Covariance in Performance Across Multiple False-Memory Paradigms and the Validity of Web-Based Administration of False Memory Tasks.

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Abstract

False memory is a real and persistent phenomenon that has been observed under many different conditions, both in and out of the laboratory. This study asked two main questions: can these conditions be generalised to administration over the world wide web; and do the false memories observed in these different conditions share common mechanisms? This study adapted common DRM, source confusion, and misinformation tasks to a web-friendly format. The DRM was presented visually; two sets of three word lists, each consisting of 15 words and clustering around a common concept, were administered to participants through their browser for a period of 1.5 seconds per word; the participants were latter presented with a new list of words, containing both old and new words, and were required to report if they believed if each of these words were previously presented, including one word for each list that represented the common concept. The source confusion procedure presented participants with an image of an office, a story relating to that image, and a questionnaire requiring the participant to answer several questions regarding the office and the story and to indicate the source of several items. The misinformation task presented the participants with a series of slides about which they were required to answer two questionnaires; several multi-choice questions in the first questionnaire did not contain the correct answer but required that the participant provide an answer despite this. The correct answers to these questions were available in the second questionnaire. The results demonstrated that these tasks can be administered over the world wide web and still display similar false memory characteristics to laboratory-based administration. Participant responses to these tasks, the digit-number sequencing task, and the Wonderlic Quick-Test were found to provide partial, though weak, support for the notion that common mechanisms underlie different kinds of false memory; weak to moderate correlations were found among the false memory tasks and between the false memory tasks and the digit-number sequencing task and the Wonderlic Quick-Test. The administration of false memory tasks over the world-wide-web, now demonstrated to be possible, is expected to open up a substantial population of potential participants and offer new methods to study false memory.

Table of Contents

Abstract .... **iii**

Table of Contents .... **v**

List of Tables .... **ix**

List of Figures .... **xi**

Acknowlegements .... **xiii**

1 Introduction **1**

2 Literature Review - Phenomena **5**

2.1 False Memory as a Robust Phenomenon *5*

2.2 Web-based presentation *16*

2.3 Conclusions *17*

3 Literature Review - Theory **19**

3.1 Memory Networks *19*

3.2 Dual-Process Theories of Memory *30*

3.3 A Common-Process Theory of Memory *34*

3.4 Evaluation of False-Memory Theory *37*

3.5 Application of Theory to False Memory Paradigms *39*

3.6 Hypotheses *51*

4 Method **55**

4.1 Participants *55*

4.2 Materials and Design *55*

4.3 Procedure *66*

5 Results **70**

5.1 Errors *70*

5.2 Initial Data Analysis *71*

5.3 Correlations Among Tasks *74*

6 Discussion **79**

6.1 The validity of a web-based medium for the presentation of false memory tasks *79*

6.2 Covariance in False Memory Propensity Across Tasks *84*

6.3 Working Memory as a Contributing Factor in False Memory Performance *87*

6.4 Intelligence as a Contributing Factor in False Memory Performance *89*

6.5 The Implications of the Findings for Theory *90*

6.6 Limitations and Recommendations for Further Research *92*

6.7 The Word Recognition Task as a More Pure Measure of False Memory Performance *98*

6.8 Further Research *98*

7 Conclusion **101**

8 References **103**

A Ethics Approval **109**

B Recruitment **111**

B.1 Recruitment Invitation *111*

B.2 Information Page *112*

C Word Recognition **115**

C.1 The Wordlists *115*

C.2 The Recognition Lists *118*

D Source Recollection **119**

D.1 Presentation *119*

D.2 Data collection *120*

E Eyewitness Memory **121**

E.1 Slides *121*

E.2 Questions...*124*

F.Letter-Number Sequencing 127

G.Wonderlic Quick-Test 129

List of Tables

Table 4.1. Words contained in the Beautiful word list. 58

Table 4.2 Example Letter-Number Sequencing sequences and answers. 65

Table 4.3. Example questions for the WPT-Q and the provided answers. 66

Table 5.1. The rate at which the items of each word list were indicated as recognised by the participants. 71

Table 5.2. The distribution of participant scores across all scales. 73

Table 5.3 A comparison of the rate of incorrect answers as elicited by the primary tasks and separated based on the presence of manipulation. 74

Table 5.4. The Pearson's 'r' values for correlations among the number incorrect lure items in each of the primary scales. 75

Table 5.5. The Pearson's 'r' values for correlations between the total number of incorrect answers for the primary scales. 76

Table 5.6. The Pearson's r, Spearman's ρ, and the relevant powers for the correlation between the number of incorrect items in each of the primary tasks and the letter-number sequencing task. 77

Table 5.7 The Pearson's 'r', Spearman's 'ρ', and the relevant powers for the correlation between the primary scales and the Wonderlic quick-test. 78

Table C.1.1 Primary word list: Cold. 115

Table C.1.2 Primary word list: Beautiful. 115

Table C.1.3 Primary word list: Bread. 115

Table C.1.4 Primary word list: Health... 116

Table C.1.5 Primary word list: Long. 116

Table C.1.6 Primary word list: Whistle. 116

Table C.1.7 Secondary word list: Anger. 117

Table C.1.8 Secondary word list: Fruit. 117

Table C.1.9 Primary word list: Slow. 117

Table C.2.1 Example recognition word list A. 118

Table C.2.2 Example recognition word list B. 118

Table D.1 Queried items in the source recollection task. 120

Table E.1 The provision of correct answers in the second section of the eye-witness testimony task. 124

Table E.2 The questions and options presented as part two of the eye-witness testimony task. 124

Table F.1 WAIS-III letter-number sequencing sequences and answers. 127

List of Figures

Figure 3.1. A hierarchical model of the semantic associations between various living things according to Collins and Quillian (1969)..................... 21

Figure 3.2. Semantic networks as proposed by Collins and Loftus (1975)......... 24

Figure 3.3. A neural network trained to differentiate between the properties of various forms of life...27

Figure 3.4. A sigmoid curve. 28

Figure 4.1. Source recollection: Image. 61

Figure 4.2. Slides three and five of six.. 63

Figure A.1. Ethics Approval. 109

Figure D.1 The image utilised for the source recollection task. 119

Figure D.2 The story utilised for the source recollection task. 119

Figure E.1 Slide one. 121

Figure E.2 Slide two. 121

Figure E.3 Slide three..122

Figure E.4 Slide four. 122

Figure E.5 Slide five. 123

Figure E.6 Slide six...123

Figure G.1 Example questions for the WPT-Q. 129

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1 Introduction

Memory is of a fundamental importance to our everyday functioning: were it not for our ability to remember information about the world that surrounds us, we would be unable to successfully navigate that world, obtain sustenance, or successfully participate in inter-personal relations. Our ability to access accurate memories is crucial to our continued survival; how accurate, though, are our memories?

The ease at which false memories may be formed can be demonstrated easily through a simple multi-choice memory task: Without looking back at the cover-page, which of the following images matches the image presented on the cover-page?

α ψ δ

If you have answered alpha (α) or delta (δ), then you either paid little attention to the cover page or your memory has led you astray. If you have answered psi (ψ), you are still incorrect. The image that was presented on the cover-page was, in fact, an uppercase psi (Ψ); while the form of the lowercase psi is similar to that of the uppercase psi and, for the most part, shares the same meaning, the image is, to no small degree, different. If you answered in the affirmative to any of the above images, as I hope you did, then you have displayed inaccuracy in your memory. While small in impact, this inaccuracy, none-the-less, displays a memory which does not accurately reflect reality; false memory. False memory, and the impact there-of, serves as the central topic for the rest of this chapter and, in fact, the entire thesis.

False memory has been defined as the remembering of episodic events in a way which is incorrect (Brainerd, Reyna, & Ceci, 2008); the memory could be otherwise accurate but the date could be confused, two events could have merged in to one, or the event may have never even happened. Here, episodic events could range from the witnessing of a murder to reading a single word on a projector. Errors in these events could range from misidentifying the time, place, and participants in a murder to remembering the word as starting with a capital letter when it, in fact, started with a lower-case letter. For the purposes of this thesis, a more restricted definition will be used: false memories are memories of episodic events that include incorrect *positive claims*. As with the definition of Brainerd et al. (2008), memories which include the presence of a non-present item will be considered false memories, as will memories where a present item is identified as non-present. Memories where details are missing but otherwise accurate, however, are not considered false memories as no positive claim is being made; the item is not claimed to be, or not to be, present. This definition is adopted to avoid claiming memories as false where information is not available to the individual regarding an item simply due to that item's lack of prominence (e.g., the colour of a pen in the pocket of an assailant).

While the confusion of the case of a letter may be little more than a curiosity to most, false memories such as those which may occur with eye-witness testimony have the potential to severely impact the lives of numerous people. An example of this would be where a witness to a crime, potentially the victim themselves, misidentifies the culprit; this could lead to the mistaken imprisonment of an innocent individual while the culprit remains free and may, potentially, go on to commit further offences. Perhaps one of the most clear-cut cases of such a false memory is that involving Dr. D. Thompson (Baddeley, 2004): In this well-known case, a woman was raped in her apartment and was adamant that Dr. Thompson was the offender. Luckily for Dr. Thompson, he had a strong alibi; at the time, he was taking part in a live broadcast alongside an Assistant Commissioner of the Police. With witnesses and video-based evidence, Dr. Thompson was fortunate; should he had not have had such an alibi, Dr. Thompson could have found himself imprisoned or, even if not found guilty, severely impacted in his personal and public life as a direct result of this unfortunate error in memory.

This study focused on three main questions: Can tasks used to investigate false memory in the laboratory be generalised to web-based assessment, do individuals display a common susceptibility to false memory phenomena across these tasks, and does an individual's tendency to err in memory vary with their ability to store and use information? Toward this end, the following chapter establishes false memory as a real and persistent part of our lives. Later chapters discuss theoretical frameworks for false memory, the design and the implementation of a pseudo-experiment designed to investigate underlying similarities in false memory, and the findings there-of.

2 Literature Review – False Memory Phenomena and Methods

2.1 False Memory as a Robust Phenomenon

In order to investigate false memory, it must first be established that false memory exists and that it does so in a robust manner. Put another way, it must be demonstrated that false memories do not exist as a momentary error in reporting but, rather, as a persistent distortion of the underlying memory. This section discusses several experimental manipulations which have been used to create and assess false memories in participants and the association of those tasks with other false memory phenomena. The review of these tasks will act to demonstrate that false memory is a real and robust phenomenon, even if it cannot speak to the frequency of major memory distortions in every-day life.

2.1.1 Episodic Distortion

Loftus and Palmer (1974; Experiment 1.) presented participants with seven short films featuring traffic accidents; four of these films featured collisions between two motor vehicles. For each of these films, participants were asked to answer several questions; one of which asked the participants to estimate the speed of the motor vehicles involved in the collisions. This question, presented for each collision, took the form of "About how fast were the cars going when they hit each other?" As the experimental manipulation, the word *hit* was substituted for *smashed*, *collided*, *bumped*, or *contacted* for 36 of the 45 participants. The actual speed of the vehicles involved in the collisions were 20, 30, 40, and 40 mph (M=32.5); the average estimates of speed ranged from 31.8 mph when the word contacted was substituted to 40.8 mph when smashed was substituted.

Loftus and Palmer (1974; Experiment 2.) performed a similar experiment in which they used only a single film and a larger sample (n=150). The film depicted a low-speed collision between two motor vehicles. The perceived speed of the motor vehicles was gauged with the same question as used in Experiment 1. Fifty participants were presented with this question, 50 participants were presented with this question with *smashed* replacing *hit*, and 50 participants were not asked this question. Participants in the hit condition reported a mean speed of 8 mph while participants in the smashed condition reported a mean speed of 10.46 mph, displaying the same trend observed in experiment. Participants were called back after one week and asked to complete a questionnaire consisting of 10 questions; one of these questions asked "Did you see any broken glass?". No broken glass was presented in the film. The control group, which was not asked about the speed of the motor vehicles in the initial questionnaire, and the hit group both reported broken glass at a frequency of .13; the smashed group, however, reported broken glass at a frequency of .32.

The results obtained by Loftus and Palmer would seem to suggest that the words used in questioning are capable of distorting the recollections of participants. That is to say, our use of language can actually affect the memories of a person (or, at the least, the reporting of those memories) without the need for more invasive, or even deliberate, techniques. The results of Experiment 2, in particular, would seem to indicate that these distortions are both persistent and capable of corrupting other aspects of a memory which may be related to the initial distortion.

2.1.2 Testimony

Gabbert, Memon, and Allan (2003) investigated the effect of collaborative remembering on later eyewitness reports. Gabbert et al. (2003) produced two short videos of an incident, each from a separate viewpoint and with slight variations. In one of the videos, the subject is seen to have stolen money from the wallet of another individual. In the other video, the subject does not commit this theft but, instead, disposes of paper in a nearby bin. Half of the participants were presented with the video in which the crime was depicted while the other half were presented with the video in which the crime was not depicted. Following the presentation of these videos, the participants were asked to fill out a questionnaire relating to the video; half of the participants were required to fill out the questionnaire individually while the other half were paired with another witness, who had witnessed the other video, and were required to fill out the questionnaire in consultation with their partner. Following a 45 minute distraction task, the participants were again asked to fill out, individually, a questionnaire regarding the incident. Of those individuals that completed the initial questionnaire individually, none reported remembering even a single event from the video they were not presented with. Of those participants that completed the initial questionnaire in pairs, 71% reported remembering at least one event from the video they were not presented with. Of those participants who had not witnessed the theft but had been paired with a participant who had, 60% reported that they could provide evidence of the subject's guilt based on what they had seen. Of those participants who had witnessed the theft and completed the initial questionnaire in pairs, approximately 17% reported that they could not provide evidence of the theft based on what they had seen.

The statements of others can affect how we remember events regarding other individuals; what of creating memories of entirely new experiences? Loftus and Pickrell (1995) investigated this by interviewing a relative of each potential participant and gaining reports of three events that happened during each participant's childhood. Using the information obtained in these interviews, booklets were generated which asked the participant to report on their memories of these events. In addition to the three events gained through the interview, an event was reported which the participant had not experienced. The event regarded getting lost in a mall and was customised based on the information obtained in the interview. Two weeks after the booklet, the participants were called in for an interview to discuss these events. The interview was repeated one to two weeks later. Sixty-eight percent of the true events were remembered to some degree while 25% of the made-up events were remembered. The average certainty rating as to the truth of the memory was 6.3 out of a possible 10 for the true memories across both interviews, 2.8 for the false memories in the first interview, and 3.6 for the false memories in the second interview. Wade, Garry, Read, and Lindsay (2002) performed a similar experiment in which each of the 20 participants had a close family member who was willing to act as a confederate and provide the experimenters with information and photographs regarding the participant's history. Each participant was presented with three true photographs and one false photographs regarding events during the childhood of the participant. The false photo depicted a hot-air balloon ride which had never taken place. Participants were asked to recall as much information regarding the events depicted in the photograph as they were able. Three interviews took place across the space of 7 to 16 days and all photographs were presented in each interview. Wade et al.

(2002) found that participants recalled details about the true events 93% of the time in the first interview and 97% of the time in the third interview; participants recalled the false events 0% of the time when initially presented with the false photograph, 35% of the time by the end of the first interview, and 50% of the time at the third interview. Twenty percent of participants reported clear, highly detailed, memories of the event. Garry and Wade (2005) report similar results to Wade et al. (2002) in relation to the use of photographs and produce even stronger results where a narrative is presented.

Kassin (2005) reviews a large number of high profile cases where suspects in criminal investigations have admitted to being guilty of a crime for which they were later found to be not guilty of due to the actual perpetrator being found and/or contradicting forensic evidence was produced. In many of these cases the suspects did not initially believe that they were guilty but, through repeated questioning and interrogation, came to believe that they were guilty. The subjects were often able to remember and describe their participation in the crimes, often erroneously (i.e., the details that the suspects reported would often poorly reflect the actual evidence). These types of false memories have been investigated experimentally by Kassin and Kiechel (1996): Participants were recruited under the premise of participation in an experiment examining typing ability. During the testing participants were accused of pushing a button on their keyboard that caused the computer to crash and the experimental data to be lost; a button which they had been warned not to touch. A confederate participating in the task with the participant then either indicated that they saw the participant press the button or that they did not see the participant press the button. Participant confidence was manipulated by encouraging the participant to go slowly and accurately or quickly and less accurately. Following this part of the task, the participant encountered another confederate who asked the participant what had happened. Each participant was later brought back into the room and asked to re-enact the events. None of the participants had actually pressed the button. In total, 69% of the participants confessed to the experimenter that they had pressed the button, 28% reported to the second confederate that they had caused the problem, and 9% included the pressing of the button in their re-enactment. The respective rates are 35%, 0%, and 0% for the group which was allowed a slow typing pace and for which the first confederate did not report witnessing the event and 100%, 65%, and 35% for the group which was encouraged to type quickly and for which the first confederate claimed that they witnessed the participant press the button. Horselenberg, Merchelbach, and Josephs (2003) repeated this experiment without the first confederate, with no direction as to the speed of the typing, and with the presence of a penalty should participants admit their guilt. In the place of the first confederate, the experimenter claimed to have personally witnessed the pressing of the button. Eighty-two percent of participants confessed to the experimenter, 42% admitted guilt to the confederate, and 58% later described their memory as to at which point they pushed the button. The penalty for admitting having pushed the button was the loss of 80% of the dividend received for participation in the experiment.

In each of the studies discussed in this section, the participant often ended up reporting events that did not actually occur. In each case these false memories are only developed following some form of interaction with another individual who reports events which differ from the experience of the individual. It appears that the influence of the reports of others can not only encourage an individual to re-evaluate their own memories, but to actively modify those memories to adhere more closely to the reports of others, even if the modified memories are false or previously non-existent.

2.1.3 Confusion of Source

To what degree do our preconceptions about a subject have an effect on the way that we remember that subject? Brewer and Treyens (1981) recruited a large number of undergraduate students who volunteered to participate in a psychological experiment. While the students did participate in such an experiment, the experiment for which they were supposedly recruited did not take place. Prior to the supposed start of the experiment, each participant was asked to wait in what they were told was a postgraduate student's office. The office lacked a number of items which would typically be expected in the office of a postgraduate student (e.g., books) and contained some items that would not be expected in the office of a postgraduate student (e.g., a skull). Participants waited in the office for 35 seconds before being removed from the room and asked to indicate, on a questionnaire, how certain they were that each item mentioned in the questionnaire was or was not in the room. The questionnaire mentioned 61 items that were in the office and 70 items that were not in the office. Of the 51 most strongly recognised items, 13 (25.5%) were not actually present in the office. Prior to the experiment, each item had been ranked based on the proposed strength of the association between the conceptualisation of a postgraduate student and the item. Of the 13 most strongly falsely recognised items, 12 were from among the top 23 non-present items based on this ranking.

In a similar experiment, Lindsay and Johnson (1989; Experiment 2) presented participants with a slide depicting a “complex office scene” and followed the presentation with a story describing the scene. Half of the participants were presented with an accurate story while the other half were presented with a misleading story which mentioned items not presented in the scene. Finally, participants were required to complete a questionnaire by indicating if they remembered seeing the item in the office slide. The questionnaire contained 8 items which were present in the office slide only, 8 items which were present in both the office and the story, 8 items which were mentioned in the misleading story but were not present in the office, and 8 items which were not presented in either the story or the office but were consistent with the scene. Participants who read the misleading story identified items that were only mentioned in the misleading story as being a part of the image 33% of the time. The same participants identified items that were in neither the story nor the image as being in the image 17% of the time. For participants who were not presented with the misleading story, the respective rates were 23% and 17%.

The studies by Brewer and Treyens (1981) and by Lindsay and Johnson (1989) show a baseline rate of incorrect responses independent of any experimental manipulation or attempts to cause confusion in the participants. As these incorrect responses were reported with high certainty on the part of the participants, it seems fair to say that these incorrect responses represent false memories as to the contents of the offices used in these experiments. The Brewer and Treyens (1981) study found that participants routinely, and strongly, remembered items that were not present in the office. The fact that these items are those which most strongly fit the common conceptualisation of a postgraduate student may be taken to indicate that a person's preconceived notions may corrupt memory. In the Lindsay and Johnson (1989; Experiment 2) study, participants who were presented with the misleading story falsely identified an average of 10% more non-present items as present than did participants who were presented with an accurate story. The results of these two experiments may be taken to indicate that false memory may be partially due to a misattribution of the source of the memory (discussed in Chapter 3). Put another way, some false memories may be the result of confusing where the memory came from.

2.1.4 False Fame and Familiarity

The *false fame* task was first used experimentally by Jacoby, Kelley, Brown, and Jasechko (1989) and has been used in many different forms since its initial appearance. Most pertinent to our discussion, here, is the form it takes in Experiment 2. In Experiment 2 of their 1989 paper, Jacoby, Kelley, et al. presented participants with a list of 150 non-famous names and, after the presentation of these names, a questionnaire consisting of 120 items. Of the items contained in this questionnaire, 15 names were drawn from the list of 150 names, 45 names were non-famous and not previously presented, and 60 were famous and not previously presented. The non-famous names were selected semi-randomly from a phone book while the famous names were selected based on the perceived likelihood that participants would recognise the person's name but not the reason for the person's fame. Two conditions were used: In the first condition, participants were asked to indicate simply if the name belonged to a famous person. In the second condition, participants were asked to indicate if the name was presented in the list of 150 non-famous names (*old*) or if they were not included (*new*) in addition to the fame judgement used in the first condition. Participants placed in condition one identified 63% of famous names as famous, 32% of new non-famous names as famous, and 38% of old non-famous names as famous. Participants placed in condition two identified 59% of famous names as famous, 23% of new non-famous names as famous, and 20% of old non-famous names as famous.

The false fame paradigm reliably elicits false memories in that non-famous names are routinely remembered as being famous, even when the names are newly presented to participants. While the observed difference between the rate of incorrect response for new non-famous names and for old non-famous names is only 6% (Jacoby, Kelley, et al., 1989; Experiment 2), this general trend is maintained across many different instances of the task (e.g., Jacoby, Kelley, et al., 1989), suggesting a real, if small, effect from the previous presentation of the names. Perhaps most interesting, the frequency of incorrect responses drops dramatically when participants are required to identify the source of their familiarity with the name (Jacoby et al., 1989), suggesting that the frequency at which a participant experiences false memories may be adjusted through the participant's use of information external to the relevant memories. This is further supported by research by Jacoby, Woloshyn, and Kelley (1989; Experiment 1) that found that the rejection of an old non-famous name as non-famous took significantly longer than for a new non-famous name and that the acceptance of an old non-famous name as famous took significantly less time than for a new non-famous name. Jacoby, Woloshyn, et al. (1989; Experiment 2) found that when the attention of participants was diverted from the initial presentation of the non-famous names by requiring participants to complete math tasks, participants identified old non-famous names as famous significantly more often than when the participants' attention was not diverted. Jacoby, Woloshyn, et al. (1989; Experiment 3) found that diverting the participants' attention during the fame recognition section of the task resulted in participants identifying old non-famous names as famous at more than twice the rate of participants without such distraction.

2.1.5 The Deese/Roediger and McDermott Paradigm

The Deese/Roediger and McDermott paradigm *(DRM)* was first used in a recognisable embodiment by Deese (1959) and was latter reformulated into its modern form by Roediger and McDermott (1995). In Experiment 2 of their 1995 paper, Roediger and McDermott formulated 24 *word lists*, each consisting of 15 words. Each of these lists was generated by selecting a *target* word, for which the list would be named, and then selecting 15 words which most strongly elicited that word (i.e., the list words were selected due to the frequency at which individuals think of the target word when presented with the list word.).

The 24 word lists were divided into three groups of eight; each of the word lists in two of these groups was read out to participants. Following the presentation of one of these groups, participants were asked to perform a *recall task*; participants were asked to write down every word with which they could remember being presented. Participants reported that the target word of each list was presented 55% of the time despite the target word not actually having been presented in any of the analysed lists. Following the presentation of the other group of words, participants were asked to solve math problems. Five minutes following the completion of the math or recall task, participants were asked to perform a *recognition task*; participants were presented with a questionnaire containing a list of words consisting of words from the presented word lists, the non-presented word lists, and every target word. Participants were asked to indicate if the word was presented and, if they thought the word was presented, if they remembered the word (i.e., had an explicit memory of the word being presented) or if they just knew (i.e., had a gut feeling that the word was presented but no explicit memory of that presentation; see Tulving, 1985 for a further discussion of this remember/know distinction). Participants correctly reported presented words as having been presented 79% of the time when they had been asked to perform the recall task and 65% of the time when they had been asked to perform the math task. Participants incorrectly reported the target words for the presented lists as having been presented 81% of the time when they had been asked to perform the recall task and 72% of the time when they had been asked to perform the math task. Non-target words which were not presented were identified as having been presented at a frequency of 11%.

The DRM paradigm represents a clear case of false memory; participants report memories of particular events, however minor, that have not happened, as having actually happened. It is notable that the frequency at which false memories of the target words being presented are reported exceeds not only the frequency of other non-presented words, but of the words which were actually presented. The paradigm has been widely used and the results have been replicated many times, including in the present study, using a variety of procedural variations. Due to their tendency to lure participants in to false memory, target words are often referred to as *critical lures* when used in conjunction with the aforementioned recall and recollection tasks.

2.1.6 Reports of Alien Abduction

Clancy, McNally, Schacter, Lenzenweger, and Pitman (2002) investigated reports of abduction by aliens (i.e., extraterrestrial life-forms). For the purposes of this investigation, it was assumed that these reports of alien abduction were highly unlikely to be true. This provided a more readily verifiable instance of major false memories in a real-life circumstance than did the recovered memories of childhood sexual abuse which had been previously investigated (e.g., Clancy, Schacter, McNally, & Pitman, 2000). Three groups of participants were recruited; individuals who reported recovered memories of alien abduction (n=11), individuals who believed that they had been abducted by aliens but had no memories of such (n=9), and individuals who claimed to have never been abducted by aliens (n=13). In all cases, those individuals who reported abduction by aliens reported an instance of symptoms similar to sleep paralysis and a gradual process of reasoning through which the individual concluded that they had been abducted. None of these participants reported a continuous recollection of the events but, rather, the participants reported that the memories had to be uncovered, having been previously forgotten. These reports would seem to suggest that, at least in these participants, these memories are not the product of a hallucination but, rather, of many of the processes previously discussed in this chapter.

Participants in the Clancy et al. (2002) study were asked to complete a number of tests relating to depression, post-traumatic stress disorder, dissociative experiences, personality, and schizophrenia in addition to 24 DRM memory tests. Participants who reported alien abduction scored significantly higher on the Perceptual Aberration scale, the Magical Ideation scale, and the absorption sub-scale of the Dissociative Experiences scale than did those participants that did not report alien abduction; while the same trend persisted throughout the other scales, sufficient statistical significance was not achieved. Participants who reported recovered memories of alien abduction displayed significantly (ps < .01) higher rates of false recognition and false recall than did participants that reported alien abduction without the memories; participants that reported alien abduction, memories or not, displayed significantly ($ps < .01$) higher rates of false recognition and false recall than did the group that denied alien abduction. Additionally, participant rates of false recall and false recollection in the DRM paradigm were found to be significantly ($ps < .05$) and positively correlated with participant scores on the Magical Ideation scale, the Beck Depression Inventory, and the absorption sub-scale of the Dissociative Experiences scale. While non-significant, most of the other scales displayed weak to moderate positive correlations with false recall and false recollection.

French, Santomauro, Hamilton, Fox, and Thalbourne (2008) performed a similar experiment to that of Clancy et al. (2002) but used only two groups: participants reporting alien abduction (experiencers, n=18) and participants not reporting alien abduction (controls, n=19). French et al. (2008) found that experiencers reported sleep paralysis at a significantly higher rate than controls. Experiencers also scored significantly higher than controls on measures of dissociation, absorption, fantasy proneness, and hallucinations. Notably, French et al. (2008) did *not* find a significant difference between experiencers and controls on DRM memory tasks; a small and non-significant trend was detected, with experiencers falsely reporting 59% of lures and controls falsely reporting 49% of lures ($F(1, 35)=1.88$).

The evidence provided by Clancy et al. (2002) and French et al (2008) would seem to indicate that a person's tendency toward false memory can be related to a large number of other attributes about that individual. Perhaps more interesting, the evidence would seem to suggest that the susceptibility of an individual to one type of false memory may be shared with another type of false memory (i.e., participants who possess false memories regarding alien abduction are more susceptible to false memories induced by the DRM paradigm). This interpretation, and the validity of the results, is further supported by the similar results obtained by Meyersburg, Bogdan, Gallo, and McNally (2009) in relation to memories of past lives and by Clancy et al. (2000) in relation to memories of childhood sexual abuse. Research by Peters, Horselenberg, Jelicic, and Merckelbach (2007), investigating the relationship between memories of past lives and the famous names task, supports the notion that this is not limited to the DRM paradigm. Research by Watson, Bunting, Poole, and Conway (2005), which found that working memory capacity is related to susceptibility to the DRM, suggests that susceptibility to false memory tasks may be related to phenomena which are not, themselves, false memory phenomena.

2.2 Web-based presentation

The previous section has established the existence of false memory phenomena and shown that these phenomena may be observed through a variety of different methods. If false memory is not limited to the laboratory and is, in fact, a natural and persistent part of life, it may be expected that false memory can be created outside of the laboratory environment by using similar methods to those used within the laboratory. While false memory tasks have generally been administered in controlled laboratory settings, the world-wide-web offers another medium through which participants may be recruited and, potentially, through which these tasks may be administered (Birnbaum, 2004). While the world-wide-web does not offer the control often desired in psychological experiments, it does offer a much larger potential pool of participants, a wider demographic than found in undergraduate psychology papers, and substantially reduced recruitment costs should remuneration be required (Paolacci, Chandlet, & Ipeirotis, 2010). Services such as Amazon's Mechanical Turk (https://www.mturk.com/) provide immediate access to hundreds of thousands of willing participants, a readily usable and customisable environment for experimental presentation, and a built in remuneration system (Mason & Suri, 2011).

The world-wide-web has long been used to collect survey data (see Couper & Miller, 2008 for a discussion) but has not been used extensively for cognitive tasks that are not amenable to a questionnaire format (i.e., the tasks require a static presentation of stimuli and multi-choice answers such as is often found in reasoning tasks). As web-browsers have advanced, however, opportunities have arisen for more complex tasks to be implemented; cognitive tasks such as digit span, mazes, and various tests of attention have started to be used in web-based research (e.g., Silverstein, Berten, Olsen, Paul et al., 2007), web-based cognitive assessment batteries such as WEXTOR (Reips & Neuhaus, 2002) have been developed, and many websites, such as Cognitive Fun (http://www.cognitivefun.net/), offer wide a variety of cognitive tasks (e.g., the Stroop test, the flanker test, and various reaction time tests) for individuals to complete for fun or out of interest. While, to the author's knowledge, no false memory tasks have been adapted for this medium, the world-wide-web could open up a massive participant base should false memory tasks prove able to be adapted to this new environment; tasks such as the DRM would seem to lend themselves readily to such an adaption.

2.3 Conclusions

This chapter has presented a wide variety of tasks which have been used to reliably produce false memories under experimental conditions. The fact that these tasks are capable of reliably producing these memories establishes false memory as a real and pertinent phenomenon. The observed relations between various false memory producing tasks and suspected real-life instances of false memory would seem to indicate that common processes may underlie the formation of these different kinds of false memories. The success of the world-wide-web as a medium for the experimental administration of psychological tasks was discussed, as was the potential adaption of false memory tasks to this medium. The next chapter investigates popular theories which have been used to investigate the false memory phenomenon and evaluates the predictions of these theories in relation to three common methods of experimental false memory production. These predictions are then used to formulate the hypotheses which form the basis of the method and results sections of this thesis.

3 Literature Review - Theory

In this chapter various theories relating to false-memory phenomena, and the mechanisms which are proposed to underlie these phenomena, are discussed. This starts with a discussion of the semantic networks on which these theories, at least implicitly, rely and then progresses to discuss the connectionist networks which, while making broadly similar predictions, display greater apparent ecological validity in that they are based on units similar to those found within the brain. Following this I discuss the two predominant paradigms of false memory theory and the predominant theory within each of these paradigms. These theories are related to several major false memory tasks before the implications of these theories are discussed and predictions are made.

Both of the major theories of false memory discussed in this chapter, as well as the mechanisms proposed to underlie false memory, explain each of the experimental results discussed in the last chapter using the same processes, though those processes vary between the theories. That is to say, each theory uses the processes and mechanisms which they propose to explain multiple false memory phenomena. As the same processes are utilised to explain these phenomena, even if these processes are used to different degrees with different instances of false memory, it may be expected that an individual's performance on false memory tasks will correlate positively with their performance on other false memory tasks. It is this prediction that formed the basis of much of the exploratory research presented in this thesis and on which this chapter will elaborate.

3.1 Memory Networks

3.1.1 Spreading-Activation Networks

Suppose that you were asked to think about the name *Alex*. Assuming that you know someone who goes by that name, you would likely think about aspects of that someone in addition to the name itself. This is the basic idea behind the notion of the semantic network; concepts are not accessed in isolation but, rather, they are accessed in conjunction with related concepts. The semantic network is a mechanism for understanding how accessing various concepts can also result in accessing semantically-related concepts.

One of the first attempts at understanding these networks was the spreading-activation theory of Quillian (1962). Quillian proposed that concepts and categories may be viewed as nodes in a network and that each node is connected to other nodes by a conceptual relation such as *Isa* (is a) or *Has*. In the Alex example, the individual Alex and the name Alex represent separate nodes and are connected by the relation Isa: "Alex (individual) is an example/member of Alex (name)". Similarly, the node for Alex (individual) may be related to the node for blond hair via the relation Has: "Alex (individual) has blond hair". Activation of any of these nodes results in the spread of activation to associated nodes which may, in turn, spread activation to further nodes.

The Quillian (1962) model suggests that the truth of a statement such as "Some people named Alex have blond hair" must be evaluated by, first, tracing out a path between the Alex (name) node and the blond hair node and then checking if the relations contained in that path (e.g. Isa) fit with the syntax of the statement. The path is traced through the spread of activation between nodes and the activation resulting from that spread (priming). The time that it takes for activation to spread between two nodes is proportional to the distance between those nodes; the further two nodes are from each other in the network, the more time it takes for activation to spread.

Collins and Quillian (1969) suggest that having any concept possessed by all members of a category connected, individually, to each member is an inefficient use of resources. To solve this, Collins and Quillian (1969) suggest the idea of *cognitive economy*; instead of each such member being connected to the concept directly, these members are connected indirectly via a connection between the concept and the category itself. To illustrate this, consider a canary, a blackbird, and a hawk; each of these has wings, feathers, and talons, but each is also a bird. By storing the concepts wings, feathers, and talons in relation to the category "Bird", the connections become less direct but far more efficient.

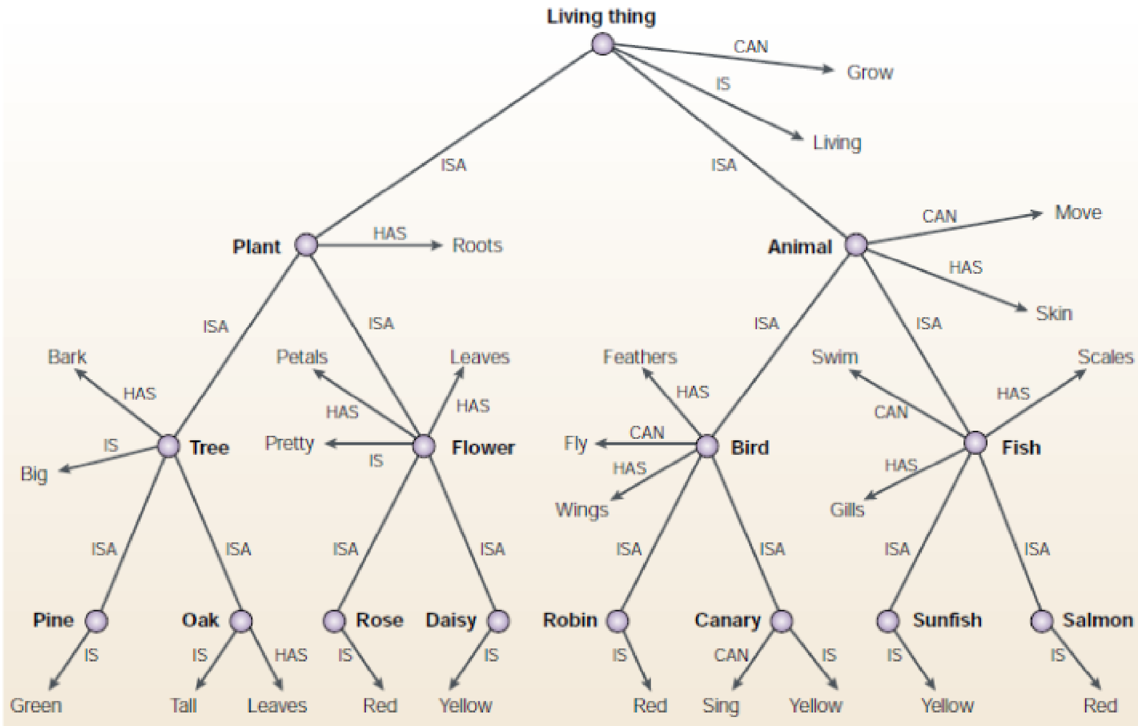

Figure 3.1. A hierarchical model of the semantic associations between various living things according to Collins and Quillian (1969). Note: Reprinted from "The parallel distributed processing approach to semantic cognition" by McClelland & Rogers, 2003, *Nature Reviews Neuroscience, 4,* p.311.

Drawing on the previous paragraphs it may be predicted that it will take you longer to evaluate that an example of Alex (name) has blond hair than it will that Alex (individual) has blond hair and that it will take you longer to evaluate that a canary has wings than it will to evaluate that a canary is a bird. While these examples appear to be true in many instances, this is not always the case and thus brings the veracity of the theory into question (Conrad, 1972; Rips, Shoben, & Smith, 1973).

Collins and Loftus (1975) extended the Quillian theory to compensate for the inability of the theory to account for the apparent discord between the predictions and the obtained results. To achieve this they reject the idea of cognitive economy, adopt a non-hierarchical model (Fig. 3.2.), and propose a further four assumptions about local processing (1-4), three assumptions about global processing (5-7), and six assumptions about the decision process (8-13):

1) The processing of a concept results in a spread of activation originating at that concept. The intensity of the activation is inversely proportional to the distance from the processed concept.
2) Only one concept can be processed at a time and the total activation originating at that node, and thus spreading throughout the network, is proportional to the length of that processing.
3) The activation decays over time when the concept is no longer being actively processed.
4) When activation from multiple sources is experienced by the same node, the combined activation may surpass the threshold for the firing of the node and thus a path between two nodes may become evident and able to be evaluated.
5) The greater the number of common properties between two concepts, the stronger the effective connection between these concepts is. This is not purely because of the strength of the direct connection but due, also, to the increased number of indirect connections between the two concepts which act to spread further activation between the nodes. This is demonstrated in Figure 2.2 where the concept "fire truck" shares more connections with "vehicle" than it does with "red" and thus will receive more activation from "vehicle" than it would from "red".
6) The names of the concepts are stored in a separate lexical network. The names are relatable to the concepts and are connected to each other based on the phonemic similarity of the names in a similar manner to the semantic network with the shared meaning of the concepts.
7) Individuals can allow and disallow the spreading of activation amongst nodes. Individuals can choose to prime words in the lexical network which are similar, or associated with, the name of the concept and/or concepts in the semantic network which are similar, or associated with, the concept itself.
8) Activation may also act as inhibition where the relationship between two concepts is exclusive. The degree to which two

concepts match each other is determined by the summation of the activation and inhibition of intermediate connections. The summed score must exceed a positive criterion for the match to be accepted and a negative criterion for the match to be rejected. Failure to reach these criterion results in a “don’t know” response.

9) An Isa or a Not Isa (is not an example/member of) relation is strong evidence for or against membership. For example, the Isa connection between ‘canary’ and ‘bird’ and ‘bird’ and ‘animal’ would be very strong evidence for a canary being an animal.
10) Commonalities among the compared concepts represent positive evidence while differences represent negative evidence. Negative evidence from mismatch is seen as stronger evidence than is positive evidence from commonalities.
11) One concept may be compared to *examples* of the other concept rather than directly to the other concept. For example, a canary may be compared to a raven rather than ‘bird’ to determine its membership to the ‘bird’ category. Commonalities represent positive evidence while mismatch represents negative evidence. Here, positive and negative evidence have equal weighting.
12) Two concepts may share an Isa relation with the same category. The relation may be mutually exclusive. When mutually exclusive, this relation acts as strong negative evidence. For example, canary and raven are both birds but cannot be the same entity as all members of the ‘bird’ category are mutually exclusive.
13) Evidence to the contrary, a counter-example, can be very powerful negative evidence for the truth of a statement. Take, for example, the statement “birds are canaries”; evidence that ravens are birds but not canaries acts to disprove the statement as every member of ‘bird’ must be a member of ‘canary’ for the statement to be true.

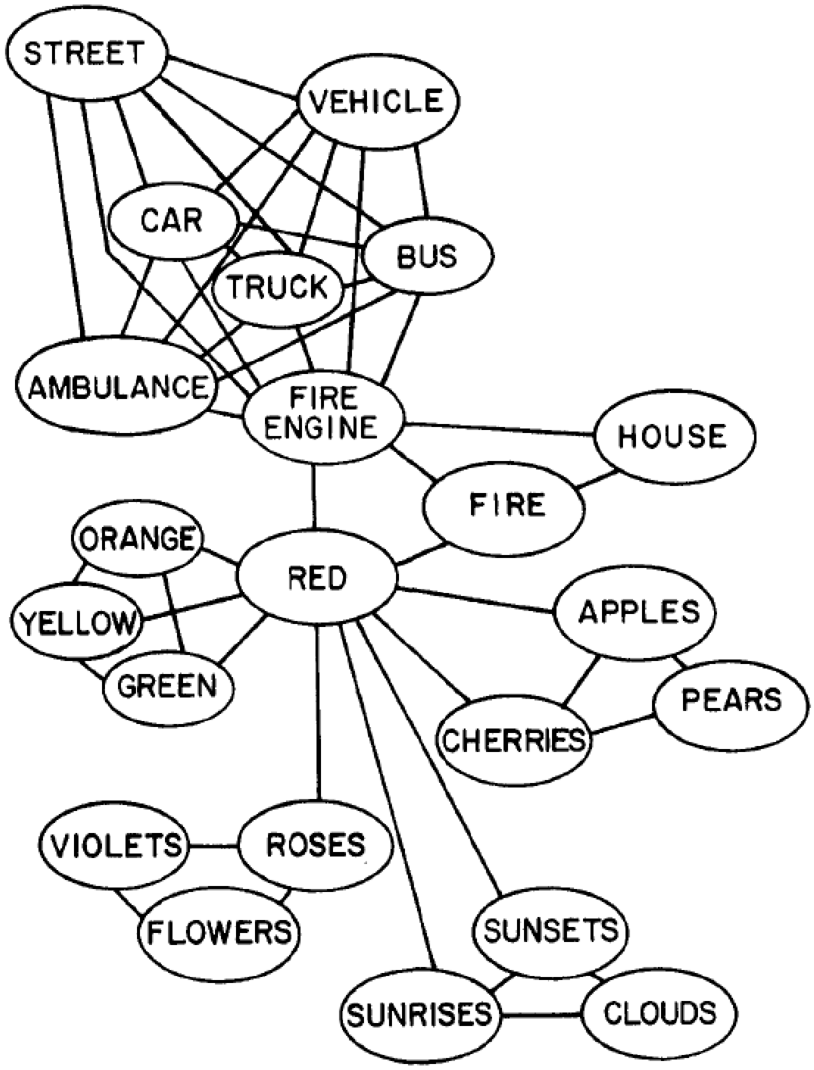

Figure 3.2. Semantic networks as proposed by Collins and Loftus (1975). Concepts are not connected in a hierarchical structure but in an amorphous network. Figure 1, p.412, Collins and Loftus (1975).

At first glance, the semantic network theory of Collins and Loftus (1975) seems to only apply to verbal statements; Collins and Loftus (1975) describe a semantic network and a lexical network but no other networks through which non-verbal phenomena may activate the semantic network. Furthermore, each of the processes by which the truth of a statement is evaluated are phrased in terms of verbal statements. Parallel to assumption 6, however, a perceptual network, consistent with the theory, may be assumed; while the lexical network deals with verbal stimuli, a perceptual network could function in a similar manner with coherent visual or tactile objects (i.e., in the same way that the perception of the word fire-truck may cause the activation of the semantic node associated with the concept fire-truck, the perception of an image of a fire truck, or the tactile sensation of a toy fire-truck, may, likewise, cause the activation of the semantic node associated with the concept fire-truck). With the assumption of a perceptual network, the semantic network theory of Collins and Loftus (1975) may be made to apply to tasks where perceptual inputs are supplied. The exact method through which this theory may be applied to false memory will be discussed latter in this, and the next, section.

3.1.2 Connectionist Semantic Networks

Connectionist semantic networks are a subset of neural networks which can be used to model semantic relations between objects and concepts (McClelland & Rogers, 2003). At first glance, connectionist networks appear very similar to spreading-activation networks: both approaches draw on nodes, and the connections between those nodes, to explain how meaning may be derived and both assume meaning to be found in the association of an object or concept with other objects or concepts. The actual functioning of these models, however, differs substantially; for connectionist models, the connection between two nodes says nothing of the nature of the connection (e.g., “is a”), only a select few nodes (output layer nodes, discussed in the next paragraph) ever directly influence the perceptions of the individual, and the nodes tend to represent factors common to multiple concepts, obvious or not, rather than the concepts themselves. This section discusses these networks in greater depth and highlights the differences in function between the two approaches. To avoid confusion, the nodes used in connectionist networks will be referred to as neurons.

Neurons function in a different manner to the nodes in spreading-activation networks. While spreading-activation networks present a multitude of unordered nodes which each represent discrete concepts, the neural network approach uses ordered layers of neurons, each layer feeding into the next, which may or may not represent a recognisable concept (Galushkin, 2007). The neurons are generally divided into three layers: the input layer, the output layer, and the hidden layers. The input layer takes in information external to the network (e.g., the presented concept) but does not actively play a role in the processing of that information, acting, rather, to relay that information to the output layer and the hidden layer. The output layer processes information received from the input and hidden layers and creates an output which affects the world external to the network or activates the input neurons of other networks. The hidden layers function in the same manner as the output layer in that they process information from the input layer and the other hidden layers but differ in that they are only considered to affect neurons within the network in question. Figure 3.3 presents a graphical depiction of a simple, and simplified, neural network designed for semantic differentiation.

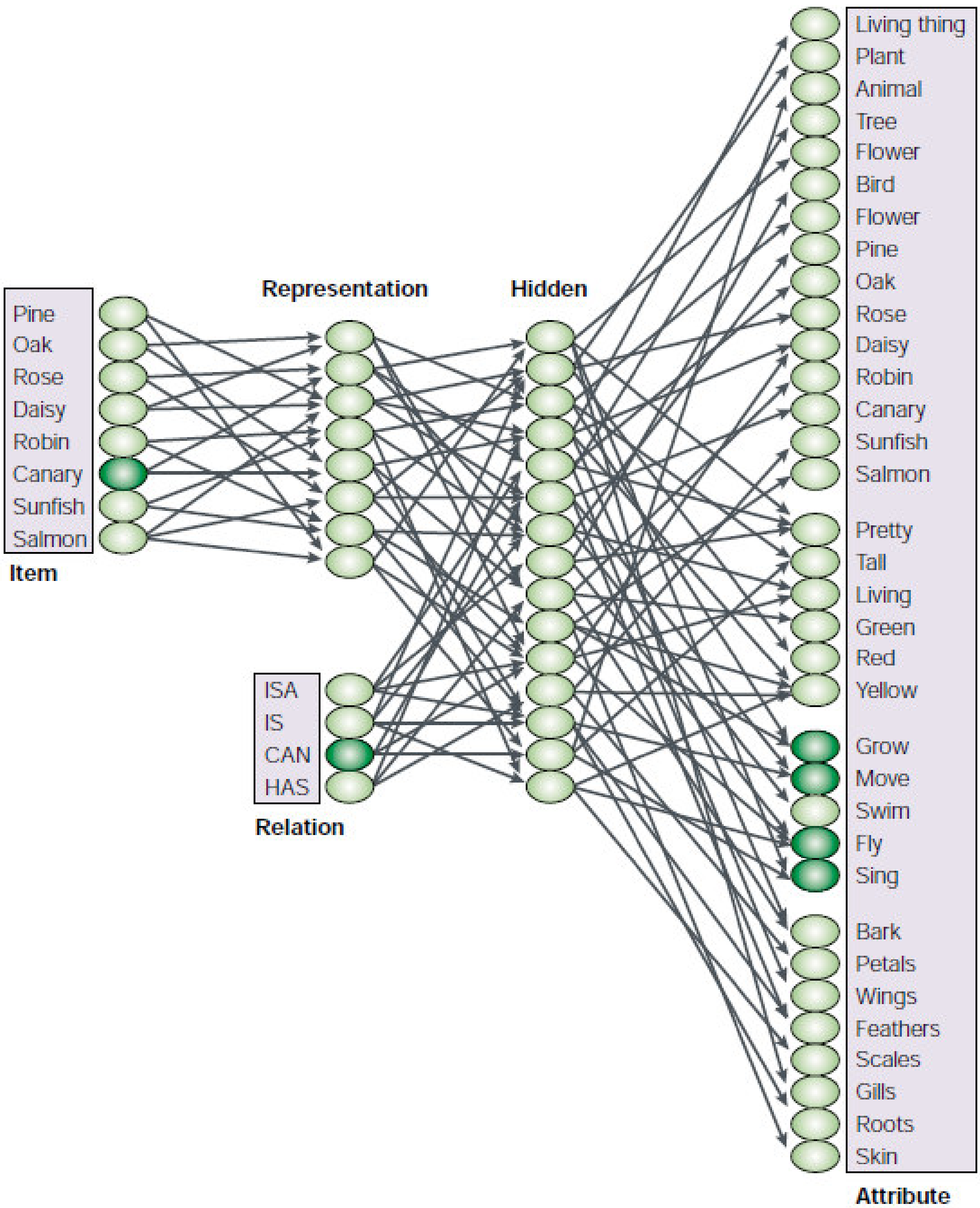

Figure 3.3. A neural network trained to differentiate between the properties of various forms of life. The activation of the neuron associated with canary and the neuron associated with can results in the activation of neurons which represent what a canary can do. Note: Reprinted from "The parallel distributed processing approach to semantic cognition" by McClelland & Rogers, 2003, *Nature Reviews Neuroscience, 4*, p.315.

It is important to note that the neurons of neural networks do not represent concrete ideas (i.e., no single neuron is directly associated with the concept of fire-truck). Rather, the neurons are sub-symbolic in that they represent abstract factors such as one may derive through factor analysis; the neurons are defined not by a concept but, rather, by how useful they are in producing the desired output. Just as with factor analysis, we may assign names to the neurons based on the connections and weightings if the neuron appears to fit a preconceived concept, but that does not mean that the neuron neatly represents that concept.

The neurons used in these networks are aptly named as they function, broadly, in the same manner as the biological neuron; the neurons take in signals, both excitatory and inhibitory, from a large number of other neurons within the network. These signals are summed and transformed (most often via a sigmoid function; demonstrated in Figure 3.4); should a predefined threshold be surpassed, the neuron will fire and excite or inhibit the other neurons with which it makes contact. The type of neural network postulated by this connectionist model is referred to as a 'feed-forward' network; these networks allow activation to travel only from the input layer, sequentially through the hidden layers, and finally to the output layer.

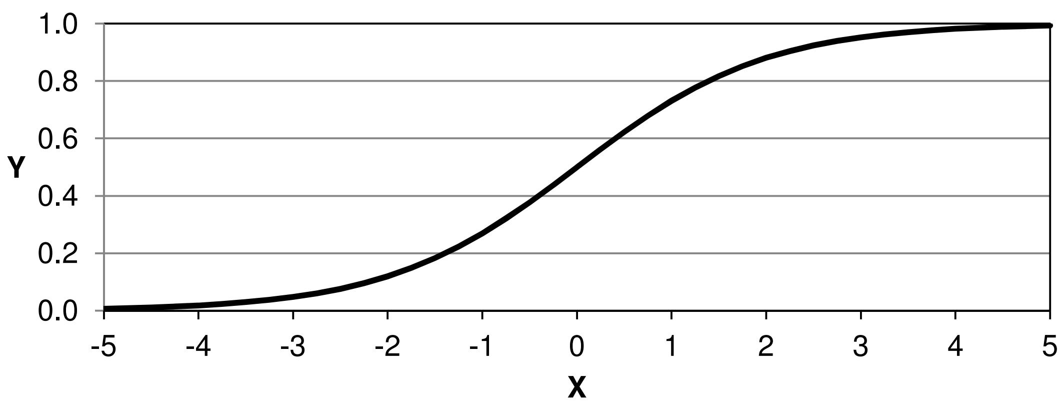

Figure 3.4. A sigmoid curve. The sigmoid function converts the value of X into a Y value which will approach, but never reach, two horizontal asymptotes. The figure provided here represents the most common sigmoid function: $Y=1/(1+e^{-X})$. The asymptotes for this function are 0 and 1.

Despite the differences in the functioning of the semantic and the connectionist networks, the predictions, to a large extent, converge. In both types of network, the concept fire-truck will cause the activation of various associated concepts; red, fire, truck, firemen, ladders, and, perhaps, Dalmatians. In both networks, if a node/neuron is repeatedly, or continuously, stimulated then the activation experienced by connected nodes/neurons may increase to the point that either appears as if activated, in the case of a node, or it fires, in the case of a neuron; if enough attention is given to the concept fire-truck, each of the concepts which are associated with fire-truck may come into conscious consideration. With the activation of the concept fire-truck beside another concept (e.g., "dog") that shares some of the same associated concepts (e.g., "Dalmatian"), those concepts which are associated with both will be more likely to be activated than those which are held by only one (ignoring, for the moment, the strength of the connections between the nodes/neurons).

Each neuron may be seen to represent a factor common to the neurons of the previous layer. The factor is derived through the strength of the connections between the relevant neuron and those neurons in the previous layer with which the neuron connects; the output of the network is, ultimately, the result of applying a large number of regression equations to the initial input to derive factors of predictive value. How, though, do these factors come to be? The simple answer is that these networks are capable of learning. The more complex answer is that the strength of the connections are either preset according to theory or they are set randomly. The strength is then modified by learning algorithms based on the concordance between the achieved output for a set of inputs and the desired output for a set of inputs; where a neuron activates in a manner that results in a correct output, the connections to that neuron which were activated are strengthened while the reverse is true if an incorrect answer is obtained. The exact mechanism through which the adjustments are made is beyond of the scope of this work but is referenced in McClelland and Rogers (2003) and explained in great detail in Gurney (1997) and Galushkin (2007). The next sections discuss various theories of false memory and relate these theories to the memory networks, discussed in this section, on which they necessarily rely.

3.2 Dual-Process Theories of Memory

The core premise of the dual-process theories is the use of two separate processes for memory retrieval and evaluation. The dual-process theory of Mandler (1980) will be discussed briefly in the following paragraph as a representative example of the dual-process paradigm; discussing each member of this paradigm would exceed the scope of this review and be largely redundant. Following this, Fuzzy-trace theory (Brainerd & Reyna, 1990; Reyna & Brainerd, 1990), around which the remainder of this section will focus, will be introduced.

3.2.1 Mandler's Dual-Process Theory

The dual-process theory of Mandler (1980) proposes that the retrieval of an episodic memory is a product of familiarity and ease of access. Familiarity serves as the first process in the evaluation of the truth of any retrieved memory; if the content of a memory feels sufficiently familiar to the individual then that memory will be evaluated as true. If the familiarity is insufficient for such an evaluation, the second process is utilised to evaluate the veracity of the memory; ease of access. The ease of access of a memory is essentially how easily a *conscious* search of one's memory network provides information about the memory in question; if the individual can retrieve information about the episode easily then the memory is more likely to be true and is more likely to be evaluated as true. If the familiarity of a memory is insufficient to be evaluated as veridical then the ease with which details relating to that memory are retrieved is factored in and the memory is either accepted as true or rejected as false.

3.2.2 Fuzzy-Trace Theory

Fuzzy-trace theory, one kind of dual-process theory, was proposed by Reyna and Brainerd in 1990 (Brainerd & Reyna, 1990; Reyna & Brainerd, 1990) and has come to be one of the most discussed approaches for understanding false memory. The basic postulate of fuzzy-trace theory is the existence of two separate processes in memory retrieval and evaluation; *verbatim* traces and *gist* traces. Verbatim traces are claimed to decay faster than gist traces and, through this decay, facilitate false memory by increasing the degree to which individuals must rely on gist traces to evaluate the veracity of a memory (Brainerd & Reyna, 2002). Brainerd and Reyna (2002) attempt to summarise the nature and effects of these traces on veridical and false memory by formulating five “explanatory principles”:

14) “Verbatim traces are episodically instantiated representations of the surface forms of experienced items, including contextual cues, and gist traces are episodic interpretations of concepts (meanings, relations, patterns) that have been retrieved as a result of encoding items' surface forms” (Brainerd & Reyna, 2002, p. 165).
15) Retrieval of stored memories relies upon the retrieval of both verbatim and gist traces and the detail contained within those traces. Verbatim traces tend to be strong when there is more detail encoded in memory about the circumstances surrounding the remembered item and the surface form of that item; because actual perception of an event often provides a bounty of such information, events which were actually perceived will generally leave stronger verbatim traces than events which were not perceived (e.g., in perceiving an accident, an individual will also perceive where the accident happened and events preceding that accident. If the accident is imagined, this information is less likely to be stored.). Gist traces are strong when there is relatively more information available about the meaning of a remembered object and its associations to other objects; because both actually experienced events and imagined events can contain large quantities of such information and because the perceived meaning of a event does not change greatly if it is imagined compared to if it actually happened, both actually experienced events and imagined events can possess strong gist traces. The preferred type of retrieval for a memory is determined by which trace is the strongest.
16) Both verbatim and gist traces assist in the veridical recollection of memories; verbatim traces provide information about the specific events and gist traces provide information about the meaning of those events. When combined, verbatim and gist traces allow the information about an event to be reconstructed. However, verbatim traces and gist traces have opposing effects in the

reconstruction of false memories: The retrieval of gist traces supports false memory recollection because the feelings of familiarity that gist traces rely on can spread through semantic networks in such a way that concepts associated with the originally activated concept may become activated sufficiently so as to be indistinguishable from the originally activated concept when the memory is next accessed. The veracity of the memory is then able to be divined through the verbatim traces: If the verbatim traces are readily accessible and agree with the gist traces, then the memory will be evaluated as true; If the verbatim traces are readily accessible and contradict the gist traces, the memory will be evaluated as false; If the verbatim traces are not readily accessible and the gist traces are weak, the memory may be evaluated as false due to the low probability of having neither verbatim nor gist traces; and if the verbatim traces are not readily accessible and the gist traces are strong, the memory will be evaluated as true as the verbatim traces are not present to contradict the gist traces. It is this final case, where the gist traces overpower the verbatim traces, that is claimed to most often result in false memory.

17) As an individual advances from childhood through to early adulthood the individual's ability to form both verbatim traces and gist traces develops. The ability to create gist traces develops faster than the ability to create verbatim traces due to the rapidly expanding semantic networks of the individual and, consequently, increases the number of associations between various objects and meanings. As individuals age from early adulthood to late adulthood their ability to create and access verbatim traces degrades faster than their ability to create and interpret gist-based traces. This suggests that young children will initially be less susceptible to false recognition that results from semantic activation than older children. As a child ages they will become increasingly susceptible to false recollection that results from semantic activation due to the rapidly expanding semantic

networks, and that as an individual approaches senescence such false recognition will continue to become more prevalent because the ability to form verbatim traces degrades faster than the associated ability to form gist traces.

18) Verbatim traces often result in vivid remembrance of a remembered item, referred to as *recollection*, which features the surface details of the remembered item. Gist traces tend to result in a less vivid form of remembrance, referred to as *familiarity*, in which items are remembered based on meaning but the details may be 'blurred'. The specific items constructed from gist traces may or may not be the items actually experienced. For memories constructed via gist traces, items will often not be explicitly recalled but, rather, the items will seem as if presented when the possibility of their presentation is suggested. That said, particularly strong gist traces may result in the explicit remembrance of items, present or not.

Fuzzy-trace theory may be understood, broadly, in terms of spreading-activation networks. The lexical networks proposed as assumption six in the Collins and Loftus (1975) spreading-activation model, and the proposed visual parallels, may be compared to verbatim traces: The surface details of the verbal or visual experience are encoded in the network and from these details the experience (and its constituent events and items) may be vividly re-experienced independent of any meaning attributed to the events. Likewise, the semantic networks of this spreading activation model may be compared to gist traces: The meaning of the experience is encoded in the activation of the various conceptual nodes and can be reconstructed from those activations; activation which has spread through the network can act to distort that reconstruction and result in false memories should a verbatim trace not exist for comparison with, and correction of, the gist trace.

Understanding fuzzy-trace theory through the use of connectionist networks seems possible but is somewhat more problematic than is the case with spreading-activation models as fuzzy-trace theory has not been explicitly discussed in relation to the connectionist models. It could be the case that the processing and storage of verbatim traces takes part in, effectively, a separate network to the processing and storage of gist traces. The network in which verbatim traces are stored could encode, for example, the items and words which are likely to be encountered when the individual is presented with any given stimuli. Here, the weights of the neurons would need to be readily adjustable so as to quickly produce an accurate 'image' of new events. The presentation of some item or word may result in the activation of output neurons associated with the most likely objects to be presented following the presentation of that item or word (e.g., the arrival of a fire truck may be followed by the emergence of firemen from that truck). The continual activation of these output neurons may cause the activation of the corresponding input neurons and, thus, further detail may be reconstructed. As memories are constantly being laid down, the connections in the verbatim network would be gradually overwritten and the verbatim traces would degrade. The network responsible for encoding gist traces would function in the same manner as the connectionist networks discussed earlier in this chapter; the activation of input neurons would result in the activation of output neurons with similar semantic form and the repetition of this process would result in the spread of activation throughout the network. The meaning associated with objects is unlikely to change quickly and as a result gist traces may be expected to stay more stable over time than is the case for the verbatim traces.

3.3 A Common-Process Theory of Memory

The core premise of the dual-process theories of memory is the existence of two different memory processes, usually *familiarity* (gist) and *recollection* (verbatim). Common-process theories, however, hold that familiarity and recollection are a product of the same mechanism; the evaluation of memories as true or false takes place based not on the contrast between the memory processes but, rather, on the application of logic and experience to what information is available. In this section I discuss the predominant common-process theory: the *Source-Monitoring Framework* of Johnson, Hashtroudi, and Lindsay (1993).

3.3.1 The Source-Monitoring Framework

The source monitoring framework, as formulated in the 1993 paper by Johnson et al., considers the phenomenon of false memory to occur due to the misattribution of a memory's source rather than an error in the retrieval of verbatim and gist traces (as proposed by Brainerd & Reyna, 1990, 2002, and Reyna & Brainerd, 1995). Johnson et al. (1993) propose three types of source monitoring distinctions; reality monitoring (internal-external source monitoring), internal source monitoring, and external source monitoring (the nature of which is addressed below). Two types of judgement processes are defined to explain the functioning of these three types of source monitoring; heuristic judgements and systematic judgements.

Reality monitoring, internal source monitoring, and external source monitoring are used to define the three different distinctions made by the heuristic and systematic judgements (Johnson et al., 1993). Reality monitoring represents those distinctions made between memories and thoughts generated from internal stimuli and memories and thoughts those generated from stimuli external to one's self. An example of reality monitoring, as applied to the DRM task, is distinguishing externally-generated list words from the internally-generated lure words associated with those list words: where a word is correctly attributed to its point of origin, the reality monitoring process has functioned correctly; where a word is incorrectly attributed to a source which is not its origin, the reality monitoring process has failed. Internal source monitoring may be defined as the process of distinguishing between the sources of two memories generated by internal stimuli. An example of internal source monitoring may be distinguishing memories of what one thought or intended to say from memories of what one actually said: where a thought is identified as a thought, the internal source monitoring process has functioned correctly; when a thought is identified as having been said, the internal source monitoring process has failed. External source monitoring may be defined as the process of distinguishing between memories derived from external stimuli. An example of this, as applied to the famous overnight task (Jacoby, Kelley, et al., 1989), may be distinguishing between names that one has been presented with through sources such as the media and names which are presented in the experimental condition: where famous names are correctly identified as famous, the external source monitoring process has functioned correctly; when an old non-famous name is incorrectly identified as famous, the external source monitoring process has failed.

Heuristic judgements and systematic judgements use the information contained in memories, and the relative balance of such information, in determining the likely source of a memory (Johnson et al., 1993). Heuristic judgements rely primarily on qualitative information such as the surface details, meaning, context, emotions, and thoughts associated with the memory. Systematic judgements rely primarily on deductive logic, inductive logic, and abductive reasoning. In distinguishing between memories of external derivation and internal creation, external perception, or internal origins, heuristic judgement processes examine the relative balance of information contained within a memory; memories heavy in surface detail, context, meaning, and emotion are more likely to have actually occurred than memories with little of the aforementioned information but which are relatively heavy in the cognitive processes involved in maintaining an illusory world or attributing motivations and emotions to others in such an illusory world (e.g., “in this situation Fred would have behaved like this”). Systematic processes, in making the same distinction, rely more on the logic of the situation; questioning if a remembered experience is physically plausible, if a person is likely to have partaken in an action, or if the consequences of an action, or inaction, by one’s self progress in a manner to be expected. Where one type of judgement process verifies a memory as likely to be externally derived, the other judgement process may intervene based on its own judgement of implausibility for that memory. An example of an intervention by a systematic judgement may be where a highly vivid memory is accepted by the heuristic judgement process based on the wealth of qualitative information but that memory is not logically plausible in that individual's world view (e.g., a memory of unaided flight). An example of an intervention by a heuristic judgement may be where a memory is accepted by the systematic judgement process based on its plausibility but due to a lack of sufficient qualitative information that memory is unlikely to have occurred (e.g., a memory of walking around town with associates but having no recollection of the surroundings, purpose, or emotive information). A memory accepted by both judgement processes is unlikely to be recognised as false in the absence of later additional, contradicting, information.

Source monitoring theory may be seen to relate well to spreading-activation theory: An item activated in the lexical network may activate its associated node, or nodes, in the semantic network; nodes activated in the semantic network may spread activation to further nodes and thus prime related concepts; those related concepts may help to reconstruct the memory; where nodes are activated from multiple sources, the reconstructed memory may reflect these sources instead of being entirely veridical in nature. Here, the lexical network is less a second process and more an access point to the semantic network.

Source monitoring theory works particularly well with connectionist networks: An input neuron which is activated will, in turn, activate output neurons for concepts related to that input; where multiple input neurons are activated (i.e., time, place, activity, people), the output neurons will be activated more strongly and may surpass threshold required for activation. Should this happen, more details will be remembered and the reconstructed memory be more vivid. The details that are present in the reconstruction may allow for the evaluation of memory source. Where several input neurons which share a common output neuron are activated, that output neuron may become activated despite not actually belonging to the memory. In this event, the reconstructed memory will include those aspects that the output neuron represents. If these aspects are sufficiently consistent with the rest of the available information, then the heuristic and systematic processes will evaluate the memory as true.

3.4 Evaluation of False-Memory Theory

As may seem apparent, both Fuzzy-trace theory and the Source-monitoring framework rely heavily on the ability of the individual to evaluate the information that they have available to them and decide if that evaluation is sufficiently favourable so as to judge the memory as true. In both cases, the individual must decide on a threshold at which a memory is considered to be true; at what volume and relative ratio of verbatim and gist traces (e.g., how much detail must be remembered and how much of that detail must be from each set of traces), in the case of fuzzy-trace theory, or at what degree of certainty, in the case of the source monitoring framework, will a memory be judged as veridical? This threshold will, henceforth, be referred to as the *criterion* (see Swets, Tanner, and Birdsall, 1961, for a discussion of the use of criterion in decision processes). A more liberal criterion will tend to result in a higher number of memories being judged as veridical while a more conservative criterion result in fewer memories being judged as veridical. This criterion functions in the same manner as the alpha-level in a test of statistical significance: A lower criterion will tend to increase the probability of correctly recognising a memory as veridical (a *hit*) but will also increase the probability of a memory being falsely recognised as veridical (a *false alarm*); a higher criterion will tend to decrease the false recognition of a memory as veridical (an increase in *correct rejections*) but will also increase the rate at which veridical memories are rejected as being false (a *miss*).

The point at which a criterion is set is of substantial importance; a criterion that results in all memories being accepted as veridical, or being rejected as false, is likely to substantially interfere with the functioning of the individual. It is, thus, important that the criterion of the individual approximates the point of optimum efficiency of judgement, preferably adapted to the specific context of the memory involved. It seems reasonable to expect that the criterion will be set based on an individual's previous experience with false memories and their ability to learn from those experiences. Given that intelligence, to a large degree, represents the ability of an individual to learn from their experiences and adapt to their environment (Nisbett, Aronson, Blair, Dickens, et al., 2012), it seems fair to assume a positive relationship between an individual's intelligence and the situational adaptability of their criterion and thus judgement accuracy (see Broder, 2003 for a discussion of the interaction between intelligence, decision strategies, and accuracy).

Further, the source monitoring framework relies on the use of heuristic judgements and systematic judgements. Systematic judgements rely on the ability of the individual to critically evaluate a memory while heuristic judgements rely on the ability of the individual to form general rules based on previous systematic judgements (Johnson et al., 1993). As systematic judgements rely on critical thinking skills, a constituent of intelligence (Neisser, Boodoo, Bouchard, Boykin, et al., 1996), and heuristic judgements rely on learning from previous experiences, part of the definition of intelligence, we may expect veridical recollection to display a positive correlation with intelligence should the source monitoring framework be accurate. As relatively larger working memory capacity allows for an individual to hold relatively more information in a form which is readily available for processing (Chapter 4; Baddeley, 2004.), we may expect that working memory capacity facilitates systematic judgements (Broder, 2003) and thus that working memory capacity varies positively with veridical recollection.

3.5 Application of Theory to False Memory Paradigms

In this section the theories discussed in the previous section are used to investigate the workings of three of the paradigms that were discussed in chapter two and which will be used in the experiment that makes up the focus of this thesis. Each task is briefly reviewed before being applied to the theories. Using the results of this investigation, the hypotheses that form the basis of the experiment are developed.

3.5.1 Word Recognition

3.5.1.1 Review.

The word recognition tasks of the DRM paradigm function by presenting the participant, visually or aurally, with a list of words which cluster around a common concept (the lure list). Subsequently, the participant is presented with another list of words (the recollection list). The recollection list contains some of those words which were originally presented, some words which were not originally presented, and a word representing the common concept embedded in the original list. Participants are asked to indicate whether they remember the words as having been presented and, sometimes, how strongly they remember this presentation. The presentation of the second list may be immediate or delayed. Participants routinely indicate that the lure words were presented. The average rate at which participants indicate the lure word as having been presented is referred to as the lure-strength of the list.

3.5.1.2 Memory networks and the word recognition task.

By applying the spreading-activation model of memory to this task, we can see that the presentation of each of the words contained in the list will result in the activation of the same word in the lexical network of the participant. For each word that is presented, the associated node in the semantic network will become activated. For each node in the semantic network which is activated, partial activation will be transmitted from the activated node to other nodes which share a common meaning. If the activated semantic nodes, across multiple words, converge on a common meaning, the semantic node that represents that meaning may become activated, even if not directly activated by the nodes of the lexical network. If the semantic network is later used to recreate the activation pattern of the lexical network, the word that represents the common meaning will appear as if it was presented. Thus, the lure word is experienced as if it was actually presented.

In connectionist networks, the words contained in the lure list activate neurons in the input layer which can be understood to represent the words. These neurons innervate neurons in the hidden layers, the connections between which may be seen to represent meaning and the concepts underlying the word, as expressed by their ultimate activation of the output neurons. The output neurons encode the data in memory for latter retrieval. As words each possess multiple meanings, if multiple words are presented in sequence and those words share a semantic connection, the output neurons may be activated in a pattern which represents not only the presented words but also words, such as the lure word, which share that meaning. When an individual attempts to remember an event, these patterns may be used to reconstruct the memory and it may appear to the individual as if the lure word was actually presented.

3.5.1.3 Theories of false memory and the word recognition task.

In fuzzy-trace theory false memory is, essentially, the result of degradation in verbatim traces (relative to gist traces) over time; the lack of, more accurate, verbatim traces forces the use of the, less accurate, gist traces. When fuzzy-trace theory is applied to the spreading activation theory of memory, verbatim traces may be seen as the products of the lexical network while gist traces may be seen as the products of the semantic network. The semantic network, having been presented with many words with common semantic meanings, should express a pattern of activation in which the concepts with which the lure word relates are strongly activated. As a result, if only gist traces are used to reconstruct the memory, the lure word will be incorporated into the memory. The lexical network should have no indication of the lure word in its pattern of activation and should, thus, indicate the absence of that word in the initial presentation of the list. The lexical network, however, degrades and weakens the verbatim traces. As a result of this degradation, the semantic network may be required to be called upon if the memory is to be reconstructed. Where the lexical network traces are weak compared to the semantic network traces, the lure word may be perceived as if it was actually presented in the initial list. Whether the participant indicates the word as actually having been presented will, thus, depend on the relative strength of their verbatim traces to their gist traces and on the stringency of the participant's criterion.

The presentation of DRM word lists is typically characterless; participants are presented with the words aurally or via text and in the absence of any other factors associated with the words (e.g., pictures). In both the spreading-activation and connectionist networks, the reconstructed memory may feature the lure word as if it was presented in the same manner as the non-lure words. As other information, such as the presentation of pictures, is not available, both systematic and heuristic judgements are severely limited in their ability to evaluate the veracity of the memories as there is little to contrast (e.g., as images are not presented along with the words, individuals may not use the lack of an associated image for the lure word to discount its presence.). The evaluation of the memories as true is, thus, highly reliant on the criterion that the participant uses and the ability of the individual to accurately encode the words when first presented.

3.5.1.4 Predictions regarding the word recognition task.

Both theories suggest that participants will, at least some of the time, experience the lure word as having been presented after having been exposed to the DRM paradigm. It may be expected that the lure word will be reported by participants as having been presented more often than words that were neither presented or a lure word.

For both the spreading activation and connectionist model of memory, the information that can be retrieved is only as good as the information that is stored. The amount of information that can be stored is directly related to the person's ability to hold and process that information. The source monitoring framework, and to a lesser extent fuzzy trace theory, both rely on the information that is available to the person in order to evaluate the veracity of a memory. For both theories, failure in the DRM task is due to a lack of available information that can refine the semantic content of the memory when the memory is reconstructed. Thus, we may hypothesise that a person's susceptibility to false memories induced by the DRM paradigm will display an inverse correlation with their working memory capacity (see Peters, Jelicic, Verbeek, and Merckelback, 2007).

Intelligence tests typically examine both an individual's knowledge of the semantic similarities between words and their ability to apply basic logic to a variety of simple problems (Neisser et al., 1996). Intelligence, as measured by these tests, may be seen to represent the ability of an individual to obtain and apply knowledge. As the connections between nodes and between neurons approximate the semantic associations between words, we may expect that individuals with a greater knowledge of these semantic relations will display a greater number, and perhaps strength, of activation of associated concepts. At the same time, the ability to apply logical processes is a core aspect of systematic judgements and the ability to learn from previous experiences, including the previous application of those logical processes, is the core of heuristic judgements. Thus, for source-monitoring theory, we may expect that intelligence will contribute to the veridical recognition of words, especially given that the semantic relations between the presented words should be recognised by most individuals. We can predict that, should fuzzy-trace theory be accurate, participant intelligence will positively correlate with participant susceptibility to false identification of the lure word as having been presented; the greater knowledge of semantic relations results in an increase in the number of connections between the concepts presented in the word-list and, thus, increases the activation of the nodes associated with the lure word. We may predict that, should source-monitoring theory be accurate, intelligence will be negatively correlated with participant susceptibility to false identification of the lure word as having been presented; while we may expect the same effect as predicted with fuzzy-trace theory, intelligence would also feed into the systematic judgement processes (which utilise logic and reasoning) and heuristic judgements (which rely on learning from previous experiences, including the previous use of systematic judgements).

3.5.2 Source Recollection

Source recollection tasks function by presenting a participant with a set of stimuli, confusing the source of those stimuli by introducing another plausible source, and then asking the participant to indicate the source of each of these stimuli. In a classical demonstration of this type of task, Brewer and Treyens (1981) invited a large number of undergraduate students to participate in a psychological experiment; participants were asked to wait in the office of postgraduate student prior to the proposed experiment. After the participants had waited in the office for 35 seconds, the participant was removed from the room and asked to either describe or draw the room and its contents. In this experiment, the postgraduate student's office acted as the circumstance in which a number of stimuli, those items which were in the office, were presented to the participants. Meanwhile, the participant's schema regarding postgraduate students of psychology acted as another source of stimuli (though internal in derivation). A similar experiment, performed by Lindsay and Johnson (Experiment 1; 1989), asked participants to study a slide of an office and then to read a narrative regarding that office. Participants were asked to indicate from which source they were presented with a number of stimuli. In a similar manner to the Brewer and Treyens (1981) task, the slide acted as the circumstance for the presentation of a number of stimuli while the narrative provided another source of stimuli regarding that circumstance. In both experiments, participants indicated some items that were actually contained in the offices to not be in the offices and some items that were not contained in the offices to actually be in the offices.

3.5.2.1 Memory networks and the source recollection task.

Applying the spreading activation model, we see that each item present in the office activates the relevant nodes in the verbatim network (e.g., a red computer mouse activates the nodes 'red' and 'computer mouse' in the verbatim network) which then activates those nodes in the semantic network that reflect the meanings of that word. Upon recall or recognition, this pattern of activation in the semantic network would create an accurate memory of the office if the influence of the individual's schema or the story did not act to distort that pattern. The presence of a schema acts to provide further activation of any nodes generally associated with the concepts that the schema represents (e.g., books may be represented as a part of the postgraduate psychology student schema). Because of this, the activation of those nodes in the semantic network that are consistent with the schema will be more strongly activated than in the absence of the schema. Items consistent with the schema may even be activated so strongly that they are included in the reconstructed memory as if they were actually presented.

Connectionist networks tell a similar story; the perception of the office results in the activation of the neurons associated with the various items in the office. The activation of these neurons results in the spread of activation throughout the network and the ultimate reconstruction of a memory of the office. As in the spreading activation model, the influence of a schema results in the enhanced activation of neurons which are associated with items consistent with the schema. As connectionist networks allow inhibition, items which are not consistent with the schema may be inhibited and recalled less frequently than they otherwise would be.

3.5.3 Theories of False Memory and the Source Recollection Task

According to fuzzy-trace theory verbatim traces will exist for those items that were actually presented in the office but not for those items that were not presented (i.e., participants will only be able to visualise the items that were actually there). Gist traces, however, may exist for the items that were present and for the items represented by the schema and/or story. As verbatim traces deteriorate at a greater rate than gist traces and the strength of gist traces relative to verbatim traces is the main criterion for the evaluation of memory veracity, we may expect the accuracy of the participant's recollection to deteriorate over time and for false memories to be reported at an increasing frequency as a result. Again, the frequency at which false memories are reported will vary with the efficiency of the participant's criterion.

In explaining errors in the participants' evaluation of source, source monitoring theory does not rely on the degradation of verbatim traces over time; source monitoring theory, instead, claims that it is the association between the memory of the event itself and the memory of the experience of that event that degrades and thus hampers the accurate attribution of source. Put another way, it is not the memory of the item that degrades with time so much as it is the memory of the thoughts and feelings that were related to the memory of that item. As those associations degrade, the thoughts "I was surprised that there were no books" and "The poster was rather ugly" are no longer available for the heuristic and systematic judgements to draw on and thus only the memory of the objects themselves remain, presented or not. With these connections lacking, there may be relatively little information for the systematic and heuristic judgement processes to utilise in evaluating the source of the memory of the objects and the schema may, thus, have an opportunity to further impact the development of false memories by adding to the perceived probability of an item being present (i.e., It seems logical, lacking countering evidence, that the office of a postgraduate student would include books). Because the relationships between the memories of the perceived objects degrade, and because the falsely-remembered items are consistent with the schema and/or story, participants may misremember the source of their memories of the objects.

3.5.3.1 Predictions regarding the source recollection task.

Both fuzzy-trace theory and the source monitoring framework predict that participants will misidentify non-presented items as presented when those items are consistent with the schema and/or story. It is predicted that, when presented with a task similar to those depicted above, participants will falsely identify items present in the schema and/or story as having been present in the office, even when they were not actually present.

According to the source monitoring framework, both the word recognition and the source recollection paradigms rely on the same underlying processes of systematic and heuristic judgement. Additionally, both fuzzy-trace theory and the source monitoring framework propose that an individual does not simply remember or not remember an episode but, rather, they evaluate the information they have available and then use a criterion, or set of criterion, to judge if they will accept or deny the veracity of the memory. Due to these commonalities, we may expect some level of positive covariance between tasks of the word recognition paradigm and tasks of the source recollection paradigm.

It was predicted earlier in this section that an individual's working memory capacity will display a positive correlation with their accuracy on the word recognition task due to the systematic and heuristic judgements on which that accuracy relies. Because the same basic mechanisms (systematic and heuristic judgements) are thought to underlie the source recollection task, it is predicted that working memory capacity will display a positive correlation with accuracy on the source recollection task. Specifically, it is predicted that individuals with a higher working memory capacity will be better able to process a greater volume of information regarding the office environment than will individuals with a lower working memory capacity and, thus, that the details regarding the office that are encoded by individuals with a higher working memory capacity may be more representative of the true contents of the office. Likewise, it is predicted that individuals with a higher working memory capacity will be better able to evaluate the veracity of the memory as they will be able to hold, and work on, more information than comparable individuals with a lower working memory capacity. As such, it is predicted that the false identification of items not present in the office as actually present will correlate negatively with a person's working memory capacity.

A participant's intelligence may also be negatively correlated with the participant's tendency to falsely identify non-present items as present: While intelligence is multi-faceted, the concept of intelligence, to a large degree, represents the individual's ability apply logic and reason and to analyse and learn from their experiences (Nisbett et al., 2012). As systematic judgements rely on the application of logic and reason to memories, it should be expected that systematic judgements benefit from increased intelligence. As heuristic judgements rely on heuristics abstracted from previous experiences, it should be expected that heuristic judgements, too, will benefit from increased intelligence as the ability to analyse and learn from previous experiences with memory errors is crucial in developing effective heuristics to combat such errors.

3.5.4 Eyewitness Memory

A wide array of memory tasks have been constructed specifically to investigate the problem of false memory in relation to eyewitness testimony (e.g., Gabbert at al., 2003, Wade et al., 2002). The *forced confabulation* approach is particularly notable in that participants are forced to provide a false answer to several queried aspects of an event; only latter being provided with the option to select the correct answers. A 2007 study by Pezdek, Sperry, and Owens (Experiment 1) presented participants with a five-minute video of a car-jacking and then followed this presentation with a face-to-face interview in which the participants were asked 16 questions which were answerable and 6 questions which had no answer but for which an answer of "I don't know" was not available; participants were, thus, forced to provide an incorrect answer to these questions. One week later, participants were again interviewed and asked the same questions, though this time they were allowed to answer "I don't know". While 45% of participants answered "I don't know" on the second of these interviews for the unanswerable questions, 40% provided the same answer as they had previously provided and they reported being more certain in this answer.

3.5.4.1 Memory networks and the eyewitness memory task.

According to the spreading activation model of memory, the presentation of the car-jacking video activated the nodes in the verbatim network representing the observed events. These nodes would have then proceeded to activate their partners in the semantic network. Upon presentation of the first questionnaire, the verbatim and semantic nodes relating to the questionnaire items would have been activated. For those items where the correct answer was not available, the presentation of the items would have resulted in the potentiating of the available options but not of the correct answer. As a result, nodes associated with the presented options may become more strongly associated with the event than is the case for the nodes associated with the correct answer. This would likely result in one of the incorrect answers that were presented as a part of the first questionnaire being selected when the final questionnaire is presented.

The connectionist model behaves in much the same manner as that of spreading activation theory. The initial presentation of the scene will result in the meaning of the scene being encoded in the connections between the neurons; when the memory of the scene is reconstructed to answer the questions posed in the first questionnaire, the reconstruction will rely on these connections. By providing participants with no correct answer for some of the questions, the participants will be forced to consider the available options and, possibly, reject the correct option, should they remember it. This will result in a strengthening of the connections between the event and the incorrect details depicted in the question and a weakening of the connections between the event and the correct details. Upon later recollection (on completing the final questionnaire), some of the incorrect answers may be activated more strongly than the correct answer, thereby leading to the participant reporting incorrect details.

3.5.4.2 Theories of false memory and the eyewitness memory task

In accordance with fuzzy-trace theory the incident witnessed in the film will create both gist and verbatim traces in the participant. Verbatim traces, however, degrade quickly and necessitate reliance on gist traces. When the first questionnaire is presented, the items for which the correct answers are available will cause the verbatim and gist traces for the correct answer to be enhanced in strength and new verbatim traces to be formed that relate to the choice of the answer. At the same time, items for which the correct answers are not available will result in the formation of new verbatim traces which represent the answering of that question, the alteration of the gist traces to fit with the selected answer, and the weakening of the verbatim traces relating to the correct option. When the second questionnaire is presented immediately, however, the verbatim traces from the original presentation will not have degraded substantially; these verbatim traces may be used to determine that the correct answer is not available and, thus, prevent any incorrect option from being perceived as correct.

The source monitoring framework suggests that the experience of viewing the car-jacking will result in the participant not merely remembering the events with which they were presented, but also the contextual detail regarding how they felt and interpreted the happenings. When presented with the first questionnaire, the participant would likely have had trouble answering the questions for which the correct answer was not available and as such they would have spent a greater amount of time reading the question. If the participant realised that the correct answer was not available, those answers that were available may become less likely to be selected on the second presentation of the questionnaire and thus the correct answer would be more likely to be selected. If the participant did not realise that the correct answer was not available, the incorrect answer which was selected would have had the connection between the event and itself strengthened and would thus be more likely to be recalled in the second questionnaire. On the presentation of the second questionnaire, the participants would have circumstantial evidence for the correct answer but greater familiarity with the incorrect answers. Depending on the participant's ability to use systematic and heuristic judgement processes to assess the veracity of a memory, and on the criterion adopted by the participant, they may either revert to the correct answer or continue to report the incorrect answer as accurate.

3.5.4.3 Predictions regarding the eyewitness memory task.

As with the other two source-confusion procedures, both fuzzy-trace theory and the source monitoring framework suggest that false memories will be reported when participants are presented with tasks from the eyewitness memory paradigm. Likewise, both approaches suggest that the criterion that the participant adopts is of importance in the evaluation of memories in this task as veridical or false; performance in the eyewitness memory paradigm may, thus, be positively correlated with performance in both the word recognition and source recollection paradigms.

The source monitoring framework suggests that performance on in the eyewitness memory paradigm is, at least partially, reliant on the participant's systematic and heuristic judgements; as with the word recognition and source recollection paradigms, systematic and heuristic judgements function as the tools through which the veracity of a memory may be evaluated. It may, therefore, be predicted that a positive correlation will exist between susceptibility to false memory in the eyewitness memory paradigm and susceptibility to false memory in the other two source confusion procedures.

As noted earlier, an individual's working memory capacity affects the ability on the individual to hold and encode information into memory. As the eyewitness memory paradigm presents the participant with a large amount of information regarding the events, and that information is important for the later evaluation of the accuracy of memories relating to those events, it may be predicted that the frequency at which participants respond incorrectly will be negatively correlated with working memory capacity. As with the other paradigms, we may expect a negative correlation between intelligence and the frequency at which participants respond incorrectly; as with the word recognition and source recollection tasks, the assessment of memory veracity relies on the application and acquisition systematic and heuristic judgements.

3.6 Hypotheses

3.6.1 Hypothesis One – False memory will be observed when the world-wide-web is used as a medium for the administration of false memory tasks

Both fuzzy-trace theory and the source monitoring framework predict that individuals will report false memories when exposed to tasks from the word recognition, source recollection, and eyewitness memory genres. Tasks from these genres will henceforth be referred to as source-confusion procedures. The ability of these procedures to create false memories is central to this thesis and is measured by the performance of participants on the word recognition, source recollection, and eyewitness memory tasks. While these tasks have traditionally been administered in laboratory settings, none of these tasks possess any components that the aforementioned theories would suggest to only exert their effects in such a setting. Given this and the success of other cognitive and false memory tasks when administered across the world-wide-web (see chapter two for a discussion of this), similar effects to those found in the lab should be observed when these tasks are administered across that same medium. The first, and most important, hypothesis is, therefore: Where the subject of a question has been subjected to a source-confusion procedure, participants will display a greater rate of incorrect answers than for scale items for which the subject has not been subjected to such source-confusion.

3.6.2 Hypothesis Two – The level of participant susceptibility to lure items will be persistent across false memory tasks

The source monitoring framework implicates two judgement processes that are applied in each of the three source-confusion procedures used in this thesis: heuristic and systematic judgements. As each of these procedures relies on the same processes, and the processes reflect both ability and previous experience, it may be expected that performance on each of these three tasks will display a positive correlation with the performance of the same individual on the other two tasks. In other words, the frequency at which participants provide incorrect answers to the lure-items in each source-confusion procedure will correlate in a positive manner with the frequency at which the participants provide incorrect answers to the lure items in each of the other source-confusion procedures.

3.6.3 Hypothesis Three – The overall accuracy of participant judgements will be similar across false memory tasks

Both fuzzy-trace theory and the source monitoring framework predict that the criteria that participants use to judge the veracity of memory will have a substantial impact on the frequency at which participants provide incorrect answers to questions across each of the source-confusion procedures, independent of if the subject of the question underwent any experimental manipulation. That is, for each of the source-confusion procedures, the frequency at which the participants provide incorrect answers, not merely incorrect answers to manipulated questions, will correlate positively with the frequency at which participants provide incorrect answers to questions in the other source confusion procedures.

3.6.4 Hypothesis Four – Participant susceptibility to false memory will co-vary negatively with their working memory capacity

The ability of a participant to process and encode memories is likely to directly affect the veridical recollection of memories at a latter point in time. Furthermore, the ability of participants to hold information in memory is likely to be positively related to their ability to evaluate the veracity of the memory to which that information relates. These abilities are encapsulated by working memory. Thus, the frequency at which participants provide incorrect answers in each of the source-confusion procedures will correlate negatively with the performance of the participants on the letter-number sequencing task (a measure of working memory capacity).

3.6.5 Hypothesis Five - Participant susceptibility to false memory will co-vary negatively with their intelligence

Intelligence encapsulates the ability of an individual to process environmental variables, to learn from their experiences, and to apply their learning to create adaptive behaviours (Nisbett et al. 2012). Each of these abilities is critical for the systematic and heuristic judgements that are proposed to underlie the evaluation of memory veracity, as discussed earlier in this chapter. The hypothesis takes the following form: The frequency at which participants provide incorrect answers to scale items which have been subjected to source confusion by the source-confusion procedures will negatively correlate with the participants' scores on the Wonderlic quick test (an I.Q. test designed to assess intelligence).

4 Method

4.1 Participants

The participant pool consisted of 60 individuals. Fifty-two of these cases completed every false memory task. Thirty-six participants completed every false memory task, the letter-number sequencing task, and the Wonderlic quick-test.

4.1.1 Participant Demographics

Participants ranged from 17 to 53 years of age (*M*=29, *SD*=9.7). Of the 52 whom completed the primary measures, 43 identified as female. Of the 36 whom completed the full set of measures, 30 identified as female.

4.1.2 Recruitment

Participants were recruited from undergraduate and postgraduate psychology courses taught at Massey University, Turitea campus. Recruitment was via an invitation (Appendix B) presented in undergraduate classes, on online class forums, and via postgraduate psychology email lists. Recruitment started on 07/03/2011 and ended on 05/09/2011. Presentations to classes took place between 07/03/2011 and 18/03/2011, presentation via online class forums persisted for the entire length of the recruitment, and presentation via postgraduate psychology email lists took place between 18/07/2011 and 05/09/2011. No financial or material reward was offered in return for participation and participants were free to complete the study at their own convenience and at an unsupervised location of their choosing.

4.2 Materials and Design

The tasks utilised in this experiment were presented over the internet via the participant's internet browser. Participants were free to use an internet browser of their choice and any computer to which they had access. The website from which the tasks were accessed was configured to appear the same across all major browsers and all screen sizes with an X-axis greater than 1100 pixels. Devices which routinely possess screens smaller than 1100 pixels (e.g., cellular phones) were excluded from accessing the tasks. The tasks utilised 'extensible hyper-text mark-up language' (XHTML) for the visual interface and 'JavaScript 1.8' to dynamically alter that interface; the combination of the XHTML and JavaScript allowed the tasks to be presented entirely on the participants' internet browser, removing the potential effect of internet connection speeds on the presentation of the tasks. All data obtained through the interface was received and processed by computer code written in the 'PHP 5.3' programming language and hosted on a secure 'Apache 2.2' internet server. The processed data was stored in a 'structured query language' (SQL) database utilising the 'MySQL 5.5' database system, hosted on the same server.

G*Power 3.1. (Faul, Erdfelder, Land, & Buchner, 2007; Faul, Erdfelder, Buchner, & Lang, 2009) was used for the calculation of all obtained β-values, d-values, and participant numbers. SPSS statistics data editor 18 was used for all statistical analysis not performed by G*Power.

This experiment consisted of five separate tasks. The first three of these tasks, the primary grouping, were selected to address the first three hypotheses and all participants were instructed to complete these tasks. The final two tasks, the secondary grouping, were selected to address the final two hypotheses; as these tasks required a substantial period of time to successfully complete; these tasks were presented to the participants as being of an optional nature.

The primary grouping consisted of the '*word recognition*', '*source recollection*', and '*eyewitness memory*' tasks. These tasks were proposed to generate false memories within a participant by presenting the participant with a situation in which the veridical recollection of memory is hampered, be it by a lack of discriminative detail, alternative sources of information, or misleading data. Under the '*source monitoring framework'* (SMF), the word recognition task represents an internal-external source monitoring task; the memory is of a source external to the participant but the distorted aspect of the memory, that which makes it false, is of an internal origin. The eye-witness testimony task, under SMF, represents an external-external source monitoring task; the memory is of an external source, as is the source of distortion. Finally, the source recollection task represents a hybrid between these two types of source monitoring; the memory remains of external origin but the sources of distortion are both internal and external.

The secondary grouping of tasks consisted of the '*letter-number sequencing task*' and the '*Wonderlic Quick-test*'. The letter-number sequencing task served to assess the working memory of the participants; the ability of participants to hold, and operate on, stimuli. The Wonderlic Quick-test, designed to assess intelligence, served to assess the ability of the participants to apply logical and heuristic processes to problems with which they are faced.

4.2.1 The Word Recognition Task

The word recognition task was based on the Deese, Roediger, and McDermott paradigm (DRM paradigm; e.g. Roediger, Watson, McDermott, & Gallo, 2001). As with other tasks of this paradigm, the word recognition task utilised multiple lists which were each composed of 15 words; the words were all conceptually related to a word which was not included in the list. The word around which the presented words cluster is referred to as the lure word and, during the latter stages of the task, acted as the means by which the presence of false memory is assessed. The word lists were extracted from the collection generated by Roediger et al. (2001). The word lists used were those designated "*Cold*", "*Beautiful*", "*Bread*", "*Health*", "*Long*", "*Whistle*", "*Anger*", and "*Fruit*"; the lists are named after the list's lure word. Due to the impracticality of controlling audio-based stimuli through the selected apparatus, the lists were presented as written, rather than spoken, words. The word list Beautiful is provided as Table. 4.1.; all of these lists are contained in Appendix C in Tables C-1. through to C-9.

Table 4.1.

Words contained in the Beautiful word list.

Ugly	Lovely	Snow
Pretty	Nice	Scene
Girls	Picture	Music
Women	Lady	Day
Homely	Mountain	Gorgeous

Note: While not included in the list, the word *Beautiful* represents a concept around which all the words which are included in the list are clustered.

4.2.1.1 The selected wordlists.

The word lists used in this task were selected based on the frequency with which the lists were reported, by Roediger et al. (2001), to elicit the recognition of the lure word; the '*lure strength*' of the lists: A '0' indicates that a list never elicits recognition of the lure word while a '1' indicates that a list always elicits the recognition of the lure word. Eight lists were ultimately used; six lists were administered in a conventional manner, while the remaining two were used in an unconventional manner which will be discussed in greater detail later in this section. Those lists that were used in the conventional manner, the '*primary lists*', were Cold, Beautiful, Bread, Health, Long, and Whistle. These lists held respective lure strengths of 0.84, 0.44, 0.64, 0.55, 0.34, and 0.19. Those lists that were used in an unconventional manner were entitled Anger and Fruit. These lists, the '*secondary lists'*, displayed respective lure strengths of 0.79 and 0.45.

4.2.1.2 Task composition.

Each primary list consisted of the full 15 words reported by Roediger et al (2001). The order of the words in these lists was randomised and each word was presented individually for two seconds, with a gap of 0.5 seconds between each presentation. The text was black, uncapitalised, and sized to 2em (twice the size the participant had their default browser text size set to.) The word lists were divided into two groups with approximately equal mean lure strengths; the first group consisted of Cold, Beautiful, and Bread while the second group consisted of Health, Long, and Whistle. The word lists within these groups were presented as a single list; the order of each list within the presented sequence was randomly determined for each participant.

An additional list of 25 words was generated for each of the two groups. These lists each consisted of four words from each of the primary lists belonging to the relevant group, the lure word of each of these lists, nine words from one of the secondary word lists, and the lure word for that secondary word list. The first grouping was assigned the secondary word list Anger and the second grouping was assigned the secondary word list Fruit. For each of these additional lists, the lure word of the assigned secondary list was the final word to be presented. The ordering of the words in these additional lists was constant across participants. These additional lists will, henceforth, be referred to as the '*recollection lists*'. An example of each recollection list is presented in Appendix C tables C-10 and C-11.

4.2.1.3 The wordlist selection criteria.

The primary lists were to be administered under approximately the same conditions as those in Roediger et al. (2001; except, of course, the medium). Due to this similarity, it was assumed that these lists would elicit lure strengths, in this task, similar to those which were observed in Roediger et al. (2001). Based on this assumption, the primary lists were selected based on the distribution of their lure strengths; by using a wide range of lure strengths, it was hoped that a gradated scale of susceptibility to this task would be created. Those lists which were considered unlikely to apply to the sample population to the same degree as to the sample population of Roediger et al. (2001) (e.g., the U.S.A. focused “Flag”, “Citizen”, and “Army” word lists) were excluded from selection.

The secondary lists were administered in a novel fashion. To maintain a reasonable probability of participants recollecting the lure words of the secondary lists, the mean lure strength of the Roediger et al. (2001) lists that were selected for inclusion in the recollection lists was allowed to approximate 0.6 rather than 0.5.

4.2.2 The Source Recollection Task

The source recollection task was inspired by the memory experiment of Brewer and Treyens (1981) and shares many similarities with Experiment 1 of Lindsay and Johnson (1989). Due to practical limitations of the medium used for this study, participants could not be made to wait in an office, as in Brewer and Treyens (1981). To get at the same underlying effect, a static image was presented to participants, as in Lindsay and Johnson (Experiment 1; 1989). The Brewer and Treyens study (1981; discussed in depth in Chapter two.) relied heavily on the context in which the participant found themselves in the office. This context was lacking in this study and thus the task utilised a story regarding the purported occupant of the office in an attempt to create context. The task consisted of three parts; the presentation of the image, the presentation of the story, and the presentation of a questionnaire. The questionnaire presented the participant with the names of items which were in the image, items that were in the story, and items that derived from neither of these sources. A total of 15 items were presented; these items are reported in Appendix D as Table D-1 along with the sources for each of these items. For each presented item, the participant was asked to indicate the source as “both image and story”, “image only”, “story only”, and “neither image nor story”. For each answer, the participant was also asked to indicate how certain they were as to the veracity of their answer by using a Likert scale of ‘1’-‘5’ with ‘1’ representing no confidence and ‘5’ representing total confidence.

4.2.2.1 The image.

The image used in this study was of an office purportedly belonging to a professor of psychology. The office included items such as a computer, a desk chair, papers, a laboratory coat, posters, and a model brain; items which one may expect to see in an office belonging to a professor specialising in neuro-psychology. The office, however, lacked items such as a computer mouse and books; item which would generally be expected to be present in an office of any academic. Items such as an archer’s bow and a welding helmet, which might not otherwise be expected in such an office, were included. Mundane items such as a cardboard box, a tin can, and a news paper were also included (Fig. 4.1).

Figure 4.1. Source recollection: Image. The image used in the source recollection task.

4.2.2.2 The story.

The story utilised in the source recollection task was designed to provide the participants with an idea as to the identity of the professor generally inhabiting the office. The story established that the office belonged to a professor of psychology, his field of expertise, and several other aspects of his identity. The story was included to encourage the participants to apply any schema they may possess regarding psychology professors or practitioners of the other activities mentioned in the story. The story included items and topics which may not generally be automatically associated the concept 'professor of psychology' (e.g., squash) and items which may be associated with this concept but were not present in the image (e.g., books). Some items, such as the stained lab coat, were present in both the image and the story. The story was as follows:

"The office featured in the image belongs to Professor Bruce. Professor Bruce teaches psychology at the local university. When he is not teaching he can often be found on the squash court or at target practice. Professor Bruce is the author of many books and is considered an expert in neuropsychology. His students note that he has an eccentric personality and often wears multi-coloured ties, odd glasses, and a stained lab-coat."

4.2.3 The Eyewitness Memory Task

The eyewitness memory task was based on the eyewitness testimony research of Elizabeth Loftus and colleagues (e.g., Loftus, Miller, & Burns, 1978; Loftus, 1979). The eyewitness memory task used here presented participants with a sequential array of six slides which depicted a mugging committed by four males against a single female. Following the presentation of the slides, participants were presented with two reports: The first of the reports consisted of ten multi-choice questions of which only five had the correct answer available as a response option. The second of these reports presented the participants with the same ten questions but differed in that the correct answers were available in all cases.

4.2.3.1 The slides.

The slides used in this task featured a mugging of one female by four males. While no description of the events was provided to participants, the slides depicted the events clearly and established the context of the events to a degree considered satisfactory for the purposes of this study. Six slides were ultimately used in this section of the eyewitness testimony task as it was felt that additional slides would draw out the task without providing sufficient extra detail to justify their inclusion.

The slides clearly depicted the mugging: The environment in which the crime took place was clear; the victim is clearly displayed approaching the scene of the crime; the approach and assault by the assailants is well documented; and all items and traits that the participants are questioned about are readily displayed in multiple slides. Two of these slides are included as Figure 4.2 and all of the slides are provided in Appendix E Figures E-1 to E-6.

Figure 4.2. Slides three and five of six. The image on the left clearly depicts the four male assailants in the process of blockading the victim's path. The image on the right depicts the assault itself and focuses on the main assailant and his weapon of choice.

4.2.3.2 The reports.

This part of the eyewitness memory task required the participants to report on several different aspects of the crime that they had witnessed. As previously mentioned, this report was presented twice: The first of the reports consisted of ten multi-choice questions of which only five had the correct answer available. The second of these reports presented the participants with the same ten questions but differed in that the correct answers were available in all cases. Those items in the first report which did not offer a correct option provided three options which were clearly false and one option which was a close approximation of the true answer. The same item in the second report replaced one of the clearly false options with the correct option. For example, the first item of the first report asked the participant the question "What colour of top was the main assailant wearing?" and provided the options "Yellow", "Black", "Brown", and "Red". Of these options, only "Black" was close to the correct answer "Blue". In the second report, the option "Yellow" was replaced with the correct answer, "Blue". The purpose of these alterations was to emulate the results of misleading questioning regarding some prominent event on latter recollection of the same event. The items contained in the reports, and the available answers, are available in Appendix E Tables E-1 and E-2.

4.2.4 Secondary Tasks

4.2.4.1 The letter-number sequencing Task (working memory measure)

The Letter-Number Sequencing task presents the participant with an array of strings; each of these strings consists of both numbers and letters. The participant is required to organise these numbers and letters such that all of the numbers are first in the sequence and all of the letters are last, though equal credit is still rewarded if the participant reverses the order of the numbers and letters. The characters must be in order from zero to nine and from A to Z. The strings progress in length from two characters up to eight characters. For each string length, there are three cases (i.e. there are three strings of length two and three strings of length three), these cases are grouped together (i.e. all those strings with a length of three characters are presented in sequence), and each group of strings is one character larger than the previous group (i.e. the group of three-character strings is preceded by the group of two-character strings and followed by the group of four-character strings). In the current study, the participant was allowed to continue through to the end of the task even if the participant failed to organise two previous strings. The strings used in this study were extracted from the Wechsler Adult Intelligence Scale - Third Edition Letter-Number Sequencing task (Wechsler, 1997) version of the same task. An example is provided in Table 4.2 and the full list is provided in Appendix F, Figure F-1.

Table 4.2
Example Letter-Number Sequencing sequences and answers.

Provided String	Correct Answer	Acceptable Answer
L-2	2-L	L-7
H-1-8	1-8-H	H-1-8
K-2-C-7-S	2-7-C-K-S	C-K-S-2-7
D-1-R-9-B-4-K-3	1-3-4-9-B-D-K-R	B-D-K-R-1-3-4-9

4.2.4.2 The Wonderlic quick-test.

The Wonderlic Cognitive Ability Pre-Test, also known as the Wonderlic Quick-Test (WPT-Q), is a shortened version of Wonderlic Personnel Test (WPT) that was designed to quicken the process of cognitive testing without losing accuracy. The WPT compares well, in terms of external validity, with the WAIS (e.g., Dodrill & Warner, 1988; Hawkins, Faraone, Pepple, Seidmanm & Tsuang, 1990) These tests are designed to test the ability of the participant to utilise basic logic, to make connections between concepts, to perform mathematical tasks, and the rate at which participants are able to do this (Wonderlic Inc., personal communication, 2011). The WPT-Q is a new test and thus reliability data is minimal; the comparison to the, well established, WPT is, however, favourable (Wonderlic, 2004). The WPT-Q is administered online and presents the participant with a variety of cognitive tasks involving logical and computational problems similar to those in the full version. The task is allocated a maximum time of eight minutes and only those questions which are answered in that time count toward the test score. A test score of 20 points represents the mean score. Participant scores can be converted to WAIS-R I.Q. scores; an approximation of these scores may be obtained by multiplying the test score by two and adding 60 (Wonderlic Inc., personal communication, 2011). The test content is copyrighted and cannot be provided here; Table 4.3 and Appendix F, Table F-2, provide example tasks.

Table 4.3.

Example questions for the WPT-Q and the provided answers.

Question 4:	PRESERVE RESERVE - Do these words have similar meanings, contradictory meanings, or mean neither the same nor opposite?
Options:	1) have similar meanings 2) have contradictory meanings 3) mean neither the same nor opposite.
Question 10:	Three individuals form a partnership and agree to divide the profits equally. X invests \$9,000, Y invests \$7,000, and Z invests \$4,000. If the profits are \$4,800, how much less does X receive than if the profits were divided in proportion to the amount invested?
Options:	Free answer
Question 12:	A boy is 17 years old and his sister is twice as old. When the boy is 23 years old, what will be the age of his sister?
Options:	Free answer

Note: Those items which provide the option "Free answer" allow the participant to enter their own response rather than selecting from provided choices.

4.3 Procedure

The recruitment invitation, included in Appendix B, directed interested individuals to a webpage which presented those individuals with the Information Page, also included in Appendix B. Those individuals who decided to participate in the study after reading the information page were redirected to a new webpage where they were able to enter their contact details, age, sex, and to indicate their desire to receive further information regarding the study. At this point, participants were allocated to either 'condition one' or 'condition two' through the use of a pseudo-random-number generator and the participants were directed to their first task.

4.3.1 The Primary Tasks

The order of the tasks, provided below, is true for participants belonging to condition one only. Participants belonging to condition two participated in the same tasks but in a different order; parts one, three, and five were swapped, respectively, with parts six, eight, and ten. The time that it may have taken participants to read the instructions for each task is not included in the time reported for each part. It was estimated that participants would take no longer than 30 minutes to complete all primary tasks, including the time it may take to read the instructions and answer the questions.

4.3.1.1 Part one – Image presentation.

Participants belonging to condition one were presented with the image section of the source recollection task. Here, participants were asked to absorb as much information regarding the image as they were able. Participants were instructed that they would be presented with the image once they pressed a button indicating that they were ready. The image was presented for a period of 60 seconds before participants were presented with the instructions for part two.

4.3.1.2 Part two – DRM wordlist presentation, part one.

Participants were presented with each word from each list in either the first group of word lists or the second group of word lists; which list was used was randomly determined. Each word was presented; each word was presented for a period of two seconds and was followed by 0.5 seconds in which a blank screen was presented. Three seconds were given between the presentations of each word-list. A total of 2 minutes was required for the presentation of part two.

4.3.1.3 Part three – Story presentation.

Participants belonging to condition one were presented with the story section of the source recollection task. The participants were instructed to read a paragraph about the occupant of the office displayed in the previously presented image and to remember as much as they were able. Participants were allowed as much time to read this paragraph as they desired.

4.3.1.4 Part four – DRM recollection list presentation, part one.

Participants were presented with the recollection list for the word recollection task. The recollection list with which they were presented was the pair of the word list group with which they were presented in part two. Participants were allowed as much time as they needed to complete this task.

4.3.1.5 Part five – Source recollection questionnaire.

Participants belonging to condition one were presented with the questionnaire section of the source recollection task. The participants were instructed to take as much time as they needed to answer the questions and to indicate how certain they were in their answers. This part did not have a time limit.

4.3.1.6 Part six – Slide presentation.

Participants belonging to condition one were presented with the slide section of the eyewitness memory task. The participants were instructed that they were about to be presented with slides detailing a crime and were asked to remember as much about the events and actors as they were able. The participants were instructed to push a button to start the slides when they were ready. The six slides were presented in sequence and for six seconds each with no delay between slides. This slide presentation took a total of 36 seconds.

4.3.1.7 Part seven - DRM wordlist presentation, part two.

Part seven was almost identical to part two. The only difference is that the word-list group used in part seven is the word-list group not used in part two (i.e., if the first word list grouping was used in part two, the second word list grouping would be used in part seven).

4.3.1.8 Part eight – Eyewitness memory questionnaire, part one.

Participants belonging to condition one were presented with the first questionnaire of the eyewitness memory task. Participants were instructed to use as much time as they needed to answer the questions and to indicate how certain they were that their chosen answers were correct. There was no time limit on this part.

4.3.1.9 Part nine - DRM recollection list presentation, part two.

Part nine was almost identical to part four. The recollection list which was presented to the participant in part nine is the recollection list for the word list grouping used in part seven.

4.3.1.10 Part ten - Eyewitness memory questionnaire, part two.

Participants belonging to condition one were presented with the second questionnaire of the eyewitness testimony task. Participants were instructed to use as much time as they needed to answer the questions and to indicate how certain they were that their chosen answers were correct. There was no time limit on this part.

4.3.2 The Secondary Tasks

4.3.2.1 The letter-number sequencing task.

Following the presentation of the primary tasks, participants were asked whether they wished to participate in the Letter-Number Sequencing Task. Participants were informed that the task would take approximately six to eight minutes to complete. Starting with two characters and ending with eight characters, participants were presented with 21 arrays of characters. Each character was presented for one second and was immediately followed by the next character in the sequence; when the sequence was complete, a text entry field was presented to the participant. The total presentation time was approximately two minutes, excluding the time it took for participants to read the instructions and enter their responses.

4.3.2.2 The Wonderlic quick-test.

Following the presentation of the Letter-Number Sequencing Task, participants were invited to make a further contribution to the study by completing the WPT-Q. Participants were informed as to the nature of the task and were instructed that the task would take exactly eight minutes, plus approximately one minute to read the instructions. This was the final task in which participants were asked to participate.

5 Results

5.1 Errors

Unfortunately, the tasks, as detailed in the Method section, were not administered as intended. The server on which the study was hosted experienced an error shortly before the launch of the study. As a consequence the server was reset to a previous state which did not possess the most recent alterations to the software. This was not noticed until well into the study and a satisfactory way to correct for the presentation of the incorrect version of the tasks without restarting the study was not found. Given that many individuals had already participated, it was decided to continue with the study. The errors are highlighted in the following paragraphs.

While the newest version of the word recognition task used the word list entitled "*Whistle*", the older version used the wordlist entitled "*Slow*" in its place. The server reset caused the wordlist Slow to be presented to participants in place of Whistle during parts two and six of the study. Unfortunately, the secondary word lists which were used in parts four and eight of the study were fully up-to-date and did not feature those words which were a part of the Slow wordlist. As a result, only five primary lists were available for analysis. The Whistle wordlist could not be added to the secondary wordlists as the lure word had not been presented at the end of the secondary lists and only five other words were presented from which the lure word may have been primed.

The source recollection task was affected by the server reset in a similarly detrimental manner. While the newest version of the task queried the participants regarding the presence, or absence, of 15 items in the image, the older version only queried 12 such items. As a result participants were not queried regarding the presence of pens, puzzles, or shoes in the office. This resulted in only three items being available for scale construction and analysis.

5.2 Initial Data Analysis

5.2.1 Descriptive Statistics

5.2.1.1 Word Recognition Task

The word recognition task performed as expected. With the exception of the Beautiful wordlist, each of the wordlists belonging to the primary groups displayed only minimal differences from the lure strengths reported by Roediger et al (2001). The word lists belonging to the secondary group revealed lure strengths substantially different to the lure strengths reported by Roediger et al. (2001). With the exception of the Cold and Beautiful lists, all lure words displayed higher rates of recognition than the old words (those that were actually included in the list; see Table 5.1.).

Table 5.1.

The rate at which the items of each word list were indicated as recognised by the participants.

Wordlist	Presented Words	Lure Words	Roediger et al. (2001)
Cold	0.84	0.73	0.79
Beautiful	0.44	0.33	0.76
Bread	0.64	0.75	0.81
Health	0.55	0.74	0.75
Long	0.34	0.56	0.68
Anger	0.08	0.17	0.79
Fruit	0.04	0.22	0.45

Note: The statistics presented in the 'presented words' column exclude the lure words. The 'Roediger et al. (2001)' column presents the lure word recognition rates of Roediger et al. (2001).

The five lures belonging to the primary wordlists were summed to create the '*Word Recollection – Primary'* scale. This scale ranged from 0 to 5 (M=3.12, SD=1.35) and only two participants successfully rejected all lures. This items used in this scale (the lure words) displayed a Cronbach's α of .52.

The two lures belonging to the secondary wordlists were summed to create the '*Word Recollection – Secondary*' scale. This scale ranged from 0 to 2 (*M*=0.38, *SD*=0.64) and 67% of the 50 participants obtained a score of 0. The two items of which this scale is composed displayed a Pearson's *r* of .30.

5.2.1.2 Source recollection task.

The source recollection task was not as successful in the creation of false memories as was the word recognition task. The scale score for the source recollection task was calculated by summing the number of items not presented in the image that the participant believed had been presented in the image. This yielded a possible score of between 0 and 3 (*M*=1.35, *SD*=0.86). As three items were ultimately used in the scale, the mean rate of recollection for each item is 0.45 (c.f. the 0.69 obtained by Lindsay and Johnson, 1989, in a similar task; Experiment 1).

5.2.1.3 Eyewitness memory task.

The eyewitness memory task elicited a high frequency of false memory. The scale was constructed by totalling the number of incorrect responses to items in the second questionnaire where the correct responses to the items were not available in the first questionnaire of this task. This produced a scale ranging from 0 to 5 (*M*=4.05, *SD*=0.98). The probability of false identification in these items was, thus, 81%. This contrasts with the probability of 41% for those items for which the correct answer was present in both questionnaires. No participant provided an incorrect answer less than twice.

5.2.1.4 Letter-number sequencing task.

The letter-number sequencing task was scored by summing the number of correct answers which were provided by each participant. This resulted in a scale ranging from 0 to 21 (*M*=12.74, *SD*=3.89). These scores indicate that a representative individual would have been able to process approximately six characters. The score compares well with administrations of the test to similar populations (e.g., Crowe, 2000; *M*=12.20). Thirty-nine participants completed this task.

5.2.1.5 Wonderlic quick test.

The Wonderlic quick test displayed a mean score of 25.62 (*SD*=3.82), a minimum score of 19, and a maximum score of 32. Twenty-six participants went on from the letter-number sequencing task to complete this task.

5.2.2 Data normality.

With the exception of the Wonderlic quick test, all the tests that were used in this study displayed substantial and significant violations of normality. This is, perhaps, best shown by the word recognition lists and source recollection scales, where the mean score is only slightly more than half of the standard deviation away from the lower limit of the scale, indicating a substantial positive skew. The mean for the eyewitness memory scale is approximately one standard deviation from the upper limit of the scale, indicating a substantial negative skew. The substantial violations of normality that are observed in these results act to limit the range of statistical methods available for the analysis of this data. While non-parametric tests were performed where practical, caution should be taken interpreting the results of any parametric tests which are reported.

Table 5.2.
The distribution of participant scores across all scales.

Scale	Mean	SD	Shapiro-Wilk	Kolmogorov-Smirnov
Word Recognition - Primary	3.12	1.35	0.92***	0.20***
Source Recollection	1.35	.86	.87***	.25***
Eyewitness Memory	4.05	.98	.83***	.25***
Letter-Number Sequencing	12.74	3.89	.87**	.17**
Wonderlic Quick Test	25.62	3.82	.95	.13

Note: ** $p < 0.01$, *** $p < 0.001$

5.3 Correlations Among Tasks

5.3.1 False memory on the world wide web.

Each of the false memory tasks was deliberately designed so that those items which were subjected to a source-confusion procedure were assessed alongside items which were not subjected to this procedure. This provided a within-subjects method of assessing the effects of the manipulation on the frequency with which participants provided incorrect answers. Unfortunately, the effects of the server error on the source recollection task resulted in only three manipulated items, and only one non-manipulated item, being available for comparison.

A within-subjects *t*-test was used to assess the significance of the observed effect; the results are displayed in Table 5.3. The observed power estimates obtained for the word recognition and eyewitness memory tasks were found to be satisfactory (Power > .99) while the power for the source recollection task fell below acceptable levels (Power = .44). The Wilcoxon Signed Rank Test was used to further examine the effects without the assumption of normality; the word recognition and eyewitness memory tasks retained their level of significance, though that of the source recollection task increased from $p = .07$ to $p = .09$.

Table 5.3

A comparison of the rate of incorrect answers as elicited by the primary tasks and separated based on the presence of manipulation.

Task	Base rate	Manipulated Rate	Cohen's '*d*'	t
Word Recognition	.08	.62	2.09	1.76***
Source Recollection	.31	.45	.26	1.83
Eyewitness Memory	.41	.81	1.32	9.51***

Note: *** p < 0.001.

5.3.2 Correlations of Incorrect Responses to Lure-Items Among the False Memory Tasks

Despite the efficacy of the primary tasks in manipulating the rate at which participants produce false memory, no significant positive correlation was discovered among the various tasks in the frequency of incorrect responses to the lure-items. The correlations found among the primary scales were weaker than expected for the word recognition and eyewitness memory tasks and for the source recollection and eyewitness memory tasks. In all cases, the observed correlations are in the opposite direction to that which was. Both of the Pearson's product-moment correlation and the Spearman's rank correlation equations were applied for each pair of the primary tasks; no substantial difference was noted between the two and the Pearson's '*r*' values are reported in Table 5.4. Post-hoc, the power of the correlation between the word recognition and source recollection scales was found to be sufficient, though not ideal, (Power = .74) while that of the word recognition and source recollection scales with the eyewitness memory scale were found to be severely lacking (Power = .12, Power = .50, respectively).

Table 5.4.
The Pearson's 'r' values for correlations among the number incorrect lure items in each of the primary scales.

Task	Word Recognition	Source Recollection	Eyewitness Memory
Word Recognition	1.00		
Source Recollection	-.36*	1.00	
Eyewitness Memory	-.11	-.01	1.00

Note: * $p < 0.05$.

5.3.3 Correlations in the overall inaccuracy of participant responses among the false memory tasks

The overall inaccuracy of participants in each of the false memory tasks was calculated by summing every incorrect answer that the participant provided in the relevant task. The scores thus obtained were correlated with each other using the equations of both of the Pearson's product-moment correlation and the Spearman's rank correlation; the Pearson's '*r*' values are provided in Table 5.5. Unlike the Pearson's '*r*' values reported in Table 5.5, none of the Spearman's ρ values achieved statistical significance. Furthermore, the correlation coefficients were less substantial for the word recognition task and the source recollection task (ρ=.27) and for the word recognition task and the eyewitness memory task (ρ=.13); the coefficient were more substantial for the source recollection and eyewitness memory tasks (ρ=.12). The obtained power levels for the correlation between the word recognition and the source recollection tasks ($Power_{(r)}$ = .53, $Power_{(\rho)}$ = .47) and between the word recognition and the eyewitness memory tasks ($Power_{(r)}$ = .60, $\beta_{(\rho)}$ = .16) were less than the .80 cut-off; for the correlation between the source recollection and eyewitness tasks ($Power_{(r)}$ = .06, $Power_{(\rho)}$ = .13), the power was almost non-existent.

Table 5.5.
The Pearson's 'r' values for correlations between the total number of incorrect answers for the primary scales.

Task	Word Recognition	Source Recollection	Eyewitness Memory
Word Recognition	1.00		
Source Recollection	.29*	1.00	
Eyewitness Memory	.31*	.04	1.00

Note: * $p < 0.05$

5.3.4 False memory and working memory

Participant scores on the letter-number sequencing task were correlated with the inaccuracy scores for each false memory task, as calculated in the previous sub-section. The correlations were performed using the equations of both of the Pearson's product-moment correlation and the Spearman's rank correlation; the strength of the correlations varied substantially between the two tests and both are reported in Table 5.6.

While all of the obtained coefficients were in the predicted direction, the eyewitness memory task had almost no correlation with the letter-number sequencing task. Both the word recognition task and the source recollection task possessed approximately the expected *r* value. The word recognition task displayed a substantially worse *ρ* value than its *r* value, supporting the decision to run both parametric and non-parametric tests. In all cases, the obtained power was lacking.

Table 5.6.

The Pearson's r, Spearman's ρ, and the relevant powers for the correlation between the number of incorrect items in each of the primary tasks and the letter-number sequencing task.

Statistic	Word Recognition	Source Recollection	Eyewitness Memory
Pearson's 'r'	-.21	-.21	-.05
$Power_{(r)}$	.26	.25	.06
Spearman's 'ρ'	-.11	-.29	-.01
$Power_{(\rho)}$	.10	.45	.05

5.3.5 False memory and intelligence

Participant scores on the Wonderlic quick-task were correlated with the inaccuracy scores for each false memory task, as calculated previously. The correlations were performed using the equations of both of the Pearson's product-moment correlation and the Spearman's rank-order correlation; the strength of the correlations varied substantially and, thus, both are reported in Table 5.7.

While the obtained coefficients for the word recognition and source recollection scales were in the predicted direction, the eyewitness testimony scale displayed a correlation in the opposite direction to that which was predicted. Each task showed approximately the expected *r* value and *ρ* value when the mean of the two values for each scale was taken. In all cases, the obtained power was low.

Table 5.7

The Pearson's 'r', Spearman's 'ρ', and the relevant powers for the correlation between the primary scales and the Wonderlic quick-test.

Statistic	Word Recognition	Source Recollection	Eyewitness Memory
Pearson's '*r*'	-.23	-.13	.11
$\text{Power}_{(r)}$	.20	.10	.08
Spearman's '*ρ*'	-.16	-.24	.10
$\text{Power}_{(\rho)}$	.12	.28	.08

6 Discussion

This chapter discusses the findings of this thesis and the implications of those findings for theory and future research. The first section examines the validity of the world-wide-web as a tool for false memory research; first, the presence of the expected effects are established and, second, these effects are compared to similar tasks that were used by other researchers in laboratory environments. It is established that, while not perfect analogues, the observed effects are, at the least, real and appear to be similar to the effects observed in tasks with similar experimental manipulations. Using these conclusions as a foundation, the second section proceeds to assess the degree to which participant responses on each of the false memory tasks relate to their responses on the other tasks; first, the lure-items, those items which were explicitly manipulated, are examined and, second, the inaccuracy of participants across the entirety of each of the tasks is compared. It is established that, while some modest correlations were observed, the answer is not as clear-cut as was initially expected. The third section compares inaccuracy on the false memory tasks with working memory and intelligence and finds evidence for the impact of these factors on resistance to false memory.

Latter sections discuss the limitations of this research, recommend methods and directions for future research, and discuss the implications of the results on the predominant theories in the fields of false memory research and memory networks. A final section is dedicated to discussing interesting points that have arisen in the pursuit of this thesis and which may be of importance to future research in this field.

6.1 The Validity of a Web-based Medium for the Presentation of False Memory Tasks

The false memory tasks that were used in this study were adapted to function over the world wide web. While this may be less interesting from a theoretical standpoint than the issue of a common susceptibility to false memory phenomena, this aspect of the thesis is just as important. If false memory tasks can be administered over the world wide web, a far wider range of participants become available to researchers and large-scale studies become practical as a consequence of the larger population and reduced costs. Further, and perhaps most crucially, if no effect of the experimental manipulations is noticed in the results, this thesis becomes an investigation of memory accuracy rather than susceptibility to false memory and the predictions made in this thesis would need to be severely re-evaluated.

The validity of the world wide web as a medium for the administration of false memory tasks was assessed for each task individually. First, the base frequency of incorrect answers in each task was compared to the frequency of incorrect answers to items that have been subjected to the source confusion procedure; this comparison is used to support, or not support, the efficacy of the source confusion procedure. Second, as no laboratory-based controls were used in this study, the efficacy the source confusion procedures used in this study is compared to studies which use similar procedures in a laboratory environment; the demonstration of similar effect sizes is used to support the idea that the web-based false memory tasks are assessing the same type of false memory as those other studies and, thus, that the results obtained in this thesis may, potentially, be generalised to non-web-based false memory tasks. Overall, the results are considered to be favourable for the purposes of informing further analysis.

6.1.1 The Validity of the Word Recognition Task

Participants routinely provided incorrect answers in the word recognition task. These incorrect answers were observed under all conditions; words which were presented were often reported as not having been presented, words which were not presented were sometimes reported as having been presented, and the lure words (the words that were not presented but shared semantic similarities with each of the words that were actually presented) were frequently reported as having been presented. These incorrect answers represent an error in reporting. Taking into account the fact that the lure words were ‘remembered’ far more frequently than words that were not semantically-related to previously presented words but were, likewise, not themselves presented, it may be concluded that the task succeeded in increasing the rate at which the lure words were reported incorrectly, over and above the rate at which the non-presented non-lure words were incorrectly reported.

While the information contained in the previous paragraph shows that the manipulations involved in the word recognition task (the presentation of a large array of words that were semantically-related to the lure word) successfully manipulated the rate at which the lure word was incorrectly reported as having been presented, the information is insufficient to conclude that what was observed was, in fact, the same false memory phenomenon observed by other DRM-like tasks. To investigate this, the results of this study were compared to those of Roediger et al. (2001), the most comprehensive review of DRM-like tasks and the source of the word lists used in this study. The results of this comparison were found to support the notion that the word recognition task likely assessed the same phenomena as other tasks based on the DRM paradigm; with the exception of the word list entitled *beautiful*, the frequencies with which lure words were incorrectly reported as having been previously presented in the word recognition task was within six percentage points of the frequencies observed in those same lists by Roediger et al. (2001).

6.1.2 The Validity of the Source Recollection Task

Participants were asked to indicate where they had been presented with 12 items; in the office image, in the story, in both, or in neither. Three of these items were not presented in the office. The average (mode) participant reported only one of these three items as being present in the office. Based on the median, there was approximately a 45% chance of a participant indicating any single one of these three items as being present in the office image. The base rate at which participants misidentified the source of an item (any incorrect answer not included in the previous statistic; not just attributing a story-consistent or schema-consistent item as having been present in the office) was calculated as 32%. This represents a 13 percentage point difference between the base rate at which participants provided incorrect answers and the rate at which participants provided a specific incorrect answer to a select number of questions, the latter being higher. Should no effect be present, a 13 percentage point difference in favour of the manipulated items would not be expected; in fact, as such specific incorrect answers are a subset of incorrect answers, a trend in the opposite direction would be more likely. Though no control group was used and the ability of the task to differentiate individuals was severely limited, the aforementioned difference may be taken as an indicator, even if more weak than preferred, that this task was successful in manipulating how the participants remembered the image of the office.

The source recollection task is closely paralleled by one used by Lindsay and Johnson (1989; Experiment 1); both tasks rely on an image of an office instead of placing the participant in the office itself and both feature a story regarding the occupant of the office. While participants in the present study reported items which were not present in the office as being present in the office only 45% of the time, participants in Lindsay and Johnson's 1989 (Experiment 1) task made the same error 69% of the time. This difference of 24% is substantial, but not unexpected; Lindsay and Johnson's 1989 (Experiment 1) task used a far greater number of items than the three used by the present research, the items contained in their office were rated based on prominence, and the items in their questionnaire component were piloted to assess the degree to which they tapped into the schema used in the task. The items used by the present research were not piloted in this manner and, thus, the participants' adherence to the schema and the prominence of items in the office image were, at best, educated guesses; the task used in this study was unlikely to be as effective as that used in the aforementioned 1989 study. The 24% difference observed between these tasks represents a difference of less than one item in the present study; due to the lack of discriminative ability provided by the source recollection task, the external validity of this task can neither be accepted nor rejected.

6.1.3 The Validity of the Eyewitness Memory Task

The eyewitness memory task presented participants with slides depicting a mugging. Following the presentation of the slides, participants were presented with two questionnaires, both containing the same multi-choice questions but differing in the available answers. Of the ten questions, five did not have the correct option available in the first questionnaire. The second questionnaire was presented after a delay and made the correct answers available in all cases. Participants provided an incorrect answer on the second questionnaire 41% of the time for each of the five questions for which the correct answer was available in the first questionnaire. The comparable frequency for questions for which the correct answer was not available in the first questionnaire was 81%. This would appear to indicate that forcing participants to provide an incorrect answer in the first questionnaire causes participants to provide incorrect answers in the second questionnaire at almost twice the frequency that they otherwise would. While the lack of a control sample (a sample for which the correct answers were available in the first questionnaire), however, leaves open the possibility that this difference in frequency could be due to the questions themselves rather than the aforementioned manipulation, there is no readily apparent (at least to the present author) difference between the questions which is sufficient to justify such a substantial difference in the frequencies.

Few tasks in the literature (as far as the author is aware) are methodologically similar to the eyewitness memory task used here. Several tasks, however, are conceptually similar and compare well with the results found in the current study. The task used by Gabbert et al. (2003) used the reports of other witnesses in place of the first questionnaire, finding that 71% of participants reported witnessing events that they did not but which the other participant reported and witnessed. The task used by Kassin and Kiechel (1996) presented participants with claims from a witness that the participant themselves had committed an act with destructive consequences; participants admitted their guilt 69% of the time. A replication of the task by Horselenberg et al. (2003) found that participants admitted their own guilt 82% of the time, even with a financial penalty. Though the different methodologies make a direct comparison difficult, the frequencies at which participants in the present study provided incorrect answers is similar to that which was observed in the other studies. Thus, it seems reasonable to conclude that the eyewitness memory task taps similar mechanisms to the conceptually similar tasks mentioned above and in the literature review sections of this thesis.

6.1.4 Conclusions about the Validity of the Tasks

The first hypothesis predicted that the word recognition, source recollection, and eyewitness memory tasks would create false memories in participants despite the fact that they were administered over the world wide web. This section has discussed each of these tasks and shown that, for each of these tasks, a substantial difference is observed in the frequency with which incorrect answers are provided between questions that target manipulated aspects of the tasks and questions that targeted non-manipulated aspects of the tasks. As this difference in frequencies is in a direction consistent with the theoretical underpinning of the task, and because the frequencies approximate those of conceptually similar tasks, it is concluded that the tasks used in the present study successfully increase the rate at which false memories are perceived as true by the participant and, thus, that the world wide web offers a valid means through which false memory tasks may be administered.

6.2 Covariance in False Memory Propensity Across Tasks

Both the second and the third hypotheses argued that the tasks used in the present study would correlate positively with each other. The second hypothesis held that positive correlations would be observed between the subset of questions in each of the tasks for which the participants were subjected to a source confusion procedure in an attempt to increase the frequency at which participants provided incorrect answers to those questions (e.g., the lure words in the word recognition task, the objects that were in the story but not the office in the source recollection task, and the questions that lacked a correct answer in the first questionnaire of the eyewitness memory task.). The third hypothesis held that a positive correlation would be observed between the total numbers of incorrect answers (false reports of memories where there was no deliberate manipulation as well as those memories that were deliberately manipulated) provided by participants for each of the tasks used in the present study. This subsection focuses on evaluating the results of this study in relation to these hypotheses.

6.2.1 Correlations for Manipulated Item-sets between the False Memory Tasks

Hypothesis two was not supported by the results of the present research. The expected positive correlation between the eyewitness memory task and each of the other two tasks was not found to be substantial or significant. The expected positive correlation between the word recognition task and the source recollection task was found to be negative and of a moderate strength (as defined by Cohen's standards; Cohen, 1988). This lack of support for the hypothesis was not considered to differentially favour either of fuzzy-trace theory or the source monitoring framework as, in this case, both theories made the same prediction.

6.2.2 Correlations for Full Item-sets between the False Memory Tasks

Unlike hypothesis two, hypothesis three was found to be partially supported by the results of the present research. Where hypothesis two related only to items that were subjected to the source confusion procedures, hypothesis three related to the total number of incorrect answers, manipulated or not. The word recognition task was found to correlate with both of the source recollection and eyewitness memory tasks; those correlations were recorded as being close to the weak/moderate criterion (again, according to the Cohen, 1988 standards). No substantial or significant correlation was found, however, between the source monitoring and eyewitness memory tasks. It could not be concluded that the hypothesis was supported by the research.

6.2.3 A Discussion of Observed Trends in Relationships Among the False Memory Tasks

When only those items which were subjected to the source confusion procedures were considered, no substantial correlations were found between each of the tasks. When the total number of incorrect answers was considered, regardless of if the question was manipulated or not, substantial correlations were noted only between the word recognition task and the other two tasks; these correlations were positive, as predicted, but not statistically significant. The exact implications of these results for a common susceptibility to false memory phenomena is unclear; while the positive correlations that were found were supportive of the hypothesis, many of the predicted correlations were not present. Combined with the lack of power, the minimal range of scores, and the inability to detect individual differences that was displayed by this exploratory research, it could be the case that the predicted correlations do exist in the actual phenomenon but that the limitations of the scales used in the present study have masked that fact. Alternatively, the predicted correlations might not actually exist in the phenomena and the correlations that were observed could have resulted purely from statistical artefacts.

While there has been very little investigation into the possibility of a common susceptibility to verifiable false memory, the alien abduction research of Clancy et al. (2002) and French et al. (2008) investigates, at least implicitly, this notion (there has been research comparing the DRM to recovered memories; the truth of recovered memories, though, is far harder to verify than alien abduction; e.g., Clancy et al., 2000). Clancy et al. (2002) found significant differences in DRM performance between individuals reporting alien abduction and individuals who made no such report. French et al. (2008) did not find significant differences when making the same comparison. Along with this study, these results are taken to indicate that, if the common susceptibility to false memory phenomena does exist, it is harder to assess than would otherwise be expected.

Other than the limitations of the scales to assess the phenomena, why would the predicted correlations be absent if the theory underlying the predictions was correct? The first explanation is that, while the mechanisms proposed to underlie false memory do exist and do influence false memory, the common covariance that would be created by this was overshadowed by noise that differentially affects the different tasks. That is to say, other factors which were not measured may have had such a great impact on individual susceptibility to each of these tasks, and on each task to a different degree, that the underlying processes represented only a minor proportion of the observed variance. Examples of such factors could be previous experience with similar situations, suspicions that they are being tricked, or, simply, how motivated the individual is to perform.

A second, potential, explanation lies in the formation of the memories themselves and the mechanisms that reconstruct those memories. The word recognition task relied, at least theoretically, on the semantic associations that the individual held between the various words that were presented to them and the lure word; individuals who possessed stronger semantic associations would experience relatively greater excitation of the lure word and would, thus, be more likely to remember that word. As there was little extra information available from the context of the presentation to be used in the evaluation of the memory, neither of systematic/heuristic processes or gist/verbatim traces could have been readily applied. By contrast, the source recollection task relied very little on the semantic similarities of the items presented in the image and the story but, rather, on the judgement processes the involved in evaluating the memories; regardless of if the participant remembered a basketball, the participant needed to ask themselves if a basketball was likely to be in the office and if their memories, or lack thereof, of the basketball constituted enough evidence for, or against, the presence of the basketball in the office. By contrast, again, the eyewitness memory task was designed such that the first questionnaire would, theoretically, overwrite the information that the individual stored in memory. Here, judgement processes were an important factor in determining the veracity of the memory; when these processes are applied to the memories relating to the scene and the memories relating to the questionnaire, and the details contained in these two memories are contrasted, the veracity of the memory of the scene may be assessed. While the judgement processes, theoretically, had little impact on the word recognition task, they were the main source of confusion in the source recognition task and the main source of veridical recollection in the eyewitness memory task.

Why would some of the predicted correlations be present if the theory underlying the predictions were incorrect? As a corollary to the first explanation, it is possible that an unmeasured variable has caused the observed correlations. In particular, it is possible that different individuals will tend to develop criterion (as per signal detection theory) across different tasks in a self-consistent manner. That is to say, the factors that affect the selection of a participant's criterion in any given task might affect the selection of that participant's criterion in other tasks such that the tendency of the participant to err is preserved across tasks (i.e., a participant may persistently adopt criterion which result in that participant accepting noise as signal at a less-than-optimal rate). The existence of such a variable would produce correlations between the tasks where the criterion selection in those tasks is affected by similar factors.

6.3 Working Memory as a Contributing Factor in False Memory Performance

Both semantic network and connectionist network models of memory suggest that, when a memory is stored, information other than the core memory in is stored also; be it information about the experience or the environment. Furthermore, both of the spreading activation framework and fuzzy-trace theory suggest that this information is crucial in false memory performance. As a greater working memory capacity allows an individual to process a greater volume of information over a longer period of time, it could be expected that an individual with a large working memory capacity may be able to store more detail regarding an event than a similar individual with a smaller working memory capacity. This would provide the former individual with more information to work with when evaluating memories and may, thus, increase their performance on false memory tasks.

For the most part, these predictions were supported; albeit weakly. A weak positive correlation was found between participant performance on the working memory task and participant performance on the word recognition and source recollection tasks. No notable correlation was found between the working memory task and the eyewitness memory task, potentially due to the relatively large amount of time allotted to the task and the potential for stimulus saturation (i.e., most individuals may be able to readily obtain most of the information in the slides in the allotted time without the need for larger working memory capacity.). While correlation does not automatically indicate causation, it does hint at the potential for causation and, given the set-up of this exploratory study, is the best that could be hoped for. At the least, it may be concluded that the predictions do not clash with the findings.

Investigating any correlations between the DRM and forward digit span, backward digit span, and OSPAN tasks, Peters et al.(2007) observed no significant correlations between the DRM, forward digit span, and OSPAN tasks. Despite this, performance on the backward digit span task, across two experiments, correlated significantly, and negatively, with the number of incorrect answers provided by participants on the DRM task (r=-.49, p<.01). The correlations found in this study between the DRM and the digit span task, while not statistically significant, exceeded the strength obtained by Peters et al. (2007) for forward digit span and OSPAN tasks but were far weaker than was the case with the backward digit span task.

Research by Gerrie and Garry (2007) compared participant scores on the OSPAN task with the ability of individuals to discriminate between previously presented slides and slides which were not previously presented. Every slide was consistent with a single story (a female going through her morning routine). Gerrie and Garry (2007) found that working memory had no bearing on the ability of individuals to correctly recognise presented slides or to correctly discount slides that were not presented and not crucial to the story. Where an impact of working memory was found, though, was when a slide was not previously presented but was crucial to the story (e.g., placing toothpaste on the tooth brush); individuals with a smaller working memory capacity were significantly more likely to report these slides as having been presented than were individuals with larger working memory capacities, as measured by OSPAN (r=-.40, p=.01). Alongside the results of the present study, these results indicate that the relationship between working memory and false memory is far less clear-cut than was originally expected; working memory appears to affect only some types of false memory task (and only certain parts of those tasks) and, even then, the effects are only seen with certain methods of assessing working memory.

6.4 Intelligence as a Contributing Factor in False Memory Performance

The intelligence quotient (IQ) is proposed to measure, at least partially, the ability of an individual to reason and to interpret information made available to them (Neisser et al., 1996). For both of the semantic network and connectionist network models of false memory, the storage of information is dependent on the associations made between the subject of the memory and other aspects of the event; the more readily an individual can apply reason to, and interpret, information, the more information will be available for later recall. IQ may, thus, be expected to vary alongside memory performance, albeit weakly, because of the reliance of both IQ and memory performance on the ability of the individual to reason and make connections between concepts. More substantially, the spreading activation framework proposes that an individual relies on systematic and heuristic judgements to evaluate the truth of a memory; judgements which utilise reason to interpret the information that is available from memory.

As expected, both the word recognition and the source recollection tasks displayed weak positive correlations with IQ. As with working memory capacity, the eyewitness memory task failed to perform in the expected manner; instead of a weak positive correlation, a weak negative correlation was found. None of these correlations were found to be significant. As the sample size was relatively small and this research is exploratory in nature, these correlations were seen as worth reporting, if only as a point of interest.

The only other study to properly examine the relationship between intelligence (so far as the author is aware) was Zhu, Chen, Loftus, Lin et al. (2010). The authors compared a misinformation task, similar to the eyewitness testimony task used in this study, to the Wechsler Adult Intelligence Scale (WAIS) and Raven's Advanced Progressive Matrices (Raven's APM). The authors found that the number of incorrect answers to the misinformation task correlated negatively, and significantly, with both of these tests; Raven's APM displayed a correlation of -.35 (p<.001) while the verbal and performance components of the WAIS displayed respective correlations of -.13 (p<.01) and -.29 (p<.01). The correlations obtained by Zhu et al. (2007) stand in stark contrast to those obtained in this study.

6.5 The Implications of the Findings for Theory

This thesis was inspired by, and informed by, the predominant theories in the field of false memory; fuzzy-trace theory (Brainerd & Reyna, 1990; Reyna & Brainerd, 1990) and the source-monitoring framework (Johnson et al., 1993). It was not, however, designed to garner evidence that could help to decide which theory is a better explanation of false memory performance. According to the interpretation of these theories that was used in this thesis, both theories make the same prediction; the performance of participants on false memory tasks will display a positive correlation with the participants' performance on other false memory tasks. As discussed in the previous section, this prediction was not supported when only the manipulated items were considered (hypothesis two) but was supported only weakly when the entirety of the scales were taken into account (hypothesis three).

The lack of the expected covariance for the manipulated items would seem to suggest that any effect that the common memory processes (heuristic/systematic judgements or gist/verbatim traces) may have on participant performance on false memory tasks is minimal in comparison to the effect of other, unexplored, factors. Given the small size of the sample and the restricted range offered by the scales (discussed further in the next section), the non-adherence of the manipulated items to the hypotheses may be due to a sample which was non-representative of the general population (the sample was composed entirely of, self-selected, university students) or the inability of the scales to successfully capture much of the actual variance in participant performance. Weak to moderate positive correlations, consistent with the third hypothesis, were observed when the entire scales, rather than just the manipulated items, were compared.

Why this disparity between incorrect answers to manipulated items in isolation and incorrect answers, manipulated or not? It is possible that the reason for the covariance observed in the full scales may be because of the application, by the participants, of a similar judgement criterion (c) across each of the tasks (i.e., the covariance is not due to the underlying processes so much as it is the level of certainty that the participant requires to judge a memory as veridical). When only the manipulated items were considered, the veridical recollection of any memory relied heavily on the ability of the individual to separate what was actually presented from what was introduced from another source; c was applied to the result of this and, thus, took a secondary role to the judgement processes (the judgement processes being crucial due to the confounded information). When the entire scales were considered, the majority of items lacked the confounding sources of information (not having been subjected to a source confusion procedure) and, thus, c took a more prominent role. Assuming that the ability of an individual to separate actually presented contents from source-confused contents is partially determined by previous experience with similar situations, it is plausible that this variation in experience across the tasks acted to introduce noise which masked the effect of c and resulted in a smaller correlation than would have been seen in the absence of this variance. Put another way, the source confusion procedures decreased the reliability of c; by including the other items, the average performance of c better approximated the performance of c in the absence of the source confusion procedure and, thus, made the correlations more pronounced.

6.6 Limitations and Recommendations for Further Research

While this study managed to obtain some interesting results and succeeded in its purpose as a platform from which to launch future research, this study is defined, perhaps, more by its failures than by its success. This section discusses many of the problems that were encountered during the course of this research and, more importantly, highlights mechanisms through which these problems may be fixed and future research enhanced. Further, this section proposes several procedures that, while not used in this study, could be applied to future research that aims to exploit some of the findings of this study; most notably, the validity of the world wide web as a medium for the presentation of false memory tasks.

6.6.1 Research Sample Issues

The sample used in this thesis was inadequate for the purposes of making any strong or far-reaching conclusions. Aside from the usual sampling bias involved with the use of undergraduate university student populations and the opt-in nature of the research (Shen, Kiger, Davies, Rasch, Simon, & Ones, 2011), a post-hoc analysis of the statistical power of this thesis shows that the sample size was too small to reliably detect the observed effects. While the word recognition and eyewitness memory tasks displayed excellent statistical power (power > .99) and the correlation between the word recognition and source recollection tasks was considered sufficiently powerful (power = .74), the source recollection task was found lacking (power = .44), the correlations of the word recognition and source recollection tasks with the eyewitness memory scale were far from sufficient (power=.12 and .05, respectively), and none of the correlations of the false memory tasks with the working memory or IQ tasks exceeded a statistical power of .26. If, for example, we focus on the correlations between the word recognition task and the other two false memory tasks, as in hypotheses two and three, a sample size of approximately 70 would be required to obtain an acceptable power of .80 (Faul et al., 2009; assuming that the observed trends reflect reality).

6.6.2 Limitations of, and Recommendations for, the Word Recognition Task

The word recognition task suffered from a few major deficiencies; most notable is the range of the scale scores and the inability, partially owing to this, of the scale to discriminate between individuals: The word recognition task used only six lure words, of which only five were salvageable; this meant that participant scores could range only from zero to five, offering little ability to differentiate between individuals based on this score alone. Histograms, the Shapiro-Wilk test, and the Kolmogorov-Smirnov test indicated that a substantial positive skew was present. While the mode was a score of two (representing two lure words correctly identified), the majority of participants scored zero or one, indicating a substantial floor effect; most participants failed to identify more than a single lure word correctly as new. It is suggested that, while the administration of so few word lists saves time, inconvenience, and fatigue for the participant, a larger number and variety of word lists must be used in order to successfully differentiate individuals based on their performance in this task. A larger number of word lists would allow the selection of a wider range of lure strengths, particularly lists where the lure strength is weaker (most of the lists used here were relatively strong in their ability to produce false memories), and provide a method, potentially, of addressing the floor effect observed in this study.

6.6.3 Limitations of, and Recommendations for, the Source Recollection Task

The source recollection task suffered from the same difficulties as the word recognition task, though to a stronger degree. While the word recognition task had a potential score range of zero to five, the source recollection task, following the server errors, only had a potential range of zero to three. This task, thus, offered a very small range and minimal ability to discriminate between individuals. As was the case with the word recognition task, the Shapiro-Wilk and Kolmogorov-Smirnov reported substantial violations of normality; though, with such a small range, normality cannot readily be expected.

Despite the minimal range and ability to differentiate between individuals that is displayed by this implementation of the paradigm, participants regularly reported manipulated non-present items as present more often than non-manipulated non-present items. This is taken to indicate that the task did, indeed, work as expected in that it assessed the effects of that manipulation of participant responses. Unfortunately, though, the task failed to provide sufficient information on individual differences; a failing that made correlational comparisons with other tasks difficult. To obtain a measure that is more sensitive to individual differences and to avoid floor or ceiling effects, it is suggested that the office image, the story, and the questionnaire each contain more items, that multiple sets of these are presented to each participant, and that these items are gradated in the frequency with which participants misidentify the lure word. Increasing the number of items contained in each instance of the task is suggested because the actual presentation takes a substantial amount of time and presents the participant with ample opportunity to examine each of the items contained within that presentation; adding further items should have little deleterious effect. The presentation of multiple office/story/questionnaire sets is recommended because of practical limits on the number of items which may be included in the office and the story and still be expected to be remembered by participants. Further, the presentation of multiple sets allows for varied environments to be depicted and for different schema to, potentially, be accessed. Gradation of items based on the frequency with which participants misidentify the lure word is recommended so that individual differences may be accessed rather than, potentially, having a scale that serves only to differentiate between individuals with a low susceptibility and those with a high susceptibility.

6.6.4 Limitations of, and Recommendations for, the Eyewitness Memory Task

As with the other false memory tasks, the eyewitness memory task provided the opportunity to measure only a minimal range of scores; this, however, is overshadowed by the severe floor effect observed in the data. Almost half of participants obtained the lowest possible score (failing to identify a single manipulated item correctly) and less than ten percent obtained a score exceeding three on the eyewitness memory task (i.e., only four participants correctly recalled more than half of the items for which the first questionnaire denied the correct answer). To resolve the small potential range of scores, and the floor effect, it is recommended that further items are introduced, both manipulated and non-manipulated, which tend to be falsely recalled less frequently (i.e., they are easier). Such items should be identified by a comprehensive pilot.

The floor effect observed in this task is so pronounced that adding more questions of the same variety is unlikely to provide data that are of any more use than those that were obtained here. To improve the design of this task, the trends in the present data must be examined as they relate to the events depicted in the slides (the subject about which the participants were questioned). The most obvious item that was manipulated in this task (i.e., the item that was displayed most saliently in the slides) was the main assailant's top; while the colour of the top was blue, only 40.8% of participants correctly identified the top as blue following the manipulation performed via the first questionnaire. Participants identified black as the colour of the top 53.1% of the time, red 6.1% of the time, and no participants identified the top as yellow. Of all the manipulated items, the 'top' question provided the least number of incorrect answers. Likewise, the colour most similar to blue (black) was chosen far more often than the less closely-related red and yellow. Red may have been chosen more often than yellow simply because the main assailant wore a red cap, allowing the source of the colour to be confused in a similar manner to in the source recollection task. Both of these trends continue throughout the rest of the manipulated items, hinting that the task may be made easier (and, potentially, ameliorate the floor effect) by including a greater number of manipulated items where the subject of the manipulation is a salient, though not necessarily crucial, part of the scene. It is recommended that any new items which are to be manipulated should either be more prominent than those used in this implementation of the task or that each of the alternative options presented in the place of the correct options (as a part of the second questionnaire) should be very different to the correct option.

6.6.5 The Pearson/Spearman Discrepancy

Participant performance on the false memory tasks was compared with their performance on both of the working memory capacity and IQ tests. In both instances the word recognition task displayed a far larger correlation coefficient when using Pearson's '*r*' than when Spearman's '*ρ*' was used and the opposite trend was observed with the source recollection task. The narrow range offered by the false memory tasks makes it hard to establish the exact distribution of scores around the line of best fit, but the discrepancy between the correlation coefficients observed for the word recognition task would appear to indicate that the data points (word recognition by working memory and word recognition by IQ) likely fell in to two or more groupings along the line of best fit rather than equally along the line. Should this be the case, the correlations may be indicative of a general trend but the small range, and inability to detect individual differences, of the word recognition task would have hidden the actual strength of the relationship. The discrepancy observed in the correlation coefficients of the source recollection task with the working memory and IQ tasks, however, indicates that a non-linear, relationship is likely to be present in the dataset; Pearson's 'r' lacks the ability to accurately assess non-linear relationships as it attempts to fit the data to a straight line, should a consistent but non-linear trend be present (e.g., a curved line), Spearman's 'ρ' will produce a stronger, and more accurate, correlation coefficient (assuming, as psychologists generally do, that the relationship is monotonic in nature) Again, it appears that the lack of resolution provided by the false memory tasks has impacted the applicability, and general usefulness, of the data.

6.6.6 Recommendations for Recruitment

This thesis had an initial aim of 200 participants, but only managed to recruit 60 during the allocated time frame. No incentives were offered for participation. As a direct result of the lack of participants, insufficient power was obtained and the planned factor analyses could not be performed. This lack of participants turned out to be a substantial limiting factor. The obvious, and often suggested, solution to this problem would be to recruit more participants, be it through remuneration or a larger recruitment pool; the media through which participants are recruited and perform the task, however, presents problems for this generic approach: The online administration makes remuneration difficult and such remuneration would defeat the purpose of the administration method (a mechanism through which participants may contribute without the need for them to go out of their way to book an appointment or other inconvenience for the participant). Further, as the invitation to participate was available only to students in classes for which the course coordinator had given permission to recruit participants, the pool of potential participants was limited (though, most classes in the departments of Psychology, Politics, and Sociology were invited to participate). Fortunately, the online nature of this administration method and development of social networking sites that integrate third-party applications allows for a potential sampling pool well exceeding that which is obtainable within the university population. Furthermore, Amazon's Mechanical Turk (see Mason & Suri, 2011; discussed in the second chapter) offers a massive pool of participants, and an inbuilt payment method, to those willing to pay.

The social networking sites Facebook (http://www.facebook.com/) and Google+ (http://plus.google.com/) each host hundreds of millions of active users. Both sites allow the integration of third-party applications into the existing site framework. Both sites support themselves by advertising products and services, including these integrated applications, to their users; these advertisements can be targeted at users based on gender, location, age, and a large variety of other factors. Further, integrated applications are capable, with permission of the users, to post their own advertisements to the user's friends and thus expand their customer base. It is suggested, here, that by adapting the tasks used in this thesis to an application form, integrating this application with the social networking sites, and advertising the application, a far wider audience may be reached. By applying gamification principles (for a discussion see Deterding, Dixon, Khaled, & Nacke, 2011) to the task (e.g., providing scores, awards, etc. to encourage continued participation) and allowing participants to show their achievements to their friends, participants may enjoy participating (and, thus, be more likely to complete the tasks) and encourage friends to participate (increasing the number of recruited participants). While this may introduce a competitive element to the tasks (e.g., which friend can get the highest score or the most achievements), a far larger sample size should be made available and more representative results should, thus, be able to be obtained. Because of this, it is highly recommended that, even if the same tasks are not used, future research investigating false memory phenomena and using online administration utilises the recruitment paths made available by applications integrated into social media sites.

6.7 The Word Recognition Task as a More Pure Measure of False Memory Performance

When the false memory tasks were compared to each other (for both the manipulated items and the full scales), the word recognition task displayed a far stronger correlation with the source recollection (r=-.36, r=.29) and eyewitness memory (r=-.11, r=.31) tasks than did the source recollection task with the eyewitness task (r=-.01, r=.04). Both the source recollection task and the eyewitness task were rich in visual stimuli while the word recollection task was devoid of visual stimuli and featured only the words themselves. As discussed in chapter three, the word recognition task offers very little detail for the participant to accurately evaluate whether an item was old or new. One possible explanation of the results is that the word recognition task, being devoid of these visual stimuli, offers a less noisy assessment of false memory performance; while the words consist of sounds and meaning, images present shapes, colours, meaning, interactions between objects, and the relative positioning of objects, offering far more potential markers for participants to use when judging the veracity of the memory. Put another way, because the word recognition task does not rely on participants noticing visual stimuli, focusing on those stimuli, and drawing connections between the same stimuli, there were fewer 'confounding' factors than in the other two tasks (the task is less impacted by the experience of the individual in question with similar situations). The word recognition task, thus, acted as a more basal measure and correlated with both of the other tasks while the other tasks did not correlate with each other to any substantial degree because of the different confounding factors that were offered by the tasks. Thus, while the word recognition task is, perhaps, less ecologically valid, it may be more useful for investigating the causes of false memory than the other tasks.

6.8 Further Research

Though the quality of the measures used in this thesis could be improved, there is some evidence of weak correlations between the false memory tasks, as predicted. Any future research should start by implementing the tasks in a better form than was used here. Specifically, future studies should aim to produce scales that better assess individual differences and, thus, provide a better basis for comparison between the tasks than was obtained here. Aside from this, future research should focus, first, on obtaining a larger sample so as to increase statistical power and, second, it should examine a wider range of false memory tasks so as to document and compare the theoretical and experimental similarities between the tasks and thus drive further development of false memory theory. The DRM tasks (the word recognition task) appear to show potential as more pure (i.e., less affected by personal experience), though less ecologically valid, measures of false memory propensity; future research should include these tasks alongside any other battery of false memory tasks.

This study has demonstrated the utility of the world wide web as a medium for the administration of false memory tasks. Future research should be dedicated to refining the tasks used here and extending the range of false memory tasks (and cognitive tasks in general) that are available in a web-based, tested, format for researchers to use.

7 Conclusion

The two predominant theories of false memory phenomena, fuzzy-trace theory and the source monitoring framework, postulate mechanisms common across all forms of false memory. The current study investigated the possibility of a common susceptibility to false memory phenomena based on the assumption that a common mechanism exists. The small sample size, and the inability of the tasks to detect individual variation, provided no basis for drawing any strong conclusions. Despite this, some of the predicted covariance was observed; this covariance, however, was considered more likely to come from a different source than that predicted by the theories as the observed covariance was in total false memory rather than just false memory due to manipulation: rather than the correlation being due to this mechanism, the correlation may be the result of the cut-off point that people use when deciding if a memory is accurate; the degree of confidence they feel is needed to judge a memory as veridical. Likewise, the results regarding the covariance of false memory with working memory and intelligence were mixed; weak to moderate correlations were found, in the expected direction, between the word recognition and source collection tasks and the working memory and intelligence tasks, indicating that working memory and intelligence may play a role in the ability of individuals to resist false memory. No substantial correlations were found between eyewitness memory and the working memory and intelligence tasks and thus, assuming the validity of the eyewitness memory task, this impact may not be universal.

This study has provided a basis that further investigations of false memory may draw on; this applies especially to those investigations that focus on a common susceptibility to false memory phenomena. Future studies should focus on using measures which provide a larger range of potential scores and a greater ability to detect individual variation; possibly modifications of those tasks that were used in this study, and should attempt to draw in a larger number of participants

This study has shown that the world-wide-web is a valid mechanism for the administration of false memory tasks and had trialled three such tasks. The fact that false memory was observed while using these tasks, and exacerbated by the source confusion procedures, suggests that the world-wide-web holds substantial potential as a source of participants for future studies. Amazon's Mechanical Turk, Facebook, and Google+ all offer avenues through which future researchers may be able to access a large and varied population of willing participants, potentially for very little financial cost.

In sum, this exploratory study has achieved its purpose: it has demonstrated, albeit weakly, that false memory does not happen in a vacuum, but, rather, in interaction with several other cognitive phenomena; it has raised many potential points of interest for false memory researchers including, but not limited to, the question of what the false memory tasks are actually assessing; finally, this study has provided a proof of concept in showing that false memory tasks may be administered across the world wide web and, in doing so, has started to open up new avenues for false memory research. Most importantly, this study, especially its flaws, has caused the author to develop as a researcher and has provided an experience that no taught paper could ever hope to provide, albeit at the cost of a massive number of hours.

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A Ethics Approval

MASSEY UNIVERSITY

26 January 2011

Mr Christopher Stichbury
114 Albert Street
PALMERSTON NORTH

Dear Christopher

Re: HEC: Southern B Application – 10/74
Is memory accuracy consistent across tasks?

Thank you for your letter dated 18 January 2011.

On behalf of the Massey University Human Ethics Committee: Southern B I am pleased to advise you that the ethics of your application are now approved. Approval is for three years. If this project has not been completed within three years from the date of this letter, reapproval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

Yours sincerely

Dr Karl Pajo, Chair
Massey University Human Ethics Committee: Southern B

cc Dr Stephen Hill
School of Psychology
PN320

A/Prof Mandy Morgan
School of Psychology
PN320

Figure A.1. Ethics Approval.

B Recruitment

B.1 Recruitment Invitation

Hello,

My name is Christopher Stichbury and I am presently completing my Masters of Arts in Psychology. For my thesis research I am looking at peoples memory abilities and how those abilities vary across tasks. I would like to request that you assist me in my research by providing me with the data born of your participation.

The tasks involved will take no longer than thirty (30) minutes to complete and can be done online at your convenience. The first task will present you with two lists of words and will assess how accurate your memory is following a delay. The second task will assess your ability to pick up and recall seemingly minor details when presented with a more pressing situation. The third task will assess your ability to differentiate the various sources of your memories. Should you have time, and be feeling particularly generous, another set of tasks is available which will take twelve (12) minutes and will assess your ability to mentally manipulate data; a subset of your IQ.

The experiment may be found here:

http://psych-research.massey.ac.nz/stichbury/

Thank you for your time,

Christopher Stichbury.

APPENDIX B

B.2 Information Page

Hello,

My name is Chris Stichbury and I am a Master's student at Massey University. Between 01/02/11 and 01/05/11 I will be conducting a project looking at how a person's memory accuracy changes across different tasks and how this accuracy relates to a person's memory capacity and reasoning ability. I would like to invite you to participate in this project.

Memory is an important part of our everyday lives - without our memory we would be left unable to function. Despite the importance of our memory, it is not perfect; we frequently forget important details, what we do remember is subject to forgetting, and some things which we believe we may have remembered may have not happened at all. This project aims to investigate memory accuracy: First, we aim to examine how a person's accuracy on one memory task relates to their accuracy on other memory tasks. Second, we aim to investigate whether a person's memory capacity and reasoning ability have any bearing on the accuracy of their memory.

To investigate the first aim we will ask you to participate in each of three different tasks which assess memory accuracy. One task will present you with an image of an office from which we will ask you to remember items. Another task will present you with a series of slides depicting a crime and will ask you to pick out a number of details regarding the crime. The final task will present you with a number of words which you will later be asked to recall. The order of these tasks is randomised so that the order in which you encounter them will not matter. Each of these tasks is divided into smaller sub-sections to make them easier to understand and perform.

To investigate the second aim we will present you with two different tasks. The first task assesses working memory capacity and will involve sorting letters and numbers so that all of the numbers precede the letters. The second task will take the form of an IQ test in which you will be asked to answer a number of questions relating to a variety of reasoning problems.

The total time which this task should take is approximately thirty minutes, though this time will vary based on how fast you read. All data from your participation will be stored electronically in a secure database and will be kept separate from any contact details; we will not be able to identify which datasets belong to any individual. You may withdraw from the study at any point prior to completion.

Once this project had finished, you will receive a summary of the findings and a further explanation of the tasks you will encounter.

A copy of your scores will be retained by Wonderlic Inc for the purposes of further analysis of the properties of the IQ test. Wonderlic Inc will not be provided with any personal details you may provide; your data will be totally anonymous.

Thank you for your interest,

Chris Stichbury.

If you have any concerns relating to this project, or you would like more information, please feel free to contact my supervisor Dr. Stephen Hill or myself:

Researcher:	Supervisor:
Chris Stichbury School of Psychology Room P2.08 Manawatu Campus Massey University	Dr Stephen Hill School of Psychology Manawatu Campus Massey University New Zealand
Telephone: 04 3569-099, Ext 7058 Email: C.Stichbury@psych.like.co.nz	Telephone: 04 3569-099, Ext 7566 Email: S.R.Hill@massey.ac.nz

C.Word Recognition

C.1The Wordlists

Table C.1.1

Primary word list: Cold.

Hot	Wet	Freeze
Snow	Frigid	Air
Warm	Chilly	Shiver
Winter	Heat	Arctic
Ice	Weather	Frost

Table C.1.2

Primary word list: Beautiful.

Ugly	Lovely	Snow
Pretty	Nice	Scene
Girls	Picture	Music
Woman	Lady	Day
Homely	Mountain	Gorgeous

Table C.1.3

Primary word list: Bread.

Butter	Jam	Crust
Food	Milk	Slice
Eat	Flour	Wine
Sandwich	Jelly	Loaf
Rye	Dough	Toast

APPENDIX C

Table C.1.4

Primary word list: Health.

Sickness	Doctor	Body
Good	Service	Vigor
Happiness	Strong	Centre
Wealth	Hospital	Pain
Ill	Disease	Robust

Table C.1.5

Primary word list: Long.

Short	Underwear	Far
Fellow	Hair	Distance
Narrow	Island	Line
John	Road	Low
Time	Thin	Rope

Table C.1.6

Primary word list: Whistle.

Stop	Train	Noise
Sing	Blow	Tune
Sound	Dog	Song
Shrill	Boy	Lips
Wolf	Call	Loud

Note: An error caused this word list was replaced by Slow in the first part of the task.

Table C.1.7

Secondary word list: Anger.

Mad	Fury	Hatred
Fear	Ire	Mean
Hate	Wrath	Calm
Rage	Happy	Emotion
Temper	Fight	Enrage

Table C.1.8

Secondary word list: Fruit.

Apple	Ripe	Basket
Vegetable	Pear	Juice
Orange	Banana	Salad
Kiwi	Berry	Bowl
Citrus	Cherry	Cocktail

Table C.1.9

Primary word list: Slow.

Fast	Lethargic	Stop
Listless	Snail	Cautious
Delay	Traffic	Turtle
Hesitant	Speed	Quick
Sluggish	Wait	Molasses

Note: An error caused this word list to replace “Whistle” in the first part of task.

C.2 The Recognition Lists

Table C.2.10

Example recognition word list A.

Toast	Girls	Hot
Chilly	Hatred	Fight
Cold	Loaf	Wrath
Lovely	Flour	Rage
Beautiful	Rye	Mad
Fury	Gorgeous	Freeze
Enrage	Pretty	Frost
Fear	Bread	Emotion
Anger		

Table C.2.2

Example recognition word list B.

Sickness	Orange	Hair
Apple	Cocktail	Shrill
Short	Lips	Salad
Happiness	Distance	Basket
Banana	Whistle	Berry
Health	Train	Doctor
Long	Body	Pear
Tune	Citrus	Far
Fruit		

D. Source Recollection

D.1 Presentation

Figure D.0.1 The image utilised for the source recollection task.

"The office featured in the image belongs to Professor Bruce. Professor Bruce teaches psychology at the local university. When he is not teaching he can often be found on the squash court or at target practice. Professor Bruce is the author of many books and is considered an expert in neuro-psychology. His students note that he has an eccentric personality and often wears multi-coloured ties, odd glasses, and a stained lab-coat."

Figure D.1.2 The story utilised for the source recollection task.

D.2 Data collection

Table D.1.1

Queried items in the source recollection task.

Item	Location
Lab Coat	Both image and story
Computer	Image only
Archer's Bow	Image only
Newspaper	Image only
Papers	Image only
Model Brain	Image only
Keyboard	Image only
Desk Chair	Image only
Books	Story only
Squash Racket	Story only
Glasses	Story only
Computer mouse	Neither image nor story
Pens	Neither image nor story
Puzzles	Neither image nor story
Shoes	Neither image nor story

E. Eyewitness Memory

E.1 Slides

Figure E.1.1 *Slide one.* The to-be victim approaches the location of the crime.

Figure E.1.2 *Slide two.* The to-be victim attempts to pass by the assailants.

Figure E.10.3 *Slide three.* The assailants blockade the path of the victim.

Figure E.0.4 *Slide four.* The main assailant attempts to deprive the victim of her handbag. The handbag is clearly displayed.

Figure E.1.5 *Slide five.* The main assailant threatens the victim with a knife. The assailant's apparel is clearly displayed, particularly the hooded top and baseball cap.

Figure E.0.6 *Slide six.* The victim leaves the scene of the robbery while the assailants berate her.

APPENDIX E

E.2 Questions

Table E.2.1

The provision of correct answers in the second section of the eye-witness testimony task.

Question number	Correct answer	Availability
One	Blue	Not Available
Two	Black	Available
Three	Four	Available
Four	Hunting Knife	Not Available
Five	Three	Not Available
Six	Brown	Not Available
Seven	Cloudy	Available
Eight	One	Available
Nine	Red	Available
Ten	Car	Not Available

Note: To avoid confusion, the baseball cap in question seven was treated as red rather than orange and the option "orange" was not provided.

Table E.2.2

The questions and options presented as part two of the eye-witness testimony task.

Question 1:	What colour of top was the main assailant wearing?	
Options:	Yellow	Black
	Brown	Red
Question 2:	What colour pants were worn by the victim?	
Options:	Blue	Black
	Beige	Brown

Question 3:	How many individuals stopped the victim?	
Options:	One	Two
	Three	Four
Question 4:	What type of weapon was the main assailant using?	
Options:	Large Kitchen Knife	Pistol
	Small Steak Knife	Taser
Question 5:	How many of the assailants were wearing hoodies?	
Options:	All	One
	Two	None
Question 6:	What colour was the handbag that was stolen?	
Options:	White	Black
	Purple	Blue
Question 7:	What condition was the weather?	
Options:	Clear	Cloudy
	Raining	Frosty
Question 8:	How many of the assailants were wearing backpacks?	
Options:	None	One
	Two	All
Question 9:	What colour baseball cap was the main assailant wearing?	
Options:	Blue	Red
	Black	Yellow
Question 10:	Which of these features was not in the background?	
Options:	Rubbish Bin	Lake
	Houses	Pigeon

Note: Items in bold were replaced with the correct answer for section three.

F. Letter-Number Sequencing

Table F.1

WAIS-III letter-number sequencing sequences and answers.

Provided String	Correct Answer	Acceptable Answer
L-2	2-L	L-7
6-P	6-P	P-6
B-5	5-B	B-5
F-7-L	7-F-L	F-L-7
R-4-D	4-D-R	D-R-4
H-1-8	1-8-H	H-1-8
T-9-A-3	3-9-A-T	A-T-3-9
V-1-J-5	1-5-J-V	J-V-1-5
7-N-4-L	4-7-L-N	L-N-4-7
8-D-6-G-1	1-6-8-D-G	D-G-1-6-8
K-2-C-7-S	2-7-C-K-S	C-K-S-2-7
5-P-3-Y-9	3-5-9-P-Y	P-Y-3-5-9
M-4-E-7-Q-2	2-4-7-E-M-Q	E-M-Q-2-4-7
W-8-H-5-F-3	3-5-8-F-H-W	F-H-W-3-5-8
6-G-9-A-2-S	2-6-9-A-G-S	A-G-S-2-6-9
R-3-B-4-Z-1-C	1-3-4-B-C-R-Z	B-C-R-Z-1-3-4
5-T-9-J-2-X-7	2-5-7-9-J-T-X	2-5-7-9-J-T-Z
E-1-H-8-R-4-D	1-4-8-D-E-H-R	D-E-H-R-1-4-8
5-H-9-S-2-N-6-A	2-5-6-9-A-H-N-S	A-H-N-S-2-5-6-9
D-1-R-9-B-4-K-3	1-3-4-9-B-D-K-R	B-D-K-R-1-3-4-9
7-M-2-T-6-F-1-Z	1-2-6-7-F-M-T-Z	1-2-6-7-F-M-T-Z

G.Wonderlic Quick-Test

Figure G.1

Example questions for the WPT-Q.

Question 1:	Assume the first 2 statements are true. Is the final one: true, false, or not certain? The boy plays baseball. All baseball players wear hats. The boy wears a hat.		
Options:	True	False	Not certain
Question 2:	Paper sells for 21 cents per pad. What will 4 pads cost?		
Options:	Free answer		
Question 3:	How many of the five pairs of items listed below are exact duplicates?		
	Nieman, K.M.	Neiman, K.M.	
	Thomas, G.K.	Thomas, C.K.	
	Hoff, J.P.	Hoff, J.P.	
	Pino, L.R.	Pina, L.R.	
	Warner, T.S.	Wanner, T.S.	
Options:	Free answer		
Question 4:	PRESERVE RESERVE - Do these words have similar meanings, contradictory meanings, or mean neither the same nor opposite?		
Options:	1) have similar meanings	2) have contradictory meanings	
	3) mean neither the same nor opposite.		
Question 5:	A train travels 20 feet in 1/5 second. At this same speed, how many feet will it travel in three seconds?		
Options:	Free answer		

APPENDIX E

Question 6:	When rope is selling at $0.10 a foot, how many feet can you buy for sixty cents?
Options:	Free answer
Question 7:	The ninth month of the year is:
Options:	1) October 2) January 3) June 4) September 5) May
Question 8:	Which number in the following group of numbers represents the smallest amount?
Options:	7 0.8 31 0.33 2
Question 9:	In printing an article of 48,000 words, a printer decides to use two sizes of type. Using the larger type, a printed page contains 1,800 words. Using smaller type, a page contains 2,400 words. The article is allotted 21 full pages in a magazine. How many pages must be in smaller type?
Options:	Free answer
Question 10:	Three individuals form a partnership and agree to divide the profits equally. X invests $9,000, Y invests $7,000, and Z invests $4,000. If the profits are $4,800, how much less does X receive than if the profits were divided in proportion to the amount invested?
Options:	Free answer
Question 11:	Assume the first two statements are true. Is the final one true, false, or not certain? Tom greeted Beth. Beth greeted Dawn. Tom did not greet Dawn.
Options:	True False Not certain
Question 12:	A boy is 17 years old and his sister is twice as old. When the boy is 23 years old, what will be the age of his sister?

Options: Free answer
