al., 2014) this positive effect would not be seen. The findings of this work, therefore, suggest that models of deception processing incorporate enhanced truthful information as granting a positive effect on the ability to process both truth and lie responses. Response time of each response type may not be impacted by a better memory of the truth, though an enhanced ability to provide either a truth or lie based on this better encoded memory is apparent from the findings of this work.

In conclusion, the findings of this research indicated that lies are more difficult within their processing than truth telling, represented by slower average response time and lower response accuracy. Support is, therefore, provided for experimental evidence (Debey et al., 2014, 2012; Sporer, 2016; Suchotzki et al., 2015; Vrij et al., 2018, 2006) and for the findings in chapters one, two, and three suggesting established processing theory should account for a greater difficulty in the processing of lies. Applied to a working memory model (Sporer, 2016), the greater associated load within this processing appears to be related to an additional stage of manipulation of information recalled when lying. Direct evidence of this additional processing step was provided in this experiment, as lie responses retained their average slower response time over truth responses when their accuracy levels were the same. When information was as easy to accurately recognise for each response type, lie responses were still found to be slower on average, supporting the concept of an additional stage associated with the manipulation of the recalled truthful information (McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014).

Further support of a first step of truth recall within lying (Debey et al., 2014; McCornack et al., 2014; Walczyk et al., 2014) was also provided, as rehearsal of the truth facilitated the accuracy of lie responses. It is suggested that this is the result of the better encoded truthful information being accessed successfully during lie processing, causing lie responses to accurately change their response with greater frequency. If there was no first step of truth recall within deception, better encoded truthful information would have had no effect on this response type, as the truthful information would not be accessed within the provision of this response type. These findings, in combination with those of chapter two, demonstrate the importance of the first step of truth recall in deception processing. When this information was poorly encoded, lies became more difficult to process, whereas when information was well encoded, lies appear to become easier to process.

An overall positive effect of rehearsal of the truth is concluded, with an increase in response accuracy of both response types. Importantly, the negative effect of an enhanced truthful memory predicted within the ADCAT model (Walczyk et al., 2014) was not supported, indicating no greater difficulty within lying related to proactive interference of the truth, or a greater difficulty in the suppression of truthful information. Models of deception processing are, therefore, recommended to view an enhanced truthful memory as having a positive effect on the ability to provide both a truthful, and a lie response.

Experimental Chapter Five: The processing of truths and lies with rehearsal of the lie.

Introduction

Previous research in chapters one, two, three and four has provided consistent evidence of a greater difficulty in the processing of lie responses than truth responses, supporting experimental findings (Debey et al., 2014, 2012; Suchotzki et al., 2015; Vrij et al., 2018, 2006) and the proposition of a greater cognitive demand within the working memory model of deception processing (Sporer, 2016). Support is provided for the existence of a first step of truth recall within deception processing (Debey et al., 2014; McCornack et al., 2014; Walczyk et al., 2014) as a poorly encoded truthful memory was found to inhibit the processing of lie responses, while better encoding of this truthful information was found to facilitate these responses. Additionally, when applied the working memory model of deception processing (Sporer, 2016) evidence is provided of an additional step within deception processing, accounting for the consistent finding of a slower response time and lower response accuracy. Further evidence of this additional step was provided within chapter four, as even at equal response accuracy, and so the same difficulty of retrieval of information, lie responses were found to be slower than truth responses. This additional response time may be used to indicate an additional step in the construction of a lie (Walczyk et al., 2003).

Chapter four indicated a positive effect on the response accuracy of both truth and lie responses related to the rehearsal of truthful information, debating the negative effect proposed within the ADCAT model (Walczyk et al., 2014). No effect was seen on response time, though this may be related to a difference between the processing of implicit and explicit memory systems (Graf & Schacter, 1985) or a floor effect of rapid response time.

In the further investigation of the impact of rehearsal on the processing of truth and lie responses, the current experiment aimed to investigate the effect of rehearsal of the lie on these response types. Rehearsal within lying is claimed to be a commonly practiced behaviour (Vrij et al., 2009) and is used as a load reducing technique (Lykken, 1998). Related to processing models, it may be suggested that rehearsal allows for a construction stage of lying (Walczyk et al., 2014) to be skipped during the provision of a lie. The information related to the lie has already been constructed and rehearsed before it is required (Granhag et al., 2003; Vrij et al., 2009), meaning this information only requires recall from memory, similar to the cognitive demands of truth telling (Walczyk et al., 2014). An argument can be made, therefore, that rehearsal of information has the ability to limit the cognitive demand of lying to the same level of, or lower than, that of truth telling (Walczyk et al., 2014).

The ADCAT model elaborates, to an extent, upon the expected effect of the rehearsal of a lie on lie processing. As a lie response is committed to long term memory, the associated load is lessened (Walczyk et al., 2014). This may be related to the fulfilment of a construction stage within processing, and the requirement only of recall from long term memory consuming fewer cognitive resources (Baddeley, 2007; Sporer, 2016). It is also predicted, however, that a slightly rehearsed lie may incur a higher associated load than an entirely unrehearsed lie (Walczyk et al., 2014) though within the model the reasons for this are unclear. Applied to the working memory model, a slightly rehearsed lie may have some information stored within long term memory which will require resources to access (Baddeley, 2007; Sporer, 2016). This information is incomplete, however, due to the slight rehearsal and a partial recall of information from explicit memory (Rovee-Collier et al., 2000). Further resources are then required in the recall of truth information and manipulation of this to construct the lie (Sporer, 2016). This, therefore, explains why a slightly rehearsed lie may incur a higher load, as the stages involved within the recall of truth and manipulation of information are present, plus the initial recall of the slightly rehearsed lie. The rehearsal of a lie, therefore, may have two distinct effects on lie processing, either a faciliatory effect where only recall of the lie information is required making lies as easy or easier than truth telling (Walczyk et al., 2014). Or an inhibitory effect, in the case of a slightly rehearsed lie, where the possibility of additional processes (Sporer, 2016) causes lies to become more difficult (Walczyk et al., 2014). The current research aims to investigate this effect, and the impact of lie rehearsal on the processing of a lie.

In addition to the impact of lie rehearsal on lie responses, current research offers no insight into the impact of lie rehearsal on the ability to provide the truth. Applied to a first step of recall in truth telling (Debey et al., 2014; McCornack et al., 2014; Walczyk et al., 2014) it may be predicted that a positive effect could be expected. If lying requires a recall of the truth, rehearsal of the lie should also involve this truth recall, effectively making rehearsal of the lie rehearsal of both the truth and lie. Should this be the case, a similar effect on truth responses, as was found within chapter four, may be expected following lie rehearsal. Such an investigation of truth responses has not, to my knowledge, been conducted. In addition to the impact of lie rehearsal upon the processing of lies, this research also aims to investigate the impact of lie rehearsal on truth processing.

Within memory, two distinct types are identified: explicit, the memory for information remembered, and implicit, the procedural memory of how to perform a task (Graf & Schacter, 1985; Warrington & Weiskrantz, 1968, 1970). These two systems are distinctly different in terms of their functioning and processing, and manipulations affecting one typically do not affect the other (Graf & Schacter, 1985). Rehearsal functions to enhance the encoding of information stored within explicit memory, to enhance the remembered information (Pyc & Rawson, 2009; Staniland et al., 2015). Implicit memory of how to perform a task should not be affected by a form of rehearsal designed to enhance encoded information in the explicit memory due to the differences in their functioning (Graf & Schacter, 1985). This difference in function was a possible explanation of the findings of chapter four, where rehearsal enhanced the information held within explicit memory allowing this to be more accurately recognised, but did not impact the processing of information held within implicit memory, represented by no change in response time of either truth or lie responses.

As previously discussed, rehearsal functions to enhance the encoding of information and facilitate its recall (Pyc & Rawson, 2009). Many methods exist to achieve this, and can be grouped into methods of passive rehearsal, an access of the information, and active rehearsal, an access and use of the information (Staniland et al., 2015). It is found that active forms of rehearsal are more effective than passive, granting enhanced encoding and retrieval of information in comparison to passive rehearsal (Staniland et al., 2015). Within lie rehearsal, it is suggested that lie information is constructed before it is required at recall and committed to long term memory (Walczyk et al., 2014). Rehearsal of this information will then enhance its encoding (Pyc & Rawson, 2009; Staniland et al., 2015) lowering the associated load of lying to a level the same as, or lower than, that of truth telling (Walczyk et al., 2014).

Literature provides evidence of the common use of rehearsal within lying (Vrij et al., 2009), suggested as being a load reducing countermeasure, essentially a way to make lying easier (Lykken, 1998). Rehearsal appears to be a commonly used practice by individuals in interview situations, partly related to a reduction of associated load during recall and partly to ensure greater consistency to appear truthful during report (Granhag et al., 2003; Vrij et al., 2009). If a lie is constructed and rehearsed before the information is required, then only the recall of this lie information is needed (Walczyk et al., 2014), eliminating the load associated with lie construction. This, however, can be exploited through the use of unexpected questions, where construction is required (Vrij et al., 2009). Differences between rehearsed and unrehearsed lies do seem to exist, such as the provision of wordier responses and increased eye movement in rehearsed lies in comparison to unrehearsed lies and truthful responses (Walczyk, Griffith, Yates, Visconte, & Simoneaux, 2013). Differences in the cognitive processing of these responses are unclear, however, as literature tends to focus on the ability to detect deception based on these factors. Even within deception detection literature, however, too few studies exist utilising rehearsal of the lie to provide a meaningful comparison in meta-analysis (Sporer & Schwandt, 2007). Further research is needed into the effects of rehearsal of the lie on both the processing of lie responses and truth responses as literature has yet to address this factor in processing models.

The current research aims to provide this insight into the processing differences of lies related to rehearsal of the lie. It also aims to investigate the effect of lie rehearsal on truth responses related to the first step of truth recall in lying as, to my knowledge, no research has considered the effects of lie rehearsal on the ability to provide the truth. In the processing of deception, a stage of truth recall is required where the known truthful information is recalled before a deceptive response can be provided in its place (Debey et al., 2014; Walczyk et al., 2014). Evidence of this first step of truth recall is provided by the findings of chapters two and four, where a poorly encoded truthful memory inhibited lie responses and enhanced truthful memory facilitated the more accurate construction of lie information. It can be proposed, therefore, that rehearsal of the lie is in fact rehearsal of both the truth and lie, as truth information must be accessed to construct a lie (Walczyk et al., 2014) and so will receive enhanced encoding due to the access of this information (Pyc & Rawson, 2009). If this is the case, it can be expected that lie rehearsal will facilitate truth recall, though in current literature this effect has yet to be tested.

Based upon the discussed theory, the following research hypotheses will be tested. Lie responses will be significantly slower in their response time and lower in their response accuracy than truthful responses; this will test theory suggesting a greater difficulty in the processing of deception (Debey et al., 2014; Suchotzki et al., 2015) and the findings of previous experiments which have all provided this conclusion.

Based on literature suggesting facilitated encoding and retrieval of information related to rehearsal (Pyc & Rawson, 2009; Staniland et al., 2015) and literature providing evidence of the load reducing properties of rehearsal on lies (Granhag et al., 2003; Vrij et al., 2009; Walczyk et al., 2014) it is expected that lie responses will become significantly more accurate following rehearsal. In terms of the effect of rehearsal of the lie on the response time of lies, no change may be expected due to differences in the processing of explicit and implicit memory. Rehearsal will enhance information held within explicit memory and should not impact processing steps held in implicit memory causing no change in response time as was previously found in chapter four.

Related to a first step of truth recall within deception processing (Debey et al., 2014; McCornack et al., 2014; Walczyk et al., 2014) and the relation of retrieval of information in the processing of explicit memory (Graf & Schacter, 1985; Warrington & Weiskrantz, 1968, 1970) it is expected that truth responses will become significantly more accurate following rehearsal. As with lie responses, no effect on response time may be seen due to the differences in processing of explicit and implicit memory systems.

Method

Design

This experiment utilised a repeated measures design; all participants took part in both rehearsal and no rehearsal conditions, were presented with both male and female faces, and were instructed to be truthful and deceptive. The block order of these variables was randomised for each participant to counter any order effects of the design and to balance effects of proactive interference.

The first independent variable was the instructed response type with two levels of an instructed truthful response or an instructed lie response; instruction provided by the word 'truth' or 'lie' onscreen. The second independent variable was the task rehearsal split between two levels of no rehearsal and rehearsal of the lie. A within subjects design was utilised with all participants responding both truthfully and deceptively, as well as taking part in rehearsal and no rehearsal trial blocks.

The first dependent variable was the response time to the presented faces, measured in milliseconds (ms) to respond between stimulus onset and response provided. Only correct responses, hit or correct rejection, were included within analysis. The second dependent variable was the number of correct responses provided. For truthful responses this was measured as a 'yes' response to target stimuli and a 'no' response to foil stimuli, correct identification of the stimuli. For lie responses this was measured as a 'no' response to target stimuli and a 'yes' response to foil stimuli, correctly lying about identification of the stimuli.

Participants

Thirty-three participants (ten male, M-age=29, SD=12.5) were recruited as a volunteer sample via the SONA recruitment system at the University of Huddersfield; an online recruitment software containing details of the experiment and opportunity for participants to book a time most convenient to them. Participation via this system is voluntary, though a certain number of credits are required as part of the course of each student, with one credit equalling 30 minutes of research time. All participants had normal, or corrected to normal, vision and were fluent in English. One participant was excluded from data analysis due to lack of task engagement.

Apparatus

Facial stimuli and apparatus used within this experiment remained consistent with those used in chapter one, chapter two, chapter three and chapter four.

Procedure

Participants were first verbally briefed on the task, instructed that they would be asked to respond both truthfully and deceptively to stimuli and take part in both unrehearsed and rehearsed trials. After the opportunity to ask for further information or greater clarity, informed consent was provided.

Each trial block contained three stages, first a stage of encoding where facial stimuli were presented in the centre of the screen for 800ms with an inter stimulus interval of 500ms between each. Five stimuli were presented ten times each in a random order. Participants were instructed to attempt to remember the stimuli presented as they would later be expected to lie about their recognition of the stimuli. Stimuli sexes were not mixed within each trial block to prevent the possibility of an own sex bias influencing recognition, stimuli were either exclusive male or female for each block.

The second stage, rehearsal, involved a presentation of the to be remembered target faces as well as never before seen foil faces. The target faces were presented a total of three times each, with fifteen stimuli in total. This was combined with fifteen unique foil stimuli. Participants were asked to respond to the stimuli deceptively, answering yes or no to a recognition of the stimuli, with a 200ms inter stimulus interval following each response. This design allowed for the target stimuli to both be seen more than without rehearsal, and for participants to respond to these stimuli deceptively and engage with the task in a deceptive manner. This design achieved the more effective active form of rehearsal by requiring participants to both access and use stored information (Staniland et al., 2015). Foil stimuli were included within this rehearsal stage to ensure participants engaged with the task, requiring participants to appraise the recognition of the stimuli. Rehearsal stages were only present in half of the trial blocks of this experiment, with the other half acting as no rehearsal controls.

The third stage, recognition, presented ten faces in a random order, five of which were the previously seen target stimuli and five were never before seen foil stimuli. Participants were required to identify recognition of these stimuli as quickly as possible, pressing '1' for a 'yes' response, recognition of stimuli, or '0' for a 'no' response, no recognition of stimuli. Following each response an inter stimulus interval of 500ms occurred before presenting the next random face. At this stage, the word 'truth' or 'lie' was superimposed at the focal point of the face, providing instruction as to the response type required, with lie responses requiring a change in response recognition. Ten truthful responses were requested followed by ten lie responses, or vice versa. No foil stimuli were seen more than once throughout the experiment. Instructions were provided before each stage to ensure clarity of the task. Trial blocks were counter balanced for stimuli sex order, response type order, and rehearsal level order.

The experimenter was present throughout the task to offer further clarity to participants if required, and to ensure engagement with the task. Data was visually inspected before analysis with instances of complacency and lack of task engagement, usually a repeated pressing of only one response button, were removed from analysis.

Following completion, a new trial block began following the same design and with new stimuli. In total, twelve trial blocks were completed per participant, six no rehearsal trial blocks and six rehearsal trial blocks. Each block contained ten truthful responses and ten deceptive responses, equating to two hundred and forty responses in total, sixty of each response type (truth and lie) per rehearsal condition (no rehearsal and rehearsal of the lie).

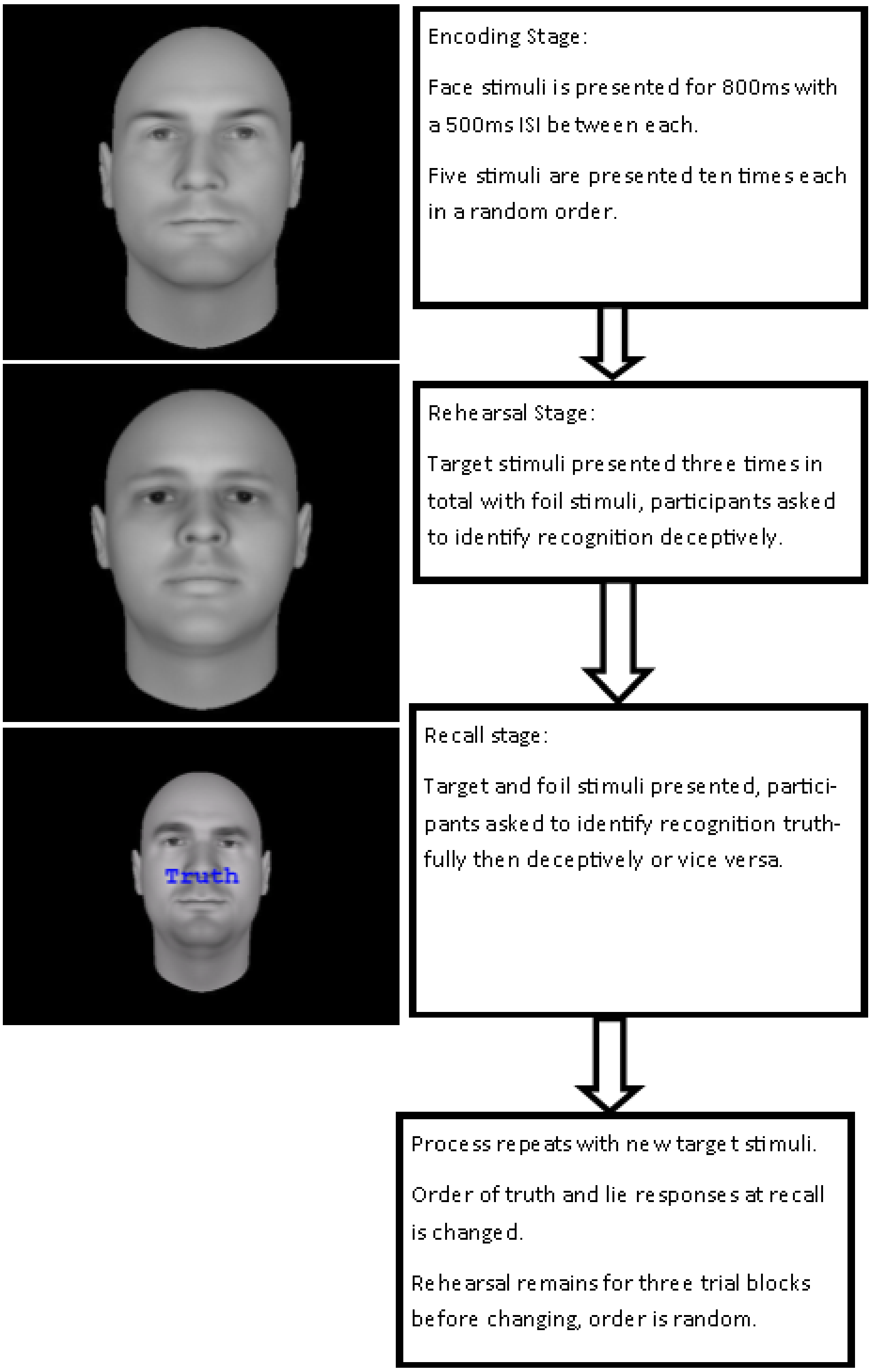

Figure 15. Flow of a single trial block in experiment 5.

Results

Response Time

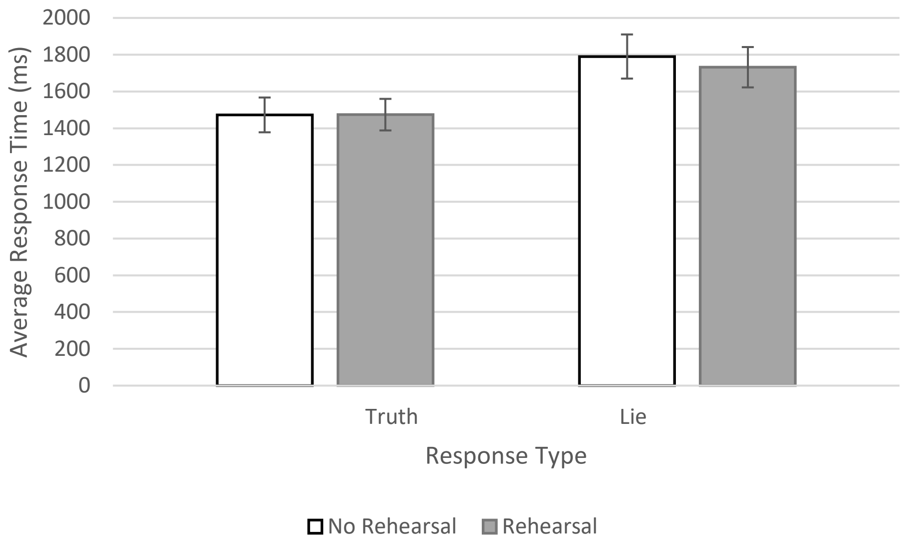

Figure 16. Average response time of truth and lie responses with and without rehearsal, error bars represent one standard error.

Mean values in figure 16. were analysed using a 2x2 repeated measures ANOVA with the alpha level set at 0.05 with response type (truth vs. lie) and rehearsal (no rehearsal vs. lie rehearsal) as the within subjects variables. The aim of which was to test for a difference in response time due to these variables.

No interaction effect was reported between response type and rehearsal $F(1,31)=0.72$, $p=0.40$, partial eta squared=0.02. A main effect of response type was found $F(1,31)=45.12$, $p<0.01$, partial eta squared=0.59, indicating significantly slower lie responses (M= 1761.02, SD= 650.03) in comparison to truthful responses (M= 1473.25, SD= 510.49). This suggests a greater difficulty in the processing of deception in comparison to the processing of truth. No main effect of rehearsal is reported $F(1,31)=0.29$, $p=0.60$, partial eta squared=0.01, indicating no effect of rehearsal on response time. As with chapter four, it appears a stage of rehearsal did not facilitate or inhibit the processing of truth or lie responses in terms of response time.

Response Accuracy

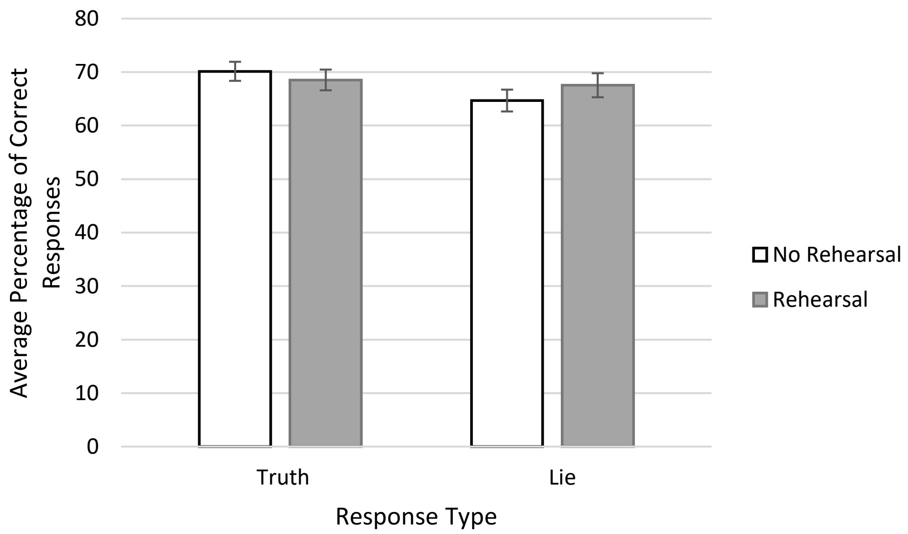

Figure 17. Average response accuracy of truth and lie responses with and without rehearsal, presented as a percentage, error bars represent one standard error.

Mean values in figure 17. were analysed using a 2x2 repeated measures ANOVA with the alpha level set at 0.05 with response type (truth vs. lie) and rehearsal (no rehearsal vs. lie rehearsal) as the within subjects variables. The aim of which was to test for a difference in response accuracy due to these variables.

An interaction effect was reported between response type and rehearsal $F(1,31)=5.17$, $p=0.03$, partial eta squared=0.14, indicating that the effect of rehearsal on response accuracy depends on the response type provided. A main effect of response type was found $F(1,31)=5.43$, $p=0.03$, partial eta squared=0.15 indicating significantly more accurate truth responses (M= 41.61, SD= 6.30) than lie responses (M= 39.67, SD= 7.28). No main effect of rehearsal was found $F(1,31)=0.23$, $p=0.64$, partial eta squared<0.01, indicating no difference in response accuracy between responses with a period of rehearsal (M= 40.83, SD= 7.10) and those without (M= 40.45, SD= 6.49).

Post hoc data used a Bonferroni adjusted alpha level of 0.025. Simple main effect analysis indicated no difference in response accuracy rate between lie responses with no rehearsal (M=38.81, SD=6.93) and lie responses with rehearsal (M=40.53, SD=7.64) $t(31)=-1.94$, $p=0.06$, $d=0.24$ and no difference between response accuracy rates of truth responses with no rehearsal (M=42.09, SD=6.04) and truth responses with rehearsal (M=41.13, SD=6.56) $t(31)=0.90$, $p=0.38$, $d=0.15$. No difference in response accuracy for either truth or lie responses is reported following a period of rehearsal of the lie.

Further simple main effect analysis indicated a significant difference between truth responses with no rehearsal (M=42.09, SD=6.04) and lie responses with no rehearsal (M=38.81, SD=6.93) $t(31)=3.07$, $p<0.01$, d=0.50 providing further evidence of greater difficulty in the processing of lies compared to truth. However, no difference between truth responses with rehearsal (M=41.13, SD=6.56) and lie responses with rehearsal (M=40.53, SD=7.64) was found $t(31)=6.14$, $p=0.54$, $d=0.08$. Evidence is therefore provided that a change in response accuracy did occur due to rehearsal resulting in no difference between response types following a period of rehearsal while a difference did exist before rehearsal, though this difference was non-significant.

Discussion

Findings in chapters one, two, three and four provide the consistent finding of a greater difficulty in the processing of lie responses, as well as offering insight into the processing steps involved within truth and lie responses. A first step of truth recall within lying was evidenced, in addition to the likelihood of an additional step within the processing of this response type. Chapter four indicated a faciliatory effect of truth rehearsal on both response types, related to a first step of truth recall within lying (Debey et al., 2014; McCornack et al., 2014; Walczyk et al., 2014). These findings also called into question the claims made within the ADCAT model as to the impact of an enhanced truthful memory (Walczyk et al., 2014).

To further investigate the role of rehearsal on the processing of truth and lie responses, the current research aimed to investigate rehearsal of the lie on the processing of these response types. Application of rehearsal of the lie will allow for information to be committed to long term memory (Walczyk et al., 2014) and possibly omit the construction stage within lying as lie information would only require recall from memory and the load associated with this (Sporer, 2016). This may reduce the load of lying to the level of, or lower than, that of truth recall as the same processing steps are involved (Walczyk et al., 2014). Additionally, the effect of rehearsal of the lie upon truth recall will be investigated. Related to a first step of truth recall in lying (Debey et al., 2014; McCornack et al., 2014; Walczyk et al., 2014) rehearsal of the lie may be expected to enhance the encoding of truthful information. No literature, however, has investigated this effect.

In terms of a difference between truth and lie responses, further support is provided of a greater difficulty in the processing of lie responses in comparison to truthful responses. Evidence of this greater difficulty in processing is provided by a slower response time within lie responses and a lower response accuracy before rehearsal. This, as with the findings in all previous chapters, provided evidence of greater difficulty in the processing of deception in comparison to truth telling and to literature suggesting a greater cognitive demand within lying (Debey et al., 2014; Suchotzki et al., 2015). No difference is seen in response accuracy between truth and lie responses when a period of rehearsal is provided, however. This reflects a slight increase in the accuracy of lie responses related to rehearsal, though this change is found to be non-significant. As with the findings of chapter four, a greater response time is still present in lies compared to truth following rehearsal when response accuracy of the two response types are equal. This provides evidence of an additional processing step within lie responses, accounting for the greater response time when the recognition of information is equal. This additional processing is proposed as being the construction stage of a lie (Walczyk et al., 2014) where recalled information is manipulated (McCornack et al., 2014) requiring additional cognitive resources from the working memory within its processing (Baddeley, 2007; Sporer, 2016).

In terms of the effect of rehearsal of the lie on lie responses, no difference is found in either response time or response accuracy between no rehearsal and rehearsal conditions. It was predicted that an increase in the accuracy of lie responses would be found due to the better encoding of information related to rehearsal (Pyc & Rawson, 2009). If the information related to lying was rehearsed and better encoded, this should have led to an enhanced ability to retrieve this information (Walczyk et al., 2014). It is suggested that this finding may be related to a difference in the processing of explicit and implicit memory, explicit memory being related to known information, and implicit memory being related to procedural information (Graf & Schacter, 1985). The rehearsal method applied during this task involved the procedural method of changing the response following recognition of the stimuli. Due to this, participants primed the procedural steps in implicit memory involved in the completion of the task and did not prime the knowledge in explicit memory to enhance the encoding of information. As previously discussed, a method of manipulating one memory system does not necessarily prime the other system (Graf & Schacter, 1985).

The rehearsal manipulation used within this design, therefore, did not prime explicit knowledge related to the lie, and so information was not easier to recognise following a period of rehearsal. Responses in the recognition stage still required an identification of the stimuli and a procedural response change regardless of rehearsal. Rehearsal did not facilitate this process as explicit memory of the lie information was not improved. Related to theory, a construction stage was still required in lie responses following stimuli recognition regardless of the rehearsed lie information (McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014). The design of this experiment does not seem to have committed lie information to long term memory, and so the additional processing step of construction (Walczyk et al., 2014) still takes place, with the associated working memory load required (Sporer, 2016).

In terms of the effect of rehearsal of the lie on truth responses, no difference is found in either response time or response accuracy between no rehearsal and rehearsal conditions. As with lie responses, this suggests that rehearsal of the lie did not facilitate the encoding of information, and the same explanation of a difference in the processing of explicit and implicit memory systems can be applied to this response type (Graf & Schacter, 1985).

Rehearsal in this task primed the procedural systems related to response changes made during the task and did not prime information related to stimuli recognition. This finding may reflect a difference in the processing between the applied recognition paradigm and the recall paradigm applied to verbal deception processing theory (McCornack et al., 2014). In verbal deception, information must be recalled on the go using context relevant schemas to fill in the blanks (McCornack et al., 2014), such a paradigm is likely to be impacted by rehearsal as lie information can be encoded before it is required, reducing the cognitive cost of its later recall (Lykken, 1998; Vrij et al., 2009). It is likely, therefore, that a recall paradigm is required to study the impact of rehearsal upon the processing of truth and lie responses, while a recognition paradigm does not reflect these changes in processing.

An important note is that it is expected that these findings may only apply to this methodological design, and findings related to the effects of rehearsal of the lie are predicted to be different for interview methodology. To explain, within an interview design lie information can be constructed before recall is required, and committed to long term memory (Walczyk et al., 2014). It can then be expected that rehearsal of the lie will facilitate accurate recall of lie information, and is evidenced to do so (Granhag et al., 2003; Vrij et al., 2009). Within the design of this experiment, stimuli must be identified each time they are viewed, and a lie response constructed at the point of recognition rather than beforehand as in interview design research. Due to this, it may not be possible to rehearse lie information for this particular design type. It was expected that lie information would be primed by rehearsal, as truth information was in previous research, though it appears that the rehearsal method applied within this task involved the implicit memory and did not prime deceptive response knowledge.

In conclusion, the findings of this research indicated that lies are more difficult within their processing than truth telling, represented by slower average response time and lower response accuracy. Support is, therefore, provided for experimental evidence (Debey et al., 2014, 2012; Sporer, 2016; Suchotzki et al., 2015; Vrij et al., 2018, 2006) and for the findings in chapters one, two, three, and four, suggesting established processing theory should account for a greater difficulty in the processing of lies. Applied to a working memory model (Sporer, 2016), the greater associated load within this processing appears to be related to an additional stage of manipulation of information recalled within lying. Evidence of this additional processing step provided in chapter four is supported by the findings of the current experiment as lie responses retained their average slower response time over truth responses when their accuracy levels were the same. When information was as easy to accurately recognise for each response type, lie responses were still found to be slower on average, supporting the concept of an additional stage associated with the manipulation of the recalled truthful information (McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014).

No evidence of an effect on the processing of either truth or lie responses is found related to rehearsal of the lie. It is suggested that this may be related to differences in the processing of explicit and implicit memory and their relation to the design of the task (Graf & Schacter, 1985). Further research is required into the role of the rehearsal of the lie in the processing of both truth and lie response types, and it is suggested that an interview design be applied to achieve this relying on information stored in explicit memory. Such a design would allow for lie information to be committed to long term memory (Walczyk et al., 2014) and the effect upon processing to be measured as a result.

Overall Discussion

The work of this thesis aimed to investigate further the processing of truth and lie responses, providing a focus on the cognitive elements of this processing. Current processing models disagree about the associated cognitive cost of lying in comparison to truth telling and do little to account for how the processing of these responses may differ related to factors such as applied load and rehearsal of information. This thesis investigated further into this debate of the cognitive cost of lying and expands upon the current processing models with suggestions as to how the aforementioned factors impact processing, with predictions of how this will affect behaviour. A brief summary of the findings of each chapter will be provided, followed by the implications of these as a whole. Finally, a suggested processing model of truth and deception will be provided, based directly upon the findings of this thesis, accounting for the role of other factors within the processing of truth and lie responses.

Summary of Findings

Chapter one: The processing of truths and lies with cognitive load applied at encoding.

A facial recognition task was completed both truthfully and deceptively while low or high cognitive load was applied at the encoding stage. A greater difficulty in the processing of lie responses in comparison to truth responses was identified. Applied load resulted in a slower response time for truthful responses, but no difference in lie responses; response accuracy was found to increase in the high load condition for both response types. Findings indicated a greater cognitive cost of lying with slower response time and lower response accuracy in lies than truth. The recognition of truthful information may not be required to lie, however, as poor encoding of truthful information had no impact on lie response time. This finding may be explained by a ceiling effect of task difficulty.

Chapter two: The processing of truths and lies with cognitive load applied at encoding with varying exposure times.

A design similar to that implemented in chapter one was applied, though with stimuli presented at three exposure times to manipulate task difficulty. A greater difficulty in the processing of lie responses in comparison to truth responses was identified. Applied load resulted in a greater difficulty in the processing of both truth and lie responses, supporting the use of this method as a way to make lying more difficult. This finding also provides evidence of the recall of truthful information within lie processing, as a poorly encoded truth created more difficulty in the processing of a lie. No interaction effect of response type and load was identified, however, possibly indicating that applied load affected both response types to the same magnitude. Exposure time increased response accuracy, supporting the use of this method in reducing task difficulty.

Chapter three: The processing of truths and lies with cognitive load applied at recognition.

A facial recognition task was completed both truthfully and deceptively while no, low or high cognitive load was applied at the recognition stage. A greater difficulty in the processing of lie responses in comparison to truth responses was identified. As with chapter two, applied load increased the difficulty of both truth and lie responses, though with no interaction effect present between response type and applied load it is possible both response types were impacted to the same magnitude.

Chapter four: The processing of truths and lies with rehearsal of the truth.

A facial recognition task was completed both truthfully and deceptively with half of the trials including a period of active rehearsal of the truthful information. A greater difficulty in the processing of lie responses in comparison to truth responses was identified. Rehearsal of the truth increased the response accuracy of both truth and lie responses, lies to a greater extent; no impact of rehearsal on response time was found. A positive effect on the processing of lies following a period of rehearsal of the truth was concluded, and further evidence of a stage of truth recall was provided. Additionally, evidence of a construction stage was provided as when truth and lie responses were equal in their response accuracy following rehearsal. Lies maintained a slower response time, suggesting additional cognition within their processing.

Chapter five: The processing of truths and lies with rehearsal of the lie.

A facial recognition task was completed both truthfully and deceptively with half of the trials including a period of active rehearsal of the lie information. A greater difficulty in the processing of lie responses in comparison to truth responses was identified. Rehearsal of the lie resulted in no differences to either truth or lie response types; a slight increase in lie accuracy was reported, becoming as accurate as truth following rehearsal, though this difference was non-significant. Results are suggested as being related to differences in the processing of explicit and implicit memory, with this task priming implicit procedural memory and not the explicit lie information. Findings are expected to differ in other experimental contexts where lie information may be committed to long term explicit memory storage.

Overall Thesis Aims

Proposed Processing Steps in Truth and Lie Processing

A broad, overall aim, of this thesis was to provide further investigation of the cognitive steps involved within deception processing, and to elaborate upon the stages of truth processing alongside those of deception. Provision of the stages of truth and lie processing allows for direct comparison to establish which aspects are similar and which may be different, with processing theory claiming similar steps for both response types (McCornack et al., 2014; Walczyk et al., 2014) though possible differences following a first stage of truth recall highlighted in neurological research (Sun et al., 2015, 2016).

Poor encoding of truthful information in chapter two resulted in greater difficulty in the processing of both truth and lie responses, while better encoding of this information in chapter four improved the response accuracy of both response types. These findings provided evidence of the use of truthful information during lie processing and support the claim that the processing of both response types seems to rely on an activation of the truthful information (Debey et al., 2014; McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014).

Due to the controlled nature of the instructed lies used within this thesis, evidence towards a goal-oriented stage of decision making within truth and lie processing cannot be provided. Within realistic lying it may be the case that a decision is made related to goal oriented behaviour and a path of least effort elaborated on within theory (Levine, 2014; McCornack et al., 2014; Walczyk et al., 2014) and evidence is provided of differences in the processing of instructed and spontaneous lies (Kim et al., 2012; Yin et al., 2016). Based solely on the work of this thesis however, evidence towards a decision stage cannot be provided as no decision was made by participants in relation to goal oriented behaviour or a path of least effort approach. The findings of this thesis can, therefore, be expanded upon through comparison of instructed and spontaneous lying and truth telling to investigate further a stage of decision making within processing.

Each chapter of this work has provided consistent evidence of a slower average response time and lower response accuracy within lie responses compared to truth responses. Related to the working memory model of deception processing (Sporer, 2016) such a finding can be explained through an additional processing step within the cognition of lies that is not present within truth telling. This step is proposed as being the stage of construction of information (Walczyk et al., 2014) akin to a process of information manipulation (McCornack et al., 2014). Within this work, truth responses require only a recognition of stimuli and a provision of a response, while lie responses require a recognition of stimuli followed by a changing of this response to create a lie. This additional cognition requires the consumption of further working memory resources (Baddeley, 2007; Morrison et al., 2015; Sweller, 1988) and a greater difficulty within the processing of lies, hence a slower response time and lower response accuracy (Suchotzki et al., 2015).

Further support of a stage of construction present within lie processing that is not present within truth processing was provided directly within chapters four and five. Following a period of rehearsal, both truth and lie responses were equal in terms of their response accuracy, but lie responses remained slower in their response time. This additional time required within processing, despite no difference in the ability to accurately recognise information, may be related to a stage of construction and information manipulation (McCornack et al., 2014; Walczyk et al., 2014). Information can be recognised within both response types to the same level of accuracy, but due to additional effort required on the part of the working memory (Baddeley, 2007; Sporer, 2016) in the manipulation of this information to construct a lie, a longer response time is still evident within lie responses.

Evidence within this thesis, therefore, suggests the presence of a stage of construction within deception processing, where truthful information is manipulated to create a lie response (McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014). This stage occurs only within the processing of lies, however, not within the processing of truth, accounting for a greater average response time within lying even at equal response accuracy rates. This stage adds to the processing time of lying (Suchotzki et al., 2015; Walczyk et al., 2003), and the consumption of a greater number of cognitive resources within this processing as a result of an extra step (Baddeley, 2007; Morrison et al., 2015; Sporer, 2016; Sweller, 1988), resulting in a greater difficulty in the processing of lie responses compared to truth. Support is, therefore, provided for both ADCAT and IMT2 in terms of the presence of a stage of construction (McCornack et al., 2014; Walczyk et al., 2014). Though unlike these models, it is proposed that this extra stage creates a greater cognitive demand within lying compared to truth telling in line with the predictions of the working memory model of deception processing (Sporer, 2016) related to a greater effort on the part of the working memory in the recall and manipulation of information.

Overall, the ADCAT and IMT2 processing stages do seem to account for how lies are processed at the cognitive level, with evidence of a stage of activation of truthful information (Debey et al., 2014; McCornack et al., 2014; Walczyk et al., 2014) and a stage of construction of lie information (McCornack et al., 2014; Walczyk et al., 2014, 2003). The construction stage is proposed as being the key difference between the processing of truth and lie responses as lies require a greater effort on the part of the working memory within this stage (Sporer, 2016).

Cognitive Load in Deception Processing

This thesis also aimed to investigate the role of cognitive load within deception processing with IMT2 and ADCAT models predicting no greater cognitive cost within lying (McCornack et al., 2014; Walczyk, 2014; Walczyk et al., 2014). This prediction is related to a path of least effort within processing (McCornack et al., 2014; Zipf, 2016), similarity in the processing of truth and lies (Walczyk et al., 2014) and the routine practice of lie behaviour (DePaulo et al., 2003). Alternative theory and experimental evidence suggest that lying does incur a greater cognitive cost related to additional steps in processing (Morrison et al., 2015; Sweller, 1988) and a greater amount of effort required on the part of the working memory (Debey et al., 2014, 2012; Sporer, 2016; Suchotzki et al., 2015; Vrij et al., 2018, 2006).

Findings across all five experimental chapters provided the consistent finding of a slower average response time and lower average response accuracy within lie responses compared to truth responses. Both factors can be used to suggest a greater cognitive load and greater difficulty in the processing associated with deceptive responses (Suchotzki et al., 2015; Walczyk et al., 2005). As previously discussed, this may be related to a greater effort on the part of the working memory in both the recall of truthful information and the manipulation of this to construct a lie (Sporer, 2016). In addition further required processing steps consume a greater amount of limited cognitive resources (Morrison et al., 2015; Sweller, 1988). The findings of this thesis, therefore, provide strong evidence of a greater cognitive demand within lying, likely related to the additional processing step of construction (Walczyk et al., 2014) and the additional cognitive demand required within this (Baddeley, 2007; Sporer, 2016; Sweller, 1988).

Impact of Applied Cognitive Load

Application of additional cognitive load is a method used to make lying more difficult and the detection of lies easier (Vrij et al., 2018, 2006; Vrij, Fisher, et al., 2008). Applied load consumes cognitive resources, increasing the difficulty of processing (Sweller, 1988) and, in the detection of deception, reduces the amount of resources available to control for behavioural cues to deception (Zuckerman et al., 1981). Applied load is predicted to impact the processing of lies more so than truth (Vrij et al., 2006; Vrij, Fisher, et al., 2008) by applying more load to an already loaded process. If lies have a greater cognitive demand than truth telling (Debey et al., 2012; Suchotzki et al., 2015; Vrij et al., 2018) as evidenced throughout the findings of this thesis, applying further load is predicted to impact lie responses to a greater extent in relation to the level of resource consumption (Vrij et al., 2006; Vrij, Fisher, et al., 2008). This thesis aimed at further investigating the effect of applied load to determine the impact it has upon the processing of both truth and lie, as well as applying these findings to processing models to expand upon their explanatory power.

Overall findings indicated that the application of additional cognitive load to the processing of truth and lie responses does create a greater difficulty within their processing but affects both truth and lie responses equally. Findings of both chapters two and three provided this information, where load applied at both the encoding and recognition stages increased the difficulty of response types, but did not impact lie responses to a greater extent as predicted (Vrij et al., 2006; Vrij, Fisher, et al., 2008). Applied to the working memory model, additional load creates a greater difficulty in the processing of responses due to the consumption of resources (Baddeley, 2007; Sweller, 1988) but, from the findings of the current research, this effect appears to be additive not multiplicative. To explain, additional load applies X amount of difficulty to cognitive processing, directly related to the load required to complete the applied task (Morrison et al., 2015; Sweller, 1988). This amount of additional difficulty is the same for both truth and lie responses, simply adding more on to what was already required, without impacting the higher load lie responses (Debey et al., 2015, 2012; Suchotzki et al., 2015) to a greater extent than truth, as was predicted (Vrij et al., 2006; Vrij, Fisher, et al., 2008).

It is understood that the application of additional load to deception detection is often related to an increase in behavioural cues such as speech errors (Sporer & Schwandt, 2006) and gaze avoidance (Jeon & Lee, 2016). These are likely to increase as load is applied, related to a lesser ability to control behavioural cues as cognitive resources are consumed (Zuckerman et al., 1981). If, however, applied load is additive and affects both truth and lie to the same degree it may be the case that the behavioural cues related to truth telling will also increase. Furthermore, many cues may be related to the anxiety of the context (DePaulo et al., 2003) which are also likely to increase as a result of applied load. More behavioural cues are likely to be detected within deceptive responses as load is applied (Vrij et al., 2006), but if truth is also affected to the same level, applied load may also increase the number of false positives related to truth telling. While this work did not consider behavioural cues, focusing on the cognitive processing rather than deception detection, findings do indicate potential flaws within the use of load application in deception detection which warrant further investigation.

Analysis of the Processing Steps in Theory

The processing steps suggested in both IMT2 (McCornack et al., 2014) and ADCAT (Walczyk et al., 2014) are generally supported by the work of this thesis. A stage of truth recall is evident from the effect of greater or poorer encoding of truthful information on lie responses within chapters two and four. A stage of construction is evident with the consistent finding of slower response time and lower response accuracy, and maintenance of a slower response time at equal response accuracy. Such findings may be related to a working memory approach in the explanation of cognitive processing steps (Baddeley, 2007; Sporer, 2016). A decision stage was not investigated as instructed lies were used within this research, so no evidence can be provided towards the existence of this stage or its effect on processing, though it is likely that this step does take place within realistic lying.

This work also considered the working memory model of deception processing (Sporer, 2016) and the processing steps proposed within. This suggests that deception requires the use of working memory resources for the recall of truthful and schema information (Baddeley, 2007), as well as for the manipulation of this information to create a lie (Sporer, 2016). This additional processing will result in a greater difficulty within the processing of lies compared to truth telling due to the consumption of a greater number of cognitive resources within the additional processing stages (Sporer, 2016; Sweller, 1988). The findings of this thesis provided support to this theory, as slower response times and lower response accuracy are related to additional steps within processing (Suchotzki et al., 2015; Walczyk et al., 2003) which in turn can be attributed to a greater difficulty in processing and an increased load upon working memory resources (Baddeley, 2007; Sporer, 2016; Sweller, 1988). As with the explanation offered towards both ADCAT and IMT2, it is suggested that additional resources are consumed at the construction stage of deception processing, where recalled information is manipulated to create a lie (McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014). This additional stage within lying, that is not present within truth telling (Walczyk et al., 2003) consumes a greater number of cognitive resources within its processing (Baddeley, 2007) hence a greater difficulty in the processing of lies in relation to the manipulation of recalled truthful information (Sporer, 2016).

Findings within this thesis cannot be used to assess the role of the recall of additional information within deception processing. It is suggested that schema relevant information is recalled when lying, and that this information is used in the construction of a lie (McCornack et al., 2014; Sporer, 2016) which induces further load upon working memory processes (Sporer, 2016). Working memory resources will be consumed in the recall of truthful information, additional context relevant schema information, and the construction of a lie (Baddeley, 2007; McCornack et al., 2014; Sporer, 2016). The experimental designs implemented within this thesis required only a response change to construct a lie response, it is therefore unlikely that further context relevant schema information was required to construct a lie during recall.

While the findings of this thesis provide support for the role of working memory within the processing of lies, and a greater difficulty within processing related to this, support for the role of the recall of further information cannot be provided. Based on the findings provided towards the implications of additional processing steps on working memory resources

(Baddeley, 2007; Sweller, 1988), it may be assumed that an additional stage requiring the recall of further information would build further upon the difficulty of lie processing (Sporer, 2016). It is suggested that future work should consider this factor to assess the role schema recall has in the processing of truth and lie responses. This may be achieved through a multiple-choice response to a given stimuli with the instruction of creating a response as close as possible to the truth. Truthful information would still need to be recalled and manipulated, but other schema related information would also need to be recalled in order to create a response as close to the truth as possible, allowing for an investigation of the impact this stage has on deception processing.

The Effect of truth and lie Rehearsal on the processing of truth and lie responses

This thesis aimed to investigate the role of rehearsal of both truth and lie information and how this may impact the processing of each response type. Current literature offers some insight into this, such as truth rehearsal facilitating the recall of truth information (Pyc & Rawson, 2009; Staniland et al., 2015) and lie rehearsal facilitating lie processing (Granhag et al., 2003; Vrij et al., 2009). Research does not consider the effect of one type of rehearsal upon the opposite response type, however, with the effect of truth rehearsal upon lie processing and lie rehearsal upon truth processing unclear. Some predictions towards these effects are made within the ADCAT model, with truth rehearsal inhibiting lie processing related to proactive interference and a greater difficulty supressing the truthful information (Walczyk et al., 2014). Debate can be raised towards this claim, however, with evidence that an easier to recall truth primes the first step of truth recall causing lie processing to become easier (Debey et al., 2014).

In terms of the effect of rehearsal of the truth on truth processing, findings offer support for rehearsal theory and the expected effects of this, whereby an enhanced encoding of information resulted in a more accurate recall (Pyc & Rawson, 2009; Staniland et al., 2015). No change in response time was found, however, though this was likely related to a floor effect of instruction to respond as quickly as possible. Related to theory, rehearsed truthful responses required fewer working memory resources during the retrieval of information (Baddeley, 2007; Sporer, 2016) at the first step of truth recall in processing (Walczyk et al., 2014) and so became easier to process following a period of rehearsal of the truth.

The ADCAT model proposes an inhibitory effect of truth rehearsal on the processing of lies (Walczyk et al., 2014) related to an effect of proactive interference of the better remembered truthful information and a greater difficulty in the suppression of the truth (Walczyk et al., 2014). Alternative literature suggests this may not be the case, as a truthful distractor was found to facilitate lie processing, suggested as being related to a priming of the first step of truth recall within lying (Debey et al., 2014). This may be used to suggest that a better encoded truth will facilitate the processing of lies as fewer working memory resources will be used to recall truthful information (Baddeley, 2007; Sporer, 2016) which in turn results in an overall easier to process lie. The findings of this thesis provided support to a faciliatory effect of truth rehearsal on the processing of lies with an increase in response accuracy evident. Truthful information could be recognised with a greater degree of accuracy which in turn allowed for a correct lie response to be provided following the manipulation of the recognised truth (McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014). This, as with the findings related to load applied at encoding, provides further evidence of a first step of truth recall within lying (Debey et al., 2014; McCornack et al., 2014; Walczyk et al., 2014) as better encoded truthful information resulted in a greater accuracy when lying, suggesting the use of this truthful information within lie processing.

Rehearsal of the truth, therefore, provides a positive effect on the processing of both truth and lie responses. This is explained through fewer working memory resources being required (Baddeley, 2007; Sporer, 2016) during the first step of truth recall (Debey et al., 2014; McCornack et al., 2014; Walczyk et al., 2014) related to better encoded and easier to recall truthful information (Pashler, 2013). No evidence of proactive interference or a greater difficulty in suppression of the truth (Walczyk et al., 2014) was identified; processing models are recommended to incorporate an enhanced truthful memory as providing a positive effect upon the processing of both response types, related to an easier to process first step of truth recall.

Rehearsal of a lie is shown to provide a faciliatory effect on lie processing, where lie information can be constructed beforehand and simply recalled when required (Granhag et al., 2003; Vrij et al., 2009). Such a rehearsal method allows for the processing step of construction to be skipped during the provision of information as this step has been previously performed and lie information committed to long term memory. This is suggested to place the processing of lie responses equal to or easier than truth telling in terms of processing difficulty (Walczyk et al., 2014) as, like truth telling, information only requires recall from long-term memory. Rehearsal of the lie should, therefore, reduce the associated load of lying (Lykken, 1998) through the prior completion of associated processing steps, and elimination of the requirement of additional working memory resources to construct a lie on the go (Sporer, 2016).

The findings of this thesis, however, identified no change in either response time or response accuracy within lie responses following a period of rehearsal of the lie, suggesting that associated processing steps within deception still occurred, and the construction of a lie still induced a greater cognitive cost upon processing (Sporer, 2016). This finding may be explained through differences between the processing of explicit and implicit memory (Rovee-Collier et al., 2000; Warrington & Weiskrantz, 1968, 1970) where the rehearsal method implemented within the experimental design primed implicit knowledge of the task procedure, but did not facilitate the explicit knowledge of the lie information. Methods impacting the processing of one memory type do not necessarily impact the other (Graf & Schacter, 1985) and so within this design, if implicit procedural information was primed this may not have impacted explicit information. Alternative methods of experimentation are expected to provide different findings, as lie information may be committed to long-term, explicit, memory, and so can be expected to provide an impact on the processing of lies as a result (Walczyk et al., 2014). Further research is required into this form of rehearsal to ascertain the effect it has on the processing steps of both truth and lie responses.

No research currently exists, to my knowledge, investigating the effect of the rehearsal of a lie on truth telling. Such knowledge may be important, as if rehearsed lies are processed differently to unrehearsed lies (Lykken, 1998; Morgan et al., 2009), a similar impact may be seen on provided truth information. As individuals switch back and forth between truth and lie during discourse (McCornack et al., 2014) it may be expected that an interview or interrogation where lying is present will also include truthful information. A greater understanding of how lie rehearsal, a commonly practiced behaviour (Vrij et al., 2009), impacts truth telling will provide further insight into how this response is processed and may allude to methods of detecting this response, highlighting the use of rehearsed lie information.

While no work has directly investigated this effect, related to a first step of truth recall within lying (Debey et al., 2014; McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014) it can be expected that rehearsal of the lie will involve the recall of truthful information. As a lie is constructed beforehand, truthful information is recalled and used in this construction (McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014); this will in turn prime the truthful information in memory (Pashler, 2013; Staniland et al., 2015) resulting in an enhanced encoding of this information and an easier recall. The findings of this thesis, however, did not find this to be the case, with no change in either response time or response accuracy of truthful responses following rehearsal of the lie. As with lie responses, this may be explained through differences between explicit and implicit memory (Warrington & Weiskrantz, 1968, 1970) and their associated processing differences (Graf & Schacter, 1985). This design focused on the procedural practice of changing the response to create a lie, not the better encoding of information within long-term memory. As with lie responses, it is expected that different experimental designs will yield different findings related to the processing of truth responses following the rehearsal of lie information.

The Processing of Truth and Lies to Facial Stimuli

The use of facial stimuli within deception literature is an under researched area as much work focuses upon verbal deception. This is understandable due to the clear application of this work to the identification of lies within interrogation or interview contexts where lying may be expected (Vrij et al., 2009). How lies are processed in other contexts, however, is still largely under researched, and further work outside of interview contexts should be considered to investigate the cognitive aspects of deception processing (Blandón-Gitlin et al., 2014; Sporer, 2016). Additionally, investigation of responses to facial stimuli holds the application of identification of lies within a line up context, another potential aspect of interrogation. The limited amount of current literature on the use of facial stimuli in deception processing suggests similar processing steps, with evidence of a stage of truth recall and construction of deception (Sun et al., 2015, 2016). Key differences to interview context research, such as the lack of a response time difference between truth and lie responses (Bhatt et al., 2009), are also documented and warrant further investigation.

As previously discussed, the findings of this thesis provided general support for the proposed processing steps within deception processing theory (McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014), suggesting a possible universal set of processing stages for deceptive responses to different forms of stimuli. Though it is of note that these findings also suggest a greater cognitive load associated with lie processing, conflicting with theory focused on verbal deception processing (McCornack et al., 2014). Findings also provided consistent evidence of slower average response times within lie responses in comparison to truth which, as with the work of Sun et al., (2015) provides evidence of an additional processing step and greater difficulty in the processing of lies (Sporer, 2016). It may, therefore, be possible to use response time data as a reliable indicator of deception to facial stimuli in addition to its use with verbal forms of deception (Sporer & Schwandt, 2006; Walczyk et al., 2003).

Findings related to facial stimuli within deception processing provide overall support for the proposed processing steps within deception (McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014). Similar stages of processing and differences between truth and lie responses remain present, as previously discussed, within this different context and stimuli type. This suggests some level of universality of the processing of truth and lie responses, though further research will need to be conducted into various stimuli types and various contexts to fully establish if this is indeed the case.

Model of Truth and Deception Processing

Based on the findings of this thesis, the following model of deception processing is provided in figure 18. This model explains how both truth and lie responses are processed at the cognitive level in addition to the factors which influence this processing, where in processing these factors affect, and the impact this has on processing.

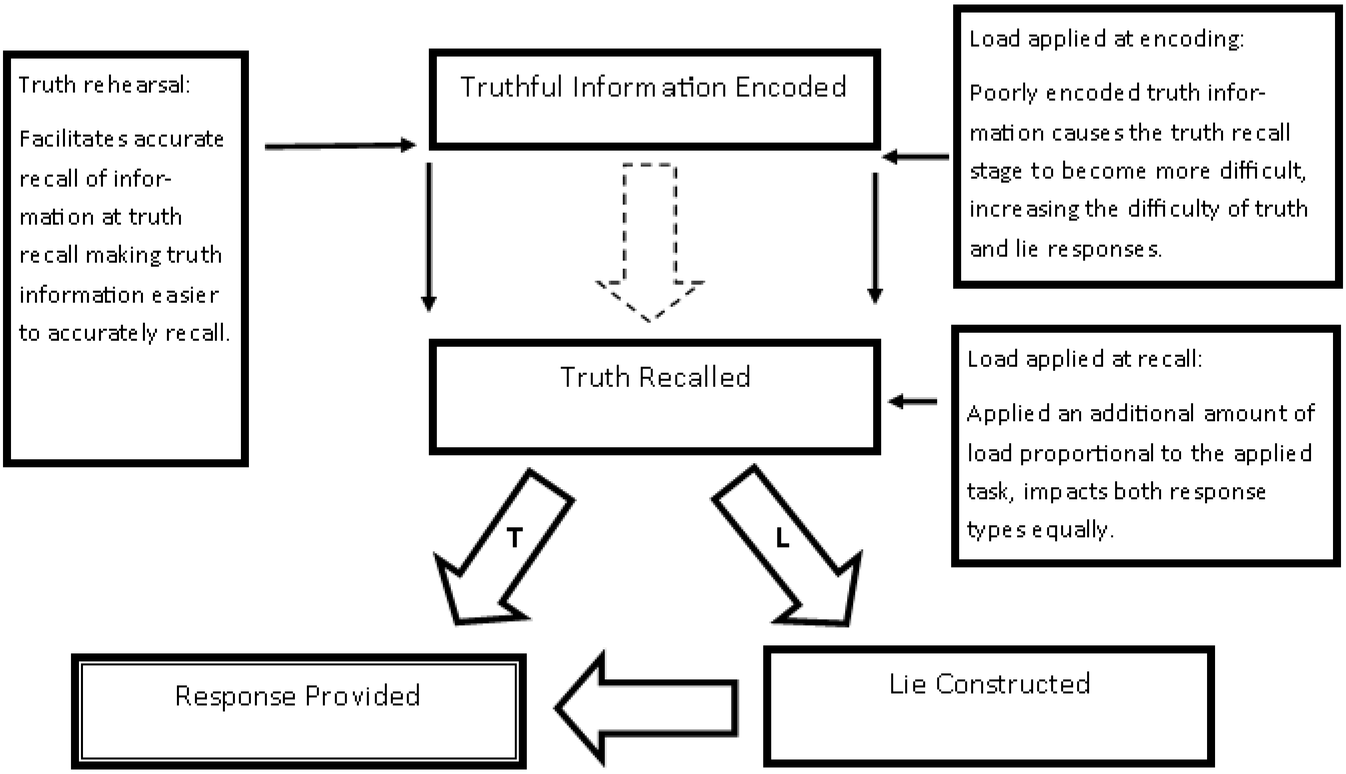

Figure 18. The flow of information of both truth (T) and lie (L) responses and the impact of additional factors upon this processing.

Within this model, block arrows represent stages of cognitive processing, line arrows represent optional factors and where they affect the processing of responses, and the dashed block arrow represents the time between information encoding and recognition. The processing model begins with the encoding of truthful information which is committed to long term memory for later retrieval. When required, effort is placed upon the working memory systems to recall the encoded information from long term memory (Baddeley, 2007; Sporer, 2016). This stage of truth recall occurs regardless of response type. Truth involves the recall of truthful information as this is required for this response type. Lies also require a truth recall (Debey et al., 2014; McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014) as evidenced within chapters two and four, where a more difficult to recognise truth inhibited lies (chapter two) and an easier to recognise truth facilitated lies (chapter four). Chapter one provided evidence that lie responses may not require this truth activation stage, related to no differences in lie responses following the application of load, though this may have been related to task difficulty. When task difficulty was manipulated within chapter two, a difference in lie responses related to load was evident, and so load at encoding is concluded to impact lie responses by increasing the difficulty of truth recognition.

Following this truth activation, responses are broken down into truth and lie, represented by the T-line and L-line. Each of these block arrows represent the processing demand of truth recall, the effort expended by the working memory in order to retrieve the truthful information from the long-term memory (Baddeley, 2007; Sporer, 2016). For truth responses, this is all that is required, and following this truth recognition, information can be provided. Lie responses, however, must engage in an additional stage of processing following the recognition of the truth, the construction of a lie (McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014). Evidence of this stage of processing is provided throughout the thesis with the consistent finding of a slower response time and lower response accuracy within lie responses in comparison to truthful responses. This provides evidence of a greater difficulty in the processing of lies compared to truth and is suggested as being the result of an additional stage in processing (Morrison et al., 2015; Sweller, 1988). Within the context of the experiments within this thesis, the changing of response of stimuli recognition accounts for a stage of construction within lie processing. Further support of this extra processing step was provided within chapters four and five, where following a period of rehearsal, accuracy of both truth and lie responses were equal, but lie responses still required a longer response time. This is proposed as being evidence of additional effort required on the part of the working memory in the manipulation of recalled information to construct a lie (Baddeley, 2007; McCornack et al., 2014; Sporer, 2016).

This additional step within deception processing then leads to the final block arrow before provision of a response, representing the additional load incurred within the processing of the lie response (Sporer, 2016). Further effort is expended on the part of the working memory to manipulate the recalled truthful information and create a lie response (Baddeley, 2007; McCornack et al., 2014; Sporer, 2016). If truthful information could not be recalled but a lie is still intended, the first available information will be provided after an effort is made to recall the truth, still requiring a greater effort from the working memory within processing.

Finally, the response is provided, truth requiring only the recognition of information, lie requiring the recognition of information and further manipulation of this to create a lie. This, therefore, accounts for the greater difficulty in the processing of lies in comparison to truth.

The processing steps proposed within the model related to the findings of this thesis are similar to those within both ADCAT (Walczyk et al., 2014) and IMT2 (McCornack et al., 2014). The key difference between these models and that proposed within this thesis, is a greater associated load within lie responses, in line with the predictions of the working memory model of deception processing (Sporer, 2016). A stage of decision is proposed within both IMT2 (McCornack et al., 2014) and ADCAT (Walczyk et al., 2014) models of deception processing related to goal oriented behaviour and a path of least effort in processing. Evidence is also provided of the existence and impact this stage has on cognitive processing, with an increase in response time within lies when a decision was required (Walczyk et al., 2003). While it is believed that this stage does exist and likely impacts the cognitive processing of both truth and lie responses, evidence of this stage cannot be provided from the work of this thesis, and so this stage is not included within the processing model. The work of this thesis focused solely on instructed lies to allow for a greater level of control over the provided responses, ensuring a certain number of truth and lie responses were provided by each participant. Future work should consider both response types as evidence of differences in processing is provided (Kim et al., 2012; Yin et al., 2016) and could be used to expand upon the provided model. One, to investigate the presence and role of a decision stage in both truth and lie processing, and two, to investigate potential processing differences between instructed and spontaneous lies. Investigation of these factors would then allow for expansion of the presented model and a more complete picture of the cognitive processing of both truth and lies.

As previously discussed, the findings of this work provide general support for the cognitive processing steps suggested within prominent deception processing theory (McCornack et al., 2014; Walczyk et al., 2014). The key way in which this model differs from those proposed is the role of cognitive load within deception processing. It is suggested that a greater effort on the part of the working memory is required within the processing of lies linked to the additional construction stage (Sweller, 1988), this being in line with the working memory model of deception processing (Sporer, 2016). While this thesis is in agreement with the cognitive processing steps involved within truth and lie processing, and that both do not differ in their basic processing outside of an additional processing step within lying, it is strongly evidenced that lying does come with a greater cognitive cost than truth telling, and a working memory model explanation of this appears to be the best explanation of this finding.

Effect of Factors on Processing

Factors such as additional applied cognitive load (Vrij et al., 2018, 2006; Vrij, Fisher, et al., 2008) and rehearsal of information (Lykken, 1998; Walczyk, Griffith, Yates, Visconte, & Simoneaux, 2013) are found to impact both truth and lie responses, though little explanation of this impact on processing is provided within the current models. The model proposed within this thesis in figure 18. attempts to elaborate on these factors, applying them to the processing model and offering suggestions as to the expected effect on the processing of both truth and lie responses as a result of these factors.

The first factor, cognitive load applied at the encoding stage, impacts the initial processing step where information is encoded. This results in an inhibitory effect where truthful information is more difficult to retrieve, and so as seen in figure 18. the effect of this factor on the processing of responses is placed on the encoding of information which later impacts the stage of truth recall. More effort is placed upon the working memory in the retrieval of poorly encoded information (Baddeley, 2007; Craik et al., 2018) increasing the difficulty of the processing of both truth and lie responses, and leaving fewer cognitive resources for the additional processing of lies. An effect on lie responses was not found within chapter one, but as previously explained this was likely related to task difficulty. When this variable was manipulated in chapter two an effect of load on lying was found, suggesting a poorly encoded truth does increase the difficulty of lies.

The second factor, cognitive load applied at the recognition stage, impacts the stage of truth recognition inhibiting the ability to provide this information. The findings of this thesis indicated that both truth and lie were impacted to the same magnitude by the application of this type of load, and the stage of truth recognition is a shared stage between the two response types (McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014). For this reason, load at recognition is applied at the point of truth recognition, as both truth and lie responses are impacted to the same extent by this load, and each response type has this stage within its processing. The later stage of construction in lying adds further to the load of these responses (Debey et al., 2012; Suchotzki et al., 2015; Walczyk et al., 2003) but does not appear to be impacted by the application of load at recognition as no greater effect on lies was found. Application of load requires the consumption of further cognitive resources in processing of the additional task (Morrison et al., 2015; Sweller, 1988), though this effect is additive, simply applying more demand on each response type, and does not impact one response type more than the other. Lie responses remain more difficult within their processing than truth telling due to the additional stage of construction, and the working memory resources consumed within the processing of this (Baddeley, 2007; Sporer, 2016).

The final factor, rehearsal of the truth, is also proposed as impacting the stage of truth recognition following its effect on the encoding of information, essentially working in antithesis to load applied at encoding by providing a positive effect on the processing of truth and lie responses. This finding is related to a first step of truth recall within processing (Debey et al., 2014; McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014) where better encoded truthful information resulted in an easier to process first step of truth recall, requiring fewer working memory resources (Baddeley, 2007). This in turn resulted in an increased accuracy of both response types; no improvement within response time was identified, though this may be related to a floor effect. The ADCAT model (Walczyk et al., 2014) provided a brief prediction as to the effect of truth rehearsal, proposing an inhibitory effect related to proactive interference and a greater difficulty in truth suppression. This was not found to be the case, with rehearsal of the truth providing a benefit to the processing of lies. As with other factors, lie responses are still more difficult overall than truth responses related to the additional working memory demand of the construction stage (Baddeley, 2007; Sporer, 2016).

The effect of rehearsal of the lie is currently absent from this model, as no differences were present within experiment five upon either truth or lie responses for both response time and response accuracy, suggesting no impact on the processing stages. It is, however, suggested that differences may be present in other contexts of lying, specifically verbal lies where lie information can be constructed in advance and committed to long term memory (Lykken, 1998; Vrij et al., 2009; Walczyk, Griffith, et al., 2013). Further research, therefore, should consider the rehearsal of information in different lie contexts so that their impact upon the processing stages of truth and deception may be used to expand upon the provided processing model.

Limitations

The work of this thesis provides an overview of the basic cognitive functioning of the processing of both truth and lie responses, detailing the steps involved in these processes. It also offers explanation as to the impact of the factors of additional cognitive load and rehearsal on the processing of each of these response types. This work can, however, be expanded upon through the consideration of other types of deception, such as spontaneous lying, and through alternate methodologies, such as the use of verbal deception.

The evidence of this work lacks support towards the role of a decision stage in deception processing, listed in theory as an important step within the goal oriented behaviour of deception (McCornack et al., 2014; Walczyk et al., 2014) and a stage which adds to the cognitive requirements of lying (Walczyk et al., 2003, 2016). Evidence towards the existence and impact of this stage is not provided through this work due to the instructed nature of the deception used within the methodological design. Such a design allowed for a greater level of control over the number of each response type provided, while spontaneous lying would not, allowing for the other stages of processing, activation and construction, and the impact of external factors, applied load and rehearsal, to be tested in a controlled environment.

Future work, therefore, should consider a comparison of the processing of spontaneous and instructed deception. Evidence exists to suggest that there are differences present in the processing of each of these lie types (Kim et al., 2012; Yin et al., 2016) with spontaneous lies demonstrating a greater cognitive demand than instructed lies. Whether such a difference is related to a decision stage is, however, unclear; additionally, such work does not consider the role of decision making upon the processing of truth telling. Examination of instructed and spontaneous response types with the consideration of a stage of decision making may provide evidence towards the existence of this stage, as well as the role it plays upon the processing of truth telling and lying. Such a design would also allow for the investigation of a more realistic lie type, relating to the goal oriented design of natural lying (McCornack et al., 2014; Walczyk et al., 2014) improving the ecological validity of the provided model of processing.

The recognition paradigm implemented throughout the methodological designs of this work means that the role of schema recall suggested within processing theory (McCornack et al., 2014; Sporer, 2016) is also not accounted for. As with a stage of decision, the retrieval of schema information in the construction of a lie is suggested as adding further to the cognitive demand of the processing of this response type (Sporer, 2016; Sporer & Schwandt, 2006). The facial recognition paradigm used within the work of this thesis did not require the recall of further schema information as only retrieval of known information was required to make a response. Implementation of a recall paradigm, such as in verbal deception, where information must be recalled along with relevant schema information to construct a response that fits with the known truth (McCornack et al., 2014) may provide further information as to the role of this stage within processing, and the impact this has upon both truth and lie processing.

A recall paradigm may add further load to the processing of both response types that is not accounted for within the current research design of this work, and the processing model provided in relation to their findings. This is due to the binary recognition of a face in comparison to the recall and verbalisation of an event, which possibly requires further recall of schema information to fill in the blanks of memory (McCornack et al., 2014; Sporer, 2016). While the binary response implemented within this research design allowed for an understanding of the basic cognitive steps involved within the processing of truth and lie, these can be expanded upon further through consideration of the more complex recall and construction of memory.

The work of this thesis offers explanation of the basic processing steps involved in the processing of both truth and lie responses, though it is likely that the processing of both response types is more complex for verbal deception, requiring recall of information, than the simpler recognition design implemented in this work. This greater complexity is likely related to the role of a stage of decision making in the processing of each response type (McCornack et al., 2014; Walczyk et al., 2014, 2003, 2016) and the recall of further schema related information filling in the gaps of memory and used to ensure a constructed lie is contextually related to the truth (McCornack et al., 2014; Sporer, 2016). The model of processing provided within this work can, therefore, be expanded upon through the consideration of different types of response, as well as methodological shifts towards the recall of information.

Conclusions and Implications

The findings of this thesis provided general support for the processing steps of deception (McCornack et al., 2014; Sporer, 2016; Walczyk et al., 2014) as well as offering a direct comparison to the processing of truth responses. Lies require an activation of truthful information (Debey et al., 2014; Walczyk et al., 2014) and differ from truth telling with an additional step of the construction of the lie (Walczyk et al., 2014) where recognised truthful information is manipulated and changed with the intent to deceive (McCornack et al., 2014). This additional step incurs a greater cognitive cost within lying over truth telling, related to a working memory approach whereby additional cognitive resources are required in the manipulation of recalled information (Baddeley, 2007; Sporer, 2016). This thesis, therefore, draws the same conclusion as the work of Sporer, (2016) in that current theories of deception processing (McCornack et al., 2014; Walczyk et al., 2014) should account for a working memory approach to the processing of truth and lies.

The factors of applied cognitive load and rehearsal of truthful information were applied to the stages proposed within theory (Walczyk et al., 2014) and those supported by the work of this thesis. This application expands upon the current models by explaining how these factors impact the processing of both truth and lie responses, as well as providing predictions of the effect on both response types in relation to these factors. Rehearsal of the truth provides a faciliatory effect on both truth telling and lying, questioning the assumption of a negative effect provided within the ADCAT model (Walczyk et al., 2014). This effect is based on an enhanced ability to recall a better encoded truth, with fewer working memory resources consumed within the recall of required truthful information (Baddeley, 2007).

Applied cognitive load causes both truth and lie responses to become more difficult to process through the consumption of cognitive resources to difficult to recall information in the case of load at encoding (Baddeley, 2007) or by the consumption of further resources processing another task in the case of load at recall (Morrison et al., 2015; Sweller, 1988). No greater effect of applied load was evident upon lie responses as predicted (Vrij et al., 2006; Vrij, Fisher, et al., 2008) however, with both truth and lie responses being impacted to the same magnitude by applied load. Findings support the use of applied load as a method of increasing the difficulty of processing of lies, and likely enhancing the ability to detect deception as fewer resources remain to disguise behavioural cues to deception (Zuckerman et al., 1981). The important point that truth responses are likely to be affected to the same degree as lying is raised, however. Even in a situation where lying may be expected, truth telling will still occur due to the modification of information during recall and the changing back and forth between truth and lie being normal (McCornack et al., 2014). If truth responses are impacted to the same extent by applied load as lie responses are, these too will become more difficult to process due to the applied load (Baddeley, 2007; Morrison et al., 2015; Sweller, 1988) as is evident within the findings of this thesis. An increase in the number of false positive identifications, where a more difficult to report truth is incorrectly identified as a lie, may too be expected to increase as a result of applied load. A recommendation is provided that deception detection methods and literature concerned with an application of cognitive load consider this as a possibility and investigate further into this possible impact.

Overall, the work of this thesis offers further insight into the processing of truth and lie responses, the associated load of lying, and applies factors that impact processing to the explanatory power of the established processing models.

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