



CREATE

Canterbury Research and Theses Environment

Canterbury Christ Church University's repository of research outputs

<http://create.canterbury.ac.uk>

Copyright © and Moral Rights for this thesis are retained by the author and/or other copyright owners. A copy can be downloaded for personal non-commercial research or study, without prior permission or charge. This thesis cannot be reproduced or quoted extensively from without first obtaining permission in writing from the copyright holder/s. The content must not be changed in any way or sold commercially in any format or medium without the formal permission of the copyright holders.

When referring to this work, full bibliographic details including the author, title, awarding institution and date of the thesis must be given e.g. Reeves, S. (2015) Exploring the effect of subliminal single-word and multiple-word primes on working memory performance. Ph.D. thesis, Canterbury Christ Church University.

Contact: create.library@canterbury.ac.uk



**EXPLORING THE EFFECT OF SUBLIMINAL SINGLE-WORD AND
MULTIPLE-WORD PRIMES ON WORKING MEMORY PERFORMANCE**

by

Samantha Sarah Reeves

Canterbury Christ Church University

**Thesis submitted
for the Degree of Doctor of Philosophy**

2015

I hereby declare that this thesis has not been submitted, either in the same or different form, to this or any other University for a degree.

Signature:

Abstract

This PhD thesis focused on subliminal priming, that is, the presentation of information below conscious awareness (Vernon, 2009), which has been shown to influence both cognitive and affective behaviours. Information can be presented subliminally using both ‘Single-Word’ and ‘Multiple-Word’ written primes, although the two prime types have not yet been compared. Currently there is no reported optimal procedure for the presentation of subliminal stimuli, thus such a comparison could guide future research concerning prime choice. Hence, this thesis empirically compared the effects produced by Single-Word and Multiple-Word primes in a series of experiments. In Experiment 1 96 participants were subliminally stimulated with one of six alternative primes, three Single-Word primes (*cognitive*: intelligent; *affective*: one; *neutral-control*: walking), and three Multiple-Word primes (*cognitive*: I am intelligent; *affective*: mommy and I are one; *neutral-control*: people are walking), and their performance measured on a range of cognitive (e.g., working memory, intelligence, selective attention) and affective (e.g., mood and state anxiety) tasks. Results of Experiment 1 showed no clear change in participants’ intelligence, selective attention, mood, or state anxiety. However, post hoc analysis found participants’ significantly improved their working memory performance following exposure to all positive (e.g., cognitive and affective) subliminal primes, regardless of prime type (i.e., Single-Word and Multiple-Word). Experiment 2 followed this up by exploring the effect of subliminal priming on working memory performance. Sixty participants were primed with one of the six subliminal stimuli to assess whether the non-differential effect between prime types found in Experiment 1 was due to the varied length of time between the end of subliminal exposure and the onset of the task. Results found all participants’ performance

improved regardless of prime type and prime content and thus was concluded to reflect a practice effect. Experiment 3 considered that the absence of any subliminal priming may have been due to participants' potential lack of motivation to attain the goal of improving working memory. Hence, 106 participants were primed with one of the six subliminal stimuli and their motivation to achieve this goal was enhanced using false-positive feedback on performance and reading a false article extract highlighting the benefit of a good working memory. Results found, despite increased motivation to improve working memory, that subliminal priming did not have any effect on performance. Experiment 4 considered whether the specific content of the subliminal stimuli, the short prime-target stimulus onset asynchrony (SOA), or the type of task could be accountable for the null results. Thus, in addition to enhancing participant motivation, the content of the stimuli were refined to become more task-relevant, the prime-target SOA was extended from 14ms to 514ms to allow more time for unconscious processing. Eighty-three participants were primed with one of four subliminal stimuli; two Single-Word primes (*memory-specific*: remember; *neutral-control*: walking) and two Multiple-Word primes (*memory-specific*: I can remember well; *neutral-control*: people are walking), and performance was measured using two working memory tasks. Results found all participants' performance improved on both working memory tasks regardless of prime type and prime content and was concluded to reflect a practice effect. Finally, a meta-analysis conducted on the data from the Conceptual Span Task from all four experiments confirmed an improvement on performance over time but no evidence of any subliminal priming effects. Overall, this thesis found it was not possible to establish a difference between the two prime types, although findings indicate that subliminal priming may not be able to improve performance of the phonological loop component of working memory.

Acknowledgements

Looking back on this journey I feel proud of the progression that I have made and whilst I have worked hard, I have not done this alone. I have been extraordinarily lucky to have such a fantastic supportive network around me and a part of this thesis is owed to each and every one of you!

Firstly, a HUGE thank-you to my supervisor Dr. David Vernon for his continued support and guidance, which has helped me reach this goal and develop my skills as a researcher. Thanks also to my supervisory panel Dr. Shane Blackman and Dr. Ian Wellard for all of the encouragement and support given. I would also like to thank Dr. Ian Hocking and Dr. Lea Hald for their helpful feedback, and to the members of the CCCU psychology department for their words of wisdom and work opportunities. Thanks also goes to Emily Withycombe without whom I am certain the AOSPAN task would not have worked and Professor Zoltan Dienes for his guidance on Bayes Factor Analysis (I've not forgotten the deal: four pints and a sub!).

I would like to thank the Graduate School for providing me with the scholarship to do this PhD, and in particular, to Julia Graviel for all her kindness and help with various academic and personal matters. Also, to each participant that gave up their time to contribute to this research - it certainly would not have been possible without you!

I count myself lucky to have such amazing friends that cheer me up both in and outside of University. Firstly, thank you to my fellow PhDers, Tammy, Caroline, and Mark, all of whom have provided invaluable advice, help, hot chocolates, and laughter! Secondly, thanks to my wonderful friends for your continued interest in my research and the happy distraction that you bring but a special thanks to Rose, Jenni, Jo, Ben, Carrie, and Sophie, all of which have been particularly wonderful.

Finally, thanks to my all my family for bearing with me! To Laura and Tim, whose support and encouragement has and always will be appreciated. To my brother Mike, sister-in-law Bev and favourite small people, Joshua and Isabella – it has been a genuine joy to watch your family grow and give me a reason to take time out to relax and play! To my mum, Therese and dad, Ray, there simply are no better parents. You have supported me in every possible way and I cannot thank you enough for everything that you have done for me. To Maisie, because there is a lot to be said for a small fluffy sounding board! And finally, to my fiancé Joe for sticking by me every step of the way! For the cuddles after the lousy days and celebrating every small triumph with me - I could not have asked for anyone better to share this experience with.

Contents

Chapter One: Synopsis	1
1.1 Research Overview	1
1.2 Scope of Present Thesis	9
1.3 Rationale for Experimental Approach	11
1.4 Summary	12
Chapter Two: Literature Review	13
2.1 Subliminal Presentation	13
2.2 Subjective and Objective Threshold	14
2.2.1 Measuring Conscious Awareness	17
2.3 Subliminal Presentation Formats	19
2.3.1 Auditory Subliminal Stimuli	19
2.3.2 Visual-Pictorial Subliminal Stimuli	22
2.3.3 Visual-Written Subliminal Stimuli	26
2.3.3.1 Mode of Stimulus Presentation	26
2.3.3.2 Stimulus Presentation Placement	28
2.3.3.3 Stimulus Exposure Duration	29
2.3.3.4 Number of Stimulus Repetitions	32
2.3.3.5 Traditional Masking Technique	34
2.3.3.5.1 Potential Issues with Traditional Backward Masking Techniques	37
2.3.3.6 Stimulus Aesthetics	39
2.3.3.6.1 Stimulus Typeface	39
2.3.3.6.2 Stimulus Typestyle and Font	41
2.3.3.6.3 Stimulus Point Size	42

2.4 Behavioural Effects of Single-Word and Multiple-Word Subliminal Primes	43
2.4.1 Single-Word Primes	43
2.4.2 Multiple-Word Primes	45
2.5 Theoretical Accounts for Behavioural Change	48
2.5.1 Subliminal Psychodynamic Activation Theory	49
2.5.2 Automaticity Theory	54
2.5.3 Goal-Directed Behaviour Theory	59
2.6 Chapter Summary	63
Chapter Three: General Method, Data Preparation and Analysis	65
3.1 Participants	65
3.1.1 Recruitment	65
3.1.2 Incentives	66
3.1.3 Allocation to Subliminal Stimulus Group	67
3.2 Materials	67
3.2.1 The Subliminal Stimuli	67
3.2.2 Presentation of Stimuli	70
3.2.3 Equipment	72
3.2.4 Subliminal Threshold Checks	72
3.2.5 Experiment Tasks	73
3.2.5.1 Conceptual Span Task (CST)	73
3.2.5.2 Lexical Decision Task (LDT)	74
3.3 Procedure	75
3.3.1 Conceptual Span Task (CST)	75
3.3.2 Lexical Decision Task (LDT)	76

3.4 Design	77
3.5 Data Preparation and Analysis	77
3.5.1 Data Preparation - Outliers	79
3.5.2 Data Preparation - Test of Assumptions	79
3.5.2.1 Data Preparation - Independence	80
3.5.2.2 Data Preparation - Homogeneity of Variance	80
3.5.2.3 Data Preparation - Normality	80
3.5.3 Data Analysis	81
3.5.3.1 Inferential Statistics	81
3.5.3.1.1 Post hoc Tests	81
Chapter Four: Experiment 1 – Which is Best, Single-Word or	83
Multiple-Word Primes? Comparing Subliminal Prime Type on Affect	
and Cognition	
Introduction	83
Method	99
Participants	99
Materials	100
4.1 Stroop Colour-Naming Task	100
4.2 General Knowledge Test	101
4.3 Short Version-Profile of Mood States (SV-POMS)	103
4.4 State Anxiety Scale (SAS)	103
Procedure	104
Design	109
Results	109
4.5 Conceptual Span Task (CST)	110

4.5.1 CST Accuracy	110
4.5.2 CST Intrusions	113
4.6 Stroop Colour-Naming Task	114
4.6.1 Congruent Response Times	114
4.6.2 Congruent Errors	115
4.6.3 Incongruent Response Times	117
4.6.4 Incongruent Errors	120
4.6.5 Neutral Response Times	121
4.6.6 Neutral Errors	122
4.7 General Knowledge Test	124
4.8 Short Version-Profile of Mood States (SV-POMS)	127
4.8.1 Tension-Anxiety (TA)	127
4.8.2 Depression-Dejection (DD)	129
4.8.3 Anger-Hostility (AH)	130
4.8.4 Fatigue-Inertia (FI)	132
4.8.5 Vigour-Activity (VA)	133
4.8.6 Confusion-Bewilderment (CB)	134
4.9 State Anxiety Scale (SAS)	135
4.10 Threshold Testing	136
Discussion	138
Chapter Five: Experiment 2 – Comparing the Immediate Effect of	154
Subliminal Single-Word and Multiple-Word Primes on Semantic	
Working Memory	
Introduction	154
Method	159

Participants	159
Materials	159
Procedure	160
Design	161
Results	163
5.1 Conceptual Span Task (CST)	163
5.1.1 CST Accuracy	163
5.1.1.1 Bayes Factor Analysis	164
5.1.2 CST Intrusions	168
5.2. Threshold Testing	169
Discussion	170
Chapter Six: Experiment 3 – Comparing Subliminal Single-Word and	175
Multiple-Word Primes on Semantic Working Memory Performance:	
Are Subliminal Primes Mediated By Motivation?	
Introduction	175
Method	181
Participants	181
Materials	181
6.1 Pilot Testing	182
6.1.1 Pilot Survey	182
6.1.2 Pilot Tests	184
Procedure	186
Design	189
Results	191
6.2 Motivation	191

6.2.1 Effort Percentage	191
6.3 Conceptual Span Task (CST)	193
6.3.1 CST Accuracy	193
6.3.1.1 Bayes Factor Analysis	195
6.3.2 CST Intrusions	196
6.4 Threshold Testing	197
Discussion	199
Chapter Seven: Experiment 4 – Comparing Memory-Specific	206
Subliminal Single-Word and Multiple-Word Primes on Working	
Memory Performance	
Introduction	206
Method	215
Participants	215
7.1 Allocation to Subliminal Stimulus Group	216
Materials	216
7.2 Automated Operation Span Task (AOSPAN)	216
7.3 Lexical Decision Task (LDT)	220
Procedure	224
Design	228
Results	228
7.4 Motivation	229
7.4.1 Effort Percentage	229
7.5 Conceptual Span Task (CST)	231
7.5.1 CST Accuracy	231
7.5.1.1 Bayes Factor Analysis	232

7.5.2 CST Intrusions	234
7.5.3 Meta-Analysis of the Conceptual Span Task	235
Accuracy Data	
7.5.3.1 Bayes Factor Analysis	237
7.6 Automated Operation Span (AOSPAN)	238
7.6.1 Absolute AOSPAN Score	239
7.6.1.1 Bayes Factor Analysis	240
7.6.2 AOSPAN Serial Recall Accuracy	242
7.6.2.1 Bayes Factor Analysis	243
7.6.3 AOSPAN Operation Errors	245
7.7 Threshold Testing	246
Discussion	248
Chapter Eight: General Discussion	261
8.1 Thesis Aim and Rationale	261
8.2 Experimental Aims, Methods and Results	263
8.2.1 Experiment 1	263
8.2.2 Experiment 2	265
8.2.3 Experiment 3	267
8.2.4 Experiment 4	268
8.3 General Discussion of Experimental Findings	271
8.4 Theoretical Implications	281
8.4.1 Subliminal Psychodynamic Activation Theory	281
8.4.2 Automaticity Theory	285
8.4.3 Goal-Directed Behaviour Theory	288
8.5 Directions for Future Research	291

8.6 Discussion Summary	298
8.7 Final Concluding Remarks	300
References	301
Appendix A Consent Form	353
Appendix B Screening Form	354
Appendix C Conceptual Span Task (CST) Response Sheet A	355
Appendix D Conceptual Span Task (CST) Response Sheet B	356
Appendix E Short Version-Profile of Mood States (SV-POMS)	357
Appendix F The State Anxiety scale (SAS)	361
Appendix G General Knowledge Test A	362
Appendix H General Knowledge Test B	363
Appendix I Experiment 1 Participant Information Sheet	364
Appendix J Experiment 1 Debrief Funnel-Style Questionnaire	365
Appendix K Experiment 2 Participant Information Sheet	368
Appendix L Experiment 2 and 3 Debrief Funnel-Style Questionnaire	369
Appendix M False Article Extract	371
Appendix N Motivation and Memory Questionnaire Pilot Survey	372
Appendix O Experiment 3 Participant Information Sheet	378
Appendix P Motivation and Memory Questionnaire (Time 1: Baseline)	379
Appendix Q Motivation and Memory Questionnaire (Time 2: Post- Enhancement)	382
Appendix R Motivation and Memory Questionnaire (Time 3: Final)	384
Appendix S Experiment 4 Participant Information Sheet	386
Appendix T Experiment 4 Debrief Funnel-Style Questionnaire	387

List of Tables

Chapter 4

Table 1.	The Hypotheses Tested in Experiment 1	99
Table 2.	Mean and SD Scores for CST Accuracy at Time 1 and Time 2	110
Table 3.	Mean and SD Scores for CST Intrusions at Time 1 and Time 2	113
Table 4.	Mean and SD Scores for Stroop Congruent Word Response Times at Time 1 and Time 2	115
Table 5.	Mean and SD Scores for Stroop Congruent Word Errors at Time 1 and Time 2	116
Table 6.	Mean and SD Scores for Stroop Incongruent Word Response Times at Time 1 and Time 2	117
Table 7.	Mean and SD Scores for Stroop Incongruent Word Errors at Time 1 and Time 2	120
Table 8.	Mean and SD Scores for Stroop Neutral Word Response Times at Time 1 and Time 2	122
Table 9.	Mean and SD Scores for Stroop Neutral Errors at Time 1 and Time 2	123
Table 10.	Mean and SD Scores for General Knowledge Accuracy at Time 1 and Time 2	124
Table 11.	Mean and SD Scores for Tension-Anxiety at Time 1 and Time 2	127
Table 12.	Mean and SD Scores for Depression-Dejection at Time 1 and Time 2	130

Table 13.	Mean and SD Scores for Anger-Hostility at Time 1 and Time 2	131
Table 14.	Mean and SD Scores for Fatigue-Inertia at Time 1 and Time 2	132
Table 15.	Mean and SD Scores for Vigour-Activity at Time 1 and Time 2	133
Table 16.	Mean and SD Scores for Confusion-Bewilderment at Time 1 and Time 2	135
Table 17.	Mean and SD Scores for State Anxiety at Time 1 and Time 2	136
 Chapter 5		
Table 18.	Mean Number of Words Correctly Recalled on the CST When Taken Immediately After the LDT and After a Delay for Participants Receiving Single-Word Compared to Multiple-Word Primes	155
Table 19.	The Hypotheses Tested in Experiment 2	159
Table 20.	Mean and SD Scores for CST Accuracy at Time 1 and Time 2	164
Table 21.	Mean and SD Scores for CST Intrusions at Time 1 and Time 2	168
Table 22.	The Minimum, Maximum and Range for the Number of Words Recalled on the CST Collapsed Across Time	171

Chapter 6

Table 23.	The Hypotheses Tested in Experiment 3	180
Table 24.	Mean and SD Scores for the Percentage of Effort (Motivation) at Time 1, Time 2 and Time 3	192
Table 25.	Mean and SD Scores for CST Accuracy at Time 1 and Time 2	194
Table 26.	Mean and SD Scores for CST Intrusions at Time 1 and Time 2	197

Chapter 7

Table 27.	The Hypotheses Tested in Experiment 4	215
Table 28.	Mean and SD Scores for the Percentage of Effort (Motivation) at Time 1, Time 2 and Time 3	229
Table 29.	Mean and SD Scores for CST Accuracy at Time 1 and Time 2	231
Table 30.	Mean and SD Scores for CST Intrusions at Time 1 and Time 2	234
Table 31.	Mean and SD Scores for CST Accuracy at Time 1 and Time 2 from all Four Experiments	236
Table 32.	Mean and SD Scores for the Absolute AOSPAN Score at Time 1 and Time 2	239
Table 33.	Mean and SD Scores for AOSPAN Serial Recall Accuracy at Time 1 and Time 2	242
Table 34.	Mean and SD Scores for AOSPAN Operation Errors at Time 1 and Time 2	245

Table 35.	The Minimum, Maximum and Range for the Number of Incorrectly Recalled Words on the CST and Number of Operation Errors on the AOSPAN Task Collapsed Across Time	250
-----------	---	-----

List of Figures

Chapter 2

- Figure 1. Schematic of a subliminal prime sandwiched between a forward and backward mask. Masks, prime and target examples from Eckstein et al. (2011) 35

Chapter 3

- Figure 2. Trial procedure for the conceptual span task 77
- Figure 3. Trial procedure for the lexical decision task 78

Chapter 4

- Figure 4. Trial procedure for the Stroop Colour-Naming Task 102
- Figure 5. Schematic of the procedure used in Experiment 1 108
- Figure 6. Showing increased mean word recall (with standard errors) on the CST from Time 1 to Time 2 for participants exposed to the Cognitive and Affective subliminal stimuli but not the Neutral stimuli. 111
- Figure 7. Showing decreased mean response times (with standard errors) in ms from Time 1 to Time 2 on the Stroop Colour-Naming Task for incongruently coloured words for all participants receiving subliminal Single-Word primes 118
- Figure 8. Showing decreased mean response times (and standard errors) in ms from Time 1 to Time 2 on the Stroop Colour-Naming Task for incongruently coloured words 119

	for all participants receiving subliminal Multiple-Word primes	
Figure 9.	Showing the change in mean General Knowledge accuracy test scores (with standard errors) following subliminal exposure to Single-Word primes	125
Figure 10.	Showing the change in mean General Knowledge test accuracy scores (with standard errors) for participants receiving the Multiple-Word Primes	125
Figure 11.	Showing mean TA scores (with standard errors) from Time 1 to Time 2 for the three Cognitive, Affective and Neutral subliminal stimuli groups	128
 Chapter 5		
Figure 12.	A schematic of the procedure used in Experiment 2	162
 Chapter 6		
Figure 13	A schematic of the procedure used in Experiment 3	190
Figure 14.	Showing the increase in mean percentage of effort (with standard errors) from Time 1 to Time 3	193
 Chapter 7		
Figure 15.	Trial procedure of the Automatic Operation Span main task	221
Figure 16.	Trial procedure of the Lexical Decision Task used in Experiment 4	223

Figure 17.	A schematic of the procedure used in Experiment 4	227
Figure 18.	Showing the change in mean percentage of effort (with standard errors) from Time 1 to Time 3	230
Chapter 8		
Figure 19.	An example of subliminal priming using the grey-scale colour contrasting technique. The image on the left is an example of a supraliminal prime and background contrast and the image on the right represents a subliminal prime and background contrast. Examples from Armstrong and Dienes (2013, Experiment 4)	296
Figure 20.	An example of subliminal priming using the continuous flash suppression technique. To the left eye the subliminal primes are gradually increased in contrast and to the right eye, colourful images are continually changed. Examples from Sklar et al. (2012, Experiment 1-2)	297

Chapter One: Synopsis

The aim of this synopsis is to provide an overview of the research conducted as part of this thesis. Firstly, there is a brief introduction to the area of research leading to the key empirical question this thesis aimed to address. This includes an outline of each of the four experiments and their rationale along with a brief indication of the results found and considerations for the cause of these findings. Secondly, the scope of this thesis will be outlined, whereby the theoretical underpinning of this research will be presented and finally, the rationale for the empirical approach adopted for this research will be outlined.

1.1 Research Overview

Research into the effects of presenting information subliminally i.e., without the awareness of the receiver, has been continuous since the turn of the 19th century (Urban, 1992). Subliminal presentation involves presenting information below the receiver's threshold of conscious awareness using for example, extremely fast exposure durations. There are three main techniques that can be used to present information subliminally: audio messages, visual pictures, and written words. Of the three techniques, audio self-help messages tend not to be very successful (see Merikle, 1988; Moore, 1995) and although subliminal presentation of visual pictures, such as isolated facial expressions, has had widespread success, their use is generally within emotion-based research (de Gelder et al., 2006; Tamietto & de Gelder, 2010) and they have not tended to be used to elicit improvements in cognition. The final technique, the presentation of written words, can be performed using one of two prime types, 'Single-Word' primes and 'Multiple-Word' primes.

Research has tended to focus on the presentation of Single-Word subliminal primes as early work suggested non-conscious processing of more than one word was not possible (e.g.,

Draine, 1997; Greenwald, 1992; Greenwald & Liu, 1985). However, more recent research has reported successful non-conscious processing of Multiple-Word stimuli (Armstrong & Dienes, 2013, 2014; Sklar et al., 2012). Although both Single-Word and Multiple-Word primes have now both been shown to be successfully processed without conscious awareness, no comparison of the effectiveness of these two types of subliminal written stimuli has yet been conducted. Hence, the aim of this thesis was to empirically address this issue by comparing the two subliminal written word prime types, Single-Word primes and Multiple-Word primes, to ascertain which elicits the most robust behavioural change (Experiments 1-4).

Specifically, Experiment 1 addressed this by comparing the difference between the two written prime types on both cognitive and affective measures. Past research has demonstrated that subliminally presented Single-Word primes have produced measureable changes across a range of cognitive and affective behaviours. This includes increased intelligence (Lowery, Eisenberger, Hardin, & Sinclair, 2007), memory (Mitchell, Macrae, Schooler, Rowe, & Milne, 2002), and self-esteem (Dijksterhuis, 2004; Riketta & Dauenheimer, 2003). Multiple-Word primes have produced similar effects across a variety of cognitive and affective behaviours. For example, research has reported improved intelligence (Ariam & Siller, 1982; Parker, 1982), improved positive mood (Weinberger, Kelner, & McClelland, 1997), and reduced state anxiety (Orbach, Shopen-Kofman, & Mikulincer, 1994). As such, it is clear that both types of subliminal stimuli are able to elicit positive changes in cognition and affect. Hence, the current research adds to the subliminal literature by directly comparing the effectiveness of subliminal Single-Word primes to that of Multiple-Word primes on both cognitive measures (e.g., intelligence, semantic working memory, and selective attention) and affective (e.g., mood and state-anxiety), to assess which type elicits the most robust effect (Experiment 1). Furthermore, Experiment 1 assessed

whether such subliminal primes were able to elicit change across both cognitive and affective measures or whether they were limited to inducing change only in their congruent cognitive or affective measures.

Within the Single-Word prime research, changes in behaviour are attributed to the specific content of the prime word that is congruent with the intended behaviour to be influenced. For example, a positive increase in exam performance was achieved using subliminal presentation of intelligence-based words e.g., ‘intelligent’ and ‘genius’ (Lowery et al., 2007) whereas, the positive enhancement of self-esteem was achieved through the subliminal presentation of positive words such as ‘beautiful’ and ‘sunshine’ (Dijksterhuis, 2004). Therefore, whilst Single-Word prime research has shown positive changes across a number of different measures, there has not been one specific word reportedly capable of eliciting a variety of cognitive *and* affective behaviours, unlike the Multiple-Word prime ‘mommy and I are one’. In Multiple-Word prime research, the affective-based subliminally presented phrase ‘mommy and I are one’ has been reported to influence a range of both cognitive and affective behaviours. This achievement is explained through its direct impact on the reduction of state-anxiety (Hardaway, 1990) and positive influence on mood (Hardaway, 1990; Weinberger, 1992), which are thought to have a mediating effect on other behaviours such as academic success (Ariam & Siller, 1982). Therefore, Experiment 1 compared subliminal stimuli that aim to differentially target either cognitive or affective behaviours within each prime type i.e., three Single-Word primes and three Multiple-Word primes on all measures. The content of the subliminal stimuli was therefore directed at ‘cognition’ (e.g., intelligent; I am intelligent), ‘affect’ (e.g., one; mommy and I are one), or ‘neutral-control’ (e.g., walking; people are walking). The effects of the three stimuli within each prime type was compared on both cognitive and affective measures to understand whether cognitive-based and affective-based stimuli are capable of eliciting any change in

their congruent measures (e.g., cognitive and affective measures respectively) as well as in their incongruent measures (e.g., affective and cognitive respectively) whereas the neutral-control Single-Word and Multiple-Word primes were expected to produce no change in behaviour.

Results of Experiment 1 found no clear changes in participant mood, state anxiety, selective attention, or intelligence, however, a marginal interaction was found for semantic working memory performance. Analysis of the interaction indicated that exposure to both prime contents, that is cognitive and affective, in both prime types, Single-Word and Multiple-Word primes, led to improved semantic working memory performance compared to neutral-control stimuli. Data from Experiment 1 suggested that semantic working memory performance seemed more susceptible to the subliminal manipulation hence, Experiment 2 attempted to extend these findings by concentrating on the possible effects of subliminal stimulation on semantic working memory. Past research has only shown specific changes in memory performance following exposure to subliminal Single-Word primes (e.g., Levy, 1996; Mitchell et al., 2002) therefore, a positive increase in memory following the presentation of subliminal Multiple-Word primes represents a unique finding. However, it was surprising that the results from Experiment 1 showed both types of subliminal stimuli to positively influence memory performance yet no differential effect between prime types was evident. This may have been due to the varied amount of time following subliminal stimulation in Experiment 1.

Time is a factor thought to influence the potency of subliminal stimuli with some researchers suggesting the effects of subliminally presented stimuli to be extremely short lived (Greenwald, Draine, & Abrams, 1996) whilst others report longer-lived effects lasting several minutes (Zemack-Rugar, Bettman, & Fitzsimons, 2007), days (Lowery et al., 2007), or even weeks (Parker, 1982). Despite some examples of longer-lived changes in behaviour

following subliminal stimulation, the precise effect of time on the potency of either subliminal Single-Word or Multiple-Word primes is unknown. Due to the number of measures tested during Experiment 1 and the counter-balanced order of these measures, some participants were presented with the semantic working memory task immediately following the subliminal stimulation stage whereas others were presented with the semantic working memory task after a delay of up to 40-minutes. Therefore, any potential differential effect of subliminal prime type on semantic working memory may have been weakened or confounded due to this difference in time between subliminal stimulation and participants completing the semantic working memory test. As such, Experiment 2 compared both types of subliminal stimuli on working memory performance whilst controlling for the factor of 'time' by presenting the semantic working memory task immediately following subliminal stimulation in accordance with procedures used in the majority of past research (e.g., Dijksterhuis, 2004; Jraidt & Frasson, 2010; Orbach et al., 1994; Radel, Sarrazin, Legrain, & Gobancé, 2009; Sohlberg, Claesson, & Birgegård, 2003).

Results from Experiment 2 showed no significant change in participants' semantic working memory performance following subliminal stimulation and was unable to replicate the marginal effect achieved during Experiment 1. This lack of replication was postulated to be due to a possible deficiency in participants' motivation to achieve the goal of improving working memory. For instance, Strahan, Spencer, and Zanna (2002) highlighted the need to prime both a 'goal relevant cognition' and ensure that participants were 'motivated' to achieve that goal as instrumental in whether or not subliminal priming would be successful in changing behaviour. Strahan et al. (2002) reported that goal-relevant subliminally presented Single-Word primes related to drinking behaviour were ineffective unless the participant was motivated to quench their thirst. Equally, in situations where the participants were thirsty, subliminally presented neutral Single-Word primes did not produce the enhanced drinking

behaviour. Such research suggests that subliminally presented stimuli alone may not be strong enough to produce a change in behaviour unless there is motivation on the part of the participant to act in accordance with the presented message. Therefore, Experiment 3 aimed to address this issue by subtly manipulating participants' motivation. Using an adapted (for working memory) version of Strahan et al.'s. (2002) procedure, participants' motivation to improve their working memory was measured prior to and after the motivation enhancement strategy. This strategy involved providing participants with I) false-positive feedback on their initial semantic working memory test performance and II) a false-positive article highlighting the benefits of working memory for students and their on-going careers. Strahan et al. (2002) only tested their theory using subliminally presented Single-Word primes thus Experiment 3 extended this to include Multiple-Word subliminal primes. Therefore, Experiment 3 builds on and extends the work carried out in Experiment 2 by comparing the effectiveness of subliminally presented Single-Word and Multiple-Word primes on semantic working memory whilst controlling for the factors of time and motivation.

Results of Experiment 3 found a significant increase in participants' motivation to improve their working memory performance following the motivation enhancement strategy. However, despite this increased motivation, no changes in semantic working memory were reported following subliminal stimulation. Reflecting on the procedure used to present the subliminal stimuli highlighted the possibility that this may have caused these non-significant results. For instance, measureable effects following subliminally presented stimuli have been discussed in past literature as 'elusive' (Greenwald et al., 1996), 'fragile' and 'hard to replicate' (Kouider & Dehaene, 2007) which may be due to the delicate balance of exposure duration, masking technique, and prime-target stimulus onset asynchrony (SOA) required when designing and presenting such stimuli. However, as yet, there is no reported agreed upon criteria for these three factors that is known to achieve consistent significant changes in

behaviour. Each of these factors has different reported ranges e.g., from extremely fast presentation speeds (e.g., 1 millisecond (ms), Mogg, Bradley, Williams, & Mathews, 1993) to far slower presentation speeds (e.g., 1,108.36ms, Sklar et al., 2012 Experiment 2), and different reported combinations of these factors throughout the literature of subliminal stimulation for example, slower presentation speed achieved through less conventional masking techniques (Armstrong & Dienes, 2013, 2014; Sklar et al., 2012) compared to faster presentation speeds via conventional backward masking techniques (see Dijksterhuis, 2004; Lowery et al., 2007; Wentura & Frings, 2005). The initial experiments (Experiments 1-3) employed the use of conventional backward masking techniques teamed with extremely short subliminal stimuli exposure durations, a combination previously reported as successful (Dijksterhuis, 2004; Pichon, Boccato, & Saroglou, 2007; Wentura & Frings, 2005). However, the prime-target SOA, which is the time between the onset of the subliminal stimuli and the onset of the target object (Van den Bussche, Van den Noortgate, & Reynvoet, 2009) remained brief.

Although several researchers advocate the requirement of short prime-target SOAs for successful subliminal priming to occur (Greenwald et al., 1996), the duration of what constitutes a short prime-target SOA varies within the literature. Some have reported effectiveness of subliminal priming using short prime-target SOA durations of 48ms (Radel et al., 2009) or longer prime-target SOA durations of 1020ms (Veltkamp, Aarts, & Custers, 2008). However, it should be noted that research specifically testing for differential effects of prime-target SOA on subliminal priming is most commonly tested on Single-Word subliminal primes rather than Multiple-Word primes. Additionally, the majority of past research has focused on testing within specific paradigms such as subliminal semantic and response priming paradigms rather than the effect of prime-target SOA in conjunction with behavioural changes following subliminal Single-Word or Multiple-Word priming.

Therefore, it is not fully understood whether longer prime-target SOAs are required to allow for more successful nonconscious processing of the stimuli to produce a measurable effect on following behavioural measures. Moreover, Sklar et al. (2012) advocate that subliminal processing has previously been limited due to the minimal time provided for nonconscious processing. Therefore, to understand whether the non-significant result following subliminal stimulation in Experiment 3 was due to the limited amount of time provided for nonconscious processing of the subliminal stimuli, an additional backward mask of 500ms was added (after; Aarts, Custers, & Holland, 2007; Dijksterhuis & Smith, 2002; Karremans, Stroebe, & Claus, 2006; Pichon et al., 2007) to extend the overall prime-target SOA duration from 14ms to 514ms.

Furthermore, the content of the subliminal stimuli were also considered to be a potentially contributing factor to the non-significant results reported in Experiments 2 and 3. The marginal improvement on semantic working memory during Experiment 1 initially indicated that the content of stimuli for both Single-Word and Multiple-Word primes was appropriate, although this finding has not since been replicated. As discussed by Strahan et al. (2002), researchers must ensure they are correctly priming the goal the participant is motivated to achieve, therefore the content of the previously 'general cognitive' based stimuli (i.e., intelligent; I am intelligent) were changed to prime a memory-specific goal (i.e., remember; I can remember well), whilst the affective-based stimuli were removed to improve the power of the statistical analysis. Furthermore, a second working memory task was added to examine whether subliminal priming was better able to improve performance on a less semantically orientated working memory task. Therefore, Experiment 4 compared the effects elicited by subliminal, memory-specific Single-Word primes and Multiple-Word primes on working memory performance measured using both the CST and Automated Operation Span Task (AOSPAN). Subliminal primes were presented at the same exposure duration as used

in Experiments 1, 2 and 3, and disguised using the traditional backward masking technique of a longer overall prime-target SOA duration (compared to Experiment 1-3) of 514ms akin to a similar combination reported as successful by Aarts et al. (2007); Dijksterhuis and Smith, (2002); Karremans et al. (2006); and Pichon et al. (2007). Results of Experiment 4 concerning the motivation manipulation replicated Experiment 3, whereby participants were significantly more motivated to improve their working memory performance. However, similarly to Experiment 3, no significant change in working memory performance was reported despite this increased motivation, longer unconscious processing time (prime-target SOA), and more specific stimuli content. Additionally, a meta-analysis was conducted on the Conceptual Span Task data from all four experiments to increase the power of the statistical analysis and further examine whether there was any evidence of subliminal priming. However, no significant change in semantic working memory performance was reported despite increased power. Results from Experiment 4 were considered to demonstrate the difficulty in improving the complex cognitions involved in phonological working memory.

1.2 Scope of the Present Thesis

The key objective of this thesis was to experimentally test for measurable changes in behaviour following subliminally presented information. In relation to this, three theoretical positions will be considered when interpreting results found. The first, subliminal psychodynamic activation theory, explains changes in behaviour following such Multiple-Word primes as ‘mommy and I are one’ through the soothing of internal symbiotic-like fantasies. That is, the notion of oneness with the “good mother of childhood” (Silverman & Weinberger, 1985, p.1297). However, consideration of this theory in relation to results found for affective-based stimuli (e.g., one, mommy and I are one) in this thesis will be interpreted in conjunction with Hardaway’s (1990) cognitive account of this psychodynamic theory

focusing on possible changes in mood and/or state variables in preference to psychodynamic theoretical accounts concerning suppressed internal wishes and fulfilment of fantasies as originally proposed for use with clinical samples (Hardaway, 1990). Second is the social-cognitive theory of automaticity (see Bargh, 2002; Bargh & Ferguson, 2000). This suggests that subliminally presented information automatically activates internal representations of behaviour related to stereotypes, traits, or concepts, and as such the behaviour is more likely to occur without the individual's conscious intent to do so. Bargh (2005) explained that the automatic activation of behaviour could occur if the intended behaviour, trait or concept is identified in the subliminal stimulus presented, and if the situation following subliminal presentation allows for the expected behaviour to emerge. Finally, goal-directed behaviour theory represents an extension to automaticity theory and suggests that pre-existing social and interpersonal goals may be automatically activated by subliminally presented information (Bargh, 1994; Bargh, 2005). Similarly, goal-directed behaviour may only occur following activation by subliminally presented information if the situation allows for the behaviour to emerge (Bargh, 2005; Bargh & Morsella, 2008). Goal-directed behaviour theory has more recently been refined to suggest that positive affect i.e., desirability of the goal (see Aarts, Custers, & Marien, 2008), or motivation to achieve the goal (see Strahan et al., 2002) may also be required to elicit the goal-directed behaviour.

Due to the research aim of presenting information subliminally (i.e., without the participants being consciously aware of the stimuli) a measure of awareness was conducted in all experiments. The measure of participants' awareness used in this research is in accordance with the social-cognitive paradigm of subliminal stimulation, whereby a mixture of self-report (subjective) and discrimination task (objective) measures were implemented and interpreted to confirm whether or not stimuli presented were indeed subliminal. If the results from this analysis indicated the stimuli were perceived by the participants then it can

be assumed that the information was *not* subliminal and therefore any effects reported could not be concluded as a result of nonconscious processing of information i.e., the subliminal manipulation will have failed. If however, participants report no awareness of the stimuli, then it can be concluded that they were indeed presented subliminally and any changes in behaviour can be discussed as a product of the unconsciously processed information.

1.3 Rationale for Experimental Approach

An experimental approach was adopted throughout this research to investigate the effects of subliminal stimuli on behaviour. Due to the complexity of measuring the effects of subliminally presented information, a purely experimental approach was deemed necessary for this research. The very nature of presenting information subliminally is to bypass the perceiver's conscious awareness of that information, therefore any qualitative experiences expressed by the participant would indicate that information had been consciously perceived and nullify the possibility that the information had been non-consciously processed. Thus, experimental procedures, as used in past social-cognitive subliminal research, were implemented in this research to ensure the nonconscious exposure to subliminal stimuli. Quantitative data were collected from participants, prior to exposure of any subliminal stimuli to provide a baseline measure, and later following subliminal stimulation. This approach allows for a clear comparison to be made between baseline scores and post-subliminal stimulation scores, highlighting any potential changes. More commonly in social-cognitive research, measures of the dependant variables are taken after subliminal stimulation only (e.g., Chartrand & Bargh, 1996; Dijksterhuis, 2004; Lowery et al., 2007; Radel et al., 2009; Riketta & Dauenheimer, 2003) and effectiveness of experimental stimuli are concluded via comparison between experimental and neutral stimuli. However, the use of pre-versus post-testing utilised in this research was considered to provide a more robust test. Whereby

changes in behaviour found following subliminal stimulation can be confidently concluded to be a product of the subliminal stimuli in light of the confirmation that no differential effects were apparent between groups (e.g., experimental versus neutral-control stimuli) prior to subliminal presentation.

1.4 Summary

In attempting to answer the empirical question, which of two written subliminal prime types, Single-Word or Multiple-Word primes elicits the most robust behavioural change, several factors considered to affect the success of subliminal priming were addressed. It has been previously reported that subliminal effects are difficult to replicate (Greenwald et al., 1996; Kouider & Dehaene, 2007) which is hampered in part by a lack of clarity concerning the specific subliminal priming procedures required to obtain consistent, significant effects. Several factors such as the timing of the behavioural measure, participant motivation and the goal-relevant content of subliminal stimuli, as well as exposure duration allowed for unconscious processing of subliminal stimuli were all addressed with the hope of informing future research on unsuccessful and conservative combinations of factors concerning the presentation speed of the stimuli, masking technique and prime-target SOA duration.

Chapter Two: Literature Review

This chapter begins by outlining what the term subliminal means, making reference to a participant's threshold level of conscious perception, in contrast to the term supraliminal. It then considers the differences between a subjective threshold and an objective threshold level and how these are thought to influence conclusions of conscious awareness of subliminally presented information. In addition, the importance of measuring conscious awareness is raised, and an account of two suitable methods that may be used to measure conscious awareness of subliminal stimuli will be outlined, i.e., individual threshold testing and funnel style questionnaires. This is followed by an exploration of the three different formats used for presenting subliminal information, i.e., auditory, visual-pictorial, and visual-written. Aspects relevant to subliminal audio and visual-pictorial techniques will be briefly outlined, whilst the visual-written technique will be examined in greater detail, as it is most pertinent to this research. This will include examination of the equipment required, placement of the stimulus on a screen, number of stimulus repetitions, stimulus aesthetics, and backward masking techniques. The chapter will then review the behavioural effects of both Single-Word and Multiple-Word written primes. Finally, the theoretical accounts of subliminal psychodynamic activation theory, automaticity theory, and goal-directed behaviour theory will each be discussed in turn.

2.1 Subliminal Presentation

Rudimentary studies such as the one conducted by Peirce and Jastrow (1884) assessed participants' non-conscious ability to detect differences between two stimuli, for instance in weight. They reported that participants could discriminate correctly (i.e., at an above chance level) on an average of 60% of trials whilst remaining unable to consciously detect the

difference in weight between the two stimuli. Rudimentary research such as this provides early evidence for the presence of unconscious processing. It has since been considered that subliminally presented information such as words, may also be unconsciously processed (Armstrong & Dienes, 2013, 2014; Greenwald & Liu, 1985; Marcel, 1983; Wickens, 1972). To present information subliminally is to present it below the receiver's threshold of conscious awareness (Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006; Vernon, 2009). In contrast, supraliminally presented information is where the information is clearly perceivable (Vernon, 2009). Subliminally presented information bypasses conscious awareness by being presented for a minimal duration (Bar & Biederman, 1998), or at a degraded quality (Druckman & Bjork, 1991). Importantly, Rouder and Morey (2009) suggest that a stimulus, however weakly presented, can still arouse unconscious activation and subsequently influence behaviour. For the purpose of this thesis, subliminal stimulation is defined as the use of subliminally presented information to produce behavioural change.

2.2 Subjective and Objective Threshold

The term threshold is used to distinguish between the perception of information presented subliminally and that presented supraliminally. Rather than a fixed point, Green and Swets (1966) have suggested that the threshold of conscious awareness is better represented by a continuum, whereby the sensory threshold of awareness varies from person to person. Furthermore, two different levels of threshold have been previously considered, i.e., the subjective and objective threshold levels. Conscious awareness of a subliminal stimulus at or above the subjective threshold is measured using introspective self-report measures. A participant can be considered to be subjectively unaware of a stimulus if they are unable to report seeing the subliminal stimulus or if they believe their performance (for example on a perceptual discrimination task), is at chance success due to the inefficiency of

their conscious perceptual experience in producing the correct answer (Merikle & Daneman, 1998). Alternatively, the objective threshold is often measured using behavioural discrimination tasks (Van den Bussche et al., 2009) to avoid the possible response bias that may occur in subjective awareness tests (Kunimoto, Miller, & Pashler, 2001). During such behavioural discrimination tasks, the participant is presented with a number of stimuli that could have been presented to them subliminally in the preceding trial, and their aim is to identify which of the selection was the one presented to them. For instance, Cheesman and Merikle (1986; see also Cheesman & Merikle, 1984) presented participants with one of four colour word primes (e.g., green, blue, yellow, orange) on each trial of the discrimination task and after each presentation asked participants to identify which of the four colour words was presented to them. To classify the participant as consciously unaware of the subliminal primes at the objective threshold, the participant must perform at not better than chance levels on such discrimination tasks.

Previously, Holender (1986a, 1986b, 1987) voiced concerns about the differences in measuring awareness of subliminal stimuli at the subjective versus objective threshold level. For instance, Holender (1986a, 1986b, 1987; see also Holender & Duscherer, 2004) noted that awareness at the subjective threshold is often measured retrospectively i.e., after a block of trials, in comparison to awareness at the objective threshold, which is often measured trial-by-trial. Hence, Kunimoto et al. (2001 Experiment 1) tested for possible differential effects between participants' subjective awareness to subliminally presented stimuli measured retrospectively after each block of trials using participants self-reported accuracy estimate, and after each individual trial using a high versus low confidence rating of their performance. The results indicated that conscious perceptual experience differentially occurred depending on how awareness was measured. When participants were asked to estimate their accuracy performance after each block of trials, participants tended to report their percentage correct to

be around chance success in comparison to confidence ratings after each individual trial that indicated far higher levels of confidence in answering correctly. Kunimoto et al. (2001) consider that response bias affected the participant's self-rated estimate of correct responses when reflecting back on their performance over the block of trials, as they may not have been certain about what they experienced, thus lowered their percentage estimate to reflect guessing. Such evidence reveals that simple subjective awareness reports provided after a block of trials might not be the most efficient way to examine conscious perceptual experience. Furthermore, Armstrong and Dienes (2013, see also Dienes, 2004) argue that unconscious processing at the objective threshold can be limited and that measurement of unconscious processing of subliminal stimuli at the subjective level should allow access to the full extent of unconscious processing as it is less conservative. Regardless of the differences between conscious awareness at the subjective compared to the objective threshold, Van den Bussche et al. (2009) stipulate the importance of ensuring that level of conscious awareness to subliminally presented stimuli *is* measured. An assessment of whether or not participants were aware of the subliminally presented information is important as it will affect the conclusions that can be made concerning the effectiveness of the subliminal primes. For example, the conclusion of successful unconscious processing of subliminally presented information could be made following clear behavioural changes reported post subliminal stimulation. However, if no measure of conscious awareness of the subliminally presented information is taken then it is not clear whether or not the participant's change in behaviour occurred due to conscious processing of the information. As such, it is important for measures of conscious awareness to be taken to ensure that conclusions drawn correctly reflect the results of the experiment.

2.2.1 Measuring Conscious Awareness

Although conscious awareness of subliminally presented stimuli was commonly measured using basic introspective reports in early research examining unconscious processing (i.e., a minimal question of awareness), such basic introspective reports are not often relied upon in contemporary research (Kunimoto et al., 2001; Merikle & Daneman, 1998) as they simply rely upon the participant's truthful admission of their awareness to subliminally presented information. As such, reports of unconscious processing following basic introspective reports are met with scepticism (Kunimoto et al., 2001; Van den Bussche, et al., 2009) because the criterion they used when reporting awareness is unknown. Contemporary research now aims to measure conscious awareness of subliminally presented stimuli through more stringent methods of subjective awareness testing such as individual threshold testing completed for example, using confidence ratings (Armstrong & Dienes, 2013, 2014; Birgegård, 2003; Sohlberg et al., 2003; Sohlberg, Samuelberg, Sidén, & Thörn, 1998) or through the use of a funnel-styled questionnaire post experiment (Aarts et al., 2005; Aarts et al., 2007; Chartrand & Bargh, 1996; Custers & Aarts, 2005, 2007; Dijksterhuis, 2004; Dijksterhuis & Smith, 2002).

Individual threshold testing can occur prior to the presentation of any subliminal stimulus, thus allowing for the subliminally presented information to be tailored to just below each participant's individual threshold (Armstrong & Dienes, 2013, 2014; Eckstein, Kubat, & Perrig, 2011), or it can occur following subliminal exposure to examine whether the presentation duration used was indeed below the participant's specific threshold (Birgegård, 2003; Sohlberg et al., 2003; Sohlberg, Billingham, & Nylén, 1998; Sohlberg, Samuelberg et al., 1998). Often, individual threshold tests are conducted by presenting the stimulus to the participant and slowly decreasing (Armstrong & Dienes, 2013, 2014; Eckstein et al., 2011) or increasing, (Sohlberg et al., 2003; Sohlberg, Billingham et al., 1998; Sohlberg, Samuelberg

et al., 1998) the exposure duration of the stimulus on each trial. Following each presentation, participants are asked to report what they saw or rate their confidence in their answer. For example in Sohlberg et al. (2003; see also Sohlberg, Billinghamurst et al., 1998; Sohlberg, Samuelberg et al., 1998), participants were asked to report what they saw e.g., ‘a flash’ until something solid was reported such as ‘a line’. Even if participants were unable to distinguish specific words within the line they reported, the duration speed at which they reported the line was considered to be their individual threshold at which conscious awareness of the subliminal stimuli was possible. Alternatively, participants may be presented with trials that replicate the experimental trials and asked to choose the word or picture that best represents the stimulus shown to them and also rate their confidence in their answer on a scale of 50-100% confident. When participants consecutively rate their confidence at 50% confident for a number of trials, for instance five trials, that presentation speed is adopted as their individual threshold level (Armstrong & Dienes, 2013, 2014).

In contrast, conscious awareness of subliminally presented information can also be assessed using a range of questions during the debrief procedure. Often, the questions are asked using a funnel-styled questionnaire (Chartrand & Bargh, 1996; Dijksterhuis, 2004; Dijksterhuis & Smith, 2002) that begins by asking participants general questions to assess their awareness and becomes more specific. Such a procedure allows the researcher to assess whether each participant was consciously aware of the subliminal stimulus and the extent to which they were aware of it e.g., noticed a flash versus noticed a flash *and* the ability to

distinguish the content correctly. Researchers adhering to the social-cognitive model¹ of subliminal priming i.e., those testing the assumptions of automaticity theory and goal-directed behaviour (Bargh, 2002; Bargh & Ferguson, 2000; see also Bargh & Chartrand, 2000), have often implemented this test of conscious awareness; as such this thesis also devised a funnel-style questionnaire to establish the participant's level of conscious awareness in accordance with social-cognitive methodology.

2.3 Subliminal Presentation Formats

Information can be presented subliminally in an audio or visual format that is, pictorial or written text. This section this thesis will highlight common factors to be considered when presenting subliminal stimuli using each format; for instance, the method of embedding audio stimuli or exposure duration of visual stimuli. Moreover, the variation of each of the factors will be outlined and as such, it will become apparent that there is a lack of any clear methodology within the field of subliminal presentation.

2.3.1 Auditory Subliminal Stimuli

Egermann, Kopiez, and Reuter (2006) report several different techniques that can be used to disguise audio stimuli. Firstly, subliminal spoken stimuli may be embedded in music below the auditory conscious threshold or embedded in the music above the auditory conscious threshold but at an inverted time-structure whereby it is played backwards (Walker, 1987). Although, Vokey and Read (1985) provide evidence to suggest this method

¹ The social-cognitive model covers an expansive area of research concerning the role of non-conscious processes in psychological and behavioural experiences (Bargh, 2002). For instance, automaticity in higher cognitive processes in early childhood behaviour, contagion and conformity, close relationships, decision making, embodied cognition, emotion regulation and processes, face perception and social judgements, motivation and goal pursuit (Bargh, Schwader, Hailey, Dyer, & Boothby, 2012). However, for the purpose of this thesis, the social-cognitive model is limited to subliminal presentation of written stimuli, and the methodology often used to present, and examine such stimuli.

may not be the most suitable as time-inverted stimuli are unintelligible, as receivers of backward audio stimuli were unable comprehend message content or delineate any semantic meaning. A third technique is for subliminal audio stimuli to be presented ‘silently’ (Egermann et al., 2006). Lowery (1992) explains that such inaudible stimuli are presented using very high or ultrasonic frequencies, for example, above 14,500 Hertz (Hz) and are transmitted in their own clear channel and thus, do not need to be masked by music or other sounds. Finally, audio stimuli may be time-compressed whereby it is presented at a percentage of its original duration (Dupoux & Mehler, 1990; Kouider & Dupoux, 2005; Egermann et al., 2006). In relation to the spoken content to be masked, there are two different types of auditory subliminal stimuli, that is, spoken single-words, or spoken multiple-word statements.

Multiple-word self-help audio products that is, audiotapes, CDs or MP3s that can be purchased by the consumer to use at home (<http://www.potentialsunlimited.com/>), often claim to present subliminal multiple-word statements advertised to enhance a plethora of behaviours (e.g., overcoming fear, <http://www.potentialsunlimited.com/>; reduced stress and smoking cessation, www.brightimages.com/). Directions for use of audio subliminal products are simply to listen to the audiotape, CD or MP3, binaurally using headphones or on a home stereo system (<http://www.potentialsunlimited.com/>). Dupoux, de Gardelle, and Kouider (2008) explain that subliminal self-help audio products disguise the vocal statements using the first of Egermann et al.’s. (2006) methods that is, embedding the spoken statements in music such as the calming sound of the ocean. Furthermore, the quality of the subliminal audio message is often degraded to help mask it further behind the supraliminal sound. However, Dupoux et al. (2008; see also Miettinen, Alku, Yrttiaho, May, & Tiitinen, 2012; Moore, 1995) have argued that the level of subliminal stimuli degradation is often to such a high degree that the stimuli are unintelligible which hinders the likelihood of the subliminal

stimulus having any effect on behaviour. Only a minority of experimental research testing the effectiveness of subliminal self-help audio products have reported supportive evidence of a clear change in behaviour following exposure to subliminal self-help products (Chakalis & Lowe, 1992). The majority of research however has not (e.g., Egermann et al., 2006; Froufe & Schwartz, 2001; Greenwald, Spangenberg, Pratkanis, & Eskenazi, 1991; Merikle & Skanes, 1992; Moore, 1995), suggesting that such products are generally not effective in producing behavioural change. However, experimental research has reported successful subliminal priming following exposure to single-word audio primes (Bermeitinger et al., 2012; Daltrozzo, Signoret, Tillmann, & Perrin, 2011; Dupoux et al., 2008; Kouider, de Gardelle, Dehaene, Dupoux, & Pallier, 2010; Kouider & Dupoux, 2005).

Kouider and Dupoux (2005) devised a successful subliminal speech-priming paradigm (see also, Dupoux et al., 2008; Kouider et al., 2010), whereby the subliminal spoken single-word primes are time-compressed that is, presented at a percentage of its original duration (Dupoux & Mehler, 1990; Kouider & Dupoux, 2005); often subliminal speech primes are time-compressed to 35% (Dupoux et al., 2008; Kouider & Dupoux, 2005; Kouider et al., 2010) of their original duration. Dupoux and Mehler (1990; see also, Kouider & Dupoux, 2005) suggest that the reason time-compression is more effective than degrading the quality of the stimuli is because the words remain intelligible after compression (see also Mehler et al., 1993). For instance, Dupoux and Mehler (1990) found that the pattern of responses (e.g., reaction times and accuracy performance) to compressed speech was similar to that of non-compressed speech suggesting speech compression does not affect the underlying processes of phoneme detection. In addition to time-compression, speech primes are also attenuated to a lower intensity for instance, 10 decibels (dB: Daltrozzo et al., 2011), or 15dB (Dupoux et al., 2008; Kouider & Dupoux, 2005; Kouider et al., 2010) in comparison to other sounds. Furthermore, the subliminal spoken primes are then disguised among a

number of speech masks that have been time-reversed, and presented both prior to and following the subliminal prime (Bermeitinger et al., 2012; Dupoux et al., 2008; Kouider & Dupoux, 2005; Kouider et al., 2010). It has been suggested that the sound of such speech-like masks is the equivalent to the sound of a room full of people talking (Kouider & Dupoux, 2005). Due to the continuous nature of the speech-like background noise and its similar spectral characteristics to the subliminal prime, such noise acts as an effective mask for the subliminal speech-prime as the speech-primes are not conspicuous amongst the speech-like masks (Kouider & Dupoux, 2005). Additionally, the randomly selected speech-like masks are often compressed by the same percentage and attenuated to the same intensity level as the subliminal prime (Dupoux et al., 2008; Kouider & Dupoux, 2005; Kouider et al., 2010). In relation to the spoken single-word audio primes, they may be recorded using male (Bermeitinger et al., 2012; Dupoux et al., 2008), female (Daltrozzo et al., 2011), or both male and female voices (Kouider & Dupoux, 2005; Kouider et al., 2010). Both the subliminal prime words and the time-reversed masks may then be presented to participants using a task such as the lexical decision task as a delivery mechanism (LDT: Daltrozzo et al., 2011; Dupoux et al., 2008; Kouider & Dupoux, 2005; Kouider et al., 2010). Whereby participants are asked to respond to target words that have been attenuated to a higher intensity than the subliminal primes and time-reversed masks, for instance at 45dB (Daltrozzo et al., 2011). Participants are presented with all sounds i.e., subliminal speech-primes, time-reversed speech-like masks, and LDT target words, binaurally through headphones (Daltrozzo et al., 2011; Dupoux et al., 2008).

2.3.2 Visual-Pictorial Subliminal Stimuli

Successful subliminal priming has occurred following the presentation of a plethora of pictures, from animals (Badgaiyan, 2000; Bar & Biederman, 1998; Dell'Acqua &

Grainger, 1999; Hermans, Spruyt, De Houwer, & Eelen, 2003 Experiment 1; Leventhal et al., 2008; Silverman & Spiro, 1967, 1968), arrows (Aron et al., 2003; Bennett, Lleras, Oriet, & Enns, 2007 Experiment 1; Chalfoun & Frasson, 2008, 2009, 2011; Klapp & Hinkley, 2002; Schlaghecken & Eimer, 2001, 2002, 2004; Schlaghecken, Rowley, Sembi, Simmons, & Whitcomb, 2007 Experiment 2), brand logos (Fitzsimons, Chartrand, & Fitzsimons, 2008), chessboard configurations (Kiesel, Kunde, Pohl, Berner, & Hoffmann, 2009), coins (Bijleveld, Custers, & Aarts, 2011), faces (Balconi & Lucchiari, 2007; Bargh, Chen, & Burrows, 1996 Experiment 3; Bennett et al., 2007 Experiment 2; Jostmann, Koole, van der Wulp, & Fockenberg, 2005; Leventhal et al., 2008; Li, Zinbarg, Boehm, & Paller, 2008; Sato & Aoki, 2006; Skandrani-Marzouki & Marzouki, 2010; Winkielman, Berridge, & Wilbarger, 2005; Winkielman, Zajonc, & Schwarz, 1997; Yang & Tong, 2010), inanimate objects (Badgaiyan, 2000; Bar & Biederman, 1998; Dell'Acqua & Grainger, 1999; Leventhal et al., 2008), lines (Boy & Sumner, 2010), plants (Badgaiyan, 2000), people (Bornstein, Leone, & Galley, 1987; Hermans et al., 2003; Silverman & Silverman, 1967; Wyer & Calvini, 2011), shapes (Bornstein et al., 1987; Schlaghecken et al., 2007 Experiment 1), and smoking paraphernalia (Leventhal et al., 2008). Such a wide range would suggest that subliminal perception of visual information is both robust and flexible. Nevertheless, there are a number of factors that need to be considered when presenting picture stimuli subliminally, such as the mode of presentation e.g., colour, size, and duration of the subliminal stimuli; screen presentation placement; participant viewing distance from the screen; and finally the requirement of masking stimuli and associated characteristics of the masking stimuli. Each of these factors will now be briefly outlined.

There is no standardised mode of presentation for subliminally presenting pictures, thus each of aforementioned factors varies between research studies. For example, whilst it is common to present subliminal visual pictures using computerised software (Balconi &

Lucchiari, 2007; Boy & Sumner, 2010; Chalfoun & Frasson, 2008, 2009, 2011; Kiesel et al., 2009; Leventhal et al., 2008; Skandrani-Marzouki & Marzouki, 2010; Wyer & Calvini, 2011; Yang & Tong, 2010), they can also be presented using a projector and screen (Hermans et al., 2003 Experiment 1; Winkielman et al., 1997) or a tachistoscope (Bornstein et al., 1987). In relation to stimulus colour, subliminal visual stimuli have previously been presented in full colour (Hermans et al., 2003 Experiment 1; Leventhal et al., 2008), grey-scale (Balconi & Lucchiari, 2007; Bargh et al., 1996 Experiment 3; Sato & Aoki, 2006) or as black schematic line drawings (Badgaiyan, 2000; Dell'Acqua & Grainger, 1999; Jostmann et al., 2005). Additionally, the size of stimulus can also vary, from a 4.5 centimetre (cm) x 3.15cm rectangle (Leventhal et al., 2008) to an 8cm x 8cm square (Winkielman et al., 2005) on a computer screen, to larger pictures measuring 45cm x 60cm rectangle on a projector screen (Winkielman et al., 1997). The duration of exposure to the subliminal pictures may also vary as a function of the mode of presentation. For example, exposure duration have previously varied from 4 milliseconds (ms) using a tachistoscope (Bornstein et al., 1987) to 10ms using a projector (Winkielman et al., 1997), and from 10ms (Balconi & Lucchiari, 2007) to 50ms (Skandrani-Marzouki & Marzouki, 2010) using computer software. Furthermore, the viewing distance may differ depending on the mode of presentation. Participants presented with stimuli on a projector screen are often required to sit between 150cm (Winkielman et al., 1997) and 300cm (Hermans et al., 2003 Experiment 1) away from the screen, whereas participants presented with subliminal stimuli on a computer screen are required to sit closer, ranging in distance from 30cm (Klapp & Hinkley, 2002) and 140cm (Li et al., 2008) away from the screen. A final aspect in relation to the subliminal picture prime itself is the placement of the prime on the screen. Subliminal pictures may be presented centrally (Leventhal et al., 2008; Schlaghecken & Eimer, 2002, 2004; Schlaghecken et al., 2007 Experiment 2; Boy & Sumner, 2010) or at multiple locations (Bar & Biederman, 1998;

Chalfoun & Frasson, 2008, 2009, 2011; Jostmann et al., 2005; Kiesel et al., 2009; Sato & Aoki, 2006). Furthermore, decisions concerning whether or not masking stimuli are required and the relevant factors associated with them may also occur.

The need to present masking stimuli may depend on the mode of presentation; for example, Bornstein et al. (1987) found that the presentation of subliminal visual stimuli using a tachistoscope was sufficient to avoid conscious awareness without the need for further masking. However, when presenting subliminal visual stimuli using computer software or projectors, the presentation of additional masking stimuli is often more common (e.g., Bijleveld et al., 2011; Dell'Acqua & Grainger, 1999; Fitzsimons et al., 2008; Skandrani-Marzouki & Marzouki, 2010; Wyer & Calvini, 2011). Additionally, further decisions concerning the number and characteristics of the particular mask used also need to be considered. For example, *both* a forward mask (i.e., presented before the subliminal picture) and a backward mask (i.e., presented after the subliminal picture) can be implemented (Bijleveld et al., 2011; Chalfoun & Frasson, 2008, 2009, 2011; Dell'Acqua & Grainger, 1999; Fitzsimons et al., 2008; Kiesel et al., 2009; Skandrani-Marzouki & Marzouki, 2010; Winkielman et al., 2005; Yang & Tong, 2010), or simply just a backward mask can be presented following the subliminal picture (Aron et al., 2003; Bar & Biederman, 1998; Bargh et al., 1996 Experiment 3; Klapp & Hinkley, 2002; Li et al., 2008; Sato & Aoki, 2006; Schlaghecken & Eimer, 2002, 2004; Schlaghecken et al., 2007 Experiment 2; Wyer & Calvini, 2011). The masking stimuli are often patterns, shapes, or lines, presented to resemble a random design (Aron et al., 2003; Bar & Biederman, 1998; Boy & Sumner, 2010; Fitzsimons et al., 2008; Hermans et al., 2003 Experiment 1; Leventhal et al., 2008; Wyer & Calvini, 2011), and may be presented in full colour (Hermans et al., 2003 Experiment 1), grey-scale (Bargh et al., 1996 Experiment 3; Dell'Acqua & Grainger, 1999; Sato & Aoki, 2006; Yang & Tong, 2010; Wyer & Calvini, 2011) or in stark black and white (Aron et al.,

2003; Bar & Biederman, 1998; Skandrani-Marzouki & Marzouki, 2010). Finally, the duration of the masking stimuli can vary from a relatively brief exposure duration of 20ms (Skandrani-Marzouki & Marzouki, 2010) to a longer exposure duration of 2000ms (Winkielman et al., 1997).

2.3.3 Visual-Written Subliminal Stimuli

An alternative visual technique is the subliminal presentation of written words. There are two types of word stimuli, subliminal Single-Word or Multiple-Word primes. Similar to subliminal audio and picture presentation paradigms, there are a number of factors that must be considered when presenting subliminal written stimuli. These include the mode of presentation, placement on the screen, exposure duration, and the number of repetitions. In addition, the masking techniques and the aesthetics of the subliminal stimuli, such as the typeface, tpestyle, font, and size of the written stimuli should also be considered. Given that the focus of this thesis is on the presentation of subliminal written-primes, each of these factors are outlined in detail below.

2.3.3.1 Mode of Stimulus Presentation

It is important to consider the equipment designed to deliver the subliminal stimulus during experimentation as this can directly impact on how fast the stimulus can be presented. Subliminal stimuli are generally presented using two different types of equipment, either a tachistoscope or using computer software. Tachistoscopes consist of a lightproof box in which visual objects or writing can be displayed to one or both eyes via the illumination of special lamps (Milgram, 1987). Such equipment allows for the precise control and rapid presentation of visual stimuli, for instance, research using such equipment has reported exposure durations as brief as 4ms (Ariam & Siller, 1982; Bryant-Tuckett & Silverman,

1984; Frauman, Lynn, Hardaway, & Molteni, 1984; Linehan & O'Toole, 1982; Meyer & Waller, 1999; Orbach et al., 1994; Parker, 1982). In contrast, modern computer and software packages are now more commonly used to present subliminal stimuli. Some, such as Radel et al. (2009), have modified instructor slideshows to present subliminal stimuli to large groups of participants, more commonly however, subliminal research takes place in controlled laboratory settings whereby subliminal stimuli are presented using specific psychology software programs such as Psychology Software Tools (E-Prime, Micro Experimental Laboratory [MEL]; Schneider, 1988); Millisecond Software (Inquisit; Draine, 1999); Cedrus Corporation (SuperLab; <http://www.cedrus.com/>); MacLab (Costin, 1988) and PsyScope Software (Cohen, MacWhinney, Flatt, & Provost, 1993). Each aims to provide researchers with precise and flexible software to be used in a multitude of research paradigms. An important consideration for computer-presented subliminal primes is the refresh rate of the screen, measured in cycles per-second, or Hertz (Hz). The refresh rate directly impacts upon the duration that a subliminal stimulus can be presented for because the subliminal prime is unable to be presented for a duration that is shorter than the refresh rate of the screen, as this is the fastest speed at which the computer can update itself. Modern computers and psychology software are capable of presenting subliminal stimuli at extremely brief durations, for instance, Mogg et al. (1993) reported subliminal presentation speed of just 1ms using a laptop installed with MEL Psychology Software Tools (Schneider, 1988) and confirmed this exposure duration using a light-sensitive diode and oscilloscope. Although, computer presented subliminal stimuli are more often presented for longer durations, for example, between 8.5ms (Dijksterhuis & Smith, 2002) and 60ms (Forster & Davis, 1984; Riketta & Dauenheimer, 2003; Zemack-Rugar et al., 2007) with an average duration of 47ms reported by Van den Bussche et al. (2009) in their review of 54 experiments.

2.3.3.2 *Stimulus Presentation Placement*

Computers and psychology software provides the flexibility to present the subliminal stimuli in a range of locations on the screen. The design of some tasks requires the subliminal primes to be presented in one of the four corners of the screen (upper left quadrant, upper right quadrant, bottom left quadrant, or bottom right quadrant; Reuter et al., 2007; Weibel, Giersch, Dehaene, & Huron, 2013). For instance, the parafoveal vigilance task, which has been implemented in numerous subliminal priming, experiments (Bargh et al., 1986; Bargh & Pietromonaco, 1982; Bargh, Raymond, Pryor, & Strack, 1995; Chartrand & Bargh, 1996; Riketta & Dauenheimer, 2003). The paravoveal vigilance task requires the participant to focus on a constant fixation point in the centre of the screen and identify whether the flash on each trial appeared in the top right/left, or bottom right/left quadrant of the screen. The ‘flash’ is actually a subliminal stimulus and its accompanying backward mask each shown for 60ms and appearing at a distance of 7.6cm from the central fixation point. Stimuli presented at this distance from the fixation point, and with participants sitting exactly 99cm away from the screen, are presented outside the foveal visual field associated with conscious awareness (Bargh et al., 1995; Chartrand & Bargh, 1996) but within their parafoveal visual field so they can still respond to the flash and unconsciously process the stimulus. These specific distances are also chosen because although the participant is instructed to focus on the central fixation point, it is not possible for the participant to see the subliminal stimulus should they try to look in the direction of the flash (Bargh & Chartrand, 2000). As Rayner (1978) explained, it takes the eye 140ms to saccade in the direction of a parafoveally presented stimulus, thus it is not possible for the participant to reach that location if the subliminal prime is only presented for 60ms (Chartrand & Bargh, 1996; Riketta & Dauenheimer, 2003).

Others however have presented subliminal stimuli in either one of two locations, i.e., the right/left side of the central fixation point (Lowery et al., 2007; Marzouki, Grainger, &

Theeuwes, 2007) or above/below the central fixation point (Levy, 1996; Levy, Hausdorff, Hencke, & Wei, 2000; Sklar et al., 2012), whereas some such as Radel et al. (2009), have reported successful subliminal priming following the presentation of stimuli in multiple locations on the screen. Nevertheless, the most common placement is the central location (Abrams & Greenwald, 2000; Armstrong & Dienes, 2013, 2014; Damian, 2001; Dijksterhuis, 2004; Dijksterhuis & Smith, 2002; Forster & Davis, 1984; Frings & Wentura, 2005; Greenwald, Abrams, Naccache, & Dehaene, 2003; Légal, Chappé, Coiffard, & Villard-Forest, 2012; Mogg et al., 1993; Veltkamp et al., 2008; Van den Bussche & Reynvoet, 2007; Van den Bussche et al., 2012). Such studies tend to use evaluative judgement or lexical decision tasks as delivery mechanisms for the subliminal stimuli whereby all stimuli, from the fixation point to the subliminal stimulus and target stimulus (e.g., word/non-word), are shown in the centre of the screen. Van den Bussche et al. (2009) have argued that consistent presentation of subliminal stimuli in a central location of the screen minimises the influence of spatial attention on the effectiveness of the subliminal prime, potentially accounting for the popularity in this presentation location.

2.3.3.3 Stimulus Exposure Duration

The exposure duration that a subliminal stimulus is presented for has also varied within the subliminal literature. Some have suggested that for a prime to be truly subliminal, an exposure duration of 50ms or below would be sufficient (Kouider & Dupoux, 2001; Wentura & Frings, 2005). However, this upper duration may vary depending on other factors such as age, type of stimulus presentation task, and masking technique. For instance, successful subliminal priming for elderly participants is reported using slower exposure durations of between 55ms and 115ms (Levy, 1996). Additionally, researchers utilising presentation tasks such as the parafoveal vigilance task have reported successful subliminal

priming following exposure durations of between 60ms (Chartrand & Bargh, 1996; Riketta & Dauenheimer, 2003) and 100ms (Bargh & Pietromonaco, 1982). Due to the task requirement of identifying flashes in one of the four quadrants of the screen, subliminal stimuli can be afforded a longer duration on the screen because participants are physically unable to saccade their eyes to its location quick enough (Rayner, 1978). Finally, less common masking techniques, such as grey-scale colour contrasting (Lamy, Mudrik, & Deouell, 2008) and continuous flash suppression (Tsuchiya & Koch, 2005) allow for primes to be presented for longer durations than that achieved using traditional backward masking. For example, Armstrong and Dienes (2013, 2014) reported a mean exposure duration of between 56ms and 80ms using grey-scale colour contrasting and Sklar et al. (2012) reported subliminal exposure durations of between 939.4ms (Experiment 1) and 1,108.36ms (Experiment 2) using continuous flash suppression. However, for subliminal stimuli presented centrally using traditional backward masking and to non-elderly participants, such long presentation durations may be consciously perceived, thus shorter exposure durations may be preferred.

In such research, the exposure duration of the subliminal prime may either be individually calculated for each participant or presented for a fixed duration across all participants. Individually calculating the exposure duration of subliminal stimuli has the benefit of ensuring that the prime is presented subliminally for all individuals although it could be considered time-consuming with the addition of a further threshold-testing task (Bargh & Chartrand, 2000; see also *2.2.1 Measuring Conscious Awareness*, p.17). Following the threshold-testing task the exposure duration for the subliminal stimuli may then be set to the speed at which each participant's accuracy performance was found to be at chance success (Armstrong & Dienes, 2013, 2014; Eckstein et al., 2011). As such, using this method the exposure duration varies from participant to participant and has been reported to cover a wide range of exposure times. For example, Eckstein et al. (2011) report exposure durations

of between 14.3ms and 71.4ms, and Armstrong and Dienes (2013, 2014) report exposure durations of between 16ms and 80ms. Alternatively, the exposure duration of subliminal primes may be set to a fixed duration and presented at this speed to all participants.

Again, researchers using such a method have reported the use of a wide range in stimulus exposure durations, from a conservative 1ms (Mogg et al., 1993) to 82ms (Klauer, Eder, Greenwald, & Abrams, 2007). Furthermore, the selected presentation equipment may influence the possible speed of the exposure duration. For instance, extremely fast exposure durations such as 4ms or 5ms are often presented using a tachistoscope (Ariam & Siller, 1982; Parker, 1982; Sohlberg, Billingham et al., 1998; Sohlberg & Birgegård, 2003; Sohlberg et al., 2003; Sohlberg, Samuelberg et al., 1998), and although short exposure durations can be achieved using computer equipment and psychology software (e.g., 1ms, Mogg et al., 1993; 8.5ms, Dijksterhuis & Smith, 2002) exposure to subliminal stimuli using a computer is rarely reported at under 10ms. More often, participants are exposed to subliminal primes for brief durations of between 10ms and 50ms (see Aarts et al., 2005; Aarts et al., 2007; Aarts et al., 2008; Abrams & Greenwald, 2000; Abrams, Klinger, & Greenwald, 2002; Custers & Aarts, 2005, 2007; Dijksterhuis, 2004; Dijksterhuis, Aarts, Bargh, & van Knippenberg, 2000; Dijksterhuis, Preston, Wegner, & Aarts, 2008; Greenwald et al., 1996; Greenwald et al., 2003; Grumm, Nestler, & Von Collani, 2009; Kaiser, Vick, & Major, 2006; Kiyonaga, Grainger, Midgley, & Holcomb, 2007; Légal et al., 2012; Marien, Custers, Hassin, & Aarts, 2012; Pichon et al., 2007; Qiao et al., 2010; Saroglou, Corneille, & Van Cappellen, 2009; Van den Bussche & Reynvoet, 2007; Van Opstal, Gevers, Osman, & Verguts, 2010; Van Opstal, Reynvoet, & Verguts, 2005a, 2005b; Veltkamp et al., 2008; Veltkamp, Custers, & Aarts, 2011; Weibel, Giersch, Dehaene, & Huron, 2013; Wentura & Frings, 2005; Wentura, Moritz, & Frings, 2008).

In sum, whilst no clear agreement exists on precisely how long a subliminal prime should be presented for, a range of exposure durations has been used, from 1ms (Mogg et al., 1993) up to 1,108.36ms (Sklar et al., 2012 Experiment 2). This range includes exposure durations that have been individually tailored for each participant (Armstrong & Dienes, 2013, 2014; Eckstein et al., 2011) and others that have been presented at a fixed exposure duration across all participants (Abrams et al., 2002; Custers & Aarts, 2007; Dijksterhuis, 2004; Dijksterhuis et al., 2008; Greenwald et al., 2003; Grumm et al., 2009; Légal et al., 2012; Marien et al., 2012; Qiao et al., 2010; Van Opstal et al., 2010; Veltkamp et al., 2011).

2.3.3.4 Number of Stimulus Repetitions

It has previously been suggested that to elicit a behavioural effect a subliminal prime is facilitated by repeated exposures (Marcel, 1983 Experiment 5; Wentura & Frings, 2005). For instance, Marcel (1983 Experiment 5) reported faster response times following repeated presentations of subliminal primes compared to a single exposure. More recently, Wentura and Frings (2005; see also Wentura et al., 2008) reported significant priming effects following subliminal primes presented 10 times in comparison to no priming effect reported when the subliminal prime was presented only once. Importantly, Marcel (1983) reported that increased repetition of the subliminal primes did not produce an increased ability to consciously detect them. However, others such as Atas, Vermeiren, and Cleeremans (2013) and Avons et al. (2009) did not agree that repeated primes improved priming effects, nor did they agree that repeat priming does not affect the conscious detection of subliminal primes. For example, Avons et al. (2009) did not find increased priming effects when using a repeated priming technique. Furthermore, whilst Atas et al. (2013) did report increased priming following multiple exposures of subliminal primes, they also reported increased subjective and objective awareness to them. However, the result of Atas et al.'s. (2013)

subjective awareness test indicates that only a minority of participants were confident of perceptually experiencing the subliminal prime (e.g., between 3% and 7% of participants) hence, such a small percentage of the sample could be removed prior to analysis of subliminal priming effects. Additionally, Holender and Duscherer (2004) argue that categorisation threshold determination tasks such as that used in Atas et al's. (2013) experiment are not as stringent as identification threshold determination tasks². As such, Atas et al's. (2013) findings do not represent a clear example of perceptual experience of the subliminal prime following a repeated priming technique, thus the benefit of increased priming effects following repeated subliminal primes remains.

Despite these negative reports (Atas et al., 2013; Avons et al., 2009), the aim of using a repeated priming technique remains the same, that is to generate a stronger representation of the subliminal prime and increase its potential priming effect (see e.g., Armstrong & Dienes, 2013, 2014; Marcel, 1983 Experiment 5; Wentura & Frings, 2005; Wentura et al., 2008). Moreover, many studies have reported successful subliminal priming and importantly no conscious awareness of the subliminal primes when using a repeated priming technique (Armstrong & Dienes, 2013, 2014; Birgegård, 2003; Chartrand & Bargh, 1996; Meyer & Waller, 1999; Riketta & Dauenheimer, 2003; Sohlberg & Birgegård, 2003; Sohlberg, Billingham, et al., 1998; Sohlberg, Samuelberg, et al., 1998; Zemack-Rugar et al., 2007). As such, research would suggest that multiple repetitions of a subliminal prime could lead to more robust behavioural effects. Such a view is consistent with the meta-analysis conducted by Van den Bussche et al. (2009) who found that repeated subliminal presentation of a prime generates a stronger priming effect and that the number of presentations can account for 24% of the variance of priming. However, it is not clear as yet precisely how many repetitions

² Holender and Duscherer (2004) explain that correctly categorising a digit above or below a fixed value (e.g., five) merely generates a congruency effect in binary decisions rather than affecting target processing spreading activation.

would be required to elicit a significant subliminal priming effect. Indeed the range of repetitions reported varies from as little as three (Armstrong & Dienes, 2013, 2014) to as many as 25 repetitions (Riketta & Dauenheimer, 2003).

2.3.3.5 Traditional Masking Technique

Masking techniques can be used to help disguise the subliminal stimuli being presented with the aim of increasing the chances of it being consciously undetected (Delord, 1998; Enns & Oriet, 2007). There are three types of traditional mask that can be applied: surrounding masks, forward masks, and backward masks. Surrounding masks often consist of additional numbers, letters or symbols presented either side of the subliminal stimuli. For instance, ‘mlhonestwd’ (Wentura & Degner, 2010; see also Wentura & Frings, 2005; Wentura et al., 2008) whereby the word ‘honest’ is the subliminal prime and the additional consonants ‘ml’ and ‘wd’ are the surrounding masks either side. The addition of surrounding masks either side of a subliminal prime are usually applied in conjunction with forward and/or backward masks and they are considered to be a very conservative masking procedure that has been reported to reduce priming effects (Avons et al., 2009). However, the application of forward and/or backward masks is the more traditional procedure. Forward masks are presented prior to the subliminal stimulus and backward masks are presented afterwards. As participants are often told to ignore these masks, the use of a forward mask essentially sandwiches the subliminal prime in between two irrelevant stimuli and is considered to render the subliminal prime undetectable (Finkbeiner & Forster, 2008; Forster & Davis, 1984; Eckstein et al., 2011, see Figure 1, p.35). However, it has been suggested that the application of forward masks are not essential and the use of a backward mask alone is sufficient (Greenwald et al., 1996). For instance, Greenwald et al. (1996) explain that incorporating a backward mask produces a break in the transfer of information from the

sensory buffer to working memory, which in turn reduces the probability that the subliminal stimuli are processed consciously (see also, Bargh & Chartrand, 2000). With regards to the use of both forward and backward masks, consideration also needs to be given to the specific nature of the mask, and its exposure duration.

While subliminal written stimuli can be masked using patterns comprised of letter fragments (Greenwald et al., 2003; Levy, 1996) or shapes such as dots or squares known as “noise masks” (Delord, 1998, p.314), Kiesel, Kunde, and Hoffmann (2007) highlight that the

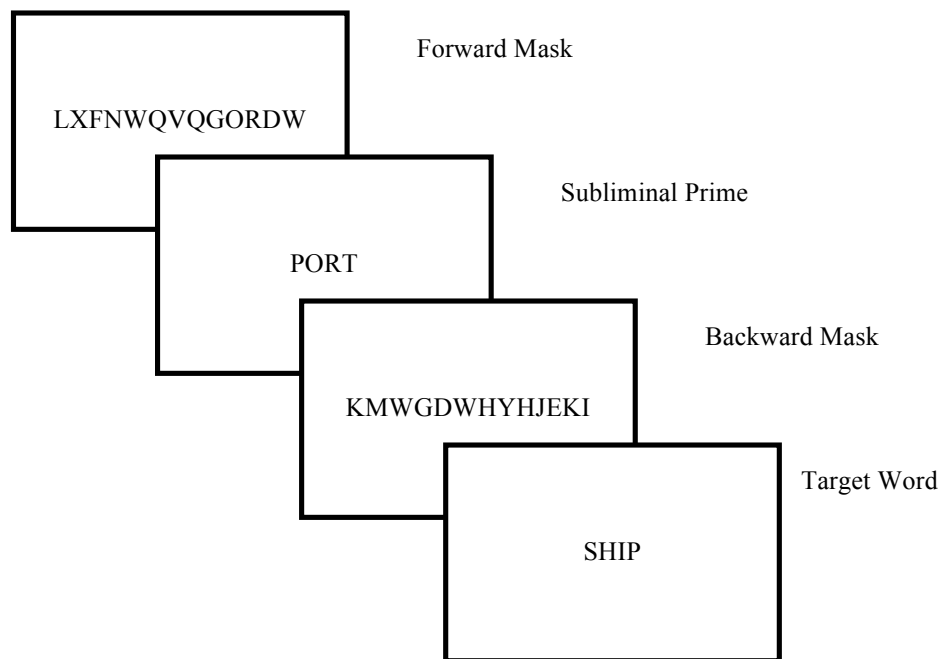


Figure 1: Schematic of a subliminal prime sandwiched between a forward and backward mask. Masks, prime and target examples from Eckstein et al. (2011).

most commonly used masks are strings of symbols such as hatch marks (see Jraidt & Frasson, 2010; Ortigue, Bianchi-Demicheli, Hamilton, & Grafton, 2007; Van den Bussche & Reynvoet, 2007), ampersands (see Armstrong & Dienes, 2013, 2014; Mitchell et al., 2002),

random letter strings (see Abrams et al., 2002; Kiefer & Martens, 2010; Marien et al., 2012; Zemack-Rugar et al., 2007) or a string of X's (see Dijksterhuis, 2004; Dijksterhuis & Smith, 2002; Pichon et al., 2007). Kouider and Dehaene (2007) have suggested that masking stimuli should share similar features or fit the contours of the subliminal prime, hence the use of stringed symbols (e.g., @@@@, Armstrong & Dienes, 2013, 2014) or a random sequence of letters (e.g., kmwdgwhyhjkei, Eckstein et al., 2011) are considered more appropriate than pattern or noise masks in rendering the subliminal prime consciously undetectable (see also Bargh, Bond, Lombardi, & Tota, 1986; Bargh & Chartrand, 2000). A second factor to consider when presenting forward and backward masks is their duration.

Currently there is no standard duration for which forward and backward masks should be presented for and as such, the reported exposure durations have varied in the literature. Both forward and backward masks have been presented for as little as 12ms (see Klauer et al., 2007; Marzouki et al., 2007) and as long as 1000ms (see Veltkamp et al., 2008), although Bargh and Chartrand (2000) suggest that the backward mask should at least be presented for the same amount of time as the duration of the subliminal prime. Equally there is no specific criterion for whether the forward and backward masks should be presented for the same speed (see Arndt, Greenberg, Pyszczynski, & Solomon, 1997; Forster & Davis, 1984; Johnson, Rowatt, & LaBouff, 2010; Marien et al., 2012; McKay, Efferson, Whitehouse, & Fehr, 2011; Saroglou et al., 2009; Veltkamp et al., 2008) or different speeds (see Abrams & Greenwald, 2000; Abrams et al., 2002; Custers & Aarts, 2005; Dijksterhuis et al., 2008; Eckstein et al., 2011; Klauer et al., 2007; Mitchell et al., 2002; Van den Bussche et al., 2012). As such, whilst the benefits of using such masks to help disguise subliminal stimuli are evident there is no agreed upon procedure for their presentation.

2.3.3.5.1 Potential Issues with Traditional Backward Masking Techniques

Concerns have arisen regarding the use of traditional masking techniques to disguise subliminal stimuli, specifically in reference to the use of backward masks. Grainger, Diependaele, Spinelli, Ferrand, and Farioli (2003) explain that backward masking may unfavourably affect the cognitive processing of the subliminal prime (see also Enns & Oriet, 2007). Furthermore, Grainger et al. (2003) suggest that some backward masks are more detrimental to the cognitive processing of subliminal primes than others. For instance, backward masks comprised of a string of random letters are considered to more strongly mask the subliminal prime compared to a string of symbols (Finkbeiner, 2011) because of the close similarity between the graphemes and phonemes of the mask and target (Perfetti & Bell, 1991). Others have suggested that the mere use of a backward mask may inhibit the activation of a subliminal prime due to its sudden arrival (Lleras & Enns, 2006), an effect referred to as ‘mask-triggered inhibition’ (Jaśkowski, 2007; see also Jaśkowski & Przekoracka-Krawczyk, 2005). Thus, it is possible that the traditional technique of backward masking may be detrimental to the processing of subliminal primes.

However, other masking techniques are available that may help to bypass the potential issues raised concerning the use of backward masking, such as continuous flash suppression (CFS; Tsuchiya & Koch, 2005), and grey-scale colour contrasting (Lamy et al., 2008). CFS (Tsuchiya & Koch, 2005) may be used to present subliminal primes for a longer duration by rapidly flashing colourful images into one eye (changing every 100ms), whilst presenting a static image of the subliminal written prime to the other eye. Similarly, grey-scale colour contrasting (Lamy et al., 2008) may also allow for a longer exposure duration of subliminal primes, whilst avoiding the issues of mask-triggered inhibition (Jaśkowski, 2007; see also Jaśkowski & Przekoracka-Krawczyk, 2005) through the presentation of subliminal stimuli in a minimally darker contrast of grey compared to the background shade of grey (Lamy et al.,

2008; see also Armstrong & Dienes, 2013, 2014). However, whilst Sklar et al. (2012) demonstrate longer exposure durations of the subliminal primes minimal research has tested subliminal priming using this technique, thus very little is known about what effect the CFS technique may have on the strength of the subliminal prime to elicit a behavioural change. Furthermore, grey-scale colour contrasting has produced less robust effects in some conditions or experiments compared to the effects achieved using traditional backward masking (see Armstrong & Dienes, 2013). Hence, until more research is conducted in relation to strength and weaknesses of such alternative masking techniques on subliminal priming, traditional backward masking may be the most preferable masking technique to implement.

In sum, there are several techniques that may be used to disguise the presentation of subliminal primes. Traditional masking techniques include the presentation of forward and/or backward masks to help render the subliminal stimulus consciously undetectable. Forward/backward masks consisting of features similar to that of the subliminal prime, such as random letter strings, are considered to more efficiently mask the subliminal prime (Kouider & Dehaene, 2007; Grainger et al., 2003). However, some have argued that the use of backward masking especially may be too conservative and potentially inhibit the effectiveness of the subliminal prime (Grainger et al., 2003; Lleras & Enns, 2006). Hence less traditional masking techniques such as CFS (Tsuchiya & Koch, 2005) and grey-scale colour contrasting (Lamy et al., 2008) are available that may avoid some of these potential issues, although it is not yet clear how such techniques may affect the strength of the subliminal stimuli in eliciting behavioural change thus traditional backward masking techniques remain the most preferable subliminal masking method.

2.3.3.6 Stimulus Aesthetics

The aesthetics of written subliminal stimuli refers to the typeface, typestyle, font, and point size. Although one aim of subliminal presentation is to ensure that the subliminal stimulus bypasses conscious awareness, a second and no less important aim is to ensure that the individual is able to process it. Hence, keeping the aesthetics of the subliminal stimulus legible in terms of processing makes logical sense. Currently, there are no standardized specifications reported concerning the aesthetics of subliminally presented written stimuli and as such each of these factors has varied within the literature and is outlined below.

2.3.3.6.1 Stimulus Typeface

Typeface relates to the design of the letters that the subliminal stimulus is comprised of, and are most legible when they remain in their basic form compared to typefaces that have been embellished, compressed, or stretched (Craig, Scala, & Bevington, 2006). Considerations concerning the stimulus typeface include, the symmetry of the written letters, letter spacing, and finally the inclusion or not of serifs.

Symmetry of the letters is thought to enhance the readability and the processing speed of typed words, as symmetrical letters are unconsciously perceived as more appealing (Larson, 2007). The second consideration of letter spacing will differ depending on whether the typeface is proportional or monospaced. Proportionally-spaced typefaces are those where the width of the space given to each letter is proportional to the letter itself whereby, there is a differential amount of space given to the letter 'I' compared to the letter 'O' because the width of the letter 'I' is smaller than that of the letter 'O'. In contrast, monospaced letters are non-proportional to the size of the letter i.e., the width of space given to the letter 'I' is the same as that used for the letter 'O' despite the letter 'I' being a thinner letter (Craig et al., 2006). For example, the font 'Times New Roman' uses a proportional typeface, whereas

'Courier New' utilises a monospaced typeface. Hill and Scharff (1997) reported that monospaced typefaces are considered more symmetrical, and as such may aid the unconscious processing of subliminally presented stimuli. The final consideration for typeface is the inclusion or not of serifs i.e., the finishing strokes on the ends of each letter (Craig et al., 2006). Fonts that include these finishing strokes, or serifs are 'Courier New' and 'Times New Roman' whereas sans-serif, that is without serif, are fonts that have no finishing strokes such as, 'Arial' and 'Helvetica'. Previously, the addition of serifs have been explained to improve the formation of words, improve legibility of text due to increased letter discrimination, maintain spacing between letters, and finally, baseline serifs i.e., those along the bottom of the letter, may aid the eye in tracking the line of type for faster more efficient reading (Arditi & Cho, 2005; see also, Morris, Aquilante, Yager, & Bigelow, 2002). However, in their examination of readability of serif versus sans-serif typeface, Arditi and Cho (2005) found no differences in the reading speed, although the sample size was very small and point size of the text remained consistent. In contrast, Hill and Scharff (1997) did report that when the point size of the text was increased, serif typefaces were easier to read. Hence, serif typeface may be more beneficial for subliminally presented stimuli as the point size tends to be larger than standard typed text (see 2.3.3.6.3 *Stimulus Point Size*, p.42).

In sum, whilst little research has been conducted on the ideal typeface for subliminally presented information, symmetrical typefaces are considered to be unconsciously preferred (Larson, 2007) and monospaced typefaces are considered to represent more symmetrical shape (Hill & Scharff, 1997), which subsequently may enhance the unconscious processing of subliminally presented stimuli. Additionally, the inclusion of serif typeface may also improve the processing of subliminally presented stimuli if text is formatted to a large point size (Morris et al., 2002; Hill & Scharff, 1997), hence a font such

as 'Courier New' that encompasses such aspects may be well suited to subliminal presentation.

2.3.3.6.2 Stimulus Typestyle and Font

Typestyle refers to the emphasis placed on each letter within a word that may change their width or weight (Craig et al., 2006). There are a number of different typestyle variations, for instance, regular typestyle whereby the typestyle is unaltered, bold typestyle whereby the letter width is thicker for strong emphasis, and italic typestyle that presents slanted letters and an increased overall letter width for subtle emphasis (Craig et al., 2006). When words are presented subliminally they are often presented in regular typestyle and rarely with added emphasis such as italic typestyle as this has been found to impinge on the legibility of consciously processed words (Subbaram, 2004) and therefore may also impair the unconscious processing of subliminally presented words. However, some have reported successful unconscious processing of subliminally presented primes with bold typestyle (e.g., Armstrong & Dienes, 2013, 2014; Klauer et al., 2007), as this typestyle does not hinder legibility of text. Additionally, whilst it is not a specific typestyle, extra emphasis can also be added to written stimuli by presenting them in upper case letters. As with other specifications discussed there is no standard procedure concerning whether the presentation of subliminal stimuli is optimal when presented in upper case or lower case letters. For consciously processed words, no difference in legibility has been found between the presentation of upper case and lower case letters as long as all letters are presented at a consistent point size (Subbaram, 2004). Hence, this may explain why robust subliminal priming effects have been elicited following the presentation of subliminal stimuli in both upper case letters (e.g., Aarts et al., 2005; Ariam & Siller, 1982; Damian, 2001; Parker, 1982; Riketta & Dauenheimer,

2003; Sohlberg et al., 2003; Wentura & Frings, 2005) and in lower case letters (e.g., Ortigue et al., 2007; Van den Bussche & Reynvoet, 2007; Van den Bussche et al., 2012).

A further consideration for subliminal written stimuli is the font in which they are presented. Font refers to the specific typeface and typestyle combination (Craig et al., 2006), and has varied greatly in the literature. There are numerous fonts that could be selected, but to remain legible the font of a subliminal stimulus is rarely presented in an embellished font, for example script, calligraphy, or curly fonts, as these hinder reading and processing speeds of consciously perceived words (Hill & Scharff, 1997) and as such may also hinder the unconscious processing of such stimuli. Hence, plain fonts are often chosen, for instance, ‘Arial’ (as in Greenwald et al., 2003; Kiyonaga et al., 2007), ‘Courier New’ (as in Armstrong & Dienes, 2013, 2014; Grainger et al., 2003; Ortigue et al., 2007; Reuter et al., 2007; Van Opstal et al., 2005a, 2005b), and ‘Geneva’ (as in Mitchell et al., 2002; Weibel et al., 2013). In relation to the legibility of typed words on computer screens, Bernard, Lida, Riley, Hackler, and Janzen (2002) compared a number of fonts and found that for consciously processed words, the Arial and Courier family fonts were most legible overall. Hence, whilst a number of different fonts have been found to elicit subliminal priming effects, those written in fonts from Arial or Courier families may be more effectively unconsciously processed.

2.3.3.6.3 Stimulus Point Size

Point size of a subliminally written stimulus is also an important factor to consider. If the point size is too large the stimulus may well be processed consciously rather than unconsciously, as intended. Past research has utilised a range of different point sizes from regular computer point sizes such as 12 (Grainger et al., 2003; Klauer et al., 2007) to larger point sizes such as 43 (Ortigue et al., 2007). The impact of point size on subliminally

presented primes has not yet been tested, but for consciously processed words, larger point sizes have been reported to be generally more legible (Morris et al., 2002; Bernard et al., 2002; Mills & Weldon, 1987). Additionally, it has been reported that for enhanced legibility, a larger point size is required when presenting words compared to single letters (Sheedy, Subbaram, Zimmerman, & Hayes, 2005). Hence, larger point sizes may be more preferable for the presentation of subliminally presented words to aid in their unconscious processing.

2.4 Behavioural Effects of Single-Word and Multiple-Word Subliminal Primes

This section will provide a brief account of the behavioural effects of subliminally presented Single-Word and Multiple-Word primes. Each subsection will begin by outlining the variety of sub-disciplines that both subliminal prime types have been researched, as well as providing an indication of the primary function for research presenting subliminal Single-Word and Multiple-Word primes as well as continued findings that have since been reported. Each subsection will also provide a brief outline of the positive behavioural effects elicited following subliminal presentation of either Single-Word or Multiple-Word primes. Finally, this section will conclude with a summary of the information presented and highlight a current issue (i.e., a comparison of the effects elicited by Single-Word and Multiple-Word primes) that has not yet been explored.

2.4.1 Single-Word Primes

Subliminal Single-Word primes have been explored across a range of psychology sub-disciplines including, clinical and psychopathology (e.g., Zeijlmans Van Emmichoven, van Ijzendoorn, de Ruiter, & Brosschot, 2003; Naccache et al., 2005); cognition (e.g., Costello, Jiang, Baartman, McGlennen, & He, 2009; Eckstein et al., 2011; Groeger, 1984); consciousness and perceptual research (e.g., Crawley, French, & Yesson, 2002; Debner &

Jacoby, 1994); neuropsychology (e.g., Kherif, Josse, & Price, 2011; Kiefer & Martens, 2010); and social psychology (e.g., Dijksterhuis, 2004; Jraidt & Frasson, 2010). Historically, Single-Word primes were used to help identify the existence of unconscious processing (e.g., Wickens, 1972). Wickens' (1972; see also Wickens, 1973) Single-Word priming research provided early evidence of unconscious processing although limitations concerning the exposure duration of the subliminal primes was apparent hence others, such as Marcel (1983) also investigated the extent of unconscious processing using subliminally presented Single-Word primes. Marcel (1983) subliminally presented participants with Single-Word primes and found that they were able to correctly identify whether the target word was semantically similar to the subliminal Single-Word prime above the rate of success expected by chance. Such results were taken to indicate that the subliminal prime was processed unconsciously. Following Marcel's (1983) research, numerous others have successfully used subliminally presented Single-Word primes to demonstrate the existence of unconscious processing (i.e., Cheesman & Merikle, 1986; Daza, Ortells, & Fox, 2002; Debner & Jacoby, 1994; Greenwald, Klinger, & Schuh, 1995; Jacoby & Whitehouse, 1989; Merikle & Joordens, 1997; Merikle, Joordens, & Stolz, 1995; see Merikle & Daneman, 1998; Merikle, Smilek, & Eastwood, 2001 for a review). Moreover, neuropsychological research has provided additional evidence of unconscious processing by demonstrating activation within the brain following the subliminal presentation of Single-Word primes (Dehaene et al., 2001; Dehaene et al., 1998; Kherif et al., 2011; Kjaer, Nowak, Kjaer, Lou, & Lou, 2001; Kiefer & Martens, 2010; Kouider & Dupoux, 2001; Kouider, Dehaene, Jobert, & Le Bihan, 2007; Naccache et al., 2005).

Given the establishment of unconscious processing, research presenting subliminal Single-Word primes has since been designed to understand how sophisticated unconscious processing is (Loftus & Klinger, 1992). For example, the presentation of subliminal Single-

Word primes has been shown to facilitate position/placement priming (Greenwald et al., 1995), repetition priming (Bodner & Masson, 1997; Forster & Davis, 1984; Grainger et al., 2003), evaluative decision making (Greenwald & Liu, 1985), and the semantic classification of supraliminal target words (Abrams & Greenwald, 2000; Abrams et al., 2002; Costello et al., 2009; Dehaene et al., 1998; Draine & Greenwald, 1998; Gaillard et al., 2006; Greenwald et al., 1996; Greenwald et al., 1995; Groeger, 1984; Kiefer & Martens, 2010; Klauer et al., 2007; Naccache & Dehaene, 2001; see Lucas, 2000 for a review). Furthermore, a range of other behavioural benefits have been reported following exposure to subliminal Single-Word primes such as, improved self-estimation (Dijksterhuis, 2004; Grumm et al., 2009; Jraidt & Frasson, 2010; Riketta & Dauenheimer, 2003), improved memory (Chartrand & Bargh, 1996; Dijksterhuis et al., 2000; Levy, 1996; Levy & Leifheit-Limson, 2009; Mitchell et al., 2002), and improved academic performance (Shih, Ambady, Richeson, Fujita, & Gray, 2002 Experiment 2; Lowery et al., 2007; Radel et al., 2009). Such results suggest that subliminal Single-Word priming is robust and able to elicit changes across a range of behaviours.

2.4.2 Multiple-Word Primes

In comparison to subliminally presented Single-Word primes, Multiple-Word primes have been explored across fewer psychology sub-disciplines including, psychodynamic and clinical psychology (Kaplan, Thornton, & Silverman, 1985; Palmatier & Bornstein, 1980; Silverman, 1966; Silverman & Candell, 1970; Silverman, Candell, Pettit, & Blum, 1971; Silverman, Frank, & Dachinger, 1974; Silverman & Spiro, 1968; Silverman, Spiro, Weisberg, & Candell, 1969; Spiro & Silverman, 1969; Thornton, Igleheart, & Silverman, 1987), psychodynamic and cognitive psychology (Bryant-Tuckett & Silverman, 1984; Ariam & Siller, 1982; Parker, 1982), the psychology of consciousness (Armstrong & Dienes, 2013, 2014; Sklar et al., 2012), and social psychology (Glassman & Andersen, 1999; Légal et al.,

2012). Subliminally presented Multiple-Word primes were also presented to establish how sophisticated unconscious processing of information was (Greenwald & Liu, 1985).

Following their experiment showing the successful unconscious processing of Single-Word primes, Greenwald and Liu (1985 Experiment 2) tested the extent of sophistication for the unconscious processing of written information. Greenwald and Liu (1985 Experiment 2) presented participants with Multiple-Word primes composed of two words oppositely different in evaluative meaning to the overall meaning of the prime. For example, ‘enemy fails’, whereby both ‘enemy’ and ‘fails’ are individually negative words, although together, the meaning of the whole phrase is considered positive. However, Greenwald and Liu (1985) reported that participants incorrectly evaluated the meaning of the whole prime, suggesting they were unable to unconsciously process the meaning of the two words in conjunction with one another. Others since agreed that unconscious processing is limited to the processing of single words only (Draine, 1997; see also, Greenwald, 1992; Loftus & Klinger, 1992), although more recently Sklar et al. (2012) and Armstrong and Dienes (2013, 2014) both report findings from a series of experiments that demonstrate successful unconscious processing of Multiple-Word primes.

For instance, Armstrong and Dienes (2013) presented participants with pairs of target noun words e.g., ‘kite’ and ‘moon’ and asked them to select the appropriate noun word as instructed by the subliminally presented Multiple-Word primes ‘pick kite’ or ‘not kite’. Inclusion of the word *pick* in the subliminal Multiple-Word prime identifies that the following noun (i.e., ‘kite’) should be selected whereas inclusion of the word *not* identifies that the following noun (i.e., ‘kite’) should not be selected. Hence, Armstrong and Dienes (2013) argued that inhibition of the latter noun word in the *not* condition would successfully demonstrate sophisticated unconscious processing. Results indeed supported their contention as participants performed at a rate above that expected by chance alone in both the *pick* and

not conditions. Additionally, slower reaction times were recorded for the selection of the noun following the *not* condition compared to the *pick* condition suggesting increased cognitive processing of the more difficult unconscious instruction. Further support for successful unconscious processing of Multiple-Word primes was provided from their second series of experiments that yielded similar results (Armstrong & Dienes, 2014). Here participants were subliminally presented with *active* (e.g., A injects B) or *passive* (e.g., B is injected by A) Multiple-Word primes and demonstrated, through a meta-analysis of the three experiments, an overall ability to select the correct image above the rate expected by chance success alone for both the active and passive sentences. Furthermore, longer response times were associated with the selection of an image following the *passive* compared to the *active* condition, suggesting increased cognitive processing of the more complex Multiple-Word primes³. The experiments by Armstrong and Dienes (2013, 2014; see also Sklar et al., 2012) demonstrate that unconscious processing may be more sophisticated than once thought (Draine, 1997; Greenwald, 1992; Greenwald & Liu, 1985; Loftus & Klinger, 1992).

Given that it is possible to unconsciously process Multiple-Word primes, other researchers have sought to test for further behavioural benefits elicited by subliminally presented Multiple-Word primes. For example, Multiple-Word primes have been reported to improve health related conditions such as, drug addiction (Thornton et al., 1987), obesity (Silverman, Martin, Ungaro, & Mendelsohn, 1978), phobias (Silverman et al., 1974), and smoking (Palmatier & Bornstein, 1980), reduce anxiety (Orbach et al., 1994; see also Hardaway, 1990), improve implicit mood (Weinberger et al., 1997; Sohlberg, Billingham et al., 1998; Sohlberg, Samuelberg, et al., 1998; Sohlberg, Arvidsson, & Birgegård, 1997), improve cognitive performance (Parker, 1982; Ariam & Siller, 1982; Bryant-Tuckett &

³ Passive sentences represent a more elaborative sentence structure that requires the participants to unconsciously transform the sentence into its most basic kernel, that is, most simple construction in order to correctly denote the agent of the two characters A and B presented (Armstrong & Dienes, 2014).

Silverman, 1984; Zuckerman, 1960), and increase trust (Légal et al., 2012). Similarly to the effects produced by subliminal Single-Word primes, the range of research indicates that behavioural benefits following the subliminal presentation of Multiple-Word primes are indeed varied and robust.

In summary, the presentation of both Single-Word and Multiple-Word primes has been extensively researched across several sub-disciplines of psychology. Whilst research concerning the behavioural effects produced following the presentation of subliminal primes has indicated that both Single-Word and Multiple-Word primes elicit a variety of robust behavioural effects, their effectiveness has never been directly compared. As such, it is not clear as yet whether a Single-Word prime may elicit more or less robust effects relative to a Multiple-Word prime. Hence, further research focusing on this issue may provide a clearer understanding of which subliminal prime type may elicit the most robust behavioural effect overall, or whether the subliminal prime types differ in where their strengths lie i.e., eliciting stronger behavioural effects for different cognitive or affective measures. In turn, such research may inform future research as to which prime type may be more suitable to elicit the best expected subliminal effects.

2.5 Theoretical Accounts for Behavioural Change

This final section provides an outline of three theoretical accounts regarding the findings of Single-Word and Multiple-Word subliminal primes. Whilst there may be a number of different theories that have been put forward to explain how subliminal presentation of written stimuli generates measurable behavioural changes, the three that will be discussed in this chapter are those that are most relevant to the research conducted in this thesis either due to the content of the subliminal primes or the methodology used to present the primes. The first theory, ‘Subliminal Psychodynamic Activation Theory’ is based on data

drawn from psychodynamic psychology and originally suggested that subliminal primes interact with the unconscious wishes or fantasies of the recipient, although more recently behavioural effects have been attributed to cognitive changes in mood and anxiety (Hardaway, 1990). The second is ‘Automaticity Theory’ which is derived from social-cognitive psychology and suggests that subliminal primes automatically activate internal stereotypes, traits, and concepts, that modify behaviour via the ‘perception-behavior’ link, (see Bargh, 1994). Finally, the ‘Goal-Directed Behaviour Theory’, also from social-cognitive psychology argues that behaviour designed to achieve a specific goal may be automatically activated by a subliminal prime if the achievement of that goal is conceived of as positive (see Custers & Aarts, 2010) and/or the individual is motivated to achieve the goal (Strahan et al., 2002).

2.5.1 Subliminal Psychodynamic Activation Theory

The Subliminal Psychodynamic Activation (SPA) theory was derived from psychoanalytic psychology with the aim of testing “clinical psychoanalytic propositions under controlled laboratory conditions” (Hardaway, 1990, p. 177). Subliminally presented information was originally examined using clinical samples often alongside existing treatments and as such was used as an adjunct (Silverman, 1982). Most notably schizophrenic patients formulated the clinical samples (Kaplan et al., 1985; Silverman, 1966; Silverman & Candell, 1970; Silverman et al., 1971; Silverman & Spiro, 1968; Spiro & Silverman, 1969) and research focused on assessing the manifestation of clinical symptoms following the subliminal presentation of aggressive stimuli (Balay & Shevrin, 1988). For example, pictorial stimuli such as a charging lion (Silverman & Spiro, 1967, 1968; Silverman et al., 1969) or a man with a dagger (Silverman, 1966), or combined picture (e.g., a man stabbing a woman) and written word stimuli (e.g., ‘destroy mother’; Silverman, Bronstein, & Mendelsohn, 1976)

were presented via a tachistoscope and found to increase schizophrenic behaviour including pathological thinking and non-verbal behaviour and considered to provide support for psychoanalytic theory (although, see Balay & Shevrin, 1988 for an alternative interpretation). Furthermore, Silverman and colleagues attempted to provide supplementary support for psychoanalytic theories through the use of the SPA method to ameliorate clinical symptoms (Silverman & Candell, 1970; Silverman et al., 1969; Silverman et al., 1971).

Such research demonstrated reduced clinical symptoms in schizophrenia following the presentation of a combined picture (e.g., two merged figures) and written text (e.g., ‘mommy and I are one’, Silverman et al., 1969) thought to activate unconscious fantasies of merging with the mother. Subliminal symbiotic activation studies, as they became known (Silverman & Weinberger, 1985), sought to test the clinical inference that symbiotic-fantasies, that is, fantasies of “oneness with the good mother of childhood” (Silverman & Weinberger, 1985, p.1297) had a soothing effect on the pathology of schizophrenia. Silverman believed that symbiotic wishes or fantasies of oneness with the mother emerged unconsciously in conflict with the schizophrenic symptoms that developed in response to the failed balance between having a secure sense of self and complete psychological abandonment of the mother as a child (Mahler, 1952). Hence, Silverman believed that activation of such symbiotic fantasies should reduce pathological clinical symptoms (Silverman et al., 1969; see also Balay & Shevrin, 1988).

Following reports of reduced clinical symptoms of schizophrenic patients after exposure to the subliminal Multiple-Word prime ‘mommy and I are one’ (Silverman & Candell, 1970; Silverman et al., 1969; Silverman et al., 1971), Silverman and colleagues examined the subliminal symbiotic activation method on a number of other clinical samples; for instance, insect phobic females (Silverman et al., 1974), heroin addicts (Thornton et al., 1987), obese females (Silverman et al., 1978), and smokers (Palmatier & Bornstein, 1980),

and reported improvements in their behaviour e.g., reduced addiction to heroin (Thornton et al., 1987) or health e.g., weight loss (Silverman et al., 1978). Furthermore, subliminal symbiotic activation studies were also conducted using non-clinical samples, such as students (Ariam & Siller, 1982; Hudesman, Page, & Rautiainen, 1992; Parker, 1982). Research testing non-clinical samples aimed to assess the potential positive cognitive improvements following exposure to the Multiple-Word prime, ‘mommy and I are one’ (Parker, 1982). Results showed that exposure to the Multiple-Word prime ‘mommy and I are one’ produced enhanced academic performance compared to the control prime (e.g., ‘people are walking’) and were extended to younger individuals of a different native language (e.g., Hebrew; Ariam & Siller, 1982). Hence, the positive results initially reported from the clinical literature were extended to include non-clinical samples and also incorporated multiple age brackets as well as individuals speaking different languages suggesting the Multiple-Word prime ‘mommy and I are one’ is able to elicit a robust effect.

It is not entirely clear which component of the Multiple-Word prime ‘mommy and I are one’ is eliciting the positive effects; it may be the notion of ‘oneness’, the focus on the ‘mother’, or a combination of the two. Each of these components have been examined within the literature, for example the notion of ‘oneness’ has been examined using different focal people e.g., ‘daddy and I are one’ (Condon & Allen, 1980), whereas the notion of the ‘mother’ has been examined by presenting different positive relationships e.g., ‘mommy and I are alike’ (Bronstein & Rodin, 1983; Orbach et al., 1994), or ‘mommy and I are two’ (Dauber, 1984; Mendelsohn, 1981; although, see Hardaway, 1990 for detailed account of alternative Multiple-Word primes). Furthermore, the majority of these alternative Multiple-Word primes are compared to the original ‘mommy and I are one’ Multiple-Word prime to examine whether it is the combination of ‘oneness’ and the ‘mother’ that elicits the most robust effect. However, results from such experiments offer no clear conclusion as to which

component elicits the positive effect. Some have reported no effect on behaviour following any of the subliminal Multiple-Word primes (Condon & Allen, 1980; Oliver & Burkham, 1982), some have reported the alternative Multiple-Word primes to be more effective compared to the original ‘mommy and I are one’ prime and control primes (Dauber, 1984; Mendelsohn, 1981). Whilst others have reported positive results only when using the original ‘mommy and I are one’ Multiple-Word prime (Bronstein & Rodin, 1983), whereas others still have reported beneficial effects elicited by all positively phrased Multiple-Word primes in comparison to control primes (see, Ariam & Siller, 1982; Orbach et al., 1994; Parker, 1982). In his review and meta-analysis, Hardaway (1990) analysed 56 subliminal symbiotic studies that matched his strict criteria⁴ and concluded that the original Multiple-Word prime ‘mommy and I are one’ was able to produce “moderate and reliable” effects (p. 184). Specifically, Hardaway (1990) explained that adaptive behaviour following subliminal exposure to ‘mommy and I are one’ improved from 40% to 60% whereas adaptive behaviour increased from 44% to 56% and from 46.5% to 53.5% for ‘other oneness’ and ‘other mommy’ Multiple-Word primes respectively, indicating that it is perhaps the combination of ‘oneness’ and the ‘mother’ that elicits the most robust effect.

The psychodynamic position explains positive behavioural results in terms of the fulfilment of unconscious fantasies (see Silverman & Weinberger, 1985). Hence, subliminal stimuli such as the Multiple-Word prime ‘mommy and I are one’ are effective because they are capable of activating unconscious wishes to be merged with, or at one with the mother. In contrast, Hardaway (1990) proposes that the effects elicited by the Multiple-Word prime ‘mommy and I are one’ are cognitive in nature and work by changing the individual’s

⁴ Hardaway’s (1990) criteria for inclusion consisted of studies that hypothesised experimental stimuli to reduce pathology or enhance performance of adaptive behaviour; compared psychodynamically relevant stimuli were with a neutral-control stimulus; selected between-groups samples from the same population; presented subliminal stimuli via a tachistoscope; and finally examined at least 10 participants per cell for each contrast.

emotional state. For example, Hardaway (1990) suggests that reductions in state variables such as anxiety may explain the effectiveness of the Multiple-Word prime, 'mommy and I are one'. Some, such as Ariam and Siller (1982), had previously theorised that their results of improved academic performance following the Multiple-Word prime was due to a reduction in anxiety, although they did not test for this specifically. However, others have since found evidence to support the notion that the Multiple-Word prime 'mommy and I are one' can reduce state anxiety (Orbach et al., 1994; Schurtman, Palmatier, & Martin, 1982; see also Hardaway, 1990). Hence, a change in behaviour via subliminal stimulation may occur following affective primes due to a reduction in anxiety that may improve the relationship with the therapist or mediate improved behavioural performance (Hardaway, 1990). Alternatively, Hardaway (1990) suggests that the Multiple-Word prime 'mommy and I are one' may produce positive behavioural changes through its capability to stabilize mood. Hardaway (1990) explains that the combined 'oneness' and 'mother' components of the Multiple-Word prime may elicit positive childhood memories in accordance with Bower's (1981) associative network theory that suggests memories congruent with the individuals current mood are more easily recalled. Hence, positive Multiple-Word primes such as 'mommy and I are one' may elicit a positive mood and trigger the recall of positive memories of the mother from childhood (Weinberger et al., 1997), which then mediates positive behavioural performance (Hardaway, 1990).

In summary, the psychodynamic activation theory was derived from research utilising psychoanalytic assumptions. Psychodynamic theorists believed that subliminally presented information was capable of antagonising or ameliorating unconscious wishes or fantasies and as such would increase (Silverman & Spiro, 1967, 1968; Silverman et al., 1969) or decrease (Silverman & Candell, 1970; Silverman et al., 1969; Silverman et al., 1971) maladaptive behavioural symptoms. Subliminal stimuli designed to reduce clinical symptoms i.e.,

‘mommy and I are one’ have been examined across numerous clinical and non-clinical samples (see Balay & Shevrin, 1988; Hardaway, 1990) and are thought to support the psychodynamic contention that behavioural clinical symptoms (e.g., Silverman et al., 1969) and cognitive performance (e.g., Ariam & Siller, 1982; Hudesman et al., 1992) can be improved through the satisfaction of the unconscious wish to be at one with the primary care giver (Silverman & Weinberger, 1985; see also Hardaway, 1990). However, Hardaway (1990) has since suggested that any ameliorative effects elicited following exposure to such Multiple-Word primes may be better explained by changes in cognitive emotional states such as reduced anxiety or improved mood.

2.5.2 Automaticity Theory

The theory of automaticity is derived from social-cognitive psychology (see Bargh, 2002; Bargh & Ferguson, 2000), and suggests that for a behaviour to be considered automatic, it should occur outside of conscious awareness, be unintentional, uncontrollable, and use attentional resources efficiently, or hold any combination of these four features (Bargh, 1994). In relation to these features, subliminal priming is considered to present information to the recipient outside of their conscious awareness. Within social-cognitive psychology, subliminally presented stimuli have taken the form of pictures, such as the face of a stereotypical group member (see Bargh et al., 1996 Experiment 3) or words relevant to stereotypes (e.g., Bargh & Pietromonaco, 1982; Dijksterhuis et al., 2000; Levy, 1996; Levy & Leifheit-Limson, 2009), traits (e.g., Erdley & d’Agostino, 1988; Légal et al., 2012; Lowery et al., 2007) or concepts (e.g., Johnson et al., 2010; McKay et al., 2011; Saroglou et al., 2009). The presentation of subliminal information outside of awareness has demonstrated that such cues presented in the environment may influence behaviour without conscious intention (Bargh & Chartrand, 2000) and furthermore, it has also been shown that a wide

range of complex, social behaviour may be automatically, that is, unintentionally elicited (Hassin, Uleman, & Bargh, 2005).

For instance, social behaviour including racial stereotypical behaviour (Bargh & Pietromonaco, 1982; Devine, 1989), negative stereotyping (Graham & Lowery, 2004), age-related stereotypical behaviour (Dijksterhuis et al., 2000; Hess, Hinson, & Statham, 2004; Levy, 1996; Levy & Leifheit-Limson, 2009; Levy et al., 2000), positive cultural stereotyping in academic performance (Shih et al., 2002), increased helping behaviour (Aarts et al., 2005; Pichon et al., 2007), increased intelligence (Hull, Slone, Meteyer, & Matthews, 2002 Experiment 3; Lowery et al., 2007), increased trust in others (Légal et al., 2012), increased effort (Aarts et al., 2008), and increased feeling of authorship (Dijksterhuis et al., 2008) have all been elicited following the subliminal presentation of traits, concepts or stereotypical words. Bargh and Chartrand (1999) suggest that the ‘perception-behavior link’ whereby the mere perception of a behavioural concept, trait, or stereotype in the environment may elicit the corresponding physical behaviour, might explain how the subliminal presentation of such information can activate such a wide array of complex behaviours. Although, see Newell and Shanks (2012) for an alternative argument⁵.

Bargh and Chartrand (1999; see also Bargh & Ferguson, 2000) explain the ‘perception-behavior’ link as a two-stage process. Firstly, perceptual activity of behaviour in the individual’s environment must occur. That is, internal representations of specific behaviour(s) associated with traits, concepts or social groups, are automatically created following the observation of them in the environment. For example, an observation of an elderly couple walking slowly will automatically create the internal representation that elderly people are stereotypically slow. The more frequently these behaviours are perceived,

⁵ See also, Doyen, Klein, Pichon, & Cleeremans (2012); Harris, Coburn, Rohrer, and Pashler (2013); Pashler, Rohrer, and Harris (2013); and Shanks et al. (2013) for further examples of failed automatic priming following unawareness to the intended influence that presented stimuli may have.

the stronger the internal representation of behaviour concerning that social group, trait, or concept becomes (Shiffrin & Schneider, 1977; see also, Bargh & Chartrand, 1999; Bargh & Ferguson, 2000). Hence, the more often elderly people are observed to walk slowly in the environment, the stronger the internal representation of this stereotypical behaviour for this social group (i.e., elderly people) will become. The second stage in the process is the behavioural propensity to act through the 'perception-behavior link' (Bargh & Chartrand, 1999; Bargh & Ferguson, 2000).

Bargh and Chartrand (1999) explain that these internal representations of social groups, traits or concepts, also initiate thoughts about action, that is, the actions required to elicit behaviour(s) associated with the social group, trait or concept. Hence, the activation of the social group 'elderly' will initiate thoughts about the actions required to walk slowly, as this behaviour was previously perceived as associated with the 'elderly' social group. Hence, the more often a behaviour is perceived and associated with a social group, trait or concept, the stronger the internal representation of these social groups and behaviours become, and in turn so too are the action thoughts associated with that social group or behaviour. Therefore, through the 'perception-behavior link', if an internal representation of a social group, stereotype, trait or concept, is activated by a subliminally presented stimulus, the action thoughts associated with it are also activated and thus, the behaviour is more likely to occur (Bargh & Chartrand, 1999; Bargh & Ferguson, 2000; for an example see Bargh, Chen, & Burrows, 1996 Experiment 2; and see Doyen et al., 2012 for an alternative finding).

As such, the entire two-stage process, from the perception of behaviour in the environment to the behavioural activation following subliminal priming is considered to occur automatically without conscious intent (Bargh & Chartrand, 1999; Bargh & Ferguson, 2000). Nonetheless, Bargh (2005) advises that whilst the behaviour associated with the social group, stereotype, trait, or concept, may be activated following subliminal priming and have a

higher likelihood of occurring, the behaviour will only occur if the situation is appropriate. For instance, behaviour such as walking slowly, stereotypically associated with the ‘elderly’, may only be elicited if the individual is provided with an opportunity to walk slowly.

However, a brief note should be made in relation to the ‘crisis of replicability’ (Stroebe & Strack, 2014) of non-conscious priming research that has been discussed in recent years in various academic domains (Klatzky & Creswell, 2014). The theory of automaticity was supported by key studies such as Bargh et al.’s. (1996 Experiment 2) demonstration that participants walked more slowly following non-conscious exposure to ‘elderly’ related primes but more recently, others have failed to replicate such a finding (see Doyen et al., 2012) and in addition, other failed replications of social priming research have been reported (see Harris et al., 2013; Pashler, Rohrer, & Harris, 2013; Roberts, Crooks, Kolody, Pavlovic, Rombola, & Standing, 2013; Shanks et al., 2013; for a review see Newell & Shanks, 2012). Shanks et al. (2013) condemned the field of social priming arguing that the evidence from theirs and other failed replications indicate that the past published research amounts to unconvincing evidence of unconscious processing of information (see also Newell & Shanks, 2012⁶).

Such research raised discussions examining how such original research was initially published, with many suggesting that the use of questionable research practices (e.g., *p*-hacking and the file drawer effect⁷ that have lead to false positives, Simmons, Nelson, & Simonsohn, 2011; see also Cesario, 2014; Stroebe & Strack, 2014; Vadillo, Konstantinidis, & Shanks, 2015) and publication bias (Pashler et al., 2013) are contributing factors to the publication of these past unconvincing findings. Yong (2012) also suggests that the reliance

⁶ However, Dijksterhuis (2013) and Dijksterhuis, van Knippenburg, and Holland (2014) deny that non-conscious intelligence priming specifically is unconvincing and highlight the high number of close replications that have been published (e.g., Bry, Follenfant, & Meyer, 2008; Lowery et al., 2007).

⁷ See www.psychfiledrawer.org

on conceptual replications rather than direct replications further compounded the issue as conceptual replications cannot provide important information such as the effect size of the conceptually replicated effect and furthermore, cannot offer conclusions concerning possible questionable research practices (Cesario, 2014). However, others have argued that the evidence following failed replications of research are ambiguous due to the lack of theoretical knowledge concerning the factors that may affect priming (Cesario, 2014). Hence, suggestions for future research in the social priming field have centered on the *repetition* of the research by the original researcher followed by *replication* of research findings by other research teams to examine the generalisability of the finding (Cesario, 2014). In sum, researchers in the field of social priming have considered such discussions as “a welcome, though rather loud, wake-up call” (Dijksterhuis, 2014 p. 72).

However, the majority of research in connection with such issues are those that often employ the use of non-conscious priming techniques (e.g., scrambled sentence tasks or word search tasks) whereby the participants are consciously presented with the information (e.g., words related to the trait of ‘intelligence’ or concept of ‘elderly’) but are unaware of *influence* that such words may have on their behaviour. Whilst there are some reported failed replications of subliminally primed effects (e.g., Stein, Blanchard-Fields, & Hertzog, 2002), there are notably less than those using the non-conscious priming technique and moreover, some have suggested that the more subtle techniques such as subliminal priming may well be a better technique for future research in the field (Stroebe & Strack, 2014).

In sum, the automaticity theory derived from social-cognitive psychology attempts to explain the effects of subliminal presentation of information in terms of it bypassing the participant’s conscious awareness and unintentionally eliciting behaviour (Bargh, 1994). Bargh and Chartrand (1999; Bargh & Ferguson, 2000) suggest the ‘perception-behavior’ link may explain how such behaviour is elicited. Internal representations (for social groups,

stereotypes, traits and concepts) are automatically created following the perception of behaviour in the environment, and if activated by a subliminal prime, so too are thoughts about actions associated with it, hence, the behaviour is more likely to occur (Bargh & Chartrand, 1999; Bargh & Ferguson, 2000) given that the situation following subliminal priming allows for that behaviour to occur (Bargh, 2005). More recently, the theory has come under discussion following a number of failed replications of research used in support of this theory (e.g., Doyen et al., 2012; Shanks et al., 2013). Despite this, several discussions have highlighted the importance of continuing to research in the social priming field and have suggested that such failed replications are indeed ambiguous on their own (Cesario, 2014). As such, directions for future research suggest that researchers should aim to repeat their own research findings following publication and that direct (rather than conceptual) replications should be conducted afterwards to examine for the generalisability of the priming effect and further aid in identifying possible moderators (Cesario, 2014).

2.5.3 Goal-Directed Behaviour Theory

In an extension to the automaticity theory, subliminal presentation of information has been shown to automatically activate a range of social and interpersonal goals and their relevant goal-directed behaviours (Hassin et al., 2005). For example, subliminal stimulation encouraging the pursuit of a specific goal has been shown to elicit a range of behaviours, including increased willingness to help others (Aarts et al., 2005; Fitzsimons & Bargh, 2003), increased effort (Aarts et al., 2008), increased willingness and prioritisation of achievement (Hart & Albarracín, 2009), increased fluid consumption (Karremans et al., 2006; Strahan et al., 2002; Veltkamp et al., 2008; Veltkamp et al., 2011 Experiment 1), selectively consuming a high-calorie drink to achieve the goal of consuming more calories (Strahan, Spencer, & Zanna, 2004, as cited in Kardes, Herr, & Nantel, 2005) and the consumption of energy tablets

to achieve the goal of increased concentration (Bermeitinger et al., 2009). Similar to the automatic activation of stereotypes, traits and concepts, goal-directed behaviour is also considered by Bargh (1994) to be automatically activated. Goals are described as flexible and persistent mental representations of an end-state and as such may be activated by subliminally presented stimuli that are relevant to the goal (Bargh, 2005; Bargh & Chartrand, 1999; Custers & Aarts, 2005; Förster, Liberman, & Friedman, 2007). However, a goal may only be activated by subliminally presented relevant information if the goal itself is pre-existing (Aarts et al., 2005; Bermeitinger et al., 2009) and furthermore, goal-directed behaviour following subliminal automatic activation of the goal may only occur if the situation following subliminal priming is suitable (Bargh, 2005; see also Bargh & Morsella, 2008; Bargh & Chartrand, 1999; Fitzsimons & Bargh, 2003). For example, Strahan et al. (2002) found that participants primed with the subliminal goal of quenching their thirst could only demonstrate the necessary goal-directed behaviour (i.e., drinking), if provided with drinking facilities.

It has been argued that goal representations may be built up internally over a period of time and become automatic to relinquish the need for effortful conscious consideration of which goal to pursue, and the relevant behaviours and decisions needed to achieve this goal in response to environmental experiences (Bargh & Chartrand, 1999). Similar to internal behavioural representations for social groups, traits, and concepts, internal mental representations of goals and the corresponding behaviours, decisions, and judgements needed to achieve the goals, are created following consistent and frequent pairing to specific environmental events (Bargh & Chartrand, 1999; see also Aarts, Gollweizer, & Hassin, 2004). For example, a student may form the goal of passing an exam in response to the environmental event of being informed about an upcoming exam and furthermore will also consider the action plan needed to achieve this goal i.e., to study hard. Such a goal, that is to

'pass the exam' and its corresponding behaviours and decisions needed to achieve the goal may then become an automatic response to future announcements of upcoming course exams. Such automated goals may then be activated without conscious awareness by information presented in the environment, for example, by subliminally relevant stimuli. For instance, forming an impression of a new person is a reasonably automatic goal for many (Asch, 1946) and has been shown to influence the amount of behavioural information memorised about the new person (Chartrand & Bargh, 1996 Experiment 2; see also Hamilton, Katz, & Leirer, 1980). In their experiment, Chartrand and Bargh (1996 Experiment 2) presented participants with subliminal Single-Word primes designed to activate the impression formation goal (e.g., judgement, evaluate) or neutral words (e.g., coffee, chalkboard) and reported that participants exposed to the impression formation primes showed evidence of online impression formation of a fictional character through the memory of more behavioural information in comparison to participants in the control condition who showed no evidence of impression formation. Hence, the words presented subliminally automatically activated the pre-existing goal to form an impression, which in turn led to the goal-directed behaviour of forming a judgement about the fictitious person and memorising more behavioural information about them.

More recently, however, the idea that behaviour can be influenced by the automatic activation of a mental goal representation has been extended to suggest that both positive affect and motivation to achieve the goal may be required (Aarts et al., 2005; Aarts et al., 2008; Custers & Aarts, 2005, 2007; Strahan et al., 2002). Custers and Aarts (2010) suggest that goal-directed behaviour theory features the internal consideration of the goal, assessment of the availability of behaviours or resources required to achieve the goal, and the assessment of how desirable it would be to attain the goal. Goals paired with positive valence are also unconsciously assessed as desirable and as such goal-directed behaviour is initiated. For instance, subliminally presented stimuli encouraging a specific goal-directed behaviour

paired with supraliminal positive (e.g., good, pleasant) words led individuals to expend more effort on a task compared to when no positive words were presented (Aarts et al., 2008). Others, such as Strahan et al. (2002), have suggested that motivation rather than positive affect is required for successful subliminal priming of a goal and activation of a relevant goal-directed behaviour. In their research, Strahan et al. (2002) found that only participants who were deprived of refreshment that is, were motivated to quench their thirst, *and* were subliminally presented with thirst related words (e.g., thirst, dry) designed to activate the goal of quenching their thirst displayed enhanced goal-directed behaviour by drinking considerably more beverage compared to non-thirsty participants (i.e., those not motivated to quench their thirst), and those primed with neutral words (e.g., pirate, won) not designed to activate the goal. Support for the requirement of both the subliminal activation of the goal and motivation of the participant to achieve the goal has been demonstrated numerous times (see also, Karremans et al., 2006; Strahan et al., 2004, as cited in Kardes et al., 2005; Veltkamp et al., 2008; Veltkamp et al., 2011 Experiment 1; and see Strahan, Spencer, & Zanna, 2005 for a review).

In summary, subliminal presentation of words has been found to activate goal-directed behaviours such as socializing (Custers & Aarts, 2007), helping (Aarts et al., 2005; Fitzsimons & Bargh, 2003), and thirst quenching (Karremans et al., 2006; Strahan et al., 2002; Veltkamp et al., 2008; Veltkamp et al., 2011 Experiment 1). Some have considered the automatic activation of a goal to be similar to the automatic activation of stereotypes, traits, and concepts (Bargh, 1994), although, more recently, it has also been suggested that an internal assessment of how desirable it would be to attain the goal needs to be conducted, or that pairing positive affect with a goal will increase the effort afforded to goal-directed behaviour hence, the goal-state is related to positive affect (Aarts et al., 2008; Custers & Aarts, 2005, 2007; see Custers & Aarts, 2010 for a review). Furthermore, motivation has

been suggested as important for successful subliminal activation of goals, whereby subliminal activation of a goal may not be sufficient alone and that the individual must be motivated to achieve the goal to ensure that the relevant goal-directed behaviour occurs (Strahan et al., 2002).

2.6 Chapter Summary

The term ‘subliminal’ means to present information below the receiver’s threshold of conscious awareness (see, Dehaene et al., 2006; Vernon, 2009). To ensure that information is presented subliminally threshold awareness tests are often conducted; two methods that are common in the literature are individual threshold testing and funnel-styled questionnaires (see Dijksterhuis, 2004 for an example). Information may be presented subliminally in several different formats, including auditory presentation, subliminal visual-pictorial presentation and the presentation of subliminal visual-written words. A number of factors have been considered with regards to presenting visual-written words subliminally, including the presentation duration of the subliminal word(s), point size, screen placement and masking procedure among others. On reviewing such factors it is apparent that no consistent methodological procedure exists concerning what is the optimum procedure required for presenting written words subliminally. Within the subliminal written-word technique there are two further prime types that may be used, subliminal Single-Word primes and subliminal Multiple-Word primes. A brief historical review of the use of both the Single-Word and Multiple-Word primes demonstrated the diverse nature of these different subliminal priming types, and highlighted that the two subliminal written prime types have not yet been compared. Since it has been shown that both subliminal prime types can be unconsciously processed (see Armstrong & Dienes, 2013, 2014; Greenwald & Liu, 1985; Marcel, 1983) and that both have the capacity to influence a wide range of behaviours, a comparison of the two

subliminal prime types may help inform future research as to which prime type is the most suitable to elicit robust subliminal priming effects. Finally, three theoretical accounts that attempt to explain why behavioural changes occur following subliminal written word primes were reviewed. These were the subliminal psychodynamic activation theory, the automaticity theory, and the goal-directed theory.

Chapter Three: General Methodology, Data Preparation and Data Analysis

There are a number of aspects that remained the same across the different experiments so this chapter provides a summary of the methodology used in the following experiments (Chapters 4-7) unless otherwise stated in the individual experimental chapters. This chapter will provide an overview of how the experiments were conducted and analysed, and provide a rationale for these procedures. The chapter begins by outlining information about the participants, followed by an explanation of the materials used, as well as an account of the presentation and duration of the subliminal stimuli. The chapter concludes by providing an explanation of the general design, data preparation, and analysis procedures.

3.1 Participants

The number, age and other details specific to the samples used in each experiment are outlined in the method section of the individual experiments. Convenience sampling was used, taking advantage of accessibility and proximity to the researcher. All participants were naïve as to the purpose of the experiments and completed no more than one experiment. Finally, all participants were required to read and sign a consent form (Appendix A, p. 353) informing them of both full confidentiality and their right to withdraw at any stage of the experiment.

3.1.1 Recruitment

Participants were recruited using poster and email advertising to gather interest from willing participants. Participants were pre-screened for several factors including: psychological health issues and consumption of prescribed or non-prescribed medication (see Appendix B, p. 354), as well as language, colour-blindness and vision. Colour-blindness to the colours 'red' and 'green' were vocally assessed before the start of each experiment

because its importance to the Stroop Colour Naming Task (Experiment 1, Chapter 4) and the Lexical Decision Task (LDT; Experiments 1-4, Chapters 4-7). Additionally, participants were asked to confirm they had normal or corrected-to-normal vision prior to the start of the experiment and language enquiries were made to ensure participants were native English speaking. However, in Experiments 1 (Chapter 4) and 2 (Chapter 5), both native English-speaking participants and bilingual participants proficient in English were accepted to participate. While native English-speaking participants were primarily sought as participants, due to the large number of required participants it was not possible to complete Experiments 1 and 2 relying only on native English speakers and as such, proficient bilingual speakers were also used. Although research suggests that native English speakers may have an advantage in processing subliminally presented English words due to the additional cognitive load this may include for the non-native speakers (e.g., Silva & Clahsen, 2008), robust subliminal priming effects have been elicited from non-native English speakers (Grainger & Frenck-Mestre, 1998; Rehak, 2010; Silva & Clahsen, 2008). However, in Experiments 3 (Chapter 6) and Experiment 4 (Chapter 7), only native English-speaking participants were recruited.

3.1.2 Incentives

Two incentives were used to encourage participation in the experiments; course credits (Experiments 1-4, Chapters 4-7) and monetary rewards e.g., a cash prize draw (see Amabile, 1998; Vohs, Mead, & Goode, 2006; Experiment 1, Chapter 4; Experiment 3, Chapter 6).

3.1.3 Allocation to Subliminal Stimulus Group

Participants (Experiments 1-3, Chapters 4-6) were assigned to one of the six subliminal stimuli groups meaning that each participant was shown only one of the six messages, and allocation to such message was done to ensure an equal number of participants were exposed to each subliminal stimulus. A Latin Square arrangement was utilised to ensure the rotation of subliminal stimuli conditions were even across other counterbalanced aspects of the experiments e.g., order of the Conceptual Span Task. The first participant was randomly assigned to one of the subliminal stimulus conditions using a random number generator (<http://www.random.org/>), and each participant thereafter was assigned according to the Latin Square rotation.

3.2 Materials

3.2.1 The Subliminal Stimuli

The subliminal stimuli were three Multiple-Word primes and three Single-Word primes. The six different stimuli used in Experiments 1 to 3 (Chapters 4-6) were as follows, ‘I am intelligent’, ‘mommy and I are one’, ‘people are walking’, and ‘intelligent’, ‘one’, and ‘walking’. The rationale for utilising the three Multiple-Word primes will be outlined first.

The first Multiple-Word (i.e., cognitive) prime, ‘I am intelligent’ was developed specifically for this research to target the cognitive components of the tasks. The Multiple-Word prime is based on work showing that intelligence-related subliminal Single-Word primes can improve academic performance (Lowery et al., 2007), suggesting that the trait of intelligence can be subliminally primed. To enable a sentence-like structure to form a Multiple-Word prime, Dijksterhuis’ (2004) evaluative conditioning technique was utilised. This involves subliminally presenting the word ‘I’ prior to any subliminally presented positive words. This technique has been shown to indicate that an object such as the self can

take on the valence of a prime word presented directly after it, even when that word is presented subliminally (see Dijksterhuis, 2004; Riketta & Dauenheimer, 2003). Therefore, in the current research, a Multiple-Word prime was created that paired a self-referent (e.g., 'I') with the trait word of 'intelligent' bound together using a neutral connecting word (e.g., 'am') to create the prime 'I am intelligent'.

The second Multiple-Word (i.e., affective) prime, 'mommy and I are one' aimed to stimulate increased closeness to the primary caregiver. Although early research presenting this Multiple-Word prime focused primarily on ameliorating symptoms in clinical samples (Weinberger & Silverman, 1990), positive changes in behaviour, namely increased academic performance has also been reported (Ariam & Siller, 1982; Hudesman et al., 1992; Parker, 1982). Theoretically, it has been suggested that such benefits are due to a reduction in internal (state) anxiety (Ariam & Siller, 1982) and an overall enhancement of positive mood (see Hardaway, 1990), however, changes in mood and anxiety have not been measured in conjunction with cognitive enhancements. Nevertheless, there is supportive evidence showing the symbiotic-like Multiple-Word prime can, at least, improve implicit mood (Weinberger et al., 1997) and reduce state anxiety (Orbach et al., 1994; see Hardaway, 1990 for a review). As such, 'mommy and I are one' represents an ideal candidate for investigating the effectiveness of a subliminal Multiple-Word prime on a range of affective (e.g., state anxiety, mood) and cognitive measures (e.g., intelligence, memory and attention).

In addition to these experimental positive content primes, a neutral-control Multiple-Word prime was also used. In past research studying the prime 'mommy and I are one', the Multiple-Word prime 'people are walking' has often been used as a neutral comparison (Parker, 1982; Sohlberg, Billingshurst et al., 1998; Weinberger et al., 1997; see also Hardaway, 1990 for a review). Thus, the final Multiple-Word prime to be presented in this

research was ‘people are walking’, acting as a neutral-control, which has no previously reported influence on behaviour.

With regard to the use of subliminal Single-Word primes, previous research has utilised several separate words related to the same concept (e.g. Lowery et al., 2007; Dijksterhuis, 2004; Strahan et al., 2002; Levy, 1996), as well as presenting the same Single-Word prime repeatedly presented (Mitchell et al., 2002). Both approaches have been shown to elicit changes in behaviour. As such, to remain consistent with the subliminally presented Multiple-Word primes, a single word was chosen for each subliminal Single-Word prime that related to the same concept alluded to by the Multiple-Word primes (e.g., intelligent, one, walking) and presented multiple times. To match the content of the cognitive Multiple-Word prime, the single word ‘intelligent’ was taken from the list used by Lowery et al. (2007) as it exemplifies the trait of intelligence clearly by itself. For the ‘mommy and I are one’ Multiple-Word prime, only one of the two concepts (i.e., *mommy* or *one*) could be used in the equivalent subliminal Single-Word (i.e., affective) prime; of the two, the concept of ‘one’ was chosen due to its conceptualisation by Weinberger and Smith (2011) as an unconscious motivational trait. It is evident in the subliminal literature that traits can be influenced through subliminal priming paradigms (see Erdley & D’Agostino, 1988; Bargh et al., 1996; Dijksterhuis & van Knippenberg, 1998). Therefore, it is possible that the oneness motivational trait could be activated using the single subliminal prime word ‘one’. Additionally, research by Sohlberg and Birgegård (2003) reports that the Single-Word prime ‘mommy’ did not produce the same effects as the Multiple-Word prime ‘mommy and I are one’. Finally, to be consistent with the two experimental Single-Word primes, the last word from the neutral-control Multiple-Word prime was taken to act as the neutral-control Single-Word prime i.e., ‘walking’.

3.2.2 Presentation of Stimuli

The appearance of each subliminal stimulus and the duration it was presented for remained the same in all experiments (Experiments 1-4, Chapters 4-7). The Multiple-Word and Single-Word subliminal primes were written in uppercase letters (after; Zuckerman, 1960; Parker, 1982; Weinberger et al., 1997) and presented in point size 22, using a proportional serif font (i.e., Courier New) (after; Izquierdo, Saal, & Page, 2010). The subliminal stimuli were presented in a normal typeface (i.e., no bold or italics added to the text) and were coloured 'Silver' using E-Prime 2.0 (2.0.8.90) psychology software's colour scale (RGB = 192, 192, 192). The colour of the font was chosen to decrease the visibility of the stimuli when presented on a white background (Lamy et al., 2008). All stimuli were presented in a central location on the computer screen to minimise the influence of spatial attention (Van den Bussche et al., 2009). Additionally, the subliminal stimuli (Experiments 1-3, Chapters 4-6) were backward masked using target letter strings from the Lexical Decision Task (LDT, e.g., *words*: towel, chair; or *nonwords*: curte, phlud) written in bold, black, Courier New font, and point size 70 to enable sufficient coverage of the longest subliminal Multiple-Word prime (i.e., mommy and I are one).

There is no universally standard exposure duration for subliminal stimuli; instead subliminal stimuli have been presented at speeds of between 8.5ms (Dijksterhuis & Smith, 2002) and 82ms (Klauer et al., 2007). In the current experiments the subliminal stimuli were presented for 14ms (after; Dijksterhuis, 2004; Pichon et al., 2007; Wentura & Frings, 2005). BlackBox ToolKit⁸ equipment, designed to provide millisecond precision on the timing of stimuli presented on a computer screen (Plant, 2003), confirmed the speed the subliminal stimuli were presented at was consistent across all conditions and experiments. Thus, the presentation rate of the subliminal stimuli was towards the 'short exposure duration' end of

⁸ For more information about the Black Box ToolKit, see <http://www.blackboxtoolkit.com/aboutus.html>.

the spectrum and consistent with others who have used such durations and elicited successful behavioural changes (Custers & Aarts, 2007; Dijksterhuis & Smith, 2002; Mogg et al., 1993; Parker, 1982; Sohlberg, Billinghamurst et al., 1998; Sohlberg & Birgegård, 2003; Wentura & Frings, 2005). Finally, all subliminal stimuli were presented to participants for a total of 30 repetitions during a LDT. Similar to the issue of exposure duration, there is no set number of repetitions agreed upon to achieve successful results. Previous research has reported successful behavioural changes following either one presentation (Zuckerman, 1960) or exposure to a total of 86 subliminal presentations (Radel et al., 2009). In their meta-analysis, Van den Bussche et al. (2009) advised that researchers should consider the length of the task the subliminal stimuli are presented in, because fatigue of participants, caused by long-duration tasks (i.e., tasks with a large number of trials) could influence the effectiveness of the subliminal stimuli. Although they report that a higher number of repetitions of subliminal stimuli generate stronger priming effects, they also explain that this factor only accounts for 24% of the variance. In addition, they report that subliminal priming “can be expected even when few trials are used” (p. 464). Dijksterhuis (2004) asked participants to complete a LDT consisting of 30 trials but only inserted subliminal stimuli into 15 (50%) of the trials. Results of the study showed positive subliminal priming, indicating that 15 exposures to subliminal stimuli was sufficient to generate behavioural change, and that 30 trials on the LDT is not thought to be fatiguing to the participant. Lie and Watten (1994) report detrimental effects such as eye muscle fatigue, neck, back, and head pain may occur after three hours of continued computer-based work (see also Anshel, 2005) therefore, a 30-trial LDT should be suitable to use in the current research as such a task should take considerably less than three hours to complete. Thus, the experiments in this thesis will use a similar methodology to that of Dijksterhuis (2004) regarding the 30-trial LDT, but will expose participants to subliminal

stimuli in all of the 30 trials in an attempt to elicit a stronger priming effect (Van den Bussche et al., 2009) whilst not fatiguing the participant.

3.2.3 Equipment

Participants completed the computer tasks using a Super RiteMaster computer tower installed with Windows 7 enterprise and Intel(R) Core(TM)2 Duo CPU processor and a 32-bit operating system, in combination with a 17 inch Belinea screen at full brightness operating with a 60Hz refresh rate. The computer utilised the software presentation platform E-Prime 2.0 (2.0.8.90) to build and run all computer-based tasks for the experiment. Additional hardware used included a RiteMaster keyboard used with the Conceptual Span Task (CST) and a Cedrus response pad (model: RB-530) used with the LDT. Participants sat in front of the computer at a distance of 53 centimetres (cm), with the keyboard or response pad placed directly in front of them (22 cm between their chest the centre of the keyboard/response box).

3.2.4 Subliminal Threshold Checks

At the end of each experiment all participants were asked to complete a funnel-style questionnaire to assess their level of awareness of the subliminal stimuli presented to them (see Dijksterhuis, 2004; Riketta & Dauenheimer, 2003). The questionnaire began by asking the participant general questions about the study (e.g. ‘Did you notice anything unusual during the study?’) to gauge their level of subjective awareness of the subliminal stimuli, and ended with a specific forced-choice decision. Participants were asked to choose out of all the subliminal stimuli used in the experiments, which they thought they were exposed to, in order to test their objective awareness of the subliminal stimuli.

3.2.5 Experiment Tasks

3.2.5.1 Conceptual Span Task (CST)

An adapted version of the CST (Haarmann, Davelaar, & Usher, 2003) was utilised in all experiments (Chapters 4-7) as a measure of participants' working memory. The task was adapted to include an additional category of 'musical instruments' (increasing the number of categories from six to seven) with nine nouns (Snodgrass & Vanderwart, 1980) forming each category, and 21 trials were presented to each participant as opposed to 16 in the original. For each trial, nine nouns were presented in total; three nouns from three different categories (e.g. carrot, pear, train, orange, motorcycle, corn, bicycle, cherry, asparagus), thus each noun only appeared for recall once during the 21 trials of the CST. At the end of each trial, participants were given a category cue (e.g., fruit) and were required to recall all the nouns presented from that category (e.g., pear, orange, cherry). A random number generator (<http://www.random.org/sequences/>) was used to randomise the order of the nouns. In addition to the 21-recorded trials, two practice trials were also provided to ensure the participants understood the instructions of the CST and what they were required to do. It should be noted that the nouns and categories used in the practice trials were different to those used in the recorded CST trials, although every other aspect of the practice trials was kept the same. During all the trials of the CST, both practice and recorded, a Courier New point size 26 font was used for the fixation crosses, nouns, and category prompts. The nouns were presented in standard lowercase letters whilst the fixation cross shown at the start of every trial, and the category prompt shown at the end of each trial were both written in bold uppercase letters. All written stimuli were presented in black font on a white background. Instructions were written using black, Courier New, point size 12 font, on a white background.

3.2.5.2 Lexical Decision Task (LDT)

A LDT (Meyer & Schvaneveldt, 1971) was utilised as a delivery method for the subliminal stimuli in all experiments (Experiments 1-4, Chapters 4-7) due to the success previous researchers have had embedding subliminal stimuli in such a task (e.g., Bodner & Masson, 1997; Dijksterhuis, 2004; Forster & Davis, 1984). Subliminal stimuli were presented in each of the 30 trials for a brief duration ($M = 14\text{ms}$), and were backward masked by a supraliminal random letter strings. Participants were not informed of the subliminal content presented prior to the supraliminal letter strings and were instructed to make a word/nonword decision on each of the target letter strings. The 30 target letter strings used in the task comprised of 15 neutral household nouns (e.g., chair, bedstead) of between four and eight letters in length ($M = 5.8$ letters), none of which appeared in the CST, and 15 pseudohomophones (i.e., a nonword that is phonetically correct, see Rastle, Harrington, & Coltheart, 2002). The nonwords were selected from the ARC nonword database (Rastle et al., 2002; <http://www.cogsci.mq.edu.au/~nwdb/>), and were also between four and eight letters in length ($M = 5.8$). The 30 target letter strings were presented to participants in a computerised random order, and participants moved through the task by indicating their decision using button presses on a Cedrus Response Pad, whereby 'RED' indicated a nonword and 'GREEN' indicated a word. Additionally, the order with which the green button was placed on the right hand side was counter-balanced to control for handedness. During all trials of the LDT, supraliminal stimuli were written in uppercase letters and presented in Courier New, point size 70, black font on a white background. The point size of the supraliminal content was large in order to sufficiently mask the longest of the subliminal stimuli, namely the subliminal Multiple-Word prime, 'mommy and I are one'. Task

instructions were presented in black, Courier New, point size 12 font, on a white background⁹.

3.3 Procedure

The following will outline the two tasks used consistently in all experiments (Chapters 4-7), namely the CST and LDT. Other tasks used will be outlined specifically in the relevant chapters. In all experiments, the CST was completed both prior to, and after the LDT; therefore the CST was completed twice whereas the LDT was only completed once.

3.3.1 Conceptual Span Task (CST)

At the start of the CST participants were shown an instruction screen that outlined what they were required to do (i.e., silently read the nine words presented to them on the screen and recall out loud the words from one of the presented categories). Participants were also given a verbal account of these instructions and were offered the chance to ask questions to clarify the task. Participants were then instructed to press the space bar on the keyboard in front of them to move onto the practice trials. At the end of the practice trials a second instruction screen was shown to signify the end of the practice round and to instruct the participant to move on to the recorded CST trials by pressing the space bar. At the end of the

⁹ A pilot study was conducted on the efficiency of the LDT used for this thesis. The sample consisted of 12 participants; six female and six male, ranging from 20 to 25 years of age ($M = 22.85$, $SD = 1.54$). Results from the pilot study indicated the method selected to present the subliminal stimuli was efficient. Zero participants noticed the subliminal stimuli presented to them. When asked to complete the forced choice decision test, the majority of 10 participants (88.33%) guessed incorrectly. The reason provided for selecting that option from the list of six possible subliminal stimuli by the two participants that did guess correctly (16.66%) was based on the LDT target letter strings they saw, and as such, did not suggest any conscious awareness to the subliminally presented information.

recorded trials, the participants were shown a final screen to signify the end of the CST, and to ask the experimenter for further instruction.

Each trial of the CST (both recorded and practice) began with the presentation of a fixation cross (X) in the centre of the screen, shown for a period of 500ms. The fixation cross was immediately followed by the nine nouns, each shown for 1000ms in the centre of the screen and participants were instructed to read these words silently. Following the list of nouns, a category prompt was presented in uppercase (e.g. VEGETABLE?) for 5000ms in the centre of the screen to signify to the participant that they needed to recall the words from the list that related to that category (e.g., carrot, corn, asparagus). Correctly recalled answers were recorded by the experimenter on a response sheet (Appendix C-D, p. 355-356), and in addition to these correctly recalled words, the experimenter also noted down any additional words (i.e., intrusions) recalled by the participant. Once the participant had finished recalling the words from the list that related to the category, they were required to press the space bar on the keyboard to begin the next trial. Before the trial began an inter-trial-interval (ITI) (e.g., presentation of a blank (white) screen for a period of 1000ms) was shown (see Figure 2 for a diagram of the CST task trial, p.77).

3.3.2 Lexical Decision Task (LDT)

At the start of the LDT, participants were shown an instruction screen that outlined what they were required to do. Participants were also given a verbal account of these instructions and were offered the chance to ask questions to clarify the task. The LDT had no practice element, participants were simply asked to press the white circle in the centre of the Cedrus response pad to begin the task. At the end of the LDT participants were shown a final screen indicating the end of the task and to ask the experimenter for further instruction.

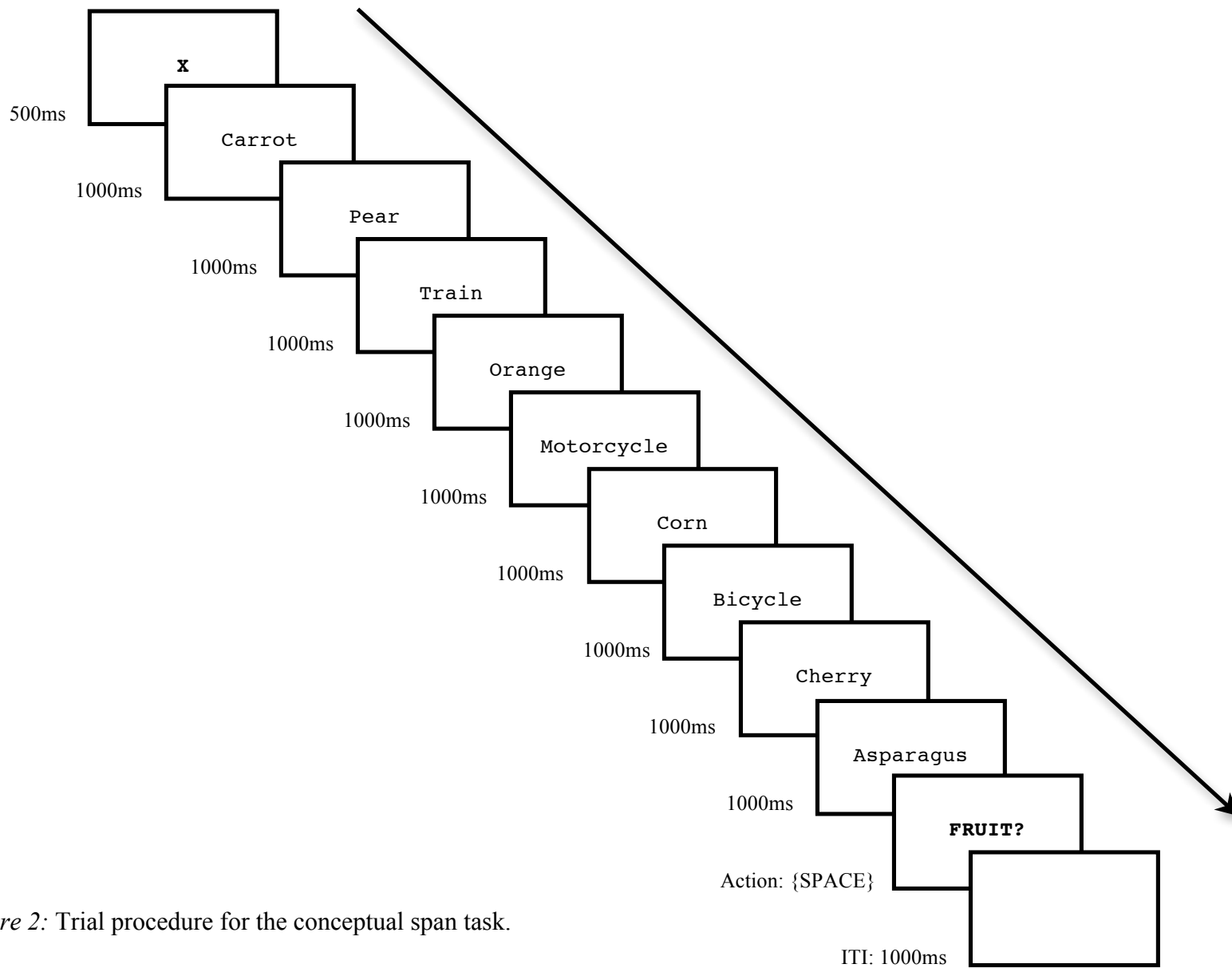


Figure 2: Trial procedure for the conceptual span task.

To begin each trial, participants were presented with a fixation cross (X) for 500ms, followed by a brief presentation of the subliminal stimulus shown for 14ms. The subliminal stimulus was immediately replaced (backward masked) by a randomly chosen target letter string from the LDT (Experiments 1-3, Chapters 4-6) which remained on screen until the participant made their decision, as indicated by a button press on the Cedrus response pad (RED = nonword; GREEN = word). Finally, an ITI of 1000ms followed the participants' response before the next trial began (see Figure 3, for a diagram of the LDT task, p.78).

3.4 Design

Experiments 1-3 utilised a 2 (Time: *Time 1 vs. Time 2*) x 2 (Prime Type: *Multiple-Word Prime vs. Single-Word Prime*) x 3 (Prime Content: *Cognitive; Affective; Neutral-Control*) mixed design, with Time as a within-participants factor of two levels and both Prime Type and Prime Content as between-participants factors, the former with two levels and the latter with three. The independent variables were the manipulation of Prime Type (Multiple-Word Prime vs. Single-Word Prime; Experiment 1-4, Chapter 4-7), and Prime Content (Cognitive, Affective, or Neutral-Control; Experiment 1-3, Chapters 4-6). The dependant measures are outlined in each experiment.

3.5 Data Preparation and Analysis

This section outlines the methods for data preparation and analysis used in all experimental chapters of this thesis (Chapters 4-7). Firstly, an outline of the data preparation prior to data analysis is presented, describing the procedure used to check for and deal with outliers, as well as measures taken to test the parametric assumptions of the data. Secondly, both the inferential statistical and post hoc approaches used will be outlined.

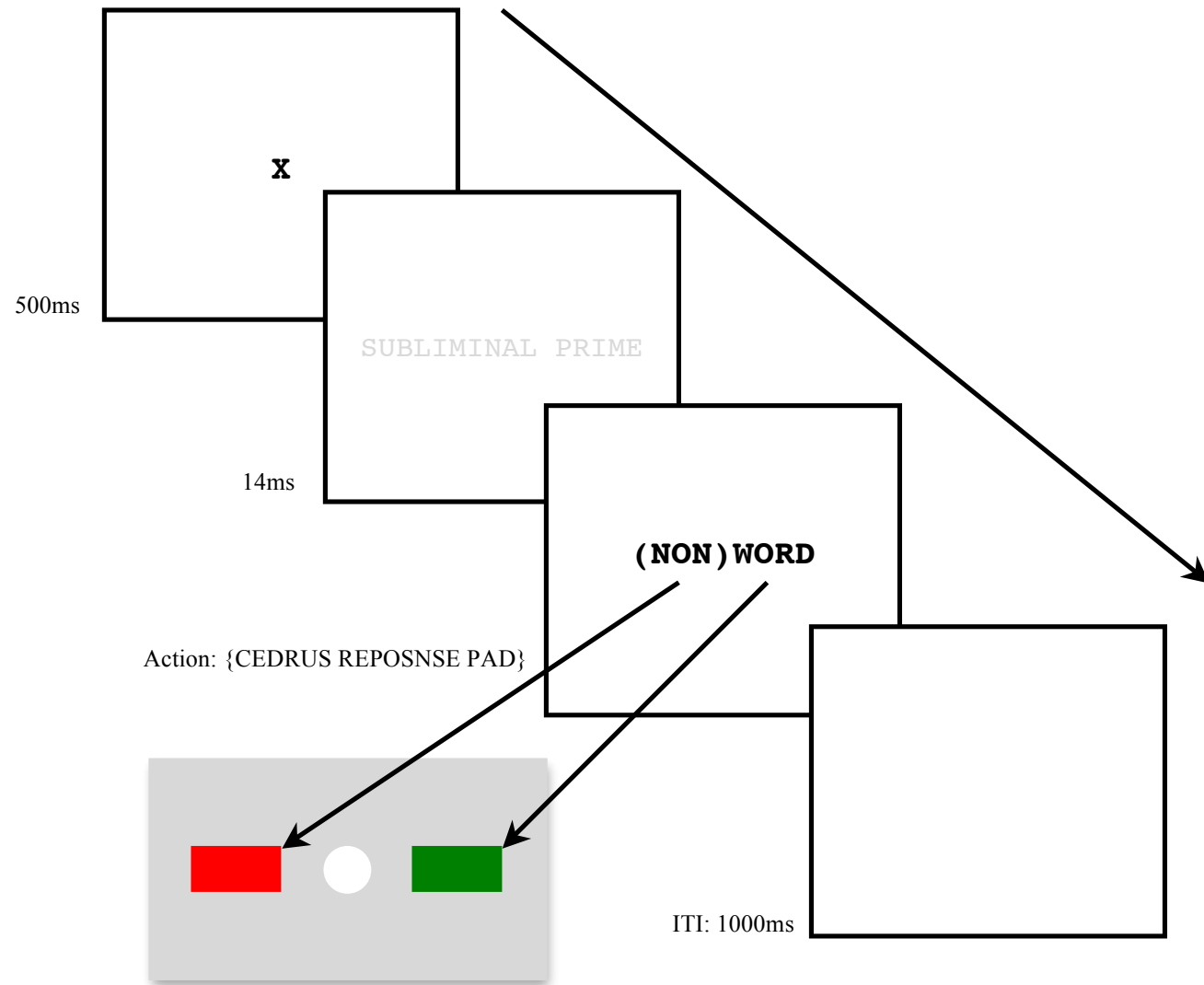


Figure 3: Trial procedure for the lexical decision task.

3.5.1 Data Preparation - Outliers

Outliers are individual data-points considered to be anomalies. For example, in response time data such as that recorded in the LDT and Stroop Colour-Naming Task, outliers are considered to be incorrect responses (errors) or could be the result of fast guesses, inattention, or failure to reach a decision, among others (see Ratcliff, 1993). It is important to deal with incorrect responses (errors) as they can have different distributional properties from correct responses (Ratcliff, 1993), thus eliminating them is the common procedure and as such, will be the procedure used in this thesis. Ratcliff (1993) explains empirical response time analysis should aim to analyse 85%-95% of the distribution, therefore trimming the data set will remove any extreme scores hence, minimizing their overall effect. A standard procedure tested by Ratcliff (1993) was trimming the data at a 'cut off' using a set number of standard deviations away from the mean response time¹⁰. A conservative cut-off of three standard deviations from the mean response time (Field, 2009) was employed in the analysis of response time data.

3.5.2 Data Preparation - Test of Assumptions

It is good practice to test the assumptions of the parametric tests prior to statistical analysis to ensure that the data are suitable to use with repeated measures parametric tests and to enable accurate conclusions to be drawn from the analysis (Field, 2009). These assumptions are, I) independence, II) homogeneity of variance, and III) normality. Each assumption is briefly explained followed by an explanation of the procedure for dealing with possible violations of such an assumption.

¹⁰ In an analysis examining the effectiveness of trimming the data set on the overall power of the statistical test (e.g., Analysis of Variance; ANOVA), Ratcliff (1993) reported that this method retained a higher power compared to other common procedural methods for dealing with outliers.

3.5.2.1 Data Preparation - Independence

In a mixed design which includes both repeated and between participant factors, such as is used in this thesis, participants' scores *should not* be expected to be independent across the repeated-measures factor, but *should* be independent across the between-participants factor (Field, 2009). To ensure this assumption was met, all experiments were conducted with each participant individually to eliminate any confounding or interaction between participants.

3.5.2.2 Data Preparation - Homogeneity of Variance

Homogeneity of variance implies that the variances of different groups of data are equal i.e., the difference between the variance is zero (Field, 2009). Field (2009) advises that when sample sizes are equal, ANOVA is robust to the broken assumption of homogeneity of variance. Homogeneity of variance will be tested statistically using Levene's test (Levene, 1960). In such instances of confirmed heterogeneity of variance, transformations of the data are suggested (Bryk & Raudenbush, 1988) to ensure the relationship between variables is not affected (Field, 2009). The square root transformation (\sqrt{Xi}) will be applied when data are heterogeneous due to the natural scores of zero in the data set for LDT, and because data for the CST is in the form of counts (e.g., number of correct words recalled; Howell, 2002).

3.5.2.3 Data Preparation - Normality

The assumption of normality was examined using I) visual methods, II) Skewness and Kurtosis values, and III) specific omnibus test of normality. DeCarlo (1997) and Razali and Wah (2011) recommend all three methods be used in the assessment of normality hence, all three will be tested in this thesis.

To visually check the assumption of normality histogram, probability-probability (P-P), and quantile-quantile (Q-Q) plots will be consulted. Visual assessments of the distribution

can be confirmed by consulting the skewness and kurtosis values. The values of both skew and kurtosis should be 0 in a perfectly normal distribution (Field, 2009), but small sample deviations from are considered to reflect normality and they are consistent with population normality (Tabachnick & Fidell, 2014). Finally, the Shapiro-Wilks (SW) test (Shapiro & Wilk, 1965¹¹) will be conducted to test the normality of the sample distribution. Although, it is considered that statistical tests such as ANOVA are robust to deviations from normality when sample sizes are larger than 30 participants (Elliott & Woodward, 2007), a square-root transformation will be applied if the assumption of normality is moderately violated (Tabachnick & Fidell, 2014), despite the larger sample sizes (i.e., > 60) in all experiments of this thesis.

3.5.3 Data Analysis

3.5.3.1 Inferential Statistics

Inferential statistics will be conducted using a mixed ANOVA. A mixed ANOVA works by comparing the degree of ‘systematic’ to ‘unsystematic’ variance within the data, and is beneficial to conduct in comparison to multiple *t*-tests due the decreased chances of producing a Type 1 error (Field, 2009). In the event of a significant interaction between two or more factors following the mixed ANOVA further tests will be conducted.

3.5.3.1.1 Post hoc Tests

In this thesis, the post hoc test method will be employed to further analyse where possible differences lie following significant interactions identified from the mixed ANOVA analysis. Post hoc testing can run the risk of making Type I errors therefore a statistical

¹¹ The SW test was found to retain the most power in comparisons to other statistical tests of normality for sample sizes ranging from 30 to 2000 (Razali & Wah, 2011), and is therefore suitable for use on the sample sizes in this thesis.

correction must be applied to avoid making this error (Field, 2009). There are several different statistical corrections that can be applied, but the Bonferroni correction will be applied in this thesis, as it is considered to be one of the more conservative corrections (Howell, 2002). The Bonferroni correction successfully controls for Type 1 errors by dividing the standard acceptance criterion (e.g., $p=0.05$) by the number of comparisons being made. For instance, if there were three comparisons, the new acceptance criterion would become .017 (Howell, 2013).

Chapter Four: Experiment 1 – Which is Best, Single-Word or Multiple-Word Primes?

Comparing Subliminal Prime Type on Affect and Cognition.

Introduction

The aim of Experiment 1 presented in this chapter is to establish which of the two written subliminal prime types; Single-Word or Multiple-Word primes generate the most robust behavioural changes in affect and cognition. Prior research has established the effectiveness of subliminal stimulation using both Single-Word primes (e.g., Dijksterhuis, 2004; Dijksterhuis et al., 2000; Dijksterhuis & Smith, 2002; Grumm et al., 2009; Hess et al., 2004; Hull et al., 2002; Jraidt & Frasson, 2010; Mitchell et al., 2002; Ortigue et al., 2007; Pichon et al., 2007; Radcliff et al., 2009; Riketta & Dauenheimer, 2003; Strahan et al., 2002, 2005; Zemack-Rugar et al., 2007) and Multiple-Word primes (e.g., Ariam & Siller, 1982; Birgegård, 2003; Bryant-Tuckett & Silverman, 1984; Glassman & Andersen, 1999; Hardaway, 1990; Hudesman et al., 1992; Légal et al., 2012; Linehan & O'Toole, 1982; Orbach et al., 1994; Parker, 1982; Sohlberg, Billingshurst et al., 1998; Sohlberg & Birgegård, 2003; Sohlberg et al., 2003; Weinberger et al., 1997; Zuckerman, 1960). However, thus far no direct comparison has been made between the two subliminal prime types, hence the aim of Experiment 1 was to conduct such a comparison to see which prime type elicits the strongest change across a range of affective and cognitive measures. This chapter will focus on presenting a range of research demonstrating reported changes in affect then cognition following subliminal presentation of Single-Word and Multiple-Word primes. Beginning with reported changes in affective measures such as self-esteem, implicit mood and anxiety, research testing for changes within each sub-category of affect following subliminal Single-Word priming will be presented first, followed by the reported changes following subliminal

Multiple-Word priming. Next, reported changes in cognitive measures such as memory, intelligence, and selective attention will be presented. Research testing for changes within each sub-category of cognition following subliminal Single-Word priming will be presented first, followed by reports of the effects following subliminal Multiple-Word priming. After the presentation of research the hypotheses for Experiment 1 will be presented followed by the method, results and discussion of Experiment 1.

Changes in affective measures have been reported following subliminal priming using Single-Word and Multiple-Word primes. Focusing first on the reported changes following Single-Word priming, positive and negative Single-Word primes have been shown to affect self-esteem and mood. Riketta and Dauenheimer (2003) demonstrated increased self-esteem following positive subliminal prime words (e.g., good, great) compared to negative subliminal primes (e.g., bad, lousy) when paired with a self-referent (i.e., the German word for I). Results were consistent over four experiments and using two self-report self-esteem measures (e.g., Fleming & Courtney, 1984; Heatherton & Polivy, 1991) as well as a measure of self-serving bias¹². Results followed the predicted direction, with positive subliminal primes producing higher levels of self-esteem on both self-reports and the self-serving bias measure, suggesting the effect to be robust across different measures of self-esteem. However, Riketta and Dauenheimer (2003) also measured changes in participant's mood, and reported no positive increase. In contrast, Dijksterhuis (2004) reported participant's mood remained stable following priming of subliminal positive words, even after receiving negative feedback on their performance. Participants were subliminally primed with positive words (e.g., happiness, summer) that were paired with a self-referent (i.e., Dutch word for I). Similarly to Riketta and Dauenheimer (2003), Dijksterhuis (2004) reported consistent

¹² Self-serving bias is the level to which individuals signify their successes or failure to either internal (i.e., their own ability) or external (i.e., luck) causes, with high self-serving bias linked to those found to have high global self-esteem (see Campbell & Sedikides, 1999).

increases in self-esteem using multiple measures of self-esteem, including Initial Preference (Nuttin, 1987), and the Self-Esteem Implicit Association Test (Greenwald & Farnham, 2000), but additionally found participants self-rating of mood on a 9-point scale remained the same following negative feedback on their intelligence, a process found to diminish mood in participants not subliminally primed with positive words. From these results and other similar research (Grumm et al., 2009; Jraidi & Frasson, 2010), it is considered that pairing a positive prime word with a self-referent (e.g., I) leads to improved self-esteem. These studies indicate that subliminal presentation of Single-Word primes is robust at increasing positive self-estimation and because self-esteem and mood are undoubtedly linked, as suggested by Brockner (1983; see also, Heatherton & Polivy, 1991), if one can be enhanced via subliminal stimulation, it may be possible for the other to also be maintained (Dijksterhuis, 2004), or potentially enhanced.

In contrast to the amount of research concerning changes in self-esteem and mood following subliminal Single-Word primes, the breadth of research concerning positive enhancement of mood following subliminal presentation of Multiple-Word primes is sparse. Previous reviews of subliminal psychodynamic activation research have often theorised positive changes in mood to be an important factor in the effectiveness of the ‘mommy and I are one’ Multiple-Word prime. For instance, Hardaway (1990) postulated that the research examined during his meta-analysis “demonstrated the role of emotional variables in subjects’ response to a symbiotic-like stimulus” (p. 187). Moreover, Hardaway (1990) explains that emotional qualities are reached through the production of positive memories with the primary caregiver, which improves overall emotional valance and in turn stabilises their mood to facilitate improvement of the dependant variable. Weinberger (1992; see also Weinberger & Smith, 2011) agreed, explaining that it is indeed reasonable to suggest that positive affect could influence cognition and performance. In support, Weinberger et al. (1997) reported

changes in the implicit mood of male participants following subliminal presentation of the Multiple-Word prime ‘mommy and I are one’ in comparison to the control Multiple-Word prime ‘people are walking’. However, limitations lie in the single measure used to indicate heightened mood in comparison to subliminal Single-Word priming research which has shown consistent changes in self-esteem using a variety of measures (see Dijksterhuis, 2004; Riketta & Dauenheimer, 2003). In addition, Weinberger et al. (1997) only demonstrate enhanced mood following the Multiple-Word prime ‘mommy and I are one’ with male participants.

Sohlberg, Billinghamurst et al. (1998) also sought to test the conjecture that changes in positive mood, as Hardaway (1990) and Weinberger (1992) both theorise, are behind the effectiveness of the ‘mommy and I are one’ Multiple-Word prime. Sohlberg, Billinghamurst et al. (1998) show support for this claim (see also Sohlberg, Samuelberg et al., 1998; Sohlberg et al., 1997), although they additionally demonstrate that change in mood is bidirectional, that is, mood is not always ‘positively’ enhanced, and that the determinant of the direction of mood change is reliant upon the participant’s level of self-mother similarity. For example, the more positive the memories of interaction with the mother were, the more positive the response to the ‘mommy and I are one’ Multiple-Word prime, and vice-versa. Furthermore, Sohlberg et al. (2003) extend this by showing that internalized shame, that is, ingrained shame “as the result of enduring, intolerable shame during development” (Sohlberg et al., 2003, p. 340, see also Cook, 1994, 1996) is also involved. Sohlberg et al. (2003) report that male participants’ implicit mood is improved by subliminal exposure to the Multiple-Word prime ‘mommy and I are one’ but moderated by the positivity of memories with the primary caregiver, the complementary nature of interactions in their memories, and level of internalised shame. A more negative influence will occur in males with higher levels of internalised shame generated through repeated unmet expectations and uncomplimentary

interactions (e.g., when the child expressed love and their mother did not accept it; Benjamin, 1996a; see also Benjamin, 1974, 1996b) during child-mother interactions. Although, this has yet to be tested in female participants, thus it is unknown whether internalised shame moderates the influence produced following the Multiple-Word primes ‘mommy and I are one’.

Whilst these studies indicate the potential for changes in mood following the Multiple-Word prime ‘mommy and I are one’ (Sohlberg et al., 2003; Sohlberg et al., 1997; Sohlberg, Billinghamurst et al., 1998; Sohlberg, Samuelberg, et al., 1998) the effect needs further clarification. Overall, Sohlberg and colleagues (Sohlberg et al., 2003; Sohlberg, Billinghamurst et al., 1998; Sohlberg, Samuelburg et al., 1998) report positive improvement in implicit mood. In addition, an implicit measure of mood was used as it was presumed to better reflect the effects of the symbiotic-like Multiple-Word prime. This measure of mood has been used in a variety of studies conducted by Sohlberg and colleagues (Sohlberg et al., 2003; Sohlberg, Billinghamurst et al., 1998; Sohlberg, Samuelburg et al., 1998) and by Weinberger et al. (1997) and although it indicates changes in mood based on the ‘associative network theory’ (Bower, 1981) no explicit self-reporting measure of mood has been utilised. As such, it would be beneficial to provide further evidence for the mood theory in addition to further understanding what aspects of mood are specifically enhanced, or possibly decreased (e.g. state anxiety; Hardaway, 1990) by examining for consciously recognised changes in mood in both male and female participants following the subliminal Multiple-Word prime ‘mommy and I are one’.

Research assessing changes in affect following the presentation of subliminal stimuli not only aim to test for changes in self-esteem (Dijksterhuis, 2004; Grumm et al., 2009; Jraidt & Frasson, 2010; Riketta & Dauenheimer, 2003) and positive mood (Dijksterhuis, 2004; Sohlberg et al., 2003; Sohlberg, Billinghamurst et al., 1998; Sohlberg, Samuelburg et al., 1998;

Weinberger et al., 1997) but also for changes in anxiety. Anxiety is a multidimensional construct that can be defined in terms of ‘trait’ anxiety and ‘state’ anxiety. State anxiety refers to the perceived feeling of tension and apprehension caused by a situation or event, whereas trait anxiety refers to the individuals’ proneness to anxiety, and as such is considered a stable personality characteristic that affects the degree of state anxiety experienced (Barnes, Harp, & Jung, 2002; Endler & Kocovski, 2001; Gupta, Khera, Vempati, Sharma, & Bijlani, 2006). Direct tests of subliminal Single-Word primes on the reduction of anxiety levels are non-existent in the current literature. Research has tended to focus on the assumption that for individuals suffering with anxiety-related issues, processing resources are automatically drawn towards negative information (Williams, Watts, MacLeod, & Mathews, 1988). Research reported by Mogg et al. (1993) provides support for this model. In their experiment they report that anxious participants are pre-attentively biased towards subliminally presented negative information but that their unconscious semantic processing of such negative stimuli was relatively superficial. For instance, participants’ response time to anxious-specific words (e.g., embarrassed, cancer) was no different to their response times for depression-related words (e.g., misery, discouraged). Mogg et al.’s. (1993) findings (see also Dannlowski et al., 2006; Mogg, Bradley, & Williams, 1995) suggest that negative information is processed at a basic level unconsciously, and aids in the understanding that those suffering from anxiety or anxiety-related disorders do have a predisposition to process negative information found in their environments. Whilst the presentation of subliminal Single-Word primes were indeed integral to such research, no further understanding concerning the potential ameliorative effects that Single-Word primes could have in the *reduction* of anxiety experienced by these individuals is provided. Researchers investigating more general concepts of mood or emotion have shown it is possible to enhance self-esteem (Dijksterhuis, 2004; Riketta & Dauenheimer, 2003) or prime specific emotions in a person which can mediate their

following behaviour (Zemack-Rugar et al., 2007), lending support to the notion that subliminal Single-Word primes could also enhance participants overall affective levels via the reduction of experienced state anxiety. Previous research regarding maintained mood states after negative experiences (Dijksterhuis, 2004) focused on simply asking how good the participant felt; further research showing a specific reduction of state anxiety (i.e., how anxious the individual is feeling at that moment in time) may help clarify the reason why they felt more positive in themselves. Thus, it is important to provide further research to understand the ability of subliminal Single-Word primes in enhancing participants' mood, and potentially decreasing their anxiety, an aspect that has not been tackled in previous research (Dannlowski et al., 2006; Mogg et al., 1993).

In contrast to Single-Word primes, Multiple-Word primes have been found to reduce levels of experienced anxiety. The subliminal presentation of the Multiple-Word prime 'mommy and I are one' has not only been connected to the positive increase in implicit mood states, but has also been theorised to reduce negative state variables, such as anxiety (Hardaway, 1990). Mayer and Merckelbach (1999) propose that subliminally presented stimuli needs to be affective in nature to enable an influence of a participant's emotional state. In his meta-analysis Hardaway (1990) discussed the reduction of anxiety following subliminal Multiple-Word primes (e.g., mommy and I are one) as a possible reason for their effectiveness, and more recently, Orbach et al. (1994) supported Hardaway (1990) by also reporting anxiety reduction (see also, Schurtman et al., 1982). In their study, one of three Multiple-Word primes were subliminally presented to female participants i.e., 'mommy and I are one', 'mommy and I are alike', and the control, 'people are walking in the street' and a measure of state anxiety using the State-Trait Anxiety Scale (Spielberger, Gorsuch, & Lushene, 1970) was taken. Orbach et al. (1994) reported that both experimental Multiple-Word primes (i.e., mommy and I are one; mommy and I are alike) produced significant

reductions in state anxiety compared to the control stimulus (i.e., people are walking in the street).

These findings support the notion that subliminal priming of Multiple-Word primes are capable of reducing experienced state anxiety. The specific Multiple-Word primes presented by Orbach et al. (1994) (e.g., mommy and I are one, mommy and I are alike) both conform to closeness with the primary caregiver. It is this closeness with the mother that is considered to be so effective in psychodynamic-based Multiple-Word primes i.e., through their ability to access the unconscious wish for oneness with the primary caregiver (Bronstein & Rodin, 1983; Dauber, 1984; Hardaway, 1990; Mendelsohn, 1981; Silverman & Weinberger, 1985). However, as the large majority of research concerning the reduction of anxiety following Multiple-Word primes has centred on the presentation of psychodynamic-based stimuli targeting the fulfilment of unconscious wishes, it is imperative to assess whether other non-psychodynamic Multiple-Word primes are also able to produce similar changes in affective measures such as reduced state anxiety.

To summarise research concerning the effects of subliminal priming on affective measures, that is, self-esteem, mood, and anxiety, Single-Word priming has reported positive changes in self-esteem (Dijksterhuis, 2004; Grumm et al., 2009; Jraidt & Frasson, 2010; Riketta & Dauenheimer, 2003) and maintenance of good mood after negative feedback (Dijksterhuis, 2004). In addition, increases in positive implicit mood (Weinberger et al., 1997; Sohlberg, Billinghamurst et al., 1998; Sohlberg et al., 2003), and the reduction of anxiety (Orbach et al., 1994; Schurtman et al., 1982; see also Hardaway, 1990) have been reported following the presentation of subliminal Multiple-Word primes. Further research concerning the presentation of Single-Word and Multiple-Word primes is suggested to fill current gaps in knowledge concerning the potential for Single-Word primes to increase positive mood and reduce anxiety and to examine whether changes in mood following subliminal Multiple-

Word priming can occur at the explicit rather than just the implicit level (e.g., Weinberger et al., 1997). However, affective-based changes following subliminal priming are not the only benefit. Changes in cognitive performance, such as in memory, have also been reported in subliminal Single-Word priming research and will now be discussed.

The influence of subliminal prime words on memory performance has been previously reported (Chartrand & Bargh, 1996; Dijksterhuis et al., 2000; DeVaul, 2004; DeVaul & Pentland, 2002; DeVaul, Pentland, & Corey, 2003; Hess et al., 2004 Experiment 2; Levy, 1996; Levy & Leifheit-Limson, 2009; Mitchell et al., 2002). For example, research such as that by Levy (1996) reported changes in memory performance following the subliminal presentation of stereotypic Single-Word primes that automatically activated the stereotype of 'elderly' (see also, Hess et al., 2004 Experiment 2; Levy & Leifheit-Limson, 2009; Stein et al., 2002). Levy (1996) tested elderly participants on a range of memory tasks, measuring aspects of memory shown to decline with age¹³ (Schacter, Kaszniak, & Kihlstrom, 1991) and found that elderly participants receiving the age-positive Single-Word primes (e.g., wisdom) showed improved performance on some memory tasks e.g., photo recall task, whereas elderly participants receiving age-negative Single-Word primes (e.g., Alzheimers') performed more poorly on some memory tasks e.g., the immediate and delayed recall performance tasks (for similar results see Hess et al., 2004 Experiment 2; Levy & Leifheit-Limson, 2009). Such research demonstrates that memory performance can be both positively and negatively influenced following the automatic activation of self-stereotypes. Although, the findings have not always been replicated (see Stein et al., 2002), and are limited to the

¹³ Levy (1996) examined performance on visual spatial recall using immediate, learned and delayed dot recall tasks (based on a modified version of, Lezak's, 1983, 7/24 task); a photo recall (using a modified photo association task, Langer, Rodin, Beck, Weinman, & Spitzer, 1979); an auditory recall task of 15 words divided into three taxonomic categories (based on a modified version of Hertzog, Dixon, & Hutsch, 1990), and two forms of metamemory i.e., prediction questions assessing immediate perception of memory, and the Metamemory in Adulthood questionnaire (Dixon, Hultsch, & Hertzog, 1988).

improvement of memory in elderly individuals as age-positive stereotypic words were not found to improve memory performance of younger participants (e.g., Hess et al., 2004 Experiment 2; Levy, 1996, Experiment 2). However, the subliminal presentation of words unrelated to the elderly stereotype has also been reported to elicit changes in memory performance.

Mitchell et al. (2002) found subliminal Single-Word priming effects on memory following the presentation of memory specific words. Mitchell et al. (2002) measured the effect of Single-Word primes related to memory i.e., ‘remember’ and ‘forget’ compared to an unrelated neutral word (i.e., extract) in an item-based forgetting paradigm (Basden & Basden, 1998). Mitchell et al. (2002) report that participants’ recollection of target words was significantly better following the Single-Word prime ‘remember’. Such results support the idea that subliminal Single-Word primes are capable of eliciting improvements in memory performance. Nevertheless, further research is needed to demonstrate whether Single-Word primes unrelated to stereotypes are successful at improving memory performance in more than just recollection memory tasks. However, whilst there is ample evidence to suggest memory is susceptible to change following the subliminal presentation of Single-Word primes (Chartrand & Bargh, 1996; Dijksterhuis et al., 2000; DeVaul, 2004; DeVaul & Pentland, 2002; DeVaul et al., 2003; Hess et al., 2004 Experiment 2; Levy, 1996; Levy & Leifheit-Limson, 2009; Mitchell et al., 2002¹⁴) there is little research documenting change elicited by subliminal exposure to Multiple-Word primes.

Previous literature concerning exposure to psychodynamic-related Multiple-Word primes such as ‘mommy and I are one’ has only been inadvertently linked to memory (Sohlberg et al., 2003; Weinberger et al., 1997; Hardaway, 1990). For instance, Weinberger et al. (1997) established the use of an implicit measure of mood, by asking participants to

¹⁴ For an alternative opinion concerning social priming research see Newell and Shanks (2012). See also 2.5.2 *Automaticity Theory* (p. 54) of this thesis.

recall as many childhood memories up until the age of 14 in four minutes and 30 seconds. Participants rated each memory as positive or negative and then rated its strength on a 7-point scale. Results showed that more positive memories were recalled, and that they were rated more positively following exposure to the subliminal Multiple-Word prime ‘mommy and I are one’ compared to the negative Multiple-Word prime ‘mommy and I are gone’ or the neutral Multiple-Word prime ‘people are walking’. These results suggest that Multiple-Word primes can influence the recollection of mood congruent memories consistent with the association network theory of mood and memory (Bower, 1981; Hardaway, 1990). The same implicit mood task has been used in several other studies (Sohlberg et al., 2003; Sohlberg, Billingshurst et al., 1998; Sohlberg, Samuelberg et al., 1998; Sohlberg et al., 1997) with consistent results following subliminal priming of ‘mommy and I are one’ which is explained by Hardaway (1990) to “stabilize mood and to evoke memories with positive emotional qualities” (p. 187). However, such research has generally been interested in changes in *affective* measures (e.g., implicit mood) elicited by the Multiple-Word primes and not in the effect that such subliminal primes may have on memory performance. Such results indicate that exposure to subliminal Multiple-Word primes influence the type of memory that the participant recalls, which then mediates changes in affect, but it is not yet known whether exposure to Multiple-Word primes can improve memory performance in general, that is, enhance memory of information not related to childhood or the primary care giver. To date, no research implementing subliminal presentation of Multiple-Word primes has demonstrated enhanced memory performance of non-familial information, and as such further research of this nature would help to establish the usefulness of Multiple-Word priming and specifically the effect of the Multiple-Word prime ‘mommy and I are one’ at enhancing cognitive performance. Other aspects of cognitive performance that have been examined following exposure to subliminal priming are intelligence, and academic performance.

For instance, in the Single-Word priming literature, several studies have reported improved performance on tests or exams following exposure to subliminally presented Single-Word primes (e.g., Shih et al., 2002 Experiment 2; Hull et al., 2002 Experiment 3; Lowery et al., 2007; Radel et al., 2009). Lowery et al. (2007) presented participants with Single-Word primes semantically related to intelligence (e.g., intelligent, genius) or neutral Single-Word primes (e.g., garden, bring) and tested academic performance on an exam taken immediately and another taken up to four days later. Results indicated that participants performed better on their exams when subliminally primed with intelligence-related words, both when the exam was taken immediately and one, two, or four days later. Results from Lowery et al. (2007) confirm that academic performance can be influenced by subliminally presented Single-Word primes, and further demonstrated that the effect elicited by Single-Word primes may be consistent over time. However, research from Lowery et al. (2007; see also Shih et al., 2002 Experiment 2; Hull et al., 2002 Experiment 3; Radel et al., 2009) only examined the effect of subliminal Single-Word primes on specific course exams or in-class tests, as such it would be beneficial to further explore whether exposure to subliminal Single-Word primes can improve intelligence more generally, that is, when measured using a general knowledge test. In addition to the research examining the effect of subliminal Single-Word priming on intelligence and academic performance, improved performance has also been reported following exposure to subliminal Multiple-Word primes.

For instance, Parker (1982) subliminally presented participants with one of three Multiple-Word primes, ‘mommy and I are one’, ‘my prof and I are one’, and the control, ‘people are walking’ over the duration of a six-week academic course with exam scores collected at two-week intervals and again four-weeks after the course had finished. Results showed that the Multiple-Word prime ‘mommy and I are one’ improved academic performance after just four weeks, and that both experimental primes (i.e., mommy and I are

one; my prof and I are one) improved academic performance at the sixth week exam and on the follow-up exam four weeks after the end of the course compared to the control prime (i.e., people are walking). Such results demonstrate that the experimental Multiple-Word primes may elicit long-lasting effects on academic performance, something not often found in subliminal priming research (see Greenwald et al., 1996). The results from Parker (1982) were extended by Ariam and Siller (1982) who demonstrated enhanced academic performance following exposure to the Multiple-Word prime 'mommy and I are one' in a younger school-aged sample and when translated into Hebrew, suggesting the effect to be reasonably robust. However, whilst the results of Ariam and Siller (1982) and Parker (1982) and others such as Hudesman et al. (1992) demonstrate improved academic exam performance for specific subjects they do not indicate whether Multiple-Word primes are capable of positively improving general intelligence, as such further research exploring the effect of Multiple-Word primes on general knowledge would be useful. In addition, the Multiple-Word primes presented by both Ariam and Siller (1982), Hudesman et al. (1992), and Parker (1982) are closely linked to psychodynamic theory concerning the fulfilment of unconscious wishes thus it would be beneficial to assess whether other non-psychodynamically-phrased Multiple-Word primes are also capable of eliciting changes in intelligence.

A final aspect of cognition previously reported on in the subliminal literature is the effect subliminal primes have had on selective attention. Selective attention is defined as the cognitive ability to attend to one target whilst simultaneously ignoring a distracting item (Robertson, Ward, Ridgeway, & Nimmo-Smith, 2001). Severance and Dyer (1973) measured the effect colour name Single-Word primes (e.g., red, green, blue) had on the colour naming performance of a Stroop task. Subliminal Single-Word colour primes were presented prior to a coloured target letter string and were either congruent (i.e., designed to aid response time)

or incongruent (i.e., designed to hinder response time) with the coloured target letter string. However, Severance and Dyer (1973) found that such subliminal Single-Word primes did not influence Stroop performance leaving them to “argue compellingly against the presence of subliminal perceptual effects” (p.188). Although Severance and Dyer (1973) only presented the subliminal stimuli for extremely short durations of between 0.53ms and 1.65ms, a factor suggested to limit the potential strength of the subliminal stimulus (Van den Bussche et al., 2009). In contrast to Severance and Dyer (1973), Marcel (1983 Experiment 3; see also, Daza et al., 2002; Merikle & Joordens, 1997; Merikle et al., 1995; see also Merikle & Cheesman, 1987 for a review) reported successful subliminal priming on a Stroop colour-naming task. Marcel (1983 Experiment 3) individually tailored the duration of the subliminal Single-Word primes for each participant, and thus the overall exposure duration was far longer than that reported by Severance and Dyer (1973). However, research exploring the effect of Single-Word primes on selective attention has only examined the effects elicited by ‘colour’ Single-Word primes (e.g., red, blue, yellow) on the Stroop colour-naming task. Hence, it would be interesting to examine whether words unrelated to colour could also elicit changes in selective attention performance.

In comparison to the literature testing subliminal Single-Word primes on the cognitive variable of selective attention (Daza et al., 2002; Merikle & Joordens, 1997; Merikle et al., 1995; Severance & Dyer, 1973), research testing the effects of subliminal Multiple-Word primes on selective attention is to current knowledge, non-existent. As such, this lack of research makes it difficult to know whether a subliminal Multiple-Word prime could influence attention or not. Nevertheless, as Multiple-Word primes such as ‘mommy and I are one’ have been previously shown to benefit cognitive performance (Ariam & Siller, 1982; Hardaway, 1990; Hudesman et al., 1992; Parker, 1982), it is possible that such a prime may also improve other cognitive processes such as selective attention. Such research would not

only be interesting but could also help to extend the current understanding of the nature and diversity of the behavioural effects elicited by exposure to the ‘mommy and I are one’

Multiple-Word prime.

With regards to influencing cognitive performance, the research outlined above shows that subliminal priming using Single-Word primes can enhance memory performance (Hess et al., 2004 Experiment 2; Levy, 1996; Levy & Leifheit-Limson, 2009; Mitchell et al., 2002), improve academic exam performance (Shih et al., 2002; Lowery et al., 2007) and facilitate selective attention performance (Daza et al., 2002; Merikle & Cheesman, 1987; Merikle & Joordens, 1997; Merikle et al., 1995). Whereas, research examining the effect of subliminal Multiple-Word primes has only shown benefits to academic performance (Ariam & Siller, 1982; Hudesman et al., 1992; Parker, 1982). As such, future research examining the effects of subliminal Multiple-Word primes on other aspects of cognitive performance such as memory performance and selective attention may be beneficial.

In summary, the research presented in this chapter has highlighted that both subliminal Single-Word and Multiple-Word primes can elicit positive improvements across a range of affective, i.e., self-esteem (e.g., Dijksterhuis, 2004; Grumm et al., 2009; Jraidi & Frasson, 2010; Riketta & Dauenheimer, 2003), implicit mood (e.g., Sohlberg, Billingham et al., 1998; Weinberger et al., 1997), and state anxiety (e.g., Orbach et al., 1994; Schurtman et al., 1982), as well as cognitive, i.e., memory (e.g., Hess et al., 2004 Experiment 2; Levy, 1996; Levy & Leifheit-Limson, 2009; Mitchell et al., 2002), academic performance (e.g., Ariam & Siller, 1982; Lowery et al., 2007; Parker, 1982; Radel et al., 2009), and selective attention (e.g., Daza et al., 2002; Merikle & Joordens, 1997; Marcel, 1983 Experiment 3) behaviours. Furthermore, evidence suggests that such benefits can be elicited following exposure to both Single-Word and Multiple-Word primes. However, no comparison has yet been conducted between the two prime types, Single-Word versus Multiple-Word subliminal

primes. Understanding which prime type is more robust, or more consistent across several areas of affect and cognition, could help inform future research as to the prime type more likely to produce the desired changes. Furthermore, changes elicited in research examining the effect of Single-Word primes on affective and cognitive behaviour are mostly attributed to the congruent content of the Single-Word primes with the behaviour intended to be influenced. For instance, increased self-esteem was achieved following the presentation of positive Single-Word primes i.e., ‘beautiful’ and ‘sunshine’ (Dijksterhuis, 2004) whereas, improved academic performance was achieved following the presentation of Single-Word words semantically associated to intelligence i.e., ‘intelligent’ and ‘genius’ (Lowery et al., 2007). However, changes elicited in research examining the effect of Multiple-Word primes on affective e.g., implicit mood (Sohlberg, Billingham et al., 1998; Weinberger et al., 1997), reduced state-anxiety (Orbach et al., 1994; Schurtman et al., 1982), and cognitive behaviours e.g., academic performance (Ariam & Siller, 1982; Hudesman et al., 1992; Parker, 1982), have mostly been reported following the affective-based prime ‘mommy and I are one’. As such, whilst Single-Word prime research has reported positive changes across a variety of different measures, there has not been one specific word reportedly capable of eliciting change over a number of affective *and* cognitive behaviours, unlike the Multiple-Word prime ‘mommy and I are one’. Hence, Experiment 1 will compare subliminal stimuli that aim to differentially target either affective or cognitive behaviours within each prime type i.e., Single-Word primes and Multiple-Word primes. The effects of the stimuli within each prime type was compared on both affective and cognitive measures to understand whether affective and/or cognitive-based stimuli are capable of eliciting changes in their congruent measures (e.g., affective and cognitive measures respectively) as well as in their incongruent measures (e.g., cognitive and affective respectively). The findings outlined above give rise to a number of testable hypotheses as outlined in Table 1, p. 99.

Table 1

The Hypotheses Tested in Experiment 1

Hypothesis	Prediction
H₁	Subliminal <i>cognitive</i> (i.e., intelligent, I am intelligent) and <i>affective</i> (i.e., one, mommy and I are one) stimuli would be significantly more effective at improving performance than subliminally <i>neutral-control</i> stimuli (i.e., walking, people are walking) on all measures of cognition and mood.
H₂	A differential prime content effect would be produced whereby <i>cognitive</i> primes are expected to elicit a stronger effect on the cognitive measures, and <i>affective</i> primes are expected to elicit a stronger effect on the affective measures.
H₃	A differential prime type effect would be produced between the Single-Word primes and Multiple-Word primes across all measures of cognition and mood.

Method

Participants

Ninety-six students were recruited to participate in this experiment. The sample consisted of 59 females and 37 males that ranged from 18 to 56 years of age ($M= 23.81$, $SD= 8.06$). Recruitment and allocation to subliminal stimulus conditions was as outlined in Chapter 3 (p.62-64).

Materials

Six tasks were performed during the experiment; two of the tasks i.e., the Conceptual Span Task (CST) and the Lexical Decision Task (LDT) were described in Chapter 3 (p. 70-71). The remaining four tasks i.e., the Stroop Colour-Naming Task, the General Knowledge Test, the Short Version Profile of Mood States (SV-POMS), and the State Anxiety Scale (SAS), were specific to this experiment and are outlined below.

4.1 Stroop Colour-Naming Task

The Stroop Colour-Naming Task (Stroop, 1935) was chosen to measure participants' attention using their response times and error rates. An adapted version (adapted by replacing two of the non-colour words e.g., bad and poor with box and folder) of the computerised Stroop Colour-Naming Task by Balota et al. (2010) was used in this experiment. Four colour words (i.e., red, blue, yellow, green) and four non-colour words (i.e., box, folder, deep, legal) were presented on-screen to participants in one of four different colours (i.e., red, blue, yellow, green). The non-colour words written in the different colour options acted as the neutral condition. The colour words and colour combinations created two further conditions, congruent whereby the colour word was presented in its corresponding colour (e.g., BLUE typed in the colour blue) and incongruent whereby the colour word did not match the colour it was written in (e.g., GREEN typed in the colour red). Before completing the main task, participants completed a practice session consisting of 12 trials involving the random presentation of four examples from each of the three conditions. The main task consisted of 104 trials with 36 trials for the congruent condition whereby each colour word in its matching corresponding colour appeared nine times, 36 trials for the incongruent condition whereby each colour word appeared nine times, three times in each of the alternative colours, and 32 trials for the neutral condition, whereby the four non-colour words were presented twice in

each of the four colour options. Participants were provided with instructions to explain the task presented on a white background using point size 12, black, Courier New font. During both the practice round and the main task a fixation cross was presented in the centre of the screen for 500ms in white, bold, Courier New font, point size 26 on a black background at the beginning of each trial. The fixation cross was immediately replaced by one of the word and colour combinations as described above. All words were presented in the centre of the screen and written in the same point size and font but were presented in one of the four colour options. These words remained on screen until the participant responded via a Cedrus Response Pad placed in front of them by pressing the congruent colour button. The position of the response pad was rotated to control for handedness so that half the participants had the green button on their left side and the remaining half had the green button on their right side. Once the participant had responded, the next trial began after a delay of 1000ms (see Figure 4, p.102).

4.2 General Knowledge Test

Level of intelligence was measured using a General Knowledge Test. Ackerman (1996) suggested that adult intelligence assessments should include aspects of knowledge gained throughout their life span. Examples of typical aspects of life to use in adult intelligence tests include those gained through successes in work, adult life, and hobbies. Such general knowledge tests have proven successful at measuring general intelligence in the past (Ackerman & Rolfhus, 1999; Bry, Follenfant, and Meyer, 2008; Dijksterhuis & van Knippenberg, 1998). Therefore, a General Knowledge Test was devised and used in this experiment to measure intelligence. The test consisted of two parts (Test A and Test B), with

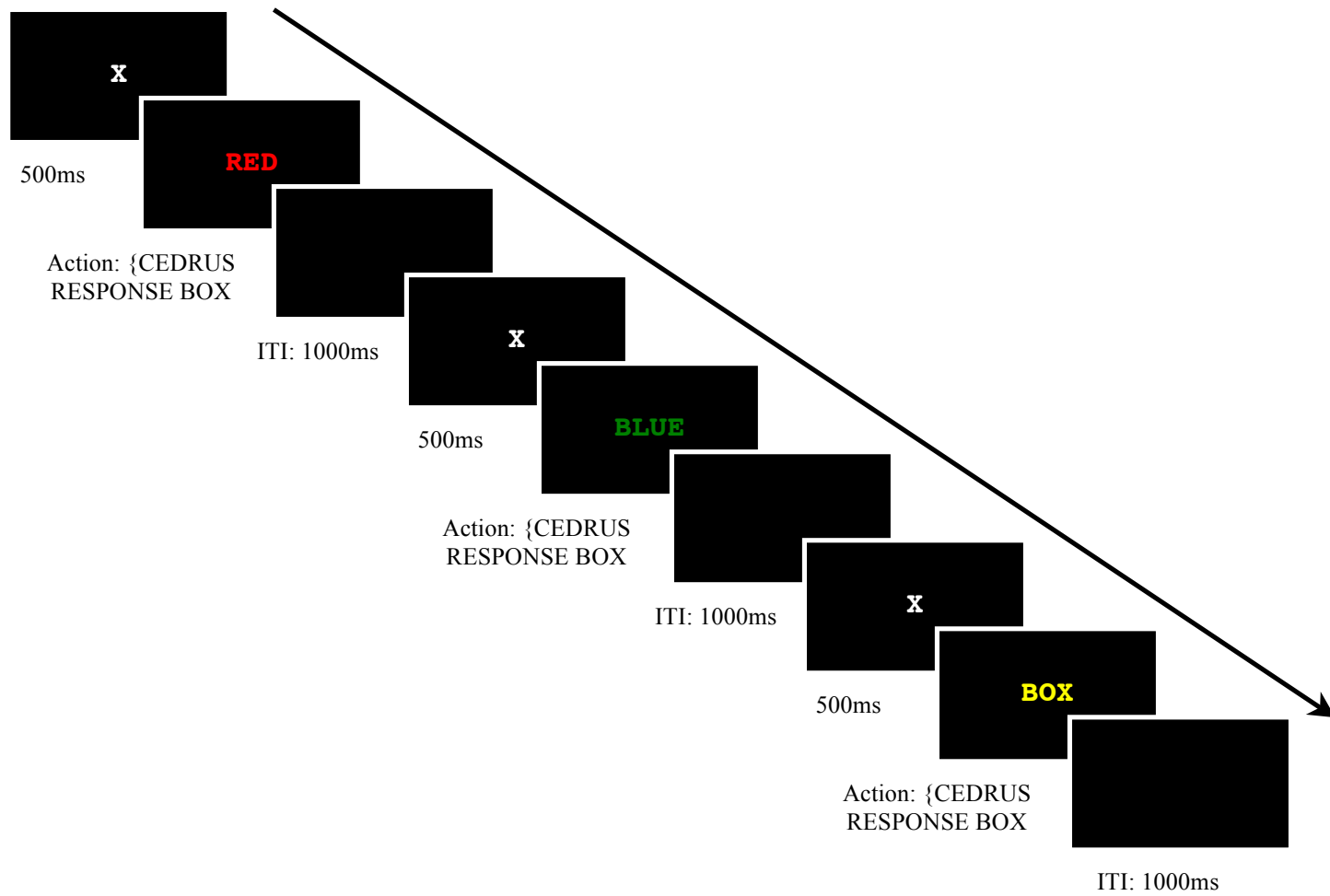


Figure 4: Trial procedure for the Stroop Colour-Naming Task.

each part containing 22 questions taken from UKwebstart (2010; <http://www.ukwebstart.com/quizpage.html>), and ranging in topic from science, history, film, music, general, mathematics, nursery rhyme and geography. The range and difficulty of questions was matched across the two versions, Test A (Appendix G, p. 362) and Test B (Appendix H, p. 363)¹⁵.

4.3 Short Version-Profile of Mood States (SV-POMS)

Participants' mood was assessed using the SV-POMS, a 37-item scale containing six subsections (Shacham, 1983; Appendix E, p. 357) that includes Tension-Anxiety, Depression-Dejection, Anger-Hostility, Fatigue-Inertia, Vigour-Activity, and Confusion-Bewilderment. The SV-POMS has a high consistency rating with the original 65-item version (Profile of Mood States, POMS; McNair, Lorr, & Droppleman, 1981), showing a correlation of .95 between the subscale scores on the SV-POMS and the POMS (Curran, Andrykowski, & Studts, 1995). Furthermore, Curran et al. (1995) reported the SV-POMS to be “an excellent alternative to the more time-consuming POMS because it preserves subscale information available in the original POMS without any significant decrease on internal consistency” (p. 80).

4.4 State Anxiety Scale (SAS)

¹⁵ A pilot study was conducted to assess whether the two general knowledge tests (e.g., Test A and Test B) were of equal difficulty. The sample consisted of four participants, three female and one male that ranged from 20 to 26 years of age ($M= 23.25$, $SD= 3.77$). The order of the two General Knowledge Tests was counterbalanced and the pilot data indicate that the two tests were of equal difficulty with participants producing a mean score of 8.25 on both Test A and Test B. All participants agreed the two tests were equally difficult and none of the two tests was highlighted as being easier than the other. Participants were asked to rate whether the question reflected general knowledge on a scale of one (strongly disagree) to five (strongly agree). Results show participants agreed the questions to reflect general knowledge ($M= 4$, $SD= .82$).

The state anxiety scale (SAS) from the State-Trait Anxiety Inventory (Spielberger, 1983; Appendix F, p. 361) is a 20-item scale used to measure the level of anxiety experienced by participants. Trait anxiety relates to feelings of apprehension, tension and heightened activity of the autonomous nervous system and is thought to be relatively stable whereas state anxiety is considered less stable, and can change as a function of the stressors an individual is experiencing at that time. The SAS provides statements for participants to rate regarding how they feel at that specific moment in time and was found by Barnes et al. (2002) in their meta-analysis to have internal consistency rating of .91 and a test-retest reliability coefficient of .70 and thought to be suitable for use with a wide range of populations.

The CST, Stroop Colour-Naming Task, General Knowledge Test, SV-POMS, and SAS, were all completed twice once before the LDT and once again after the LDT. The LDT was primarily used to present the subliminal stimuli¹⁶, consisting of the three Single-Word primes and the three Multiple-Word primes as described in Chapter 3 (p.64). Additional materials required for Experiment 1 included four videos (Blu, 2010; Golegogo Animation, 2007; Blu & Ellis, 2009; PES Film, 2008) shown respectively to each participant streamed directly from the Internet (<http://www.youtube.com/>) during the break period of this experiment. All other equipment and materials relevant to the experiment are as outlined in Chapter 3.

Procedure

The procedure of Experiment 1 was split into six stages e.g., *Stage I* ‘informed consent’, *Stage II* ‘dependant measures time 1’, *Stage III* ‘break’, *Stage IV* ‘subliminal

¹⁶ Data from the LDT was analysed however results did not yield significant response time and error data, thus results are not reported.

stimulation', *Stage V* 'dependant measures time 2', and *Stage VI* 'debrief'. Each of these six stages is described below.

Stage I: At the outset of the experiment participants were welcomed, seated at a desk and asked to read through the participant information sheet provided (Appendix I, p. 364). This gave an outline of the procedure of the experiment and participants gave informed consent by completing the screening and consent forms as outlined in Chapter 3 (see 3.1 *Participants*, p. 65).

Stage II: Participants were required to complete five tasks (CST, Stroop Colour-Naming Task, General Knowledge Test, SV-POMS; and the SAS) the order of which was counter-balanced across participants. The procedure of the CST was as outlined in the General Method (Chapter 3, 3.3.1 *Conceptual Span Task*, p. 75) and the order of the CST tasks was counter-balanced¹⁷. For the Stroop Colour-Naming Task participants were shown an instruction screen and provided with a verbal description and encouraged to ask questions. To begin the task participants pressed the centre button on the keypad to begin the practice trials. Participants reported the colour the word presented on screen was written in by pressing one of the four coloured buttons on a response pad. They were instructed to respond as quickly and as accurately as possible on each trial. On completion of the practice trials participants were shown an information screen informing them that the next set of trials would be recorded and to press the centre button to continue. The trials were presented in a computer-randomised order across the conditions (neutral, congruent, incongruent). On completion of all 104 trials the participant was shown a final information screen informing them of the end of the task. For the General Knowledge Test, participants were given a

¹⁷ Forty-six participants completed CST A first and CST B second and the remaining 48 participants completed the CST tasks in the reversed order.

paper-based test, the order of which was counter-balanced¹⁸ and were asked to complete their test with no time constraint. Questions were open-ended in style, whereby participants were required to fill the space provided with their suggested answer. Participants were allowed to leave questions they did not know the answer to blank. The SV-POMS was administered using a paper-based version completed by the participants with no time constraint. This task required participants to indicate how much or how little they were experiencing each adjective listed for each item at that moment in time. Each item on the questionnaire was answered on a Likert scale ranging between zero (not at all) and four (very much so). Finally, for the SAS, a paper-based version was provided and completed with no time constraints. All items were measured on a Likert scale ranging between one (not at all) and four (very much so). Nine items on the scale were reversed-coded (I feel... Calm, Secure, At Ease, Satisfied, Confident, Relaxed, Content, Steady, Pleasant).

Stage III: Participants were given a break lasting 25 minutes. Due to the number of tasks and the time these took to complete a break was incorporated to provide refreshments (water) and allow participants to rest sufficiently before continuing on with the experiment. During the break participants were asked to watch four videos streamed from the Internet shown in the same order. The videos were provided to maintain participants' attention and interest so as not to become bored, but with care taken to ensure a level of neutrality to limit potential interference on any of the measures, particularly mood.

Stage IV: Participants were asked to complete a Lexical Decision Task (LDT), the procedure for which is described in the Chapter 3 (3.3.2 *Lexical Decision Task*, p. 76). Unbeknown to the participants the LDT was used to deliver the subliminal stimuli a total of 30 times during the task. An explanation of the stimuli chosen and details specific to the presentation of the stimuli are outlined in Chapter 3 (p. 64-67).

¹⁸ Forty-six participants completed Test A first and Text B second and 48 participants completed the General Knowledge Tests in the reversed order.

Stage V: Participants were asked to complete the five tasks originally completed in *Stage II* again, with the order counter-balanced across participants.

Stage VI: Participants were debriefed. The debrief was completed using a funnel-styled questionnaire (Appendix J, p. 365) as outlined in the Chapter 3 (3.2.4 *Subliminal Threshold Checks*, p. 72) to assess the participant's level of subjective and objective awareness to subliminally presented stimuli. See Figure 5, for a diagram of the procedure of Experiment 1 (p. 108).

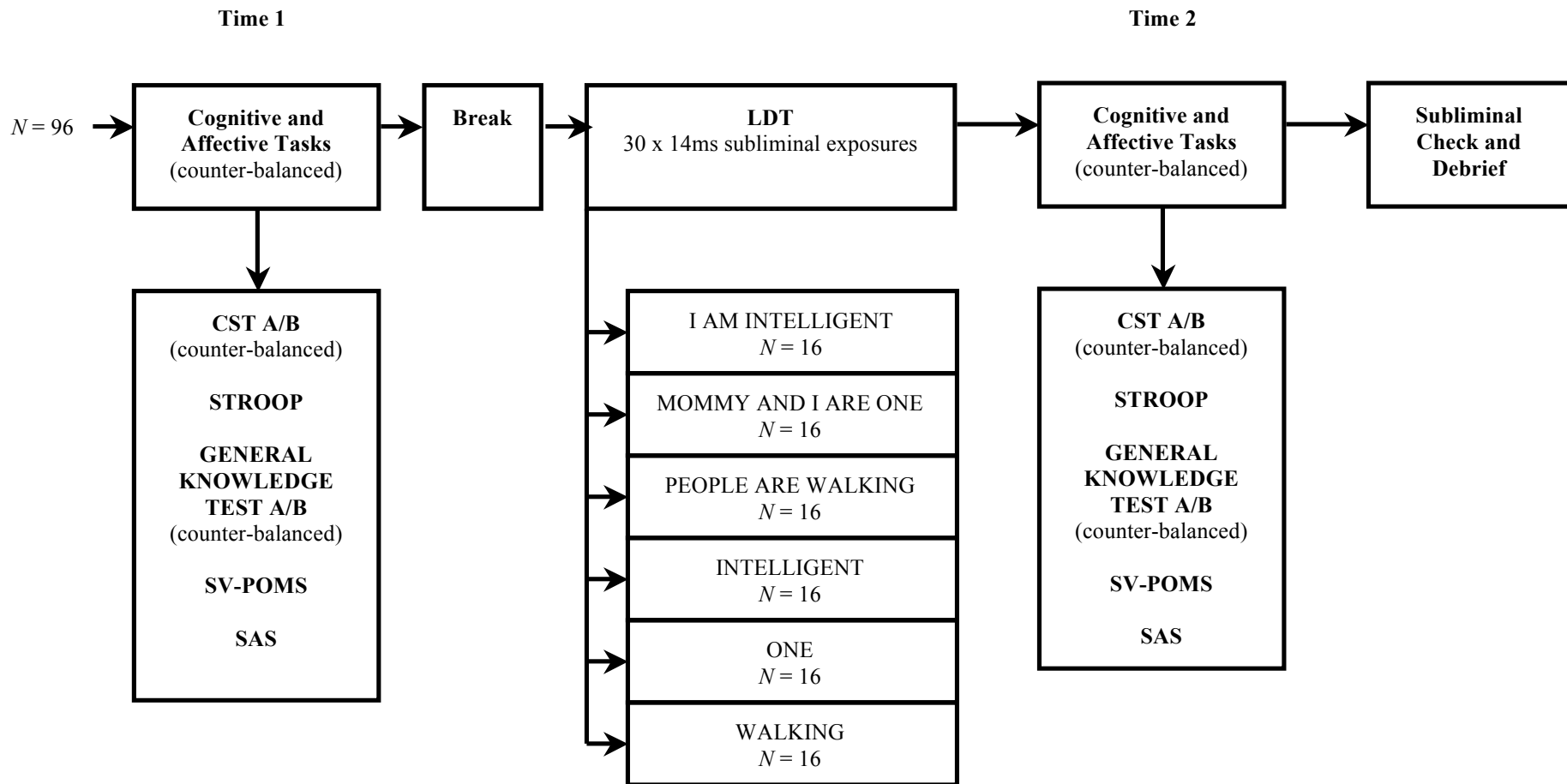


Figure 5: Schematic of the procedure used in Experiment 1.

Design

The design and independent variables of this study were the same as those outlined in Chapter 3 (3.4 *Design*, p. 77). The dependant measures were the participants' scores on each of the tasks presented. First the dependant measures for the CST were the participants' accuracy (e.g., number of correctly recalled words) and intrusions (e.g., number of incorrectly recalled words). Secondly, the dependant measures from the Stroop Colour-Naming Task were the participants' response time (e.g., mean time to react) and error rate (e.g., overall number of incorrect responses and response times recorded three standard deviations away from the mean; Balota et al., 2010) for each of the congruent, incongruent, and neutral trials. Third the dependant measure from the General Knowledge Test was the participants' accuracy score (e.g., number of correctly answered questions). Forth, the dependant measures from the SV-POMS were the participants' mean scores from each of the SV-POMS subsections (e.g., tension-anxiety, depression-anxiety, anger-hostility, fatigue-inertia, vigour-activity, and confusion-bewilderment). Finally, the fifth dependant measure was the participants' mean score on the SAS.

Results

Data from each of the measures were analysed separately using a 2 (Time: *Time 1 vs. Time 2*) x 2 (Prime Type: *Single-Word Prime vs. Multiple-Word Prime*) x 3 (Prime Content: *Cognitive, Affective, Neutral-Control*) mixed analysis of variance (ANOVA). Time was a within participants factor, and Prime Type and Prime Content were both between participants factors. Results from the CST, the Stroop Colour-

Naming Task, the General Knowledge Test, the SV-POMS, and the SAS are all reported below.

4.5 Conceptual Span Task (CST)

Accuracy (i.e., number of words correctly recalled) and intrusion (i.e., number of words incorrectly recalled) data were analysed separately and reported below.

4.5.1 CST Accuracy

Mean accuracy scores (i.e., number of correctly recalled words) and standard deviations (*SD*) for each group are provided in Table 2 (below). Higher scores indicate more words recalled.

Table 2

Mean and SD Scores for CST Accuracy at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	<i>SD</i>	Mean	<i>SD</i>
Single-Word	Cognitive	31.25	6.33	37.44	7.78
Single-Word	Affective	31.00	5.06	35.19	6.11
Single-Word	Neutral	29.63	5.95	30.89	10.33
Multi-Word	Cognitive	31.56	7.16	34.56	8.89
Multi-Word	Affective	31.81	6.52	35.50	5.57
Multi-Word	Neutral	30.00	8.35	30.69	7.91

Note. Mean represents the number of correctly recalled words from a total of 63

Analysis revealed a main effect of Time, $F(1,90)=24.400, p<.001$, $MSE=19.726, \eta^2_p=.213$, whereby participants recall accuracy improved from Time 1

to Time 2 (30.88 and 34.05 respectively). There was also a marginal¹⁹ two-way Time x Prime Content interaction, $F(2,90)=3.026$, $p=.053$, $MSE=19.726$, $\eta^2_p=.063$, (see Figure 6, below).

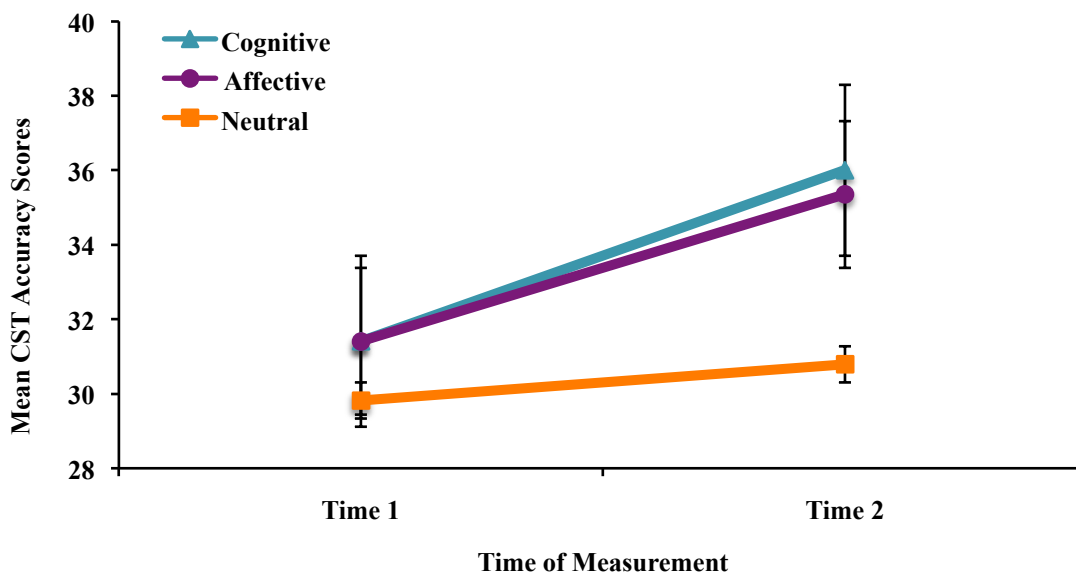


Figure 6: Showing increased mean word recall (with standard errors) on the CST from Time 1 to Time 2 for participants exposed to the Cognitive and Affective subliminal stimuli but not the Neutral stimuli.

The two-way Time x Prime Content interaction was explored further by conducting three paired samples *t*-tests using a Bonferroni correction ($\alpha/3 = .017$) for

¹⁹ Although .05 is widely recommended as the accepted α criterion it has been considered that such stringent binary decision between ‘significant’ and ‘non-significant’ may ignore potentially interesting results (Gelman & Stern, 2006; Nickerson, 2000; Rosnow & Rosenthal, 1989). Some have considered that *p* values may reflect more of a continuum for the strength of support the finding may offer (Rosnow & Rosenthal, 1989) and Greenwald, Gonzalez, Harris, and Guthrie (1996) further suggest that findings of $p \approx .05$ should be considered as interesting although replication should be sought. More specifically however, *p* values around the region of .06 have been identified as acceptable to distinguish as ‘marginally’ significant (Iacobucci, 2005; Nickerson, 2000; Rosnow & Rosenthal, 1989). Hence in this thesis, only results obtained between $p=.051$ and $p=.069$ will be considered as marginally significant and will be examined further. By keeping the range for ‘marginally’ significant results conservative the risk of making a Type I error should be reduced, as it is less likely that conclusions suggesting effective subliminal priming following such post hoc analysis would be made when they are not true.

each level of Prime Content over Time. This showed an increase in accuracy for those exposed to the Cognitive and Affective stimuli (31.41 and 36, $t(31)=-3.428, p=.002$, and 31.41 and 35.35, $t(31)=-4.926, p<.001$ respectively). However, for those exposed to the Neutral-Control stimuli there was no significant difference in the number of words recalled between Time 1 and Time 2 (29.82 and 30.79, $t(31)=-2.119, p=.042$)²⁰.

To assess whether there was any difference between the effect on CST accuracy performance following exposure to the Cognitive compared to the Affective subliminal stimuli collapsed over time, a further independent samples t -test was calculated that revealed no significant difference (36.00 and 35.34 respectively; $t(62)=.366, p=.716$).

All other analyses, which included: Prime Type, $F(1,90)=.024, p=.878, MSE=87.369, \eta^2_p=.000$, Prime Content, $F(2,90)=2.586, p=.081, MSE=87.369, \eta^2_p=.054$, Time x Prime Type, $F(1,90)=1.221, p=.272, MSE=19.726, \eta^2_p=.013$, Prime Content x Prime Type, $F(2,90)=.168, p=.845, MSE=87.369, \eta^2_p=.004$, and Prime Type x Time x Prime Content, $F(2,90)=.477, p=.622, MSE=19.726, \eta^2_p=.010$, were not significant.

²⁰ Although this result falls within the confines of a significant finding when using conventional accepted α criterion, this result is not accepted as significant in this instance due to the revised α criterion following the Bonferroni correction. Furthermore, this result is not considered to reflect a marginally significant result as the distance between the p value and new accepted α criterion exceeds that identified as acceptable for this thesis i.e., it does not fall within the range of $p= .018$ and $p= .036$.

4.5.2 CST Intrusions

The mean transformed²¹ intrusion scores i.e., the number of incorrectly recalled words, and standard deviations (*SD*) for each group are provided in Table 3 (below). Higher scores indicate more words incorrectly recalled.

Table 3

Mean and SD Scores for CST Intrusions at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	<i>SD</i>	Mean	<i>SD</i>
Single-Word	Cognitive	2.67	0.85	2.40	0.82
Single-Word	Affective	2.38	0.83	2.32	0.68
Single-Word	Neutral	2.86	1.85	2.50	1.31
Multi-Word	Cognitive	2.66	1.09	2.44	1.19
Multi-Word	Affective	2.35	1.25	2.41	1.32
Multi-Word	Neutral	2.39	1.12	2.44	1.19

All analyses which included: Time, $F(1,90)=2.313$, $p=.132$, $MSE=.385$, $\eta^2_p=.025$, Prime Type, $F(1,90)=.115$, $p=.736$, $MSE=2.316$, $\eta^2_p=.001$, Prime Content, $F(2,90)=.292$, $p=.747$, $MSE=2.316$, $\eta^2_p=.006$, Time x Prime Type, $F(1,90)=1.125$, $p=.292$, $MSE=.385$, $\eta^2_p=.012$, Time x Prime Content, $F(2,90)=.642$, $p=.528$, $MSE=.385$, $\eta^2_p=.014$, Prime Content x Prime Type, $F(2,90)=.198$, $p=.821$,

²¹ Data for incorrectly recalled words were transformed using a square-root transformation, as they did not meet the criteria for parametric test for normality as outlined in Chapter 3 (3.5 *Data Preparation and Analysis*, p.77). Square-root transformation was found to improve normality to an acceptable level.

$MSE=2.316$, $\eta^2_p=.004$, and Prime Type x Time x Prime Content, $F(2,90)=.361$, $p=.698$, $MSE=.385$, $\eta^2_p=.008$, were not significant.

4.6 Stroop Colour-Naming Task

Response time (i.e., mean time to react trimmed to +/- 3 standard deviations from the mean, see Chapter 3) and error (i.e., overall number of incorrect responses) data were analysed separately for congruent, incongruent and neutral word trials and are reported below.

4.6.1 Congruent Response Times

Mean transformed²² response times in milliseconds (ms) and standard deviations (*SD*) for each group are provided in Table 4 (p. 115). Higher numbers reflect slower response times and lower numbers indicate quicker response times to congruently coloured words.

Analysis revealed a main effect of Time, $F(1,90)=47.248$, $p<.001$, $MSE=.871$, $\eta^2_p=.344$, whereby participants response times decreased from Time 1 to Time 2 (25.82ms and 24.87ms respectively).

All other analyses which include: Prime Type, $F(1,90)=1.507$, $p=.223$, $MSE=8.272$, $\eta^2_p=.016$, Prime Content, $F(2,90)=1.088$, $p=.341$, $MSE=8.272$, $\eta^2_p=.024$, Time x Prime Type, $F(1,90)=.766$, $p=.384$, $MSE=.871$, $\eta^2_p=.008$, Time x Prime

²² Data for Stroop response time scores for congruently coloured words were transformed using a square-root transformation, as they did not meet the criteria for parametric test e.g., homogeneity of variances and normality as outlined in Chapter 3 (3.5 Data Preparation and Analysis, p.77). Square-root transformation was found to improve homogeneity of variances and normality.

Content, $F(2,90)=.435, p=.649, MSE=.871, \eta^2_p=.010$, Prime Type x Prime Content, $F(2,90)=1.916, p=.153, MSE=8.272, \eta^2_p=.041$, and Prime Type x Time x Prime Content, $F(1,90)=.533, p=.589, MSE=.871, \eta^2_p=.012$, were not significant.

Table 4

Mean and SD Scores for Stroop Congruent Word Response Times at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	SD	Mean	SD
Single-Word	Cognitive	25.40	1.90	24.55	1.91
Single-Word	Affective	25.90	1.66	24.85	1.90
Single-Word	Neutral	27.09	2.91	25.85	2.78
Multi-Word	Cognitive	25.88	2.52	25.18	2.95
Multi-Word	Affective	25.25	1.37	24.14	1.52
Multi-Word	Neutral	25.37	1.74	24.75	1.65

Note. Mean reflects the transformed response time in ms to congruently coloured words from a total of 36 trials.

4.6.2 Congruent Errors

Mean transformed²³ error scores and standard deviations (*SD*) for each group are provided in Table 5 (p.116). Higher scores indicate more incorrect answers made in response to congruently coloured words.

²³ Data for Stroop error scores for congruently coloured words were transformed using a square-root transformation, as they did not meet the criteria for parametric test e.g., homogeneity of variances and normality as outlined in Chapter 3 (3.5 *Data Preparation and Analysis*, p. 77). Square-root transformation was found to improve homogeneity of variances and normality.

Table 5

Mean and SD Scores for Stroop Congruent Word Errors at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	SD	Mean	SD
Single-Word	Cognitive	0.85	0.79	0.91	0.62
Single-Word	Affective	0.38	0.50	0.92	0.49
Single-Word	Neutral	0.58	0.61	0.70	0.59
Multi-Word	Cognitive	0.58	0.61	0.85	0.75
Multi-Word	Affective	0.65	0.53	0.97	0.57
Multi-Word	Neutral	0.95	0.71	1.00	0.58

Note. Mean transformed number of incorrect responses made to congruently coloured words from a total of 36 trials.

The analysis revealed a main effect of Time, $F(1,90)=6.940$, $p=.01$, $MSE=.355$, $\eta^2_p=.072$, whereby the number of errors increased from Time 1 to Time 2 (0.67 and 0.89 respectively).

All other analyses which include: Prime Type, $F(1,90)=1.429$, $p=.235$, $MSE=.415$, $\eta^2_p=.016$, Prime Content, $F(2,90)=.273$, $p=.762$, $MSE=.415$, $\eta^2_p=.006$, Time x Prime Type, $F(1,90)=.021$, $p=.884$, $MSE=.355$, $\eta^2_p=.000$, Time x Prime Content, $F(2,90)=1.491$, $p=.231$, $MSE=.355$, $\eta^2_p=.032$, Prime Type x Prime Content, $F(2,90)=2.549$, $p=.084$, $MSE=.415$, $\eta^2_p=.054$, and Prime Type x Time x Prime Content, $F(2,90)=.543$, $p=.583$, $MSE=.355$, $\eta^2_p=.012$, were not significant.

4.6.3 Incongruent Response Times

Mean transformed²⁴ response times in milliseconds (ms) and standard deviations (*SD*) for each group are provided in Table 6 (below). Higher numbers scores reflect slower response times and lower numbers indicate quicker response times to incongruently coloured words.

Table 6

Mean and SD Scores for Stroop Incongruent Word Response Times at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	<i>SD</i>	Mean	<i>SD</i>
Single-Word	Cognitive	26.63	2.25	25.43	1.89
Single-Word	Affective	26.88	1.94	26.15	2.19
Single-Word	Neutral	28.75	4.08	27.11	3.30
Multi-Word	Cognitive	27.01	3.09	26.27	3.48
Multi-Word	Affective	26.27	1.39	24.85	1.68
Multi-Word	Neutral	26.54	1.79	26.12	1.67

Note. Mean transformed response time in ms to incongruently coloured words from a total of 36 trials.

²⁴ Data for Stroop response time scores for incongruently coloured words were transformed using a square-root transformation, as they did not meet the criteria for parametric test e.g., homogeneity of variances and normality as outlined in Chapter 3 (3.5 Data Preparation and Analysis, p.77). Square-root transformation was found to improve homogeneity of variances and normality.

Analysis revealed a main effect of Time, $F(1,90)=39.102, p<.001$, $MSE=1.288, \eta^2_p=.303$, whereby participants response times decreased from Time 1 to Time 2 (27.01 and 25.99 respectively). Additionally, a marginal three-way Prime Type x Time x Prime Content, interaction was found, $F(2,90)=2.845, p=.063$, $MSE=1.288, \eta^2_p=.059$, (see Figure 7, below; and Figure 8, p. 119).

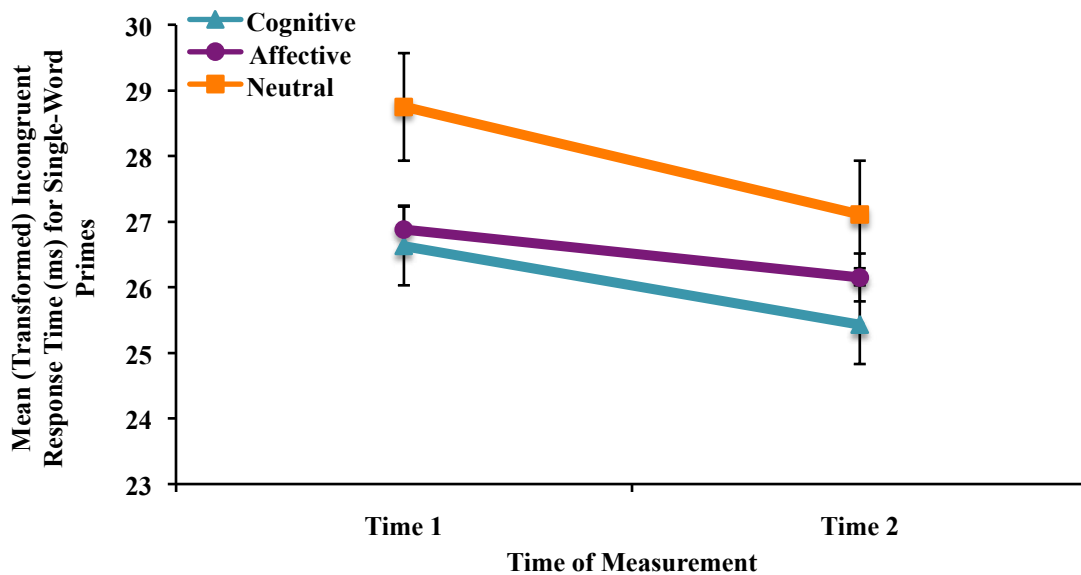


Figure 7: Showing decreased mean response times (with standard errors) in ms from Time 1 to Time 2 on the Stroop Colour-Naming Task for incongruently coloured words for all participants receiving subliminal Single-Word primes.

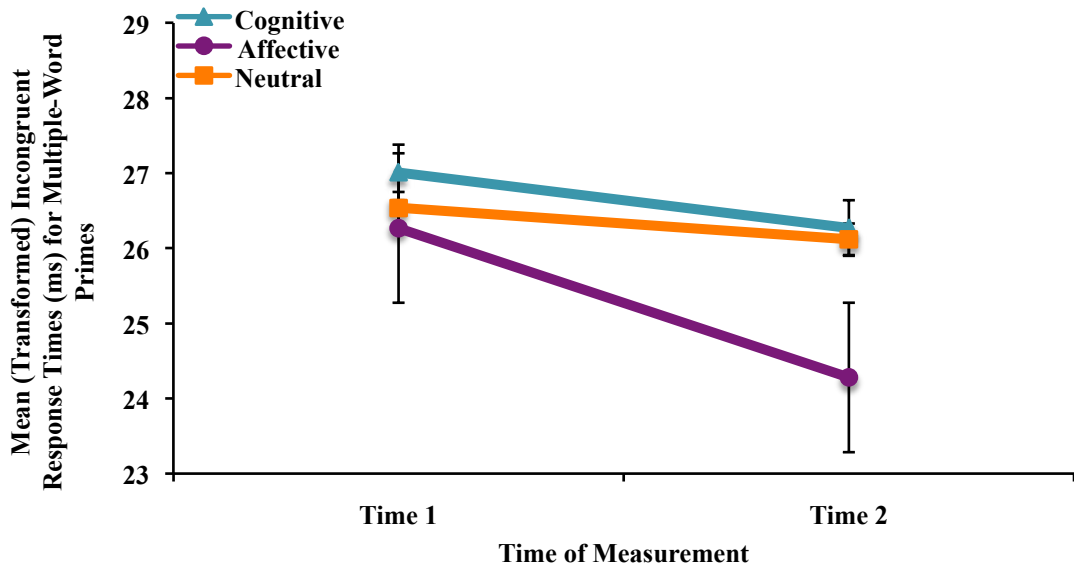


Figure 8: Showing decreased mean response times (and standard errors) in ms from Time 1 to Time 2 on the Stroop Colour-Naming Task for incongruently coloured words for all participants receiving subliminal Multiple-Word primes.

The three-way interaction was explored by conducting two 2 (Time: *Time 1* vs. *Time 2*) x 3 (Prime Content: *Cognitive*, *Affective*, *Neutral*) ANOVA's split by Prime Type (e.g., Single-Word and Multiple-Word primes).

For the *Single-Word Primes*, the analysis revealed that the Time x Prime Content, $F(2,45)=.954$, $p=.393$, $MSE=1.694$, $\eta^2_p=.041$, was not significant.

For the *Multiple-Word Primes*, the analysis revealed that the Time x Prime Content, $F(2,45)=2.374$, $p=.105$, $MSE=.882$, $\eta^2_p=.095$, was not significant.

All other analyses including: Prime Type, $F(1,90)=1.753$, $p=.189$, $MSE=11.618$, $\eta^2_p=.019$, Prime Content, $F(2,90)=1.757$, $p=.178$, $MSE=11.618$,

$\eta^2_p=.038$, Time x Prime Type, $F(1,90)=1.092$, $p=.313$, $MSE=1.288$, $\eta^2_p=.011$, Time x Prime Content, $F(2,90)=.036$, $p=.965$, $MSE=1.288$, $\eta^2_p=.001$, and Prime Type x Prime Content, $F(2,53)=1.775$, $p=.175$, $MSE=11.618$, $\eta^2_p=.038$, were not significant.

4.6.4 Incongruent Errors

Mean transformed²⁵ error scores and standard deviations (*SD*) for each group are provided in Table 7 (below). Higher scores indicate more incorrect answers made in response to incongruently coloured words.

Table 7

Mean and SD Scores for Stroop Incongruent Word Errors at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	<i>SD</i>	Mean	<i>SD</i>
Single-Word	Cognitive	1.07	0.85	1.10	0.76
Single-Word	Affective	1.02	0.59	0.93	0.78
Single-Word	Neutral	1.05	1.35	1.02	1.28
Multi-Word	Cognitive	0.77	0.76	1.21	0.55
Multi-Word	Affective	0.96	0.54	0.90	0.58
Multi-Word	Neutral	1.01	0.84	1.11	0.60

Note. Mean transformed number of incorrect responses made to incongruently coloured words from a total of 36 trials.

²⁵ Data for Stroop error scores for incongruently coloured words were transformed using a square-root transformation, as they did not meet the criteria for parametric test e.g., homogeneity of variances and normality as outlined in Chapter 3 (3.5 *Data Preparation and Analysis*, p.77). Square-root transformation was found to improve homogeneity of variances and normality.

All analyses which included: Time, $F(1,90)=.498$, $p=.482$, $MSE=.406$, $\eta^2_p=.006$, Prime Type, $F(1,90)=.076$, $p=.784$, $MSE=.977$, $\eta^2_p=.001$, Prime Content, $F(2,90)=.169$, $p=.845$, $MSE=.977$, $\eta^2_p=.004$, Time x Prime Type, $F(1,90)=1.067$, $p=.304$, $MSE=.406$, $\eta^2_p=.012$, Time x Prime Content, $F(2,90)=.987$, $p=.377$, $MSE=.406$, $\eta^2_p=.021$, Prime Type x Prime Content, $F(2,90)=.062$, $p=.940$, $MSE=.977$, $\eta^2_p=.001$, and Prime Type x Time x Prime Content, $F(2,90)=.374$, $p=.689$, $MSE=.406$, $\eta^2_p=.008$, were not significant.

4.6.5 Neutral Response Times

Mean transformed²⁶ response times in milliseconds (ms) and standard deviations (*SD*) for each group are provided in Table 8 (p. 122). Higher numbers reflect slower response times and lower numbers indicate quicker response times to incongruently coloured words.

Analysis revealed a main effect of Time, $F(1,90)=69.934$, $p<.001$, $MSE=.850$, $\eta^2_p=.437$, whereby participants response time decreased from Time 1 to Time 2 (26.21 and 25.10 respectively).

All other analyses including: Prime Type, $F(1,90)=2.084$, $p=.152$, $MSE=7.803$, $\eta^2_p=.023$, Prime Content, $F(2,90)=1.333$, $p=.269$, $MSE=7.803$, $\eta^2_p=.029$, Time x Prime Type, $F(1,90)=.574$, $p=.451$, $MSE=.850$, $\eta^2_p=.006$, Time x Prime Content, $F(2,90)=.083$, $p=.920$, $MSE=.850$, $\eta^2_p=.002$, Prime Type x Prime Content,

²⁶ Data for Stroop response time scores for neutral words were transformed using a square-root transformation, as they did not meet the criteria for parametric test e.g., homogeneity of variances and normality as outlined in Chapter 3 (3.5 *Data Preparation and Analysis*, p.77). Square-root transformation was found to improve homogeneity of variances and normality.

$F(2,90)=2.422$, $p=.095$, $MSE=7.803$, $\eta^2_p=.051$, and Prime Type x Time x Prime Content, $F(2,90)=1.340$, $p=.267$, $MSE=.850$, $\eta^2_p=.029$, were not significant.

Table 8

Mean and SD Scores for Stroop Neutral Word Response Times at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	SD	Mean	SD
Single-Word	Cognitive	25.67	2.07	24.61	1.91
Single-Word	Affective	26.43	1.60	25.45	1.85
Single-Word	Neutral	27.56	3.22	25.96	2.47
Multi-Word	Cognitive	26.36	2.50	25.26	2.60
Multi-Word	Affective	25.39	1.19	24.23	1.45
Multi-Word	Neutral	25.87	1.63	25.08	1.54

Note. Mean reflects the transformed response times in ms to neutral content words on a total of 32 trials.

4.6.6 Neutral Errors

Mean transformed²⁷ error scores and standard deviations (*SD*) for each group are provided in Table 9 (p. 123). Higher scores indicate more incorrect answers made in response to incongruently coloured words.

²⁷ Data for Stroop error scores for neutral words were transformed using a square-root transformation, as they did not meet the criteria for parametric test e.g., homogeneity of variances and normality as outlined in Chapter 3 (3.5 *Data Preparation and Analysis*, p.77). Square-root transformation was found to improve homogeneity of variances and normality.

Table 9

Mean and SD Scores for Stroop Neutral Errors at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	SD	Mean	SD
Single-Word	Cognitive	0.92	0.65	1.15	0.62
Single-Word	Affective	0.81	0.60	0.80	0.72
Single-Word	Neutral	0.70	0.69	0.87	0.58
Multi-Word	Cognitive	0.75	0.68	1.11	0.60
Multi-Word	Affective	0.57	0.62	0.77	0.66
Multi-Word	Neutral	0.58	0.61	0.88	0.66

Note. Mean transformed number of incorrect responses made to neutral content words from a total of 32 trials.

Analysis revealed a main effect of Time, $F(1,90)=7.038$, $p=.009$, $MSE=.291$, $\eta^2_p=.073$, whereby the number of errors increased from Time 1 to Time 2 (0.72 and 0.93 respectively).

All other analyses including: Prime Type, $F(1,90)=.871$, $p=.353$, $MSE=.536$, $\eta^2_p=.010$, Prime Content, $F(2,90)=2.245$, $p=.112$, $MSE=.536$, $\eta^2_p=.048$, Time x Prime Type, $F(1,90)=.997$, $p=.321$, $MSE=.291$, $\eta^2_p=.011$, Time x Prime Content, $F(2,90)=.570$, $p=.568$, $MSE=.291$, $\eta^2_p=.013$, Prime Type x Prime Content, $F(2,90)=.054$, $p=.947$, $MSE=.536$, $\eta^2_p=.001$, and Prime Type x Time x Prime Content, $F(2,90)=.029$, $p=.972$, $MSE=.291$, $\eta^2_p=.001$, were not significant.

4.7 General Knowledge Test

Mean transformed²⁸ accuracy scores (i.e., number of correctly answered questions) and standard deviations (*SD*) for each group is provided in Table 10 (below) where higher scores indicate more correctly answered questions.

Table 10

Mean and SD Scores for General Knowledge Accuracy at Time 1 and Time 2

Prime Type	Prime Content	Time 1		Time 2	
		Mean	<i>SD</i>	Mean	<i>SD</i>
Single-Word	Cognitive	2.75	0.63	2.66	0.76
Single-Word	Affective	2.43	0.76	2.62	0.76
Single-Word	Neutral	2.49	0.80	2.63	0.71
Multi-Word	Cognitive	2.59	0.83	2.86	0.65
Multi-Word	Affective	2.81	0.62	2.61	0.68
Multi-Word	Neutral	2.72	0.67	2.69	0.54

Note. Mean represents the transformed number of correctly answered questions from a total of 4.69.

Analysis revealed a three-way Prime Type x Time x Prime Content interaction, $F(2,90)=3.499$, $p=.034$, $MSE=.168$, $\eta^2_p=.072$, (see Figure 9, p. 125; and Figure 10, p.125).

²⁸ Data for the General Knowledge Test accuracy scores were transformed using a square-root transformation, as they did not meet the criteria for parametric test for normality as outlined in Chapter 3 (3.5 Data Preparation and Analysis, p.77). Square-root transformation was found to improve normality.

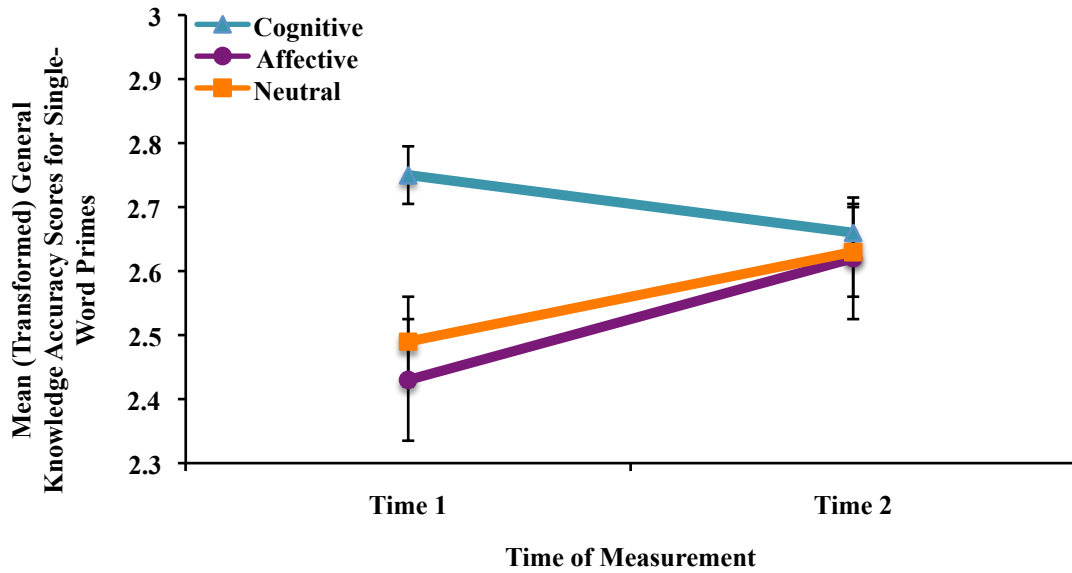


Figure 9: Showing the change in mean General Knowledge test accuracy scores (with standard errors) following subliminal exposure to Single-Word primes.

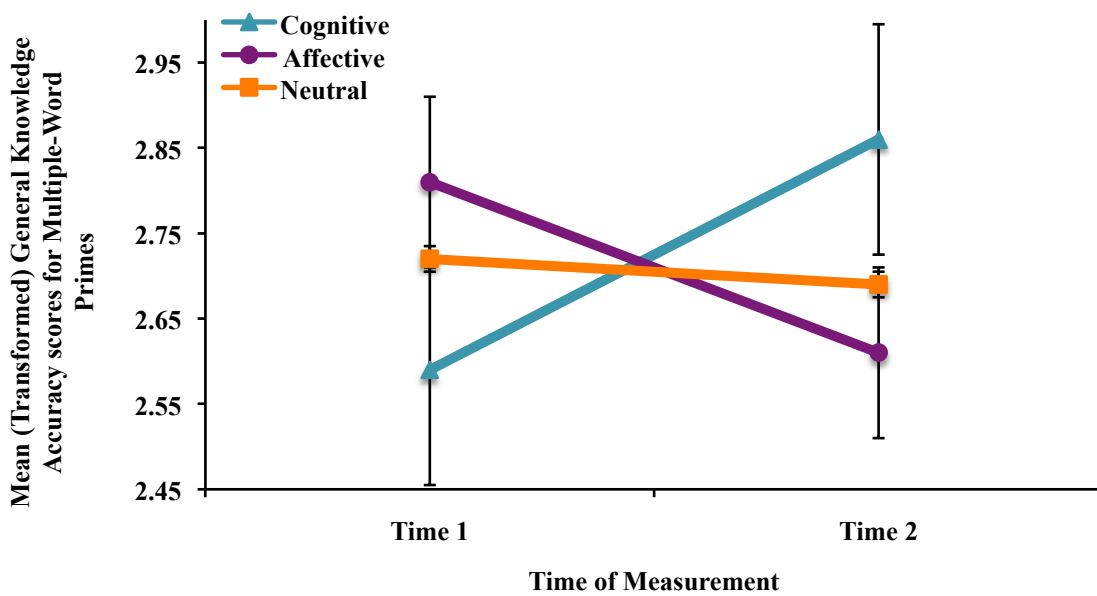


Figure 10: Showing the change in mean General Knowledge test accuracy scores (with standard errors) for participants receiving the Multiple-Word primes.

The three-way interaction was explored further by conducting two 2 (Time: *Time 1* vs. *Time 2*) x 3 (Prime Content: *Cognitive*, *Affective*, *Neutral*) ANOVA's split by Prime Type (e.g., Single-Word Primes and Multiple-Word Primes).

For the *Single-Word Primes*, the analysis revealed that the Time x Prime Content, $F(2,45)=1.141$, $p=.329$, $MSE=.159$, $\eta^2_p=.048$ was not significant.

For the *Multiple-Word Primes*, there was also no significant Time x Prime Content interaction, $F(2,45)=2.474$, $p=.096$, $MSE=.177$, $\eta^2_p=.099$.

In the interest of establishing the possible cause of the original three-way interaction, the Time x Prime Content interaction with the smallest p -values from the *Multiple-Word Prime* analysis was explored further. To explore this, three paired samples t -tests were conducted for each Multiple-Word Prime Content over Time using Bonferroni correction ($\alpha/3=.017$). The analysis revealed no significant improvement in accuracy for the *Cognitive* primes between Time 1 (2.59) and Time 2 (2.86), $t(15)=-1.816$, $p=.089$ ²⁹. Additionally, no significant improvement in accuracy was found for the *Affective* primes between Time 1 (2.81) and Time 2 (2.61), $t(15)=1.095$, $p=.291$. Finally, no significant improvement in accuracy was found for the *Neutral-Control* primes between Time 1 (2.72) and Time 2 (2.69), $t(15)=.262$, $p=.797$.

²⁹ Whilst this does not meet the requirement for a marginal effect for this thesis, it is possible that this difference between the accuracy scores achieved over time for the Cognitive Multiple-Word prime group was responsible for the original three-way interaction reported in the original analysis.

4.8 Short Version-Profile of Mood States (SV-POMS)

Mean Tension-Anxiety (TA), Depression-Dejection (DD), Anger-Hostility (AH), Fatigue-Inertia (FI), Vigour-Activity (VA), and Confusion-Bewilderment (CB) data were analysed separately and reported below.

4.8.1 Tension-Anxiety (TA)

Mean transformed³⁰ TA scores and standard deviations (*SD*) for each group are provided in Table 11 (below) where high scores reflect greater levels of tension/anxiety.

Table 11

Mean and SD Scores for Tension-Anxiety at Time 1 and Time 2

Prime Type	Prime Content	Time 1		Time 2	
		Mean	<i>SD</i>	Mean	<i>SD</i>
Single-Word	Cognitive	2.29	1.05	1.09	1.24
Single-Word	Affective	2.16	1.04	2.19	0.83
Single-Word	Neutral	2.05	0.93	1.84	1.06
Multi-Word	Cognitive	2.23	1.07	1.64	1.21
Multi-Word	Affective	1.85	1.24	1.45	1.35
Multi-Word	Neutral	2.82	0.98	2.12	0.93

Note. Mean transformed degree of TA experienced. Possible scores ranged from 0 to 4.90.

³⁰ Data for SV-POMS TA were transformed using a square-root transformation, as they did not meet the criteria for parametric test for normality as outlined in Chapter 3 (3.5 Data Preparation and Analysis, p.77). Square-root transformation was found to improve normality.

Analysis revealed a main effect of Time, $F(1,90)=22.708, p<.001, MSE=.556, \eta^2_p=.201$, whereby participants level of TA decreased from Time 1 to Time 2 (2.23 and 1.72 respectively). Additionally, there was a two-way Time x Prime Content interaction, $F(2,90)=3.631, p=.030, MSE=.556, \eta^2_p=.075$, (see Figure 11, below).

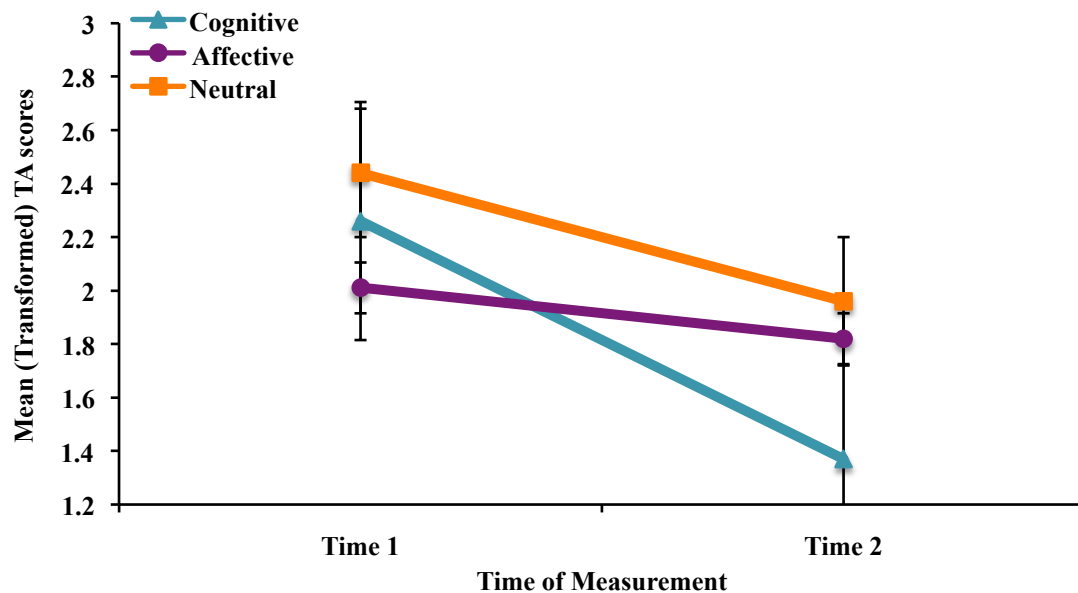


Figure 11: Showing mean TA scores (with standard errors) from Time 1 to Time 2 for the three Cognitive, Affective and Neutral subliminal stimuli groups.

The two-way interaction was explored further by conducting three paired samples t -tests using a Bonferroni correction ($\alpha/3=.017$) for each level of Prime Content over Time. Both the *Cognitive* and *Neutral-Control* groups showed a decrease in TA from Time 1 to Time 2, (2.26 and 1.37, $t(31)=4.805, p<.001$; 2.44 and 1.96, $t(31)=2.719, p=.011$ respectively). For the *Affective* group, there was no significant change in TA scores between Time 1 and Time 2 (2.01 and 1.82 respectively), $t(31)=.898, p=.376$.

All other analyses including: Prime Type, $F(1,90)=.188$, $p=.666$, $MSE=1.811$, $\eta^2_p=.002$, Prime Content, $F(2,90)=1.483$, $p=.232$, $MSE=1.811$, $\eta^2_p=.032$, Time x Prime Type, $F(1,90)=.252$, $p=.617$, $MSE=.556$, $\eta^2_p=.003$, Prime Type x Prime Content, $F(2,90)=2.641$, $p=.077$, $MSE=1.811$, $\eta^2_p=.055$, and Prime Type x Time x Prime Content, $F(2,90)=2.707$, $p=.072$, $MSE=.140$, $\eta^2_p=.556$, were not significant.

4.8.2 Depression-Dejection (DD)

Mean transformed³¹ DD scores and standard deviations (*SD*) for each group are provided in Table 12 (p.130). High scores reflect a higher level of depression/dejection experienced.

Analysis revealed a main effect of Time, $F(1,90)=17.278$, $p<.001$, $MSE=.503$, $\eta^2_p=.161$, indicating a reduction in DD from Time 1 to Time 2 (1.41 and 0.98 respectively).

All other analyses which included: Prime Type, $F(1,90)=1.104$, $p=.296$, $MSE=2.117$, $\eta^2_p=.012$, Prime Content, $F(2,90)=1.015$, $p=.367$, $MSE=2.117$, $\eta^2_p=.022$, Time x Prime Type, $F(1,90)=.211$, $p=.647$, $MSE=.503$, $\eta^2_p=.002$, Time x Prime Content, $F(2,90)=.325$, $p=.723$, $MSE=.503$, $\eta^2_p=.007$, Prime Content x Prime Type, $F(2,90)=2.018$, $p=.139$, $MSE=2.117$, $\eta^2_p=.043$, and Prime Type x Time x Prime Content, $F(2,90)=.439$, $p=.646$, $MSE=.503$, $\eta^2_p=.010$, were not significant.

³¹ Data for SV-POMS DD were transformed using a square-root transformation, as they did not meet the criteria for parametric test for normality as outlined in Chapter 3 (3.5 Data Preparation and Analysis, p.77). Square-root transformation was found to improve normality.

Table 12

Mean and SD Scores for Depression-Dejection at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	SD	Mean	SD
Single-Word	Cognitive	0.86	1.04	0.59	1.01
Single-Word	Affective	1.76	1.23	1.22	1.08
Single-Word	Neutral	1.34	1.37	0.73	0.95
Multi-Word	Cognitive	1.45	1.22	1.02	1.13
Multi-Word	Affective	1.23	1.12	0.99	1.04
Multi-Word	Neutral	1.80	1.29	1.33	1.18

Note. Mean reflects the transformed degree of experienced DD. Possible scores ranged between 0 and 5.66.

4.8.3 Anger-Hostility (AH)

Mean transformed³² AH scores and standard deviations (*SD*) for each group are provided in Table 13 (p. 131). High scores reflect a higher level of anger/hostility experienced.

Analysis revealed a main effect of Time, $F(1,90)=11.654$, $p=.001$, $MSE=.367$, $\eta^2_p=.115$, indicating decreased AH from Time 1 to Time 2 (1.13 and 0.83 respectively).

³² Data for SV-POMS AH were transformed using a square-root transformation, as they did not meet the criteria for parametric test e.g., homogeneity of variances and normality as outlined in Chapter 3 (3.5 Data Preparation and Analysis, p.77). Square-root transformation was found to improve homogeneity of variances and normality.

Table 13

Mean and SD Scores for Anger-Hostility at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	SD	Mean	SD
Single-Word	Cognitive	0.80	0.95	0.61	1.00
Single-Word	Affective	1.36	1.19	1.24	0.97
Single-Word	Neutral	0.82	0.83	0.45	0.62
Multi-Word	Cognitive	1.20	0.99	0.76	0.92
Multi-Word	Affective	0.93	1.27	0.79	1.07
Multi-Word	Neutral	1.65	1.47	1.12	1.12

Note. Mean reflects the transformed degree of experienced AH. Possible scores ranged between 0 and 5.29.

All other analyses, including: Prime Type, $F(1, 90)=.960, p=.330$, $MSE=1.864, \eta^2_p=.011$, Prime Content, $F(2,90)=.511, p=.602, MSE=1.864, \eta^2_p=.011$, Time x Prime Type, $F(1,90)=.688, p=.409, MSE=.367, \eta^2_p=.008$, Time x Prime Content, $F(2,90)=1.134, p=.326, MSE=.367, \eta^2_p=.025$, Prime Content x Prime Type, $F(2,90)=3.096, p=.50, MSE=1.864, \eta^2_p=.064$, and Prime Type x Time x Prime Content, $F(2,90)=.141, p=.869, MSE=.367, \eta^2_p=.003$, were not significant.

4.8.4 Fatigue-Inertia (FI)

Mean transformed³³ FI scores and standard deviations (*SD*) for each group are provided in Table 14 (below). High scores reflect a higher level of fatigue/inertia experienced.

Table 14

Mean and SD Scores for Fatigue-Inertia at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	<i>SD</i>	Mean	<i>SD</i>
Single-Word	Cognitive	1.79	0.74	1.54	1.07
Single-Word	Affective	2.31	1.05	2.25	0.62
Single-Word	Neutral	1.94	1.26	1.51	0.99
Multi-Word	Cognitive	2.49	1.03	2.31	1.14
Multi-Word	Affective	2.15	0.87	2.07	0.78
Multi-Word	Neutral	1.92	1.04	1.85	1.11

Note. Mean reflects the transformed degree of experienced FI. Possible scores ranged from 0 and 4.47.

Analysis revealed a main effect of Time, $F(1,90)=5.085, p=.027, MSE=.299, \eta^2_p=.053$, whereby FI was reduced from Time 1 to Time 2 (2.10 and 1.92 respectively).

All other analyses including: Prime Type, $F(1,90)=1.647, p=.203, MSE=1.667, \eta^2_p=.018$, Prime Content, $F(2,90)=1.512, p=.226, MSE=1.667, \eta^2_p=.033$,

³³ Data for SV-POMS FI were transformed using a square-root transformation, as they did not meet the criteria for parametric test for normality as outlined in Chapter 3 (3.5 *Data Preparation and Analysis*, p.77). Square-root transformation was found to improve normality.

Time x Prime Type, $F(1,90)=.818, p=.368, MSE=.299, \eta^2_p=.009$, Time x Prime Content, $F(2,90)=.538, p=.586, MSE=.299, \eta^2_p=.012$, Prime Content x Prime Type, $F(2,90)=1.998, p=.142, MSE=1.667, \eta^2_p=.043$, and Prime Type x Time x Prime Content, $F(2,90)=.515, p=.599, MSE=.299, \eta^2_p=.011$, were not significant.

4.8.5 Vigour-Activity (VA)

Mean transformed³⁴ VA scores and standard deviations (*SD*) for each group are provided in Table 15 (below). High scores reflect a higher level of vigour/activity experienced.

Table 15

Mean and SD Scores for Vigour-Activity at Time 1 and Time 2

Prime Type	Prime Content	Time 1		Time 2	
		Mean	<i>SD</i>	Mean	<i>SD</i>
Single-Word	Cognitive	3.64	0.59	3.45	0.63
Single-Word	Affective	3.50	0.69	3.28	0.78
Single-Word	Neutral	3.19	0.68	3.03	0.85
Multi-Word	Cognitive	3.30	0.58	3.06	0.69
Multi-Word	Affective	3.31	0.90	2.75	1.05
Multi-Word	Neutral	3.19	0.67	3.10	0.86

Note. Mean reflects the transformed degree of experienced VA. Possible scores ranged from 0 and 4.90.

³⁴ Data for SV-POMS VA were transformed using a square-root transformation, as they did not meet the criteria for parametric test for normality as outlined in Chapter 3 3.5 *Data Preparation and Analysis*, p.77). Square-root transformation was found to improve normality.

Analysis revealed a main effect of Time, $F(1,90)=21.836, p<.001, MSE=.130, \eta^2_p=.195$, showing a reduction in participants VA from Time 1 to Time 2 (3.36 and 3.11 respectively).

All other analyses including: Prime Type, $F(1,90)=2.492, p=.118, MSE=1.022, \eta^2_p=.027$, Prime Content, $F(2,90)=.859, p=.427, MSE=1.022, \eta^2_p=.019$, Time x Prime Type, $F(1,90)=1.025, p=.314, MSE=.130, \eta^2_p=.011$, Time x Prime Content, $F(2,90)=2.244, p=.112, MSE=.130, \eta^2_p=.048$, Prime Content x Prime Type, $F(2,90)=.822, p=.443, MSE=1.022, \eta^2_p=.018$, and Prime Type x Time x Prime Content, $F(2,90)=1.360, p=.262, MSE=.130, \eta^2_p=.029$, were not significant.

4.8.6 Confusion-Bewilderment (CB)

Mean transformed³⁵ CB scores and standard deviations (*SD*) for each group are provided in Table 16 (p. 135). High scores reflect a higher level of confusion/bewilderment experienced.

Analysis revealed a main effect of Time, $F(1,90)=9.130, p=.003, MSE=.263, \eta^2_p=.092$, whereby CB decreased from Time 1 to Time 2 (1.93 and 1.71 respectively).

All other analyses which include: Prime Type, $F(1,90)=.091, p=.764, MSE=1.459, \eta^2_p=.001$, Prime Content, $F(2,90)=.664, p=.517, MSE=1.459, \eta^2_p=.015$, Time x Prime Type, $F(1,90)=.003, p=.956, MSE=.263, \eta^2_p=.000$, Time x Prime Content, $F(2,90)=.197, p=.822, MSE=.263, \eta^2_p=.004$, Prime Content x Prime Type,

³⁵ Data for SV-POMS CB were transformed using a square-root transformation, as they did not meet the criteria for parametric test for normality as outlined in Chapter 3 3.5 *Data Preparation and Analysis*, p.77). Square-root transformation was found to improve normality.

$F(2,90)=1.673$, $p=.193$, $MSE=1.459$, $\eta^2_p=.036$, and Prime Type x Time x Prime Content, $F(2,90)=1.276$, $p=.284$, $MSE=.263$, $\eta^2_p=.028$, were not significant.

Table 16

Mean and SD Scores for Confusion-Bewilderment at Time 1 and Time 2

Prime Type	Prime Content	Time 1		Time 2	
		Mean	SD	Mean	SD
Single-Word	Cognitive	1.62	1.03	1.47	1.04
Single-Word	Affective	2.20	0.99	1.88	0.92
Single-Word	Neutral	1.89	0.93	1.70	0.88
Multi-Word	Cognitive	2.04	0.83	1.62	1.13
Multi-Word	Affective	1.65	0.70	1.63	0.76
Multi-Word	Neutral	2.19	0.91	1.95	0.94

Note. Mean reflects the transformed degree of experienced CB. Possible scores ranged from 0 and 4.47.

4.9 State Anxiety Scale (SAS)

Mean state anxiety scores and standard deviations (*SD*) for each group is provided in Table 17 (p. 136). Higher scores indicate a higher degree of state anxiety experienced.

Analyses revealed a main effect of Time, $F(1,90)=6.159$, $p=.015$, $MSE=28.318$, $\eta^2_p=.064$, whereby participants state anxiety decreased from Time 1 to Time 2 (37.68 and 33.77 respectively).

All other analyses including: Prime Type, $F(1,90)=.588, p=.445$, $MSE=129.795, \eta^2_p=.006$, Prime Content, $F(2,90)=.541, p=.584, MSE=129.795, \eta^2_p=.012$, Time x Prime Type, $F(1,90)=2.349, p=.129, MSE=28.318, \eta^2_p=.025$, Time x Prime Content, $F(2,90)=1.253, p=.291, MSE=28.318, \eta^2_p=.027$, Prime Type x Prime Content, $F(2,90)=2.136, p=.124, MSE=129.795, \eta^2_p=.045$, and Prime Type x Time x Prime Content, $F(2,90)=.053, p=.948, MSE=28.318, \eta^2_p=.001$, were not significant.

Table 17

Mean and SD Scores for State Anxiety at Time 1 and Time 2

Prime Type	Prime Content	Time 1		Time 2	
		Mean	SD	Mean	SD
Single-Word	Cognitive	34.00	5.88	32.81	7.16
Single-Word	Affective	38.63	11.61	39.44	10.64
Single-Word	Neutral	36.75	9.39	34.94	8.92
Multi-Word	Cognitive	39.75	7.83	35.50	9.24
Multi-Word	Affective	36.13	9.27	34.94	8.25
Multi-Word	Neutral	40.81	9.06	37.00	8.02

Note. Mean represents the degree of state anxiety experienced. Possible scores ranged from 20 to 80.

4.10 Threshold Testing

The majority of 58 participants (60.42%) did not notice anything unusual during delivery of the subliminal messages in the LDT. Of the remaining 38 participants, one (1.04%) did not provide an answer and 37 (38.54%) stated they did notice something unusual. When asked to elaborate, zero participants reported

suspicion of the use of subliminal stimuli during the experiment. The majority, 18.75% participants provided details about the target letter strings used in the LDT e.g., use of phonetically correct sounding non-words (i.e., 'Phlud'); 12.5% highlighted specific categories or letters (e.g., majority of words related to household objects; lots of K's in non-words); 9.38% reported aesthetic aspects of the task (e.g., font size being large) and 5.21% suggested the possibility of foreign or old English words being presented as non-words. When asked whether they noticed any words on the screen during the LDT other than the fixation crosses and target letter strings, the majority of 91 participants (94.79%) answered no. Of the remaining five participants that answered yes, three (3.13%) reported seeing a flash (e.g., 1 x red/pink flash; 2 x just a flash) however, none of the participants' data were removed as no further indication as to whether the flash contained a word or not arose. When asked to guess the content of the subliminal stimulus zero participants guessed correctly. The majority of 60 participants (62.5%) answered 'don't know' or left the question blank. Of the 36 that attempted to guess the content of the stimuli, 13.54% of the answers consisted of stimuli related to aid/hamper LDT performance (e.g., congruent or incongruent letter strings); 8.33% were mood or relaxation related stimulus (e.g., 'tense', 'happy'); 7.29% related to focus, attention or concentration (e.g., 'sharpen focus'); 4.67% were related to other tasks completed in the experiment (e.g., Stroop colours or CST categories); 2.07% were related to food/hunger related subliminal stimuli (e.g., 'hungry') and the remaining 7.29% were varied answers such as 'yawn', 'Join the army', 'University'. Finally when provided with the six subliminal stimuli 83 (86.5%) guessed incorrectly and 13 (13.5%) guessed correctly. A chi-square analysis indicated that participants were not able to guess the content of their subliminal stimuli over and above chance levels ($\chi^2(2) = .178, p = .915$).

Discussion

The aim of Experiment 1 was to test for differential effects between subliminal Single-Word and Multiple-Word primes, and furthermore, to test the effect of both subliminal cognitive and affective content primes on their congruent-content measures (i.e., cognitive and affective respectively), and incongruent-content measures (i.e., affective and cognitive respectively). Results from the experiment indicate improved accuracy performance on the CST following exposure to all positive content subliminal stimuli regardless of prime type. However, no changes in selective attention, general knowledge, anxiety, or mood were found following exposure to either subliminal prime type. The findings from each of the dependant measures (e.g., CST, Stroop Colour-Naming Task, General Knowledge Test, SAS and SV-POMS) will be discussed below in relation to the experimental aims and hypotheses as well as exploring possible limitations concerning the measures and the method/design used.

Results from the CST accuracy data revealed an improvement in the number of words correctly recalled. Specifically, the results found that participants exposed to the positive content subliminal stimuli, that is cognitive (i.e., intelligent, I am intelligent) and affective (i.e., one, mommy and I are one) subliminal primes recalled more words the second time compared to participants receiving the neutral-control stimuli (i.e., walking, people are walking). However, the results from the CST intrusions data found no clear change in performance, suggesting that subliminal priming does not reduce the number of words intruding on participants' memory during recall. In sum, whilst no change in performance was found regarding the number of incorrectly recalled words, improved performance was thought to be more

clearly represented by changes in accuracy performance. Thus, CST accuracy findings supports the first hypothesis that positive subliminal stimuli will improve performance compared to neutral-control stimuli, although no support was found for the second hypothesis because the same pattern was evident following both cognitive and affective subliminal primes. Furthermore, given this pattern was also true for both the Single-Word and Multiple-Word primes, no support was found for the third hypothesis predicting a differential effect between the subliminal prime types.

The results from Experiment 1 suggest that the cognitive measure of semantic working memory can be improved following subliminal exposure to both cognitive (i.e., congruent prime content) and affective (i.e., incongruent prime content) subliminal stimuli. Previous research has more often demonstrated that subliminal Multiple-Word primes can elicit improvements across an array of cognitive and affective measures. For example, the affective-based Multiple-Word prime ‘mommy and I are one’ has been shown to improve both cognitive performance (e.g., Hudesman et al., 1992; Parker, 1982) and affective behaviours (e.g., Orbach et al., 1994; Weinberger et al., 1997). As such, the findings from the current research support such literature and also demonstrate that Single-Word primes can enhance semantic working memory performance. However, the argument that both cognitive and affective subliminal primes enhance semantic working memory performance should be interpreted with caution, as the interaction effect between the content of the primes was only marginally significant. Additionally, whilst the post hoc analysis examining the change in performance for the neutral-control group (i.e., walking, people are walking) did not meet the specified criterion for significance, or marginal significance established for this current research, it may still be suggestive of an improvement in CST accuracy performance.

Furthermore, in terms of the prime type the results from this experiment show that both positive content Single-Word and Multiple-Word primes improved participants CST accuracy performance. This result is interesting and extends current knowledge concerning the influence of both Single-Word and Multiple-Word primes. In relation to the Single-Word priming literature (e.g., Chartrand & Bargh, 1996; Dijksterhuis et al., 2000; DeVaul, 2004; DeVaul & Pentland, 2002; DeVaul et al., 2003; Hess et al., 2004 Experiment 2; Levy, 1996; Levy & Leifheit-Limson, 2009; Mitchell et al., 2002), improvements in memory performance have been reported although performance on semantic working memory has not been examined. Furthermore, past research examining the effect of subliminal Multiple-Word primes has shown that they are able to influence the content and positivity of childhood memories recalled (e.g., Sohlberg et al., 2003; Sohlberg, Billingham et al., 1998; Weinberger et al., 1997), but have not been examined on newly learnt, non-familial information or on semantic working memory performance. Hence, the findings from the current research are unique and extend the previous literature to include subliminal priming effects using both Single and Multiple-Word primes on semantic working memory. However, no differential effect was found between the two prime types. Whilst the literature shows that both subliminal prime types can elicit changes in performance, no research has yet examined for a differential effect between the two prime types. As such, it is not clear yet whether there is a difference between the two subliminal primes types and if so, why this was not found here. Reflecting on the methodology used in this experiment two issues emerge that may possibly explain the lack of a differential effect between the two prime types. The first relates to the varied length of time between subliminal priming and completion of the CST at Time 2, and

the second is a related issue that highlights the possible interference caused by the completion of the other experimental tasks prior to completing the CST.

Due to the number of tasks measured during Experiment 1 a counter-balancing procedure was utilised across participants that meant that some participants completed the CST immediately following the subliminal priming task (e.g., LDT), whilst others completed a number of other tasks before the CST at Time 2. This varied length of time between the end of the subliminal stimulation phase and the onset of the CST measure could have reduced the effectiveness of the subliminal primes and as such may account for the non-differential effect between the prime types as it is not clear in the literature how a delay in time affects the potency of subliminally presented information. For instance, research testing the strength of subliminal primes over a delay has been inconsistent; some have argued that subliminal priming effects are only short lived (Greenwald et al., 1996; see also Daza et al., 2002) whereas others, suggest subliminal priming effects are consistent over a delay for a up to four days (Lowery et al., 2007). As such, this inconsistency in the data is suggestive that a delay may influence the effectiveness of subliminal primes. In relation to subliminal Multiple-Word primes, Parker (1982) reported consistent subliminal priming effects over a number of weeks, however the research is dated and has not yet been replicated. Thus, it is not clear exactly how a delay in time would affect each of the subliminal prime types, and whether one prime type may be more consistent over a delay compared to the other. Such possible changes in potency over time may well have contributed to the non-differential effect found between the subliminal prime types.

In relation to the delay in time following the subliminal priming task, it is possible that completion of other tasks during this time may also have interfered with

any automatic priming effects elicited by the subliminal primes. For example, Mitchell et al. (2002 Experiment 2) report that the completion of a secondary task following subliminal priming inhibited the effect of the subliminal Single-Word prime 'remember' on participants' recollection of target stimuli. It was considered that the participants' conscious goal to complete the secondary task overrode the unconscious goal to remember the target stimuli elicited by the subliminally presented prime as it required the use of more cognitive resources than the unconscious goal (Dijksterhuis & Bargh, 2001; see also Macrae & Johnston, 1998). As such, in the current research, the strength of the subliminal primes may have been reduced due to the cognitive resources participants' afforded to their external instruction, or goal to complete the other tasks to the best of their ability. As such, Experiment 2 will aim to address these issues by ensuring that participants complete the CST immediately after the subliminal priming phase of the experiment to explore the possible differential effect of subliminal prime types.

With regard to the results following subliminal stimulation on the Stroop Colour Naming Task (Stroop, 1935), the findings from Experiment 1 will be reported and discussed in relation to possible practice effects and a speed-accuracy trade-off. For all three conditions of the Stroop Colour Naming Task (e.g., congruent, incongruent, and neutral) participants' response speed to target stimuli improved over time. Such a result is indicative of a practice effect and is consistent with previous research testing the Stroop effect (e.g., Flowers & Stoup, 1977; Lemay, Bédard, Rouleau, & Tremblay, 2004; MacLeod, 1991; Melara & Mounts, 1993; Stroop, 1935 Experiment 3). In relation to the number of errors recorded, results show that participants made more errors at the second time of measurement. However, this pattern is not consistent with others who have reported faster response times as a

result of practice on the Stroop Colour Naming Task (e.g., Lemay et al., 2004). In conjunction with the faster response times it is possible that the increased number of errors occurred due to a speed-accuracy trade-off (Fitts, 1954). A speed-accuracy trade-off is where the participant forfeits the accuracy of their responses to enable quicker responses to the target stimuli (Wickelgren, 1977). Nevertheless, despite such a potential trade-off the findings from the Stroop Colour-Naming Task do not provide any indication of subliminal priming effects following Single-Word or Multiple-Word primes. As such, the results found on the Stroop Colour Naming Task failed to reject the null hypotheses that I) positive subliminal primes would not improve Stroop Colour Naming Task performance, II) that there would be no differential effects elicited by cognitive and affective prime contents, and III) that there would be no differential effects elicited by subliminal Single-Word compared to Multiple-Word prime types.

However, the null results recorded for the Stroop Colour Naming Task from Experiment 1 are consistent with the findings of Severance and Dyer (1973) who also reported that subliminally presented Single-Word primes did not influence participants' responses to supraliminal target coloured letter strings. It was argued that Severance and Dyer's (1973) results may have been due to the very fast exposure duration used to present their subliminal primes (e.g., 0.53ms and 1.65ms; see Marcel, 1983). However, in the current research, participants were exposed to the subliminal primes for a longer duration of 14ms, hence selective attention was still unaffected by subliminal priming even after these longer exposure times. However, the findings from Experiment 1 of the current research are not consistent with others who have shown subliminal primes facilitate performance on the Stroop Colour Naming Task (e.g., Daza et al., 2002; Marcel, 1983 Experiment 3; Merikle & Joordens, 1997;

Merikle et al., 1995). It is possible that the content of the subliminal primes may explain the null results found in Experiment 1.

In previous research using the Stroop Colour Naming Task the subliminal Single-Word primes presented were colour words (e.g., red, green) designed to be either congruent (i.e., same colour) or incongruent (i.e., different colour) with the target letter string (Daza et al., 2002; Merikle & Joordens, 1997; Merikle et al., 1995) or a coloured square (Marcel, 1983). Whereas the content of the subliminal primes presented in the current experiment were either cognitive (i.e., intelligent, I am intelligent) or affective (i.e., one, mommy and I are one) in nature. As such, it is possible that a change in selective attention as measured by the Stroop Colour Naming Task is only achievable through subliminal priming of congruent/incongruent colour word stimuli and not through broad cognitive or affective based primes such as those used in the current research. As the majority of research to date has examined the effect of Single-Word colour name primes (e.g., 'red') that are congruent/incongruent with target colour words/squares on response time using the Stroop Colour Naming Task (e.g., Daza et al., 2002; Merikle & Joordens, 1997; Merikle et al., 1995) future research may wish to examine whether Multiple-Word colour name primes can also influence response speed to target colour words/squares. For example, future research could adapt the subliminal negation procedure as outlined by Armstrong and Dienes (2013). Armstrong and Dienes (2013) tested the unconscious processing of negation by presenting the instruction to pick or not pick subliminally e.g., 'pick kite' versus 'not kite'. Hence, within a Stroop Colour Naming Task paradigm, future research could examine whether response times to target colour words/squares is influenced following unconscious processing of subliminal Multiple-Word instructions to 'pick red' or 'not green'.

With regards to general knowledge, there were no clear effects suggesting that subliminally presented Single-Word and Multiple-Word primes were able to improve General Knowledge Test performance. As such, results from Experiment 1 failed to reject any of the null hypotheses. The results from the General Knowledge test are discussed in terms of the sensitivity of the test with suggestions for future research, such as an alteration to the format of test used.

Previous research has reported improved intelligence performance following exposure to both Single-Word primes (Lowery et al., 2007; Radel et al., 2009; Shih et al., 2002) and Multiple-Word primes (Ariam & Siller, 1982; Hudesman et al., 1992; Parker, 1982). Hence it was expected that the subliminal stimuli presented in this current research would also improve intelligence performance. However, as discussed in Chapter 2 (*2.5.2 Automaticity Theory*, p. 54), there have been reported cases of failed replications of intelligence priming (e.g., Shanks et al., 2013) and as such, this current research is in support of their conclusions concerning the ineffectiveness of non-consciously improving intelligence and can further extend this to show that the more subtle techniques, such as subliminal priming, also do not yield significant improvements in intelligence, despite being considered a more fruitful technique for future research in the social priming field (Stroebe & Strack, 2014). Nevertheless, it is possible that the format of the test used to measure intelligence may not have been sensitive enough to any potential changes following subliminal priming. For instance, in their examination of non-conscious processing of stereotypes, Dijksterhuis and van Knippenberg (1998) reported that multiple-choice questions from the game Trivial Pursuit were sensitive to change (see also Bry et al., 2008). In contrast, the results of Experiment 1 failed to find any evidence of a change in performance on the General Knowledge Test. However, the format of the questions used in the current experiment

were open-ended, requiring participants to recall information from long-term memory, unlike the fixed multiple-choice questions used by Dijksterhuis and van Knippenberg (1998; see also Bry et al., 2008) that provided a range of possible answers and simply required the participant to recognise the correct answer from a set of alternatives. Furthermore, other experiments examining the effect of subliminal primes on the performance of academic course tests and exams have also presented questions in a multiple-choice format rather than as open-ended questions (Parker, 1982; Radel et al., 2009). Hence, it may be that subliminal priming may influence performance when participants attempt to recognise the correct answer from possible alternatives, rather than recalling the answer from memory. Previously it has been suggested that there are differences in the processes required for recognition compared to recall. In general, recognition incorporates more perceptual processes (Cabeza et al., 1997) and is thought to be easier, whereas recall is considered to require additional search processes (Mandler, Pearlstone, & Koopmans, 1969) and represents a more difficult task. As it is not yet clear whether the effect of subliminal primes are moderated by the difficulty of the task, future research may wish to examine the effect of the subliminal primes from the current research on a General Knowledge Test that incorporates fixed multiple-choice answers.

During Experiment 1 the effect of subliminal priming was also examined on two affective measures (i.e., the SAS and SV-POMS). The findings from both measures will be discussed, and suggestions for future research for each will be raised. For example, the examination of subliminal primes in reducing anxiety using a clinically anxious sample, or testing for changes in experienced levels of mood using a simpler measure of explicit mood. Beginning with the SAS, results indicated that participants' self-rated level of state anxiety reduced over time regardless of type and

content of subliminal stimuli they were exposed to. Similarly, results of the SV-POMS indicated that participants' self-rated levels of mood for the majority of subsections (e.g., Depression-Dejection, Anger-Hostility, Fatigue-Inertia, Vigour-Activity, and Confusion-Bewilderment) decreased over time. It is possible that the reduction in state anxiety and mood was due to a reduction in apprehension and stress felt from participating in a research experiment. Wrightsman (1960) explained that participants may feel anxious about participating in a forthcoming experiment, thus it is reasonable to suggest that this heightened anxiousness and stress prior to taking part in the experiment may have dissipated after the initial testing session as participants became familiar with the experimental procedure. Furthermore, it is possible that participants may have become less motivated and excited by their participation in the experiment over time as indexed by the reduction for example, in experienced levels of vigour-activity. Although for the subsection of Tension-Anxiety (TA) on the SV-POMS, it was found that only participants receiving the cognitive (i.e., intelligent, I am intelligent) and neural-control (i.e., walking, people are walking) subliminal primes significantly decreased over time, whereas the participants receiving the affective subliminal primes (i.e., one, mommy and I are one) did not.

However, it is unlikely that such an interaction reflects any clear subliminal priming effects. On assessment of the descriptive statistics shown in Table 11 (p. 127), the level of TA decreased over time for *all* conditions except for the Single-Word affective group (i.e., one). This group showed a small increase in TA over time. When looking at the raw data for the SV-POMS, 20 participants overall were found to increase in experienced levels of TA from Time 1 to Time 2. Hence, it is possible that this small minority of participants experienced some elevated levels of stress or anxiousness that resulted in the overall minor increase in experienced level of TA for

the Single-Word affective subliminal prime group. On assessing the order that these participants completed the tasks at Time 2, a pattern emerges whereby all participants shown to increase in levels of experienced TA at Time 2 completed the General Knowledge Test directly before completing the SV-POMS. Whilst speculative, it is possible that completing the General Knowledge Test heightened these participants' stress/anxiety levels, which was then reflected in their self-rating of explicit anxiety. However, these 20 scores all fell within one standard deviation of the mean, with a small increase in TA between 1 to 10 points. Therefore, to examine this speculative possibility further, a median split was conducted to divide this group of 20 scores into 'lower increases in TA' and 'higher increases in TA'. All values above the median increase of 5 were removed as such values fell within the top quartile of the entire data set and could perhaps be considered as more unusual or unrepresentative in comparison to the rest of the data set whereby participants either decreased in experienced levels of TA or increased by a smaller amount. Four participants (i.e., 20% of the 20 participants that increased in TA) that more highly increased in experienced levels of TA from between six and 10 points³⁶ were removed thus overall, only 4.17% of the entire data set were removed, representing those participants subject to order affects that may have been more unduly affected by general knowledge test anxiety or stress. Of these four participants, two were found to be in the Single-Word affective subliminal prime group³⁷. When the analysis of the

³⁶ Of these four participants, one was found to increase in experienced levels of TA by six points, one increased by seven points, one increased by eight points, and finally, the last participants increased by 10 points.

³⁷ Of the remaining two participants, one was in the Single-Word neutral-control subliminal prime group, and the other was in the Multiple-Word affective subliminal prime group.

SV-POMS TA data was conducted following the removal of these four participants the interaction between prime content and time was no longer found³⁸.

Overall, the new results indicate that subliminal priming of the cognitive or neutral-control primes were no more effective at reducing levels of experienced TA than the affective subliminal primes. Such a result is consistent with the findings from the SAS that also demonstrated a reduction over time but no clear subliminal priming effects. Given that the majority of items (i.e., five out of six) found in the TA sub-section of the SV-POMS are also found in the SAS it should be acceptable to suggest that the TA sub-section of the SV-POMS also provides a measure of state anxiety as opposed to any other types of anxiety (e.g., trait anxiety). As such, the consistency in results across these measures provides further support for the conclusion that no clear subliminal priming effects were found on state anxiety. In sum, the findings of the SAS and SV-POMS failed to reject the null hypotheses. This pattern of results however raises a number of possibilities. Firstly, it is possible that subliminal priming is unable to influence anxiety or mood. Secondly, the subliminal primes presented may have been unsuitable and/or insufficient to influence affective measures. A third, possibility it is that participants must experience a specific level of the affective state, such as elevated levels of anxiety, for the subliminal priming to have any influence. Finally, it is possible that the measures used, such as the SAS and the SV-POMS may not have been sufficiently sensitive to possible changes in affective state.

³⁸ The results show a main effect of Time, $F(1,86)=42.088, p<.001, MSE=.474, \eta^2_p=.329$, whereby participants level of TA decreased from Time 1 to Time 2 (2.30 and 1.67 respectively). All other analyses including Prime Content, $F(2,86)=1.565, p=.215, MSE=1.878, \eta^2_p=.035$, Prime Type, $F(1,86)=.132, p=.717, MSE=1.878, \eta^2_p=.002$, Time x Prime Content, $F(2,86)=2.094, p=.129, MSE=.474, \eta^2_p=.046$, Time x Prime Type, $F(1,86)=.024, p=.878, MSE=.474, \eta^2_p=.000$, Prime Type x Prime Content, $F(2,86)=2.128, p=.125, MSE=1.878, \eta^2_p=.047$, and Prime Type x Time x Prime Content, $F(2,86)=2.736, p=.070, MSE=.474, \eta^2_p=.060$, were not significant.

In relation to the first possibility, it is that subliminal priming is unable to alter a participant's affective state. However, previous research has shown that both anxiety and mood have been influenced by subliminal priming (Dijksterhuis, 2004; Orbach et al., 1994; Weinberger et al., 1997). Hence, this suggestion is not consistent with past literature. Alternatively, the null results found in the current research may instead be due to ineffectiveness of the subliminal primes. For instance, the content of the cognitive subliminal primes (i.e., intelligent, I am intelligent) may not be suitable and/or sufficient to elicit changes in affective behaviours. To current knowledge, no research has examined the impact of cognitive-based subliminal primes on their effectiveness at improving affective behaviours. Thus, the finding from the current research provides suggestive evidence that such primes may not be capable of eliciting any change. However, the current research also examined the influence of affective-based subliminal primes (i.e., one, mommy and I are one) and whilst the effects of the Single-Word prime 'one' has not previously been examined, the Multiple-Word prime 'mommy and I are one' has been shown to affect both levels of anxiety (Orbach et al., 1994) and mood (Sohlberg, Billingshurst et al., 1998; Sohlberg, Samuelberg et al., 1998; Sohlberg et al., 2003; Weinberger et al., 1997). As such, the possible ineffectiveness of the subliminal primes used in this experiment may not be the only contributing factor.

A further possibility is that the baseline levels of affect need to be taken into account when attempting to elicit any change. As discussed, past research has shown that Multiple-Word primes such as 'mommy and I are one' and 'mommy and I are alike' have reduced state anxiety (Orbach et al., 1994; see also Hardaway, 1990). However, it is possible that subliminal priming was not found to reduce state anxiety in the current research because the sample examined were not experiencing

sufficiently high levels of anxiety. For instance, the mean state anxiety scores reported at both Time 1 and Time 2 were relatively low (e.g., 37.35 and 35.77 respectively) on the SAS scale of 20 (low experienced state anxiety) to 80 (high experienced state anxiety). Previously, research has overcome this by inducing feelings of anxiousness and as such, has reported a higher level of state anxiety prior to subliminal stimulation. For instance, Orbach et al. (1994) reported that participants' rated their agreement with currently exhibiting state anxious behaviours between 2.33 and 2.93 (on a scale of 1= totally disagree and 4 = totally agree) prior to subliminal stimulation. In comparison, using the same scale, the current research found participants rated their agreement with currently exhibiting state anxious behaviours prior to subliminal stimulation at 1.88. Hence, experienced state anxiety was lower than experienced state anxiety reported by Orbach et al. (1994). As such, it is possible that subliminal affective stimuli may only provide an ameliorative effect on anxious behaviour that is excessive. Hence, future research may wish to examine the effect of subliminal stimuli used in this current research on a clinically anxious sample.

A final alternative is the possible insensitivity of the measures used to examine changes in affect. For instance, previous research has reported changes in affective mood in non-clinical, or non-artificially mood manipulated samples (e.g., Dijksterhuis, 2004; Sohlberg et al., 2003; Sohlberg, Billingham et al., 1998; Weinberger et al., 1997), as such the null result found in the current research may instead be due to the insensitivity of the SV-POMS used to measure explicit mood. The SV-POMS is a comprehensive measure of several sub-components of mood and as such may have been too complicated. In contrast previous research such as Dijksterhuis (2004) have instead implemented a simpler measure of mood. For example asking participants to rate 'how good they currently feel' on a nine-point

Likert scale from one (very bad) to nine (very good). Similarly, state anxiety could be also measured on a nine-point scale from one (not at all) to nine (very much so) by simply asking the participant to rate how tense or anxious they feel. This simpler technique may be more sensitive to changes in positive/negative mood and general level of anxiety experienced in non-clinical samples rather than having to decipher each aspect of their mood or anxiety. Alternately, physiological indicators could be used to assess changes in positive/negative mood and anxiety as subliminal priming has been shown to influence physiological measures (e.g., Levy et al., 2000; Hull et al., 2002 Experiments 4-5). For example, changes in systolic and diastolic blood pressure, electrodermal activity, and heart rate have been reported (Levy et al., 2000), all of which could be indicative of reduced stress, anxiety and therefore improved mood.

In summary, the findings from the SAS and SV-POMS in the current research provide no evidence for a reduction in state anxiety or any sufficient evidence for a clear change in participants' explicit mood. Although there is evidence that both anxiety (Orbach et al., 1994) and mood (Dijksterhuis, 2004; Weinberger et al., 1997) can be affected by exposure to subliminal priming, the current research offers no support for this. Instead it is suggested that reductions seen in anxiety and mood over time may instead be accounted for by the reduction in participants' possible stress and anxiousness as they become more familiar with the setting and requirements of the task (Wrightsmann, 1960). To examine whether the subliminal primes used in the current research are capable of eliciting changes in experienced anxiety and/or mood future research could consider utilising participants with either naturally or induced elevated levels of anxiety (see Orbach et al., 1994), alter the focus of the primes to more specifically target anxiety/mood, and consider adapting the current measure of

explicit anxiety/mood to a more simpler version similar to that used in past research (e.g., Dijksterhuis, 2004), or alternatively, incorporate more direct physiological measures of any potential changes in anxiety/mood e.g., changes in heart rate (Levy et al., 2000).

In conclusion, results from the CST reveal improved working memory performance following exposure to both cognitive (i.e., intelligent, I am intelligent) and affective (i.e., one, mommy and I are one) subliminal primes in comparison to the neutral-control subliminal primes (i.e., walking, people are walking). However, results from the Stroop Colour-Naming Task, General Knowledge Test, SAS and SV-POMS do not indicate any clear evidence of subliminal priming effects. It was suggested that the non-differential effects between subliminal prime types on CST performance may have been due to the varied length in time between exposure to the subliminal primes and start of the second CST. In addition, the external goal to complete a range of other tasks within this time may have elicited an interference effect and reduced the impact of the subliminal primes (see, Dijksterhuis & Bargh, 2001; Macrae & Johnston, 1998; Mitchell et al., 2002). Hence Experiment 2 will aim to address these issues by ensuring that all participants complete the CST immediately after the subliminal priming phase of the experiment at Time 2.

Chapter Five: Experiment 2 - Comparing the Immediate Effect of Subliminal Single-Word and Multiple-Word Primes on Semantic Working Memory

Introduction

The findings from Experiment 1 indicate that subliminally presented Single-Word and Multiple-Word primes were unable to produce a clear change in participants' mood, level of state anxiety, general knowledge performance, or selective attention. However, a marginal interaction found for the number of correctly recalled words on the Conceptual Span Task (CST) showed that both the cognitive (i.e., intelligent, I am intelligent) and affective (i.e., one, mommy and I are one) subliminal stimuli, regardless of prime type, significantly improved semantic working memory performance from Time 1 to Time 2 whereas no significant increase was found for participants receiving the neutral-control stimuli (i.e., walking, people are walking).

A possible explanation for the non-differential effect between the different prime types of subliminal stimuli (e.g., Single-Word and Multiple-Word) is the varied length in time between the end of subliminal stimulation and the beginning of the semantic working memory task. Due to the nature of counter-balancing the five tasks completed in Experiment 1, some participants completed the CST at Time 2 immediately following the Lexical Decision Task (LDT), whereas others completed the CST at Time 2 after a delay of up to 40 minutes. It is possible that this difference in the delay between the end of exposure to the subliminal stimuli and the beginning of the CST task influenced performance (Greenwald et al., 1996). For instance, looking at the CST accuracy data, a larger difference in the number of words correctly

recalled is evident between participants receiving subliminal Single-Word and Multiple-Words primes when the CST was performed immediately after the LDT, although this difference is much smaller and reversed, when the CST was performed after a delay³⁹ (see Table 18, below).

Table 18

Mean Number of Words Correctly Recalled on the CST When Taken Immediately After the LDT and After a Delay for Participants Receiving Single-Word Compared to Multiple-Word Primes

	<u>Conceptual Span Task Position</u>	
	First Task – Immediately	Last Task - Delayed
Single-Word Primes	38.5	34.29
Multiple-Word Primes	34.6	35.11

This variation in time between the end of subliminal stimulation (LDT) and the onset of the CST presents two issues. The first is the variable delay in time, and the second is the possible interference with regards to the automatic activation of the primed behaviour caused by completing other tasks prior to the CST.

In relation to the first issue of a variable time delay, there is an inconsistency in the literature with concern to the effect that a delay has on the potency of a subliminal stimulus. Some, such as Greenwald et al. (1996), demonstrate that subliminal Single-Word primes are only capable of producing change after a short period of time; in their research they show the optimal impact of a subliminal prime is

³⁹ Inferential statistics were not performed on these data due to the small number of participants included in these groups.

between 60-100ms following stimulation. However, others such as Levy (1996) and Zemack-Rugar et al. (2007) demonstrate a longer-lasting effect of subliminal stimulation over several minutes. Levy (1996) reported that negative age-related Single-Word primes decreased participants' performance on a dot-location task after a delay of eight minutes, whereas Zemack-Rugar et al. (2007) showed that Single-Word primes produced emotion congruent behaviour after a five minute delay. Furthermore, Lowery et al. (2007) found that intelligence related Single-Word primes produced a significant increase in academic performance over a longer delay of between one and four days after subliminal stimulation. In relation to subliminal Multiple-Word primes, the majority of research has demonstrated their effectiveness at changing behaviour immediately after subliminal stimulation (for example, Glassman & Andersen, 1999; Légal et al., 2012; Orbach et al., 1994; Weinberger et al., 1997), although less research has tested whether Multiple-Word primes are effective after a delay. One such study by Parker (1982) reported continued enhanced academic performance four weeks after the last subliminal exposure. Whilst Parker's (1982) results are indeed interesting, the research is dated, and the method used is substantially different to the one adopted in the current research, whereby Parker (1982) presented subliminal stimuli over the course of a six-week period rather than in one session, and presented a total of 60 exposures to the stimulus, double the number of presentations used in the current research. However, more recent research by Sohlberg and Birgegård (2003) provides evidence that Multiple-Word primes such as 'mommy and I are one' and 'mommy and I are dissimilar' presented during one session can produce stronger correlations between participants' rating of similarity with their mother and other variables such as depression after several days compared to participants receiving neutral primes.

In sum, whilst there is research to indicate that the effect of both subliminal Single-Word (Levy, 1996; Lowery et al., 2007; Zemack-Rugar et al., 2007) and Multiple-Word primes (Parker, 1982; Sohlberg & Birgegård, 2003) *can* be consistent over time, the descriptive results from Experiment 1 (see Table 18, p. 155) are *not* consistent with this literature (Levy, 1996; Lowery et al., 2007; Zemack-Rugar et al., 2007). Descriptive statistics from Experiment 1 (see Table 18, p. 155) instead indicate that time may have impacted negatively on the potency of the subliminal Single-Word primes presented.

A plausible reason that could explain why the delay in time negatively impacted the effectiveness of the subliminal Single-Word primes is the possible interference of automatically primed behaviour between initial exposure to the subliminal stimulation and the onset of the CST. During Experiment 1 some participants completed a number of other tasks after the LDT and before beginning the CST. The completion of these other tasks may have interfered with any automatic priming effects by creating additional task-specific goals that may have competed with, and possibly overshadowed the potency of any potential priming effect following subliminal Single-Word primes (Dijksterhuis & Bargh, 2001; Macrae & Johnston, 1998). Research testing the effect interference has on subliminally presented primes is sparse. However, Mitchell et al. (2002 Experiment 2) report that the positive effect on recollection performance in a memory task produced by the subliminal Single-Word prime to ‘remember’ (see Experiment 1) was inhibited when participants performed a secondary task after each trial of the priming task. It is possible that the new external goal (i.e., to complete the secondary task as instructed) and the automatic goal (i.e., to remember the target stimuli) competed for sufficient cognitive resources required to achieve these goals, and the automatic priming goals’

need for cognitive resources was diminished in favour of the new external goal (Dijksterhuis & Bargh, 2001). Therefore, it is possible that the subliminal Single-Word primes presented in Experiment 1 may have been less effective for participants who were required to complete a number of other tasks prior to completing the CST, due to the diminished cognitive resources afforded to enable the automatic activation of the primed behaviour in relation to participants' external goal to complete the other tasks to the best of their ability.

Therefore, to further explore whether there is a difference between the effectiveness of the two subliminal prime types, Single-Word and Multiple-Word primes, Experiment 2 tackled the issues raised concerning the variable delay in time between the end of the subliminal stimulation phase of the experiment (e.g., the LDT) and the onset of the CST, and the possible interference of the automatic primed behaviour caused by the completion of other tasks, by testing for differential effect between the subliminal prime types *immediately* after the LDT. Experiment 2 tested two hypotheses (see Table 19, p.159).

Table 19

The Hypotheses Tested in Experiment 2

Hypothesis	Prediction
H₁	All experimental subliminal stimuli (i.e., <i>cognitive</i> : intelligent, I am intelligent; <i>affective</i> : one, mommy and I are one) would produce significant positive improvements on semantic working memory as measured by the CST in comparison to subliminally presented <i>neutral-control</i> stimuli (i.e., walking, people are walking) consistent with the results reported from Experiment 1.
H₂	A differential prime type effect would be produced on semantic working memory performance between the Single-Word primes and Multiple-Word primes.

Method

Participants

Sixty students were recruited to participate in this experiment in return for course credit. The sample consisted of 45 females and 15 males that ranged from 18 to 50 years of age ($M= 20.58$, $SD= 5.62$). Recruitment and allocation to subliminal stimulus conditions remained the same as outlined in Chapter 3 (p. 62-64).

Materials

Two tasks were performed during the experiment; the Conceptual Span Task (CST) and the Lexical Decision Task (LDT) as described in Chapter 3 (p. 70-71). The

CST was completed twice, once before the LDT and again after the LDT. The LDT was primarily used to present the subliminal stimuli⁴⁰, three Single-Word primes and three Multiple-Word primes as used in Experiment 1 and described in Chapter 3 (p.64). All other equipment and materials relevant to the experiment are as outlined in Chapter 3.

Procedure

The procedure of Experiment 2 was split into five stages e.g., *Stage I* ‘informed consent’, *Stage II*, ‘dependent measure time 1’, *Stage III* ‘subliminal stimulation’, *Stage IV* ‘dependant measure time 2’, *Stage V* ‘debrief’. Each stage is outlined below.

Stage I: At the outset of the experiment participants were welcomed, seated at a desk and asked to read through the participant information sheet provided (Appendix K, p. 368), which outlined the procedure of the experiment and they were encouraged to ask questions should anything be unclear. Once satisfied, participants were then asked to complete the screening and consent forms as outlined in Chapter 3 (*3.1 Participants*, p. 65).

Stage II: Participants then completed the dependant measure e.g., the CST⁴¹, which was completed as outlined in Chapter 3 (*3.3.1 Conceptual Span Task CST*, p. 75).

⁴⁰ Data from the LDT was analysed however results did not yield significant response time and error data, thus results are not reported.

⁴¹ The presentation order of the CST was counter-balanced across participants. Thirty participants completed CST A at Time 1 and CST B at Time 2 and the remaining 30 participants completed the CST tasks in the reversed order.

Stage III: Upon completion of the CST, participants completed the LDT during which they were exposed to thirty presentations of their subliminal prime as outlined in Chapter 3 (3.3.2 *Lexical Decision Task LDT*, p. 76).

Stage VI: The LDT was immediately followed by the second attempt at the CST.

Stage V: Finally, after completing all the tasks, participants were debriefed using a funnel styled questionnaire (Appendix L, p. 369) as outlined in Chapter 3 (3.2.4 *Subliminal Threshold Checks*, p. 72) to assess the participant's level of subjective and objective awareness to subliminally presented stimuli (see Figure 12 for a diagram of Experiment 2 procedure, p.162).

Design

The design and independent variables of this study were the same as those outlined in Chapter 3 (3.4 *Design*, p. 77). The dependant measures were the participants' accuracy (e.g., number of correctly recalled words) and intrusions (number of incorrectly recalled words) on the CST at Time 2.

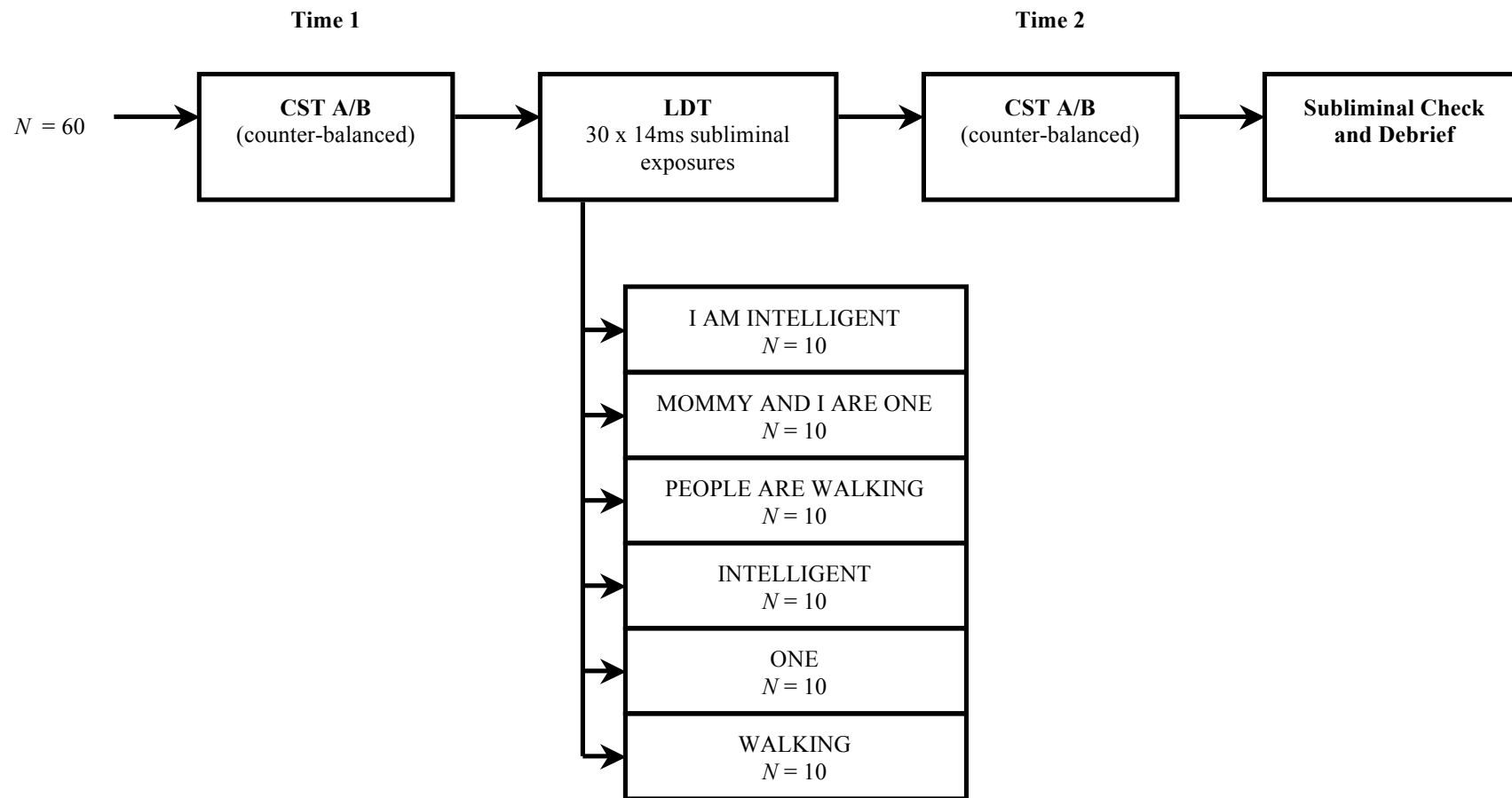


Figure 12: A schematic of the procedure used in Experiment 2.

Results

Data from all the measures were analysed separately using a 2 (Time: *Time 1 vs. Time 2*) x 2 (Prime Type: *Single-Word Prime vs. Multiple-Word Prime*) x 3 (Prime Content: *Cognitive, Affective, Neutral-Control*) mixed analysis of variance (ANOVA). Time was a within participants factor and Prime Type and Prime Content were both between participants factors. In the eventuality of non-significant CST results⁴², Bayes Factor analysis was conducted to assess whether data provides support for the alternative or the null hypotheses, or whether the data were insensitive. Results for the CST are reported below.

5.1 Conceptual Span Task (CST)

Mean accuracy (number of words correctly recalled) and intrusion (number of words incorrectly recalled) data were analysed separately and reported below.

5.1.1 CST Accuracy

The mean accuracy scores i.e., the number of correctly recalled words, and standard deviations (*SD*) for each condition are provided in Table 20 (p. 164). Higher scores indicate more words correctly recalled.

Analysis of the mean CST accuracy scores revealed a main effect of Time, $F(1,54)=14.127, p<.001, MSE=11.071, \eta^2_p=.207$, whereby participants recall accuracy improved from Time 1 to Time 2 (29.9 and 32.18 respectively). A main effect of Prime Type was also found, $F(1,54)=4.359, p=.042, MSE=85.112, \eta^2_p=.075$, whereby higher accuracy scores were achieved following the Multiple-Word prime compared to the Single-Word prime (32.80 and 29.28 respectively).

⁴² Bayes factor analysis was only calculated on CST accuracy data as experimental hypotheses were related to memory improvement.

Table 20

Mean and SD Scores for CST Accuracy at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	SD	Mean	SD
Single-Word	Cognitive	27.20	4.54	30.50	5.97
Single-Word	Affective	28.70	6.96	30.00	6.07
Single-Word	Neutral	28.50	7.93	30.80	6.91
Multi-Word	Cognitive	28.30	8.12	29.70	8.08
Multi-Word	Affective	32.30	7.86	35.60	7.26
Multi-Word	Neutral	34.40	6.69	36.50	5.85

Note. Mean represents the number of correctly recalled words on the CST from a possible total of 63.

All other analyses, which included: Prime Content, $F(2,54)=1.674$, $p=.197$, $MSE=85.112$, $\eta^2_p=.058$, Time x Prime Type, $F(1,54)=.001$, $p=.978$, $MSE=11.071$, $\eta^2_p=.000$, Time x Prime Content, $F(2,54)=.005$, $p=.995$, $MSE=11.071$, $\eta^2_p=.000$, Prime Content x Prime Type, $F(2,54)=1.041$, $p=.360$, $MSE=85.112$, $\eta^2_p=.037$, and Prime Type x Time x Prime Content, $F(2,54)=.863$, $p=.427$, $MSE=11.071$, $\eta^2_p=.031$, were not significant.

5.1.1.1 Bayes Factor Analysis

Although non-significant effects are reported it cannot be concluded whether data provide evidence for the null hypothesis i.e., no difference in the number of words correctly recalled for participants receiving experimental subliminal stimuli compared to those receiving neutral-control stimuli; the alternative hypothesis i.e., that there is a difference; or whether the data are insensitive i.e., providing no support for either the null or alternative

hypothesis (Dienes, 2011; Dienes, 2014). Therefore, a Bayes Factor (B) was used to establish whether the data provides support for the null hypothesis, the alternative hypothesis, or are indeed insensitive. A Bayes Factor of 3 or more constitutes substantial evidence for the alternative hypothesis, a Bayes Factor of under 1/3 (0.33) provides substantial evidence for the null hypothesis, and a Bayes Factor falling between 0.33 and 3 provides only weak evidence and is generally considered to be insensitive (Jefferys, 1961; see also, Dienes, 2011, 2014, 2015). Dienes (2011, 2014, 2015) explains that for a Bayes Factor to be calculated, first a representation of the alternative hypothesis must be given (i.e., uniform, normal or half-normal⁴³) to stipulate the predictions of the alternative hypothesis and secondly, the necessary summary of the data are provided. Dienes (2015) suggests a parameter estimate e.g., sample mean difference and its standard error (SE) as useful data summary.

Therefore, to understand whether the data provides evidence for the alternative hypothesis that there is a difference between the number of words correctly recalled on the CST following experimental subliminal stimuli compared to neutral-control stimuli a Bayes Factor using the data from the *Neutral-Control* participants and the two experimental stimuli groups i.e., *Cognitive* and *Affective*, individually was calculated. For the *Cognitive* participants, the number of words correctly recalled at Time 1 and Time 2 were collapsed across stimulus Prime Type (i.e., Single-Word and Multiple-Word primes) to provide a mean

⁴³ Dienes (2015) explains a uniform distribution with all possible population parameter values occurring within a specific range e.g., from a minimum (typically 0) to a maximum value are equally likely whereas, anything occurring outside that range is inconsistent with the theory. The uniform representation is used in this thesis when the hypothesis is tested using reasonable estimated effects, for instance confidence intervals. In a normal distribution, population values close to the mean are most likely, whereas values increasingly smaller or larger are therefore less likely. When using a normal representation the standard deviation (SD) needs to be identified; the mean divided by 2 is suggested. Finally, the half-normal (i.e., only the positive side of a normal distribution remains), where population values on one side of the distribution are expected and whereby values close to a mean of 0 are most likely, and larger positive effect sizes are less likely. The half-normal representation is used in this thesis when directional hypotheses are tested. The SD needs to be identified; the typical estimated effect size is suggested.

improvement from Time 1 to Time 2 of 2.35 words. The mean improvement for the *Neutral-Control* participants collapsed across stimulus Prime Type from Time 1 to Time 2 was 2.2; producing a raw effect i.e., sample mean difference of .15. The improvement in CST accuracy performance noted in Experiment 1 following the cognitive and affective primes compared to the improvement following the neutral-control primes (i.e., 3.3⁴⁴) was identified as a reasonable expectation of improvement on the CST task following cognitive and affective priming. Thus the alternative hypothesis was represented as a half-normal distribution with a standard deviation (*SD*) of 3.3. The sample mean difference between the *Cognitive* and *Neutral-Control* conditions was 0.15 words (*SE* = 1.49⁴⁵) leading to a Bayes Factor of $B = .45$ ⁴⁶, indicating the data to be insensitive with weak evidence for the null hypothesis. Secondly, for the *Affective* participants, the mean improvement in the number of correctly recalled words from Time 1 to Time 2 was 2.3, producing a raw effect (mean difference) of .1 between the *Affective* and *Neutral-Control* participants. Thus again, a half-normal with an *SD* of 3.3 was used. The sample mean difference between the two groups was

⁴⁴ This value was achieved by calculating the improvement on CST accuracy between Time 1 and Time 2 for all three prime types i.e., Cognitive (e.g., 36 - 31.41 = 4.49 words improvement), Affective (35.35 - 31.41 = 3.94 words improvement) and Neutral-Control (30.79 - 29.82 = 0.97 words improvement) groups. The average improvement following positive subliminal priming (i.e., following Cognitive and Affective primes) equalled 4.3 words and the improvement by the Neutral-Control group (e.g., 0.97) was deducted from this value (e.g., 4.3 - 0.97 = 3.3).

⁴⁵ Because Bayes Factor analysis cannot be calculated from an *F*-value with 2 degree of freedom such as that observed from the 2 (Time: *Time 1* vs. *Time 2*) x 3 (Prime Content: *Cognitive*, *Affective*, *Neutral*) ANOVA in the original analysis, the *SE* was calculated using the *t* statistic taken from an independent samples *t*-test on the difference scores (i.e., Time 2 - Time 1 accuracy scores) between the Cognitive and Neutral-Control groups. The independent samples *t*-test found a *t* of, .101. *SE* was then calculated by (raw effect) / *t* i.e., (.15) / .101 = 1.49.

⁴⁶ Calculated using the free online Bayes calculator (Dienes, 2008; see http://www.lifesci.sussex.ac.uk/home/Zoltan_Dienes/).

.1 words ($SE = 1.45^{47}$) leading to $B = .43$, showing the data to be insensitive with weak evidence towards the null hypothesis.

To understand whether there was any evidence for the second alternative hypothesis, that there is a difference in semantic working memory performance following exposure to Single-Word primes (*Cognitive* and *Affective*) compared to Multiple-Word primes (*Cognitive* and *Affective*), a uniform distribution was used to represent the data with a lower limit of zero and an upper limit of .16⁴⁸. The sample mean difference between the two experimental prime groups i.e., Single-Word and Multiple-Word at Time 2 was 7 ($SE = 2.23^{49}$) leading to $B = 1.12$, indicating the data to be insensitive.

⁴⁷ As before, the F -value from the original 2 (Time: *Time 1* vs. *Time 2*) x 3 (Prime Content: *Cognitive*, *Affective*, *Neutral*) ANOVA could not be used, thus the t statistic was taken from an independent samples t -test on the difference scores (i.e., Time 2 – Time 1 accuracy scores) between the *Affective* and *Neutral-Control* groups. The independent samples t -test found a t of, .069. SE was then calculated by (raw effect)/ t , i.e., (.1)/ .069 = 1.45.

⁴⁸ The upper limit of the uniform distribution was equal to the upper confidence interval taken from the independent samples t -test conducted on CST accuracy scores following the Single-Word and Multiple-Word primes in Experiment 1. Analysis was only conducted on CST data that immediately followed subliminal priming (i.e., not on data following a delay through completion of other tasks). This value represents the estimate for the most the difference could be when the CST is taken immediately following subliminal priming whereby the Single-Word primes produced a higher mean score (34.17) compared to the Multiple-Word primes (27.17).

⁴⁹ SE calculated using the F -value from the 2 (Time: *Time 1* vs. *Times 2*) x 2 (Prime Type: *Single-Word* vs. *Multiple-Word*) interaction of $F = .001$; $\sqrt{.001} = t$ of .03. SE was then calculated by (raw effect)/ t , i.e., (7.16)/ .03 = 238.67.

5.1.2 CST Intrusions

Mean transformed⁵⁰ intrusion scores i.e., the number of incorrectly recalled words, and standard deviations (*SD*) for each condition are provided in Table 21 (below). Higher scores indicate more words incorrectly recalled.

Table 21

Mean and SD Scores for CST Intrusions at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	<i>SD</i>	Mean	<i>SD</i>
Single-Word	Cognitive	2.45	1.19	2.23	1.46
Single-Word	Affective	2.85	1.23	2.35	1.10
Single-Word	Neutral	1.97	1.26	2.13	1.86
Multi-Word	Cognitive	1.93	0.79	1.74	1.03
Multi-Word	Affective	2.76	0.86	2.84	0.91
Multi-Word	Neutral	2.55	1.38	2.36	0.96

Analysis of the mean CST intrusions data revealed no main effects of Time, $F(1,54)=.767, p=.385, MSE=.627, \eta^2_p=.014$, Prime Type, $F(1,54)=.020, p=.888, MSE=.035, \eta^2_p=.000$, or Prime Content, $F(2,54)=2.301, p=.110, MSE=4.003, \eta^2_p=.079$.

Furthermore, the Time x Prime Type, $F(1,54)=.068, p=.795, MSE=.055, \eta^2_p=.001$, Time x Prime Content, $F(2,54)=.163, p=.850, MSE=.133, \eta^2_p=.006$, Prime Content x Prime

⁵⁰ Data for incorrectly recalled words were transformed using a square-root transformation, as they did not meet the criteria for parametric testing for normality. See Chapter 3 (3.5 *Data Preparation and Analysis*, p.77) for an outline of the procedure taken for testing and redressing parametric assumptions. Square-root transformation was found to improve normality to an acceptable level.

Type, $F(2,54)=1.308$, $p=.279$, $MSE=2.275$, $\eta^2_p=.046$, and Prime Type x Time x Prime Content, $F(2,54)=.665$, $p=.518$, $MSE=.544$, $\eta^2_p=.024$, effects all failed to reach significance.

5.2 Threshold Testing

None of the participants reported suspicion of subliminally presented information during the funnel-styled debrief questionnaire, and no participants reported seeing any flashes during the LDT. The majority (87%) of participants answered ‘No’ when questioned about noticing anything unusual during the experiment, and those that answered ‘Yes’ (13%) reported information related to either the LDT or CST target words; no participant mentioned anything consistent with the subliminal stimuli presented, as such no participants were removed at this stage. When informed about the exposure to subliminal stimuli, all participants were unable to correctly guess the content of the stimulus presented to them. The majority (58.33%) of participants answered ‘don’t know’ or left the question blank. Of the remaining participants that did provide an answer, the majority (30%) guessed the subliminal content to be related to improving memory, 8.33% guessed the content of subliminal stimuli was either congruent or incongruent to the responses required for the LDT decisions, and two participants (3.33%) guessed positive/negative words were presented. No participant reported the content of the subliminal stimuli to be consistent with the Cognitive, Affective or Neutral-Control stimuli used in Experiment 2, thus zero participants were removed at this stage. Finally, when provided with all six subliminal stimuli used in Experiment 2, participants’ were unable to guess the content of their subliminal stimuli over and above chance success ($\chi^2(2)= 3.55$, $p=.217$).

Discussion

The objective of Experiment 2 was to explore the effects of subliminal Single-Word and Multiple-Word primes on semantic working memory performance when controlling for the delay in time between the end of the subliminal stimulation phase of the experiment (e.g., the LDT) and the onset of the CST, and the possible interference to the automatic primed behaviour caused by the completion of other tasks. No clear subliminal effects were established on working memory performance, hence results are considered to reflect a practice effect.

With regard to the analysis of the first hypothesis, results of the orthodox analysis showed that all participants exhibited an increase in CST accuracy over time regardless of the content of the subliminal stimuli received. Additionally, Bayes Factor Analysis revealed the data to be insensitive regarding the possible positive improvement on working memory performance following exposure to experimental subliminal primes (i.e., cognitive and affective primes) in comparison to the neutral-control subliminal primes. Hence, the null hypothesis was neither rejected nor supported. With regard to the second hypothesis explored, results of the orthodox analysis showed that participants exposed to Multiple-Word primes recalled significantly more words on the CST compared to those receiving Single-Word primes. Although, such a result is not considered to reflect any clear difference in the effect elicited by the subliminal prime type as the difference between the subliminal primes types was not found to interact significantly with either the time of measurement or content of the subliminal stimuli.

On examination of the descriptive statistics shown in Table 20 (p. 164), the difference between the reported standard deviation for participants' receiving the cognitive Single-Word prime (i.e., intelligent) and Multiple-Word prime (i.e., I am intelligent) was larger at both

Time 1 (e.g., 3.58) and Time 2 (e.g., 2.11) than the differences between the reported standard deviations for participants' receiving Single-Word and Multiple-Word primes at Time 1 and Time 2 in the affective (e.g., 0.9 and 1.19 respectively) and neutral-control groups (e.g., 1.24 and 1.06 respectively). Such results indicate there to be a wider variation in the accuracy scores achieved on the CST for participants in the Multiple-Word prime group (see Table 22, below), which may be responsible for the significant result reported. However, this variation is not considered to reflect any clear difference in the effect elicited by the subliminal prime types because the number of words correctly recalled was measured both before and after subliminal priming. Furthermore, Bayes Factor Analysis found data to be insensitive regarding the possible difference elicited between the different prime types hence the null hypothesis was neither rejected nor supported.

Table 22

*The Minimum, Maximum and Range for the Number of Words Recalled on the CST
Collapsed Across Time*

	Minimum	Maximum	Range
Single-Word Primes	20	34.50	14.50
Multiple-Word Primes	15	41	26

Finally, results from the CST intrusions data i.e., the number of incorrectly recalled words, were analysed using orthodox statistical analysis and did not reveal any significant changes, suggesting that subliminal priming may not reduce the number of words intruding on participants' memory during recall. Overall, the results of the orthodox and Bayes Factor analysis indicated that on this occasion, subliminal priming using cognitive and affective stimuli elicited no effect on semantic working memory performance. As such, no conclusions

can be drawn concerning which prime type of subliminal stimulus is most effective i.e., Single-Word or Multiple-Word prime.

It is of course possible that subliminal priming was not successful in Experiment 2 because it is not possible to improve cognitive performance following the fleeting presentation of written words, however previously reported evidence suggests otherwise. There is an abundance of evidence that reports successful subliminal priming of behaviour following Single-Word and Multiple-Word primes (Bryant-Tuckett & Silverman, 1984; Dijksterhuis et al., 2008; Dijksterhuis & Smith, 2002; Glassman & Andersen, 1999; Johnson et al., 2010; Levy & Leifheit-Limson, 2009; Ortigue et al., 2007; Pichon et al., 2007; Radel, Sarrazin, & Pelletier, 2009; Zemack-Rugar et al., 2007) and more specifically, improvements in cognitive tasks following Single-Word (Hull et al., 2002; Jraidi & Frasson, 2010; Lowery et al., 2007; Radel et al., 2009) and Multiple-Word primes (Ariam & Siller, 1982; Parker, 1982; Zuckerman, 1960). Moreover, successful subliminal priming of memory has been reported following the presentation of Single-Word primes (Chartrand & Bargh, 1996; DeVaul, 2004; DeVaul & Pentland, 2002; Dijksterhuis et al., 2000; Hess et al., 2004; Levy, 1996; Levy & Leifheit-Limson, 2009).

Nevertheless, whilst changes in memory performance have been reported following subliminal exposure to Single-Word primes research has not reported improvements in semantic working memory following subliminal priming. In relation to the findings of the Experiment 2 it could be suggested that semantic working memory is not amenable to change following subliminal priming or that participants considered that their goal of sufficient working memory had been achieved. An alternative explanation however, is that there were no clear subliminal effects because participants may have *lacked* the goal to improve their working memory performance or the sufficient motivation to achieve this goal. In relation to goal-directed behaviour theory the lack of an appropriate goal may prevent the subliminal

stimulus from being unconsciously processed as relevant (Aarts et al., 2005). Hence, ensuring that an appropriate goal exists should be considered in on-going experiments as it may have important repercussions concerning the effectiveness of subliminally presented information (Aarts et al., 2005; Strahan et al., 2002). Strahan et al. (2002) further outline the importance of a participant's motivation to achieve a goal as this impacted on the effectiveness of a subliminal stimulus. In their research, participants were primed with subliminal words related to thirst (e.g., thirst, dry) or neutral words (e.g., pirate, won) and their level of thirst was manipulated by providing or withholding a drink of water. Results revealed that only the participants who were unable to drink, and as such were motivated to quench their thirst, were susceptible to the subliminal thirst-related primes.

Experiment 2 of the current research tested participants' semantic working memory prior to and following the LDT in which the subliminal stimuli were presented. Participants examined were aware of the requirement to complete the same memory task at different intervals during the experiment and volunteered to participate in return for course credits, and as such, it was *assumed* that participants' held the goal of improving their CST performance over the duration of the experiment. However, no such measure of their current goals or motivation to achieve those goals was taken. Thus, it is not certain that any participants were motivated to improve their working memory performance hence Experiment 3 will address this issue by enhancing participants' motivation to improve their working memory performance, whilst keeping all other aspects of the experiment the same.

In summary, no clear change in participants' semantic working memory was established using orthodox statistical analysis following positive content subliminal stimuli (i.e., cognitive and affective) in comparison to neutral-control stimuli. Furthermore, Bayes Factor analysis found substantial support for the null hypotheses that subliminally positive primes were unable to improve working memory performance. Additionally, orthodox

statistical analysis revealed no clear difference in the effectiveness elicited between subliminal Single-Word (*cognitive*: intelligent; *affective*: one) and Multiple-Word (*cognitive*: I am intelligent; *affective*: mommy and I are one) primes and Bayes Factor Analysis revealed the data to be insensitive. Whilst past research has demonstrated the effectiveness of subliminally presented information on memory performance (e.g., Chartrand & Bargh, 1996; Dijksterhuis et al., 2000; Hess et al., 2004; Levy, 1996; Levy & Leifheit-Limson, 2009), no research has yet demonstrated improved semantic working memory performance specifically, and the results of this experiment may indicate that subliminally presented information may be unable to elicit any positive improvement of semantic working memory performance. However, an alternative explanation may be that the participants lacked the appropriate goal to improve their working memory performance, or the sufficient motivation to achieve this goal. Goal-directed behaviour theory highlights the importance of relevant goals for subliminal stimuli to activate (Aarts et al., 2005), and furthermore, Strahan et al. (2002) stipulate the importance of participants' motivation to achieve that goal. Therefore, Experiment 3 will continue to test for positive changes in semantic working memory following subliminal stimulation using *cognitive* (i.e., intelligent, I am intelligent) and *affective* (i.e., one, mommy and I are one) stimuli in addition to exploring the possible differential effects produced by the different prime types of subliminal stimuli (e.g., *Single-Word* vs. *Multiple-Word*) whilst ensuring that participants are suitably motivated to achieve the goal of improving their semantic working memory performance.

Chapter Six: Experiment 3 - Comparing Subliminal Single-Word and Multiple-Word Primes on Semantic Working Memory Performance: Are Subliminal Primes Mediated By Motivation?

Introduction

Findings from Experiment 2 yielded no significant improvement in semantic working memory performance following exposure to subliminal Single-Word (*cognitive*: intelligent; *affective*: one) or Multiple-Word (*cognitive*: I am intelligent; *affective*: mommy and I are one) primes. Instead, participants' improvement over time was attributed to a practice effect, and Bayes Factor analysis confirmed that subliminal experimental (positive) stimuli, both intelligence- and affective-oriented, produced no effect on semantic working memory performance in relation to the neutral-control stimuli (i.e., walking; people are walking). Additionally, Bayes Factor analysis found the data to be insensitive concerning the possibility of a differential effect between the two subliminal prime types, Single-Word and Multiple-Word primes. It was postulated that the non-significant findings from Experiment 2 might possibly be due to participants' lack of motivation to achieve the goal of improving their working memory performance.

Strahan et al. (2005; see also Spencer Fein, Strahan, & Zanna, 2005) have researched the importance of motivation and activation of relevant goals. They advocate that subliminal priming, as a technique, is only successful at generating goal-relevant behaviour when it is combined with the pertinent motivation to achieve that goal. Förster et al. (2007) consider a 'goal' to be a representation of a desired end-state, whereas Custers and Aarts (2005) clarify it further as a mental representation of a behavioural state. Within the realms of unconscious research, Bos, Dijksterhuis, and Baaren (2008) explain that the activation of the participant's

goal is of utmost importance because, as they demonstrated, unconscious thought is entirely goal-dependent. Therefore, without the activation of a relevant goal, unconscious thought is less likely to occur. In their research, participants were required to make a decision (e.g., best car, best roommate) using information provided about several alternatives, and were either allowed to engage in conscious deliberation concerning the options or were distracted from consciously thinking about the options, and as such were considered to engage in unconscious thought. In the unconscious thought condition participants were either informed they would be required to make their decision after a secondary (e.g., distraction) task, thereby activating the goal to unconsciously process the information about each alternative during the secondary task or were informed that the task was actually complete, and that no decision was required, hence *not* considered to activate the goal to unconsciously process the information. Results showed that only participants with the activated goal to unconsciously process the information were able to correctly identify the option from the alternatives presented that was ‘best’ that is, had the most favorable attributes (see Newell & Shanks, 2012, for alternative considerations). Although in this research subliminal presentation was not used per se as participants were either manipulated to use conscious or unconscious thought, the principle of goal-activation is still relevant. For instance, if a goal is not present, then subliminally presented information may not be unconsciously processed as relevant to the individual, and as such a subliminal prime may not produce any measurable effect. Fitzsimons and Bargh (2003) explain that because goals are mentally represented (see also Custers & Aarts, 2005; Förster et al., 2007) like stereotypes and traits, goals can also be activated by a relevant subliminal prime thus activating the pertinent goal-directed behaviour to attain the goal. Hence, to enable the activation of relevant goal-directed behaviour, the goal itself must exist i.e., the individual must have mentally represented the outcome (e.g.,

improved memory performance) as desirable to achieve (Aarts et al., 2005; Bermeitinger et al., 2009).

All participants from Experiment 2 volunteered to participate in the experiment, in exchange for course credit and were all informed of the focus of the experiment on their memory performance and of the requirement to complete a working memory task twice during the session. However, no attempt was made to discuss what goals participants held and whether or not they held the specific goal of improving their working memory performance. Additionally, no measure was taken to indicate how motivated they were to attain this goal. As such, it is not known whether participants held a relevant goal to improve working memory performance or whether they were motivated to achieve this goal. In light of research stipulating the importance of a pre-existing goal for subliminal priming to be successful (Bermeitinger et al., 2009; Karremans et al., 2006; Strahan et al., 2002, 2005; Veltkamp et al., 2008; Veltkamp et al., 2011 Experiment 1), it is possible that the ineffectiveness of the subliminally presented stimuli from Experiment 2 may have been due in part to the lack of a goal to improve working memory performance and secondly, a lack in the motivation to attain that goal. However, before this idea is more fully explored consideration should be given to the pattern of effects reported from Experiment 1, where significant improvements in semantic working memory performance were found following exposure to all positive content subliminal stimuli.

Differences between the two experiments include the number of tasks participants were required to complete, whereby participants in Experiment 1 were required to complete a total of six tasks, five of which were completed twice in comparison to the two tasks completed in Experiment 2, only one of which was completed twice. The number of tasks produced a difference in the length of time participants took to complete the experiments resulting in Experiment 1 being worth more course credits than Experiment 2. The course

credit rate is pre-set to one credit per 20 minutes of experiment completed; as such Experiment 1 was worth six course credits compared to the two course credits for Experiment 2. Finally, in addition to the course credits, a cash prize draw was listed as an added incentive for participating in Experiment 1 due to the length of time the experiment required on the part of the participant. One winner from each of the six stimuli groups was selected at random to receive a cash prize of £20 whereas no such incentive was listed for Experiment 2. Whilst these differences may not specifically induce the goal to improve working memory performance, it is possible that the higher rewards offered in exchange for participation in Experiment 1 may have motivated the participants more so than the rewards offered in Experiment 2. Incentives such as course credits and money extrinsically motivate people (Amabile, Hill, Hennessey, & Tighe, 1994), and monetary incentives especially are considered to increase extrinsic motivation (Amabile, 1998; Deci, 1972; Deci, Koestner, & Ryan, 1999; Vohs et al., 2006) and increase performance (Stajkovic & Luthans, 2001). As such, the addition of the monetary incentive advertised for Experiment 1 may have increased all participants' motivation to perform well during the experiment, thus exposure to positive content subliminal stimuli in comparison to neutral-control stimuli may have amplified the effort exerted by these participants, hence eliciting improved accuracy performance on the Conceptual Span Task (CST) at Time 2. As such, participant motivation alongside the relevant goal should be considered in future research.

Strahan et al. (2002) reported that subliminal primes are only successful if the participant is motivated to achieve a pre-existing goal. Strahan et al. (2002 Experiment 1) tested this theory on drinking behaviour; some participants were deprived of refreshment during the experiment thus instigating the goal to quench their thirst. Subliminal prime words semantically related to thirst (e.g., thirst, dry) were found to increase the amount of beverage consumed in comparison to neutral words (e.g., pirate, won) but *only* if the participant was

thirsty i.e., motivated to achieve the goal of quenching their thirst. This finding was replicated in a conceptually similar experiment by Strahan et al. (2004, as cited in Strahan et al., 2005) examining the effect of subliminal Single-Word primes on un-restrained and restrained eaters i.e., individuals chronically motivated to eat due to their constant control over the intake of food and calories. Subliminal priming of words related to over-eating (e.g., binge, eat) was found to increase the consumption of a high-calorie beverage compared to neutral words (e.g., pirate, won) in restrained eaters only. These findings suggest that the subliminal prime words related to over-eating were unconsciously processed as relevant and activated the goal to intake more calories in participants who were motivated to do so, thus initiating a goal-relevant behaviour to achieve that goal.

In both experiments reported by Strahan et al. (2002, 2004, as cited in Strahan et al., 2005), the goal-related subliminal Single-Word primes *only* influenced behaviour when the participant held the pre-existing goal to perform that behaviour. Only thirsty participants consumed more of the beverage following the presentation of thirst-related primes (Strahan et al., 2002) and only the restrained eaters consumed more of the high-calorie drink (Strahan et al., 2004, as cited in Strahan et al., 2005). Importantly, in both experiments no change in behaviour was reported following subliminal priming of thirst-related words or over-eating words for participants who did *not* hold the relevant pre-existing goal. This suggests that information unconsciously processed needs to be relevant to the individual in order to initiate goal-relevant behaviour. Furthermore, the results reported by Strahan et al. (2002, 2004, as cited in Strahan et al., 2005) extend goal-directed behaviour theory to include the idea that subliminal priming may only activate relevant goal-directed behaviour if the goal itself exists. However, those unmotivated to achieve such a goal are unlikely to be influenced by such goal-relevant subliminal primes. The extension to the goal-directed behaviour theory i.e., that the relevant motivation to achieve the goal is required, has been widely replicated in drinking

behaviour research (Karremans et al., 2006; Veltkamp et al., 2008; Veltkamp et al., 2011 Experiment 1) and also in relation to concentration and consumption of energy pills (Bermeitinger et al., 2009). Such research advocates that it is possible for subliminal primes to affect behaviour, but only when participants are motivated to attain an existing goal (Strahan et al., 2002; Strahan et al., 2005). Hence, the possible lack of both a goal to improve working memory performance and the motivation to achieve this goal may account for the null effects reported in Experiment 2. As such, Experiment 3 adapted the procedure reported by Strahan et al. (2002) to include a strategy designed to increase participants' motivation to improve their working memory performance, and then utilised subliminal primes to activate this goal and the relevant goal-directed behaviour to attain that goal. Experiment 3 tested three hypotheses (see Table 23, below).

Table 23

The Hypotheses Tested in Experiment 3

Hypothesis	Prediction
H₁	Participants reported motivation to improve working memory performance would significantly increase following the motivation enhancement strategy.
H₂	All experimental, positive content subliminal stimuli (i.e., <i>cognitive</i> : intelligent, I am intelligent; <i>affective</i> : one, mommy and I are one) would lead to improved semantic working memory performance compared to those exposed to <i>neutral-control</i> stimuli (i.e., walking, people are walking).
H₃	A differential prime type effect would be produced on semantic working memory performance between the Single-Word primes and Multiple-Word primes.

Method

Participants

One hundred and six⁵¹ students were recruited to participate in this experiment in return for course credit and entry into a cash prize draw. The sample consisted of 72 females and 36 males that ranged from 18 to 49 years of age ($M= 20.28$, $SD= 3.8$). Recruitment and allocation to subliminal stimulus conditions was as outlined in Chapter 3 (p. 62-64).

Materials

The two tasks performed during Experiment 3, the Conceptual Span Task (CST) and the Lexical Decision Task (LDT) were as described in Chapter 3 (p. 70-71). The CST was completed twice, once before the LDT and again after the LDT. As before, the LDT was primarily used to present the subliminal stimuli⁵², which consisted of three Single-Word primes and three Multiple-Word primes. In addition, participants completed three short ‘motivation and memory’ questionnaires, each completed once during the experiment. The questionnaires were newly designed for the purpose of this research and were primarily used to assess participants’ motivation to improve their working memory performance on a rating scale from zero to 100 per cent effort at three intervals during the experiment. The questionnaires ranged from nine to 13 items all including the critical item i.e., the amount of effort a participant was willing to give to improve working memory performance, as well as a number of filler items relating to the participant’s self-rating of their memory performance,

⁵¹ Original sample consisted of 108 participants however two participants were removed due to the possibility of conscious awareness of the subliminal stimuli presented as indicated by their responses on the subliminal check questionnaire at the end of the experiment (see 6.3 *Threshold Testing*, p. 194).

⁵² Data from the LDT was analysed however results did not yield any significant effects with regards to the response time and error data, thus the results are not reported.

motivation orientation, and motivation and interest to complete the experiment⁵³. Finally a printed extract from a false article was given to participants to read during the experiment as part of the motivation enhancement strategy. The article extract claimed to be from a previous issue of the ‘New Scientist’ magazine and advocated the importance of a good working memory for employability following University (see Appendix M, p. 371). All other equipment and materials relevant to the experiment are as outlined in Chapter 3.

6.1 Pilot Testing

Three pilot tests were conducted before Experiment 3 commenced. The first pilot survey was conducted to assess the validity of the newly developed motivation and memory questionnaire with regards to measuring the level of motivation participants had to attain the goal of improving their working memory performance. Additionally, two pilot tests were conducted to assess the effectiveness of the motivation enhancement strategy designed to increase participants’ motivation to attain the goal of improving their working memory performance, and secondly to assess the sensitivity of the motivation and memory questionnaire in measuring changes in participants’ motivation to achieve their goal following the motivation enhancement strategy.

6.1.1 Pilot Survey

Twelve participants⁵⁴ were asked to complete the ‘motivation and memory’ questionnaire followed by a short survey about the questionnaire (Appendix N, p. 372). Four items of the survey related to the ‘ease and comprehension’ of the questionnaire. This section

⁵³ All data from the memory and motivation questionnaires were analysed, but only the results concerning the critical question for the degree of effort participants were willing to give to improve their working memory performance as a measure of their motivation to attain this goal will be reported.

⁵⁴ Eight female and four male participants aged between 20 and 56 years of age ($M = 27.5$, $SD = 9.33$) participated in the pilot survey and did not take part in the main experiment.

of the survey intended to establish how long it took participants to complete, whether it would be suitable to present multiple times without loss of interest, and whether the language was suitable for its intended audience. The second section of the survey included seven items related to the ‘applicability’ of the questions in each section of the questionnaire; three items about the ‘memory’ subsection, two items about the ‘motivation orientation’ subsection, and two items about the ‘general participant motivation’ subsection of the questionnaire.

Participants indicated the questionnaire took between two and eight minutes to complete ($M = 3.83$ minutes) and all 12 participants agreed this to be reasonable amount of time to complete a questionnaire. The majority (eight participants; 66.66%) indicated the questionnaire to be suitable for multiple repetitions, and seven participants (58.33%) thought that repetition would not lead to a loss of interest in completing the questionnaire correctly. Finally, all twelve participants agreed the questionnaire was easy to understand with suitable language for the target University student audience.

In terms of applicability of the questions within each of the three subsections (memory, motivation orientation, and general participant motivation), all participants confirmed that all questions were suitable, thus none were removed. Within the ‘memory subsection’ specifically on a scale of one (terrible) to nine (excellent), the first two items were rated to competently target overall memory ($M = 7.75$) and the second two items were considered to competently measure working memory ($M = 7.75$), hence no questions were altered. For the items targeting participants’ motivation orientation i.e., degree of intrinsic/extrinsic motivation, 10 (83.33%) participants correctly identified the two items that measured intrinsic motivation (i.e., five and seven), and 10 participants correctly identified the two items (i.e., six and eight) that measured extrinsic motivation. One minor change was made to the phrasing of question eight, *Participant 12: “I felt Q8...was too ambiguous. To me ‘earning something’ includes earning some satisfaction for completing the task, whereas*

the question suggests earning implies a 'reward' of some kind". To avoid ambiguity the nature of the external reward was changed to more specifically indicate a tangible monetary reward. Finally, all twelve participants agreed that the last four questions adequately measured general participation motivation and perceived performance, thus no changes were made.

6.1.2 Pilot Tests

Two pilot tests examined whether the motivation enhancement strategy (i.e., false-positive feedback on CST performance at Time 1 and the false article extract highlighting the benefit of a good working memory) was successful at increasing participants' motivation to improve their working memory performance and whether the motivation and memory questionnaire was sensitive enough to detect these changes in self-rated motivation. Secondly the pilot tests served to examine whether the motivation and memory questionnaire was suitable to present three times during an experiment.

The first pilot test conducted on 11 participants⁵⁵ indicated that the two-fold strategy used to enhance motivation did not significantly increase participants' motivation to attain the goal of improving their working memory performance. The mean score from the four items included in the 'general participant motivation' section of the questionnaire did not significantly increase from Time 1 (Baseline) to Time 2 (Post-Enhancement), 21.82 and 22.36 respectively, $t(10)=1.399, p=.192$. Two reasons were considered to explain this result. Firstly, it is possible that the questionnaire was not sensitive enough to detect increased motivation to attain the goal of improving working memory performance; alternatively, it is possible that the motivation enhancement strategy was ineffective. To address the first issue of a lack in sensitivity an additional item was added asking participants to rate 'How much

⁵⁵ Participants consisted of seven female and four male participants between 18 and 21 years of age ($M = 19.27, SD = 1.01$) who did not participate in the pilot survey or main experiment.

effort would you be willing to give to improve your working memory performance?'. The item was measured on a percentage scale from zero to 100%, and was thought to more clearly represent the level of motivation participants would have towards achieving the goal of improving their working memory performance. In addition, a second new item was added to the second questionnaire (Time 2: Post-Enhancement) given directly after the motivation enhancement strategy. The question 'How much did the article, highlight to you, the benefits of having a good memory?' measured on a scale of zero (not at all) to nine (completely) was added to identify participants' perception of the false article extract and whether it successfully emphasized the desirability of an improved working memory.

The second aim of the pilot test was to assess how suitable the motivation and memory questionnaire was over three repetitions. In the previous pilot survey five participants (41.66%) reported reluctance to complete this questionnaire at three different intervals and reflected that they may become bored if asked to do so. However, during this pilot test none of the participants complained about the multiple repetitions and were happy to complete the questionnaire at each of the three intervals during the experiment. On reflection of the filler items presented in the questionnaire it was considered that items concerning the participants' motivation orientation e.g., degree of intrinsic motivation (need for self-competence, interest, and enjoyment; Amabile et al., 1994) and extrinsic motivation (need for tangible rewards; Deci et al., 1999) did not need to be presented on all three questionnaires. The general level of a person's intrinsic and extrinsic motivation have been considered as trait-like and enduring across time (Amabile et al., 1994; see also Deci & Ryan, 1985), therefore, it was decided to only present these items in the first of the motivation and memory questionnaires (Time 1: Baseline) as they were not expected to change. Results from the pilot test confirmed this decision as participants' self-rated level of extrinsic motivation

was not found to change significantly during the experiment⁵⁶. In contrast, participants' self-rated level of intrinsic motivation was found to increase significantly between the first (Time 1: Baseline) and second time (Time 2: Post-Enhancement) completing the questionnaire, but not between the second and third (Time 3: Final) time⁵⁷.

A second pilot test was conducted on 11 participants⁵⁸ to assess the changes made following the first pilot test, specifically the additional item rating the degree of effort participants were willing to give to improve their working memory performance. Analysis found the amount of effort participants were willing to give to improve their working memory performance significantly increased from Time 1 (Baseline) to Time 2 (Post-Enhancement; 70.91 and 74.55 respectively, $t(10)=2.390$, $p=.038$) and remained stable from Time 2 to Time 3 (Final; 74.55 and 74.55, $t(10)=.000$, $p=1.00$). Furthermore, the mean rating of the article was 7.36 (out of a possible 9) suggesting that it adequately highlighted the benefits of an improved working memory. As such, the motivation enhancement strategy was considered successful and incorporated into the procedure of Experiment 3.

Procedure

The procedure of Experiment 3 was an adapted for working memory version of that reported by Strahan et al. (2002 Experiment 1). The procedure of Experiment 3 was split into nine stages e.g., *Stage I* 'informed consent', *Stage II* 'motivation and memory time 1', *Stage*

⁵⁶ Self-rated extrinsic motivation was analysed using repeated measures *t*-tests with Bonferroni correction ($\alpha/2 = .025$). Extrinsic motivation did not change from Time 1 to Time 2 (11.27 and 10.82 respectively, $t(10)=1.047$, $p=.320$) or from Time 2 to Time 3 (10.82 and 10.73 respectively, $t(10)=.219$, $p= .831$).

⁵⁷ Self-rated intrinsic motivation was also analysed using repeated measures *t*-tests with Bonferroni correction ($\alpha/2 = .025$). Intrinsic motivation was found to increase from Time 1 to Time 2 (11.09 and 12.82 respectively, $t(10)=3.684$, $p=.004$) but not from Time 2 to Time 3 (12.82 and 13.27 respectively, $t(10)=1.047$, $p= .320$).

⁵⁸ Nine female and two males between 18 and 36 years of age ($M = 20.63$, $SD = 5.14$) participated in this pilot test, but did not take part in any of the previous pilot tests, surveys, or the main experiment.

III ‘dependent measure time 1’, *Stage IV* ‘motivation enhancement strategy’, *Stage V* ‘motivation and memory time 2’, *Stage VI* ‘subliminal stimulation’, *Stage VII* ‘dependent measure time 2’, *Stage VIII* ‘motivation and memory time 3’, and *Stage IX* ‘debrief’. Each stage is outlined below.

Stage I: At the outset of the experiment participants were welcomed, seated at a desk and asked to read through the participant information sheet provided (Appendix O, p. 378). This gave an outline of the procedure of the experiment and participants gave informed consent by completing the screening and consent forms as outlined in Chapter 3 (*3.1 Participants*, p. 65).

Stage II: Participants completed the first short motivation and memory questionnaire (Time 1: Baseline; Appendix P, p. 379) to provide an initial indication of the percentage of effort they were willing to give to improve their working memory performance. Participants also completed all other filler questions concerning the perception of their own memory performance, motivation orientation, and general interest and motivation for participating in the experiment in accordance with the cover story they were told. Participants first completed filler items rating their general memory and working memory performance specifically using a 10-point scale from zero (terrible) to nine (excellent) followed by the critical item, rating the amount of effort they would be willing to give to improve their working memory performance using an 11-point scale from zero percent effort to 100% effort. Participants also answered filler questions relating to their general level of intrinsic and extrinsic motivation (four items) using a 10-point scale from zero (completely disagree) to nine (completely agree). Finally, participants rated their level of general motivation to participate in the experiment. These four filler items included rating their level of interest in the experiment (from zero = not at all, to nine = absolutely), the level of effort they were willing to make on all tasks (zero = no effort, to nine = all my effort), the importance to

perform well (zero = not at all important, to nine = utmost importance) and their expected performance on the experimental tasks (from zero = awful, to nine = perfect).

Stage III: Participants then completed the dependant measure e.g., the CST. The CST⁵⁹ was completed as outlined in Chapter 3 (3.3.1 *Conceptual Span Task*, p. 75).

Stage IV: To create the goal to improve working memory performance and enhance participants' motivation to achieve this goal, a two-fold motivation enhancement strategy was employed. Firstly, the participants were provided with false-positive feedback concerning their performance on the CST. This involved the experimenter informing all participants that although the CST is a difficult task, they performed well achieving an above average score of 52.4%. Secondly, participants were asked to read an extract from an article about memory whilst the next task was prepared. The article highlighted the benefit of a good working memory and the consequences it has during early career progression using the results from a fictitious study following University students over a five-year period after obtaining their degree.

Stage V: Participants were asked to complete the second motivation and memory questionnaire (Time 2: Post-Enhancement; Appendix Q, p. 382) used to assess any changes in the degree of effort they were willing to give to improve their working memory performance and how highly they rated the article at highlighting the usefulness of a proficient working memory. As before, participants completed the filler items rating their memory performance using the 10-point scale, followed by the critical item, rating the amount of effort they would give to improve their working memory performance. The additional item requiring participants to rate the effectiveness of the article extract they had read previously was included in this version of the questionnaire to assess how successful the

⁵⁹ The presentation order of the CST was counter-balanced across participants; 53 participants completed CST A at Time 1 and CST B at Time 2 and the remaining 53 participants completing CST A and CST B in the reversed order.

article was in highlighting to them the benefit (goal) of having a good working memory. Finally, participants completed the remaining filler items concerning their general motivation and interest in the experiment using the 10-point scales as before.

Stage VI: Upon completion of the second motivation and memory questionnaire, participants completed the LDT during which they were exposed to thirty presentations of their subliminal prime as outlined in Chapter 3 (3.3.2 *Lexical Decision Task*, p. 76).

Stage VII: The LDT was immediately followed by the second attempt at the CST⁶⁰.

Stage VIII: Participants were then asked to complete the last motivation and memory questionnaire (Time 3: Final; Appendix R, p. 384) to check whether there were any changes in their motivation e.g., percentage of effort.

Stage IX: Finally, after completing all the tasks, participants were debriefed using a funnel styled questionnaire (Appendix L, p. 369) as outlined in Chapter 3 (3.2.4 *Subliminal Threshold Checks*, p. 72) to assess the participants' level of subjective and objective awareness to subliminally presented stimuli (see Figure 13 for a schematic diagram of Experiment 3 procedure, p. 190).

Design

The design and independent variables of this study was the same as that outlined in Chapter 3 (3.4 *Design*, p. 77). The dependant measures were the participant's accuracy (e.g., number of correctly recalled words) and intrusions (number of incorrectly recalled words) on the CST.

⁶⁰ Fifty-three participants completed CST A first and CST B second and the 53 participants complete CST A and CST B in the reversed order.

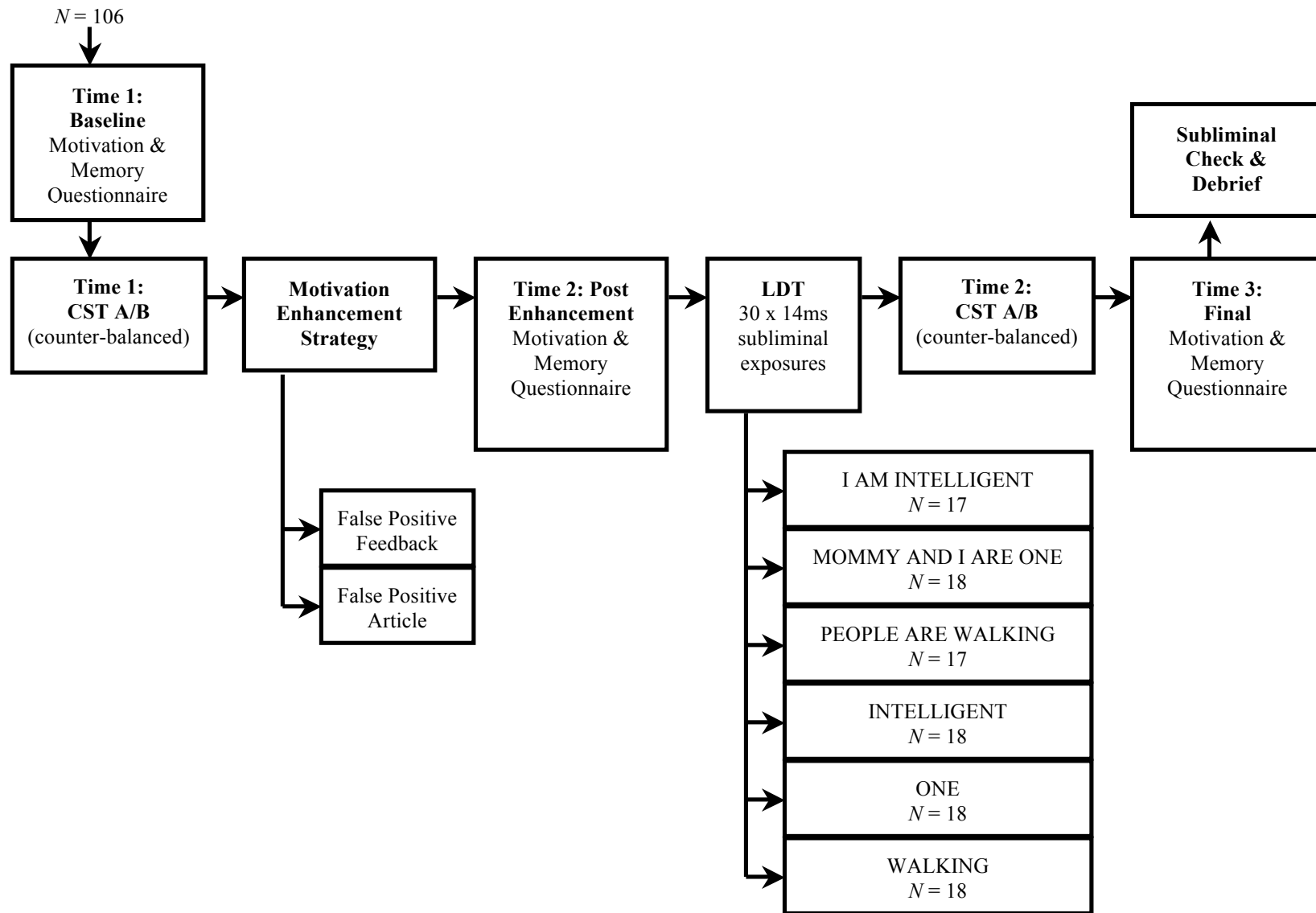


Figure 13: A schematic of the procedure used in Experiment 3.

Results

Data from the conceptual span task was analysed using a 2 (Time: *Time 1 vs. Time 2*) x 2 (Prime Type: *Single-Word Prime vs. Multiple-Word Prime*) x 3 (Prime Content: *Cognitive, Affective, Neutral-Control*) mixed analysis of variance (ANOVA). Time was a within participants factor, and Prime Type and Prime Content were both between participants factors. In the eventuality of non-significant CST results⁶¹, a Bayes Factor analysis was conducted to assess whether data provides support for the alternative or null hypotheses or whether the data were insensitive. Data from all measures are reported below.

6.2 Motivation

The amount of effort participants were willing to give to improve their working memory performance was measured on a scale of zero to 100% and analysed using a repeated measures one-way ANOVA with a single factor of Effort compared across three time intervals with planned comparisons made between Time 1 and Time 2 and between Time 2 and Time 3.

6.2.1 Effort Percentage

The mean and the standard deviation (*SD*) of the percentage of effort participants specified they would give to improve working memory performance from each of the three questionnaires are provided in Table 24 (p. 192). Higher percentages indicate greater levels of motivation.

⁶¹ Bayes factor analysis was only calculated on CST accuracy data as experimental hypotheses were related to memory improvement.

Table 24

Mean and SD Scores for the Percentage of Effort (Motivation) at Time 1, Time 2 and Time 3

	<u>Percentage of Effort</u>	
	Mean	SD
Time 1	72.55	19.42
Time 2	80.75	16.77
Time 3	82.17	16.85

Mauchly's test indicated that the assumption of sphericity⁶² was violated, $\chi^2(2) = .57.552, p < .001$, hence the degrees of freedom were corrected using the Huynh-Feldt⁶³ estimate of sphericity ($\epsilon = .708$). Using this the analysis showed a significant difference between the mean percentages of effort, $F(1,417) = 72.013, p < .001, MSE = 56.090, \eta^2_p = .407$. Simple planned comparisons revealed an increase in effort from Time 1 to Time 2 (72.55 and 80.75 respectively; mean difference = -8.208, $SE = .936, p < .001$), with a further increase from Time 2 to Time 3 (80.75 and 82.17 respectively; mean difference = -1.415, $SE = .527, p = .025$) (see Figure 14, p. 193).

⁶² The assumption of sphericity is tested in analyses with three or more groups to examine whether there are equal variances between these groups. Mauchly's test is commonly used to test sphericity (Field, 2009).

⁶³ When the assumption of sphericity is violated, a correction for the degrees of freedom is required. The Huynh-Feldt estimate of sphericity is applied when the estimates of sphericity (i.e., ϵ) are above .75 (Field, 2009; see also Girden, 1992).

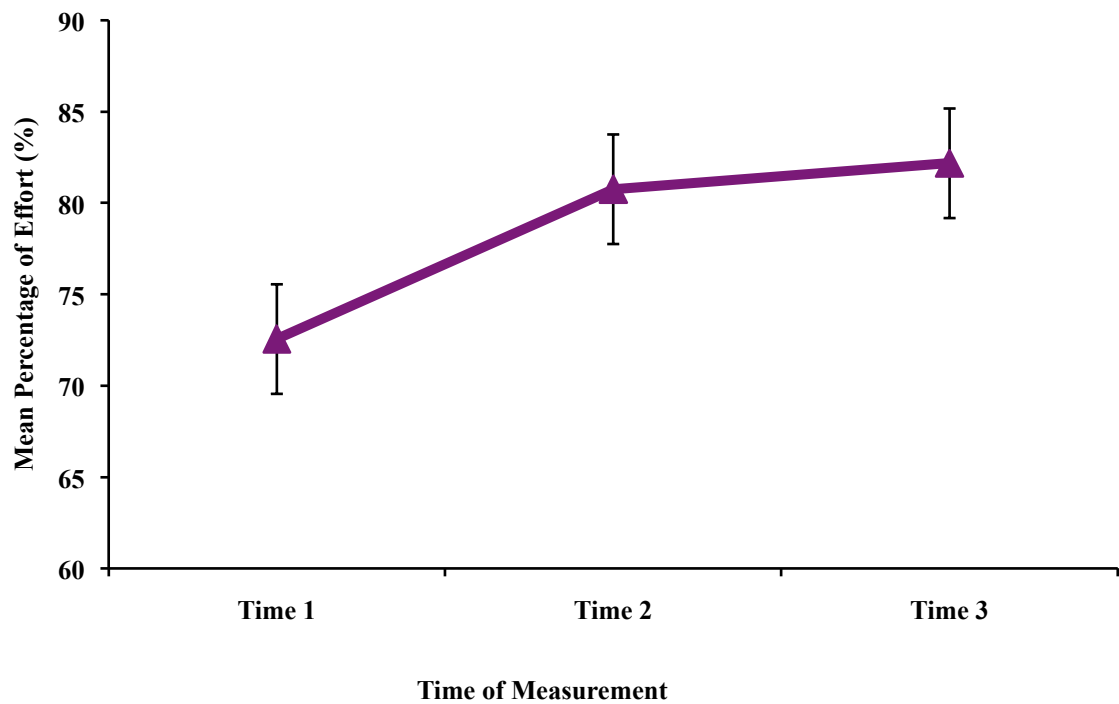


Figure 14: Showing the increase in mean percentage of effort (with standard errors) from Time 1 to Time 3.

6.3 Conceptual Span Task (CST)

Accuracy (i.e., number of words correctly recalled) and intrusion (i.e., number of words incorrectly recalled) data were analysed separately and are reported below.

6.3.1 CST Accuracy

The mean accuracy scores i.e., the number of correctly recalled words and the standard deviations (*SD*) for each condition are provided in Table 25 (p. 194). Higher scores indicate more words correctly recalled.

Table 25

Mean and SD Scores for CST Accuracy at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	SD	Mean	SD
Single-Word	Cognitive	28.72	5.69	32.17	5.83
Single-Word	Affective	31.78	8.88	35.06	8.29
Single-Word	Neutral	28.50	7.32	31.89	7.23
Multi-Word	Cognitive	27.53	7.70	31.29	9.34
Multi-Word	Affective	28.83	5.45	31.17	8.02
Multi-Word	Neutral	28.57	6.22	30.82	7.78

Note: Mean represents the number of correctly recalled words on the CST from a total of 63.

Analysis of the mean scores revealed a main effect of Time, $F(1,100)=32.867$, $p<.001$, $MSE=15.35$, $\eta^2_p=.247$, whereby participants recall accuracy improved from Time 1 to Time 2 (28.99 and 32.07 respectively).

All other analyses which included: Prime Type, $F(1,100)=1.484$, $p=.226$, $MSE=95.566$, $\eta^2_p=.015$, Prime Content, $F(2,100)=.772$, $p=.465$, $MSE=95.566$, $\eta^2_p=.015$, Time x Prime Type, $F(1,100)=.284$, $p=.595$, $MSE=15.325$, $\eta^2_p=.003$, Time x Prime Content, $F(2,100)=.234$, $p=.792$, $MSE=15.325$, $\eta^2_p=.005$, Prime Content x Prime Type, $F(2,100)=.459$, $p=.634$, $MSE=95.566$, $\eta^2_p=.009$, and Prime Type x Time x Prime Content, $F(2,100)=.173$, $p=.847$, $MSE=15.325$, $\eta^2_p=.003$, were not significant.

6.3.1.1 Bayes Factor Analysis

Bayes Factor Analysis was used to assess whether the data provides evidence for or against the alternative hypothesis that there is a difference between the number of words correctly recalled on the CST following the experimental positive content subliminal stimuli compared to neutral stimuli. A Bayes Factor Analysis using the data from the *Neutral-Control* participants and the two experimental stimuli groups i.e., *Cognitive* and *Affective*, individually were calculated. For the *Cognitive* participants, the number of words correctly recalled at Time 1 and Time 2 were collapsed across stimulus Prime Type (e.g., Single-Word and Multiple-Word primes) to provide a mean improvement of 3.6. The mean improvement for the *Neutral-Control* participants collapsed across stimulus Prime Type from Time 1 to Time 2 was 2.82, therefore producing a sample mean difference (raw effect) of .78. The improvement noted by the *Neutral-Control* group of 2.82 could be identified as a reasonable expectation of improvement of semantic working memory performance on the CST when motivation is increased, thus the alternative hypothesis was represented as a half normal with a standard deviation (*SD*) of 2.82. The sample mean difference between the *Cognitive* and *Neutral-Control* conditions was .78 words ($SE = 1.39^{64}$) leading to a Bayes Factor of $B = .69$, indicating that the data are insensitive. Secondly, for the *Affective* participants, the mean improvement of 2.81 produced a sample mean difference between the *Neutral-Control* and *Affective* participants of -.01 words recalled. Thus, again a half-normal representation with an *SD* of 2.82 was used. The

⁶⁴ As the *F*-value from the original 2 (Time: *Time 1 vs. Time 2*) x 3 (Content: *Cognitive, Affective, Neutral-Control*) ANOVA could not be used, the *t*-was taken from an independent samples *t*-test on the difference scores (i.e., Time 2 – Time 1 accuracy scores) between the *Cognitive* and *Neutral-Control* groups. The independent samples *t*-test found a *t* of, .562. *SE* was then calculated by (raw effect)/*t*, i.e., (.78)/.562 = 1.39.

sample mean difference between the two groups was -.01 words ($SE = .032^{65}$) leading to $B = .01$, providing substantial evidence for the null hypothesis.

To understand whether there was any difference in performance between the experimental subliminal Single-Word primes (Cognitive and Affective) and Multiple-Word primes (Cognitive and Affective) a uniform distribution was used to represent the data with a lower limit of zero and an upper limit of 2.12⁶⁶. The sample mean difference between the two experimental subliminal Prime Types e.g., Single-Word and Multiple-Word primes at Time 2 was 1.95 ($SE = 8.45^{67}$) leading to $B = 1.02$, thus revealing the data to be insensitive.

6.3.2 CST Intrusions

The mean transformed⁶⁸ intrusion scores i.e., the number of incorrectly recalled words, and standard deviations (SD) for each condition are provided in Table 26 (p. 197). Higher scores indicate more words incorrectly recalled.

⁶⁵ As before, the t -value was taken from the independent samples t -test on the difference scores (i.e., Time 2 – Time 1 accuracy scores) between the Affective and the Neutral-Control groups. The independent samples t -test found a t of, -.042. SE was then calculated by $SE = (\text{raw effect})/ t$, i.e., $(-.01)/-.042 = .032$.

⁶⁶ The upper limit of the uniform distribution was equal to the upper confidence interval taken from an independent samples t -test conducted on the CST scores following experimental Single-Word and Multiple-Word primes at Time 2 from Experiment 2. This value represents the estimate for the most the difference could be between the two subliminal Prime Types whereby Single-Word primes produced a larger mean score (e.g., 33.04) than the Multiple-Word primes (e.g., 31.09) when the CST was taken immediately after subliminal priming without added motivation/incentive.

⁶⁷ SE calculated using the F -value from the 2(Time: *Time 1 vs. Time 2*) x 2(Prime Type: *Single-Word vs. Multiple-Word*) interaction of $F = .284$; $\sqrt{.284} = t$ of 0.53. SE was then calculated (raw effect)/ t , i.e., $(2.4)/ .284 = 8.45$.

⁶⁸ Data for incorrectly recalled words were transformed using a square-root transformation, as they did not meet the criteria for normality to enable use of a parametric test. See Chapter 3 for an outline of the procedure taken for broken parametric assumptions (3.5. *Data Preparation and Analysis*, p.77). Square-root transformation was found to improve normality to an acceptable level.

Table 26

Mean and SD Scores for CST Intrusions at Time 1 and Time 2

Prime Type	Prime Content	Time 1		Time 2	
		Mean	SD	Mean	SD
Single-Word	Cognitive	1.94	.92	1.96	1.03
Single-Word	Affective	1.91	1.07	1.75	1.12
Single-Word	Neutral	2.19	1.21	2.23	1.30
Multi-Word	Cognitive	2.10	.67	2.05	.98
Multi-Word	Affective	2.09	1.01	1.06	1.25
Multi-Word	Neutral	2.40	.91	2.43	1.10

All analysis which included: Time, $F(1,100)=.074$, $p=.787$, $MSE=.421$, $\eta^2_p=.001$, Prime Type, $F(1,100)=1.084$, $p=.300$, $MSE=1.838$, $\eta^2_p=.011$, Prime Content, $F(2,100)=1.429$, $p=.244$, $MSE=1.838$, $\eta^2_p=.028$, Time x Prime Type, $F(1,100)=.016$, $p=.901$, $MSE=.421$, $\eta^2_p=.000$, Time x Prime Content, $F(2,100)=.189$, $p=.828$, $MSE=.421$, $\eta^2_p=.004$, Prime Content x Prime Type, $F(2,100)=.037$, $p=.964$, $MSE=1.838$, $\eta^2_p=.001$, and Prime Type x Time x Prime Content, $F(2,100)=.103$, $p=.902$, $MSE=.421$, $\eta^2_p=.002$, were not significant.

6.4 Threshold Testing

None of the participants reported suspicion of the subliminally presented stimuli during the experiment. One participant stated that they saw a flash although no further indication of knowledge towards the content of the subliminal stimuli arose throughout the questionnaire thus this participant's data was not removed. The majority, 91 participants (84.26%) did not notice anything unusual or anything other

than the expected (target letter strings and fixation cross) stimuli during the LDT. Of the remaining participants, 14 (12.96%) answered 'yes' to noticing something unusual during the LDT and elaborated with information relating to the LDT (e.g., one target remaining on screen for slightly longer than the rest) or the CST (e.g., naming category words), one participant commented on their perception of their own performance and one participant reported a flash, although they further commented that this might be due to their vision and were not able to provide a guess as to the content of the stimuli and thus were not removed from the sample.

When asked specifically whether any other words appeared except the expected stimuli (i.e., target letter strings and fixation crosses), the majority 100 participants (92.59%) answered 'no'. The remaining five (4.63%) participants that answered 'yes' generally elaborated with target words shown in the CST. One participant explained noticing a word above the fixation cross but could not elaborate further on what this word said, thus was not removed. When informed of the use of subliminal stimuli during the experiment none of the participants were able to guess correctly the content of any of the stimuli used. The majority of 44 participants (40.74%) answered 'don't know' or left the question blank. Of those that attempted to guess the content of the stimuli 27.77% guessed words from, or related to, either the LDT or CST (e.g., furniture, healthy eating, transport, tiger) and 18.52% guessed the content involved 'memory' (e.g., remember, improve memory). Less common answers included motivation (e.g., motivation) and performance (e.g., try harder) from eight participants (7.41%); and pictures (e.g., the article extract, circles around correct responses), letters/numbers, or stories by seven participants (6.48%). Three (2.78%) participants guesses included the concept of intelligence (e.g., intelligence; intelligence is the key to life) although none of these participants received the

subliminal stimuli related to intelligence (i.e., intelligent; I am intelligent) thus their data was not removed from the dataset.

Finally, when provided with the six subliminal stimuli used in Experiment 3, two participants were removed for guessing correctly and providing further information that they chose that stimulus as it seemed familiar. Of the remaining participants, a chi-square analysis indicated that participants were able to guess the content of their subliminal stimuli over and above chance success, ($\chi^2(2)= 6.713, p< .035$); three participants guessed the content of the Neutral-Control stimuli correctly (i.e., walking, people are walking), six participants guessed the content of the Cognitive stimuli correctly (i.e., intelligent, I am intelligent) and zero participants guess the content of the Affective stimuli (i.e., one, mommy and I are one) correctly. However, when questioned about their response, participants explained their choice was based on the tasks they completed (e.g., through memory's association to intelligence), thus it was considered that participants were suitably unaware of the subliminal stimuli presented to them at the subjective level and their data was not removed from the data set⁶⁹.

Discussion

Experiment 3 compared the effects of subliminal Single-Word and Multiple-Word primes on semantic working memory performance on participants motivated to achieve the goal of improving their working memory performance. A two-fold motivation enhancement strategy was devised to enhance participants' motivation to

⁶⁹ Analyses were conducted with only the participants who guessed the content of their subliminal stimulus incorrectly and all results from the analysis remained the same.

achieve this goal. The results indicate that the motivation enhancement strategy implemented was successful. Participants rated the false-article highly with a score of 7.07 on a scale between zero (not at all useful) to nine (extremely useful) suggesting that the article succeeded in highlighting to them the benefit of improving their working memory performance. Furthermore, the degree of effort participants were willing to give to improve their working memory performance increased from Time 1 (Baseline) to Time 2 (Post-Enhancement). As such, the first hypothesis that motivation to improve working memory performance would increase following the motivation enhancement strategy was supported.

During Experiment 3 participants were required to complete the CST as a measure of semantic working memory performance. In relation to the second hypothesis tested, the results of Experiment 3 reveal an improvement in the number of words correctly recalled on the CST regardless of the type or content of the subliminal primes, and as such is considered to reflect a simple practice effect. Furthermore, Bayes Factor Analysis found the data in relation to the difference in CST performance between the cognitive and neutral-control prime groups to be insensitive and as such, the second hypothesis can neither be rejected nor supported. However, Bayes Factor Analysis found the data in relation to the difference in CST performance between the affective and neutral-control group to provide evidence for the null hypothesis hence the null hypothesis was supported. Finally, orthodox statistical analysis found no evidence of a differential effect elicited between the two subliminal prime types i.e., Single-Word and Multiple-Word primes on the CST and Bayes Factor Analysis further identified the data to be insensitive. Hence, the third hypothesis explored was neither rejected nor supported.

In summary, the results of Experiment 3 provide no clear support for the hypothesis that subliminal priming of positively phrased primes improves semantic working memory performance. Furthermore, no clear support was found for the third hypothesis exploring the possible differential effect between the Single-Word and Multiple-Word primes on CST performance. Such results are indicative that the subliminal primes presented in this research were unable to improve semantic working memory performance and as such, do not support past research concerning the improvement of memory performance following subliminal priming (Mitchell et al., 2002). Furthermore, this research is not consistent with findings suggesting that subliminal primes can activate a pre-existing goal that individuals are motivated to achieve (Strahan et al., 2002; see also Strahan et al., 2005). However, one possibility is that the subliminal primes presented in this research were not specific enough to activate the goal to improve working memory performance.

In previous research testing the importance of motivation for successful subliminal priming, researchers have tended to present subliminal stimuli closely related to the dependent variable they intend to influence. For example, in Strahan et al.'s (2002) drinking behaviour research they manipulated participants' thirst levels by withholding water and subliminally primed half the participants with thirst related words (e.g., thirst, dry) and the other half with neutral words (e.g., pirate, won). Similarly, in Strahan et al. (2004, as cited in Strahan et al., 2005) only participants motivated to intake more calories and primed with words related to over-eating (e.g., binge, eat) were found to consume more of the higher calorie drink. Both of these examples (see also Bermeitinger et al., 2009; Karremans et al., 2006; Veltkamp et al., 2008; Veltkamp et al., 2011) present subliminal stimuli that are directly relevant to the pre-existing goal they intend to activate and behaviour they are intended to

change. Whereas the subliminal stimuli presented in the current research, that is, *cognitive* (i.e., intelligent, I am intelligent) and *affective* (i.e., one, mommy and I are one), whilst positive, may be generic in nature. For instance, the trait of intelligence used in the cognitive-based stimuli is more directly associated to 'intelligence' than working memory per se. Whilst the Multiple-Word prime 'I am intelligent' has not been previously examined, the Single-word prime 'intelligent' was found to improve exam performance when presented alongside other semantically similar words (Lowery et al., 2007). Nevertheless, it is possible that such improved behavioural effects may have been due to other factors such as a change in revision strategy rather than memory performance. As such, the cognitive-based primes whilst focusing on the trait of intelligence that is associated with working memory (Colom, Abad, Rebollo, & Shih, 2005; Colom, Jung, & Haier, 2007; Kane, Hambrick, & Conway, 2005; Schweizer & Moosbrugger, 2004) may not have been unconsciously processed as explicitly relevant to the activated goal of improving working memory performance. Additionally, the affective-based stimuli presented may also not have been unconsciously processed as relevant to the activated goal of improving working memory performance. For instance, the Single-Word prime 'one' was newly developed for this current research and as such has not previously been found to elicit any effects on memory performance. In contrast, the Multiple-Word prime 'mommy and I are one' has been demonstrated to improve cognitive performance, although improvements were in relation to academic performance (Ariam & Siller, 1982; Hudesman et al., 1992; Parker, 1982) and not memory performance specifically. Hence, although the affective-based stimuli were positive, they may not have been sufficiently focused in terms of their content to activate the specific goal of improving working memory performance. As such, Experiment 4 will maintain the motivation

manipulation and in addition present subliminal stimuli that are specifically focused on improving memory performance. For instance, Mitchell et al. (2002) reported successful subliminal priming following the presentation of the Single-Word prime 'remember' hence, Single-Word and Multiple-Word primes inclusive of this key word i.e., 'remember' may be unconsciously processed as relevant to the goal of improving working memory, and therefore activate the goal-directed behaviour to achieve this goal.

The specificity of the subliminal stimuli is however not the only issue that might have contributed to the lack of subliminal priming effects found in Experiment 3. A second possible reason concerns the duration of the prime-target stimulus onset asynchrony (SOA). The prime-target SOA is the amount of time between the onset of the subliminal stimulus and the onset of the target information presented in the LDT (Van den Bussche et al., 2009). The prime-target SOA in the current research was shorter than the prime-target SOA period implemented in other subliminal priming and motivation studies. For example, Custers and Aarts (2005) exposed participants to subliminal primes for a brief duration of 10ms which was then followed by a backward mask (i.e., a row of Xs) for 100ms that participants were not required to attend to, producing an overall prime-target SOA of 110ms. Whereas, in the current research the subliminal primes were presented for 14ms and were immediately backward masked by the target letter strings in the LDT requiring the participant's attention, thus producing an overall prime-target SOA of just 14ms. The use of an additional backward mask serves the dual purpose of masking the subliminal stimulus and providing some additional time during which the subliminal stimuli may be unconsciously processed. Such a proposal is consistent with the view that to successfully process complex Multiple-Word subliminal primes may require a longer

processing time (Sklar et al., 2012). As such, Experiment 4 will aim to address this issue by extending the overall length of the prime-target SOA by adding an additional backward mask presented after the subliminal stimuli and prior to the LDT target word.

A final possibility is that subliminal priming may be unable to improve semantic working memory performance as measured by the CST. Hence, a second working memory task that is reliant upon the phonological loop component of working memory (similarly to the CST) but that does not require the participant to heavily process the semantic meaning of the information presented will also be examined.

To summarise, no evidence of change in semantic working memory was found following exposure to any of the experimental subliminal primes (e.g., *cognitive*: intelligent, I am intelligent; *affective*: one, mommy and I are one) despite the existence of the goal to improve working memory performance and the relevant motivation to attain that goal. In relation to the difference between the cognitive and neutral-control group performance, Bayes Factor Analysis revealed the data to be insensitive although, evidence for the null hypothesis was revealed in relation to the difference in performance between the affective and neutral-control groups. Furthermore, there was no evidence of any difference in the effect elicited between the Single-Word and Multiple-Word primes and Bayes Factor Analysis revealed the data to be insensitive, thus in conclusion, neither the second nor the third null hypotheses could be rejected or fully supported. Three issues were considered that may have accounted for this lack of subliminal priming; first the idea that the pre-existing goal to improve working memory performance was not successfully activated by the subliminal primes as they were not directly related to the goal or associated

goal-directed behaviour (i.e., memory). Second, that the prime-target SOA period of 14ms utilised in this experiment may be too brief to elicit an effect. Finally, it is possible that subliminal priming is unable to improve semantic working memory. These issues are explored further in Experiment 4.

Chapter Seven: Experiment 4 - Comparing Memory-Specific Subliminal Single-Word and Multiple-Word Primes on Working Memory Performance

Introduction

Findings from Experiment 3 revealed no significant improvement in semantic working memory performance following exposure to subliminal Single-Word (*cognitive*: intelligent; *affective*: one) or Multiple-Word (*cognitive*: I am intelligent; *affective*: mommy and I are one) primes despite participants' increased motivation to attain the goal of improving their working memory performance. Improved performance over time suggested a simple practice effect and additional Bayes Factor Analyses indicated the data to be insensitive towards the alternative hypotheses. Following the non-significant results of the orthodox statistical analysis, and the insensitivity generated from Bayes Factor Analysis, a number of issues were considered as potential explanations for the lack of any positive change following exposure to the subliminal stimuli. For instance, it is possible that the 'general' content of the subliminal primes used in the previous experiments was insufficient to activate the goal-directed behaviour needed to improve working memory specifically. Alternatively, there may have been insufficient time for the subliminal primes to be adequately processed in order to elicit any effect. A further possibility is that participants' performance on the Conceptual Span Task (CST; semantic working memory) may not be susceptible to change using subliminal priming. Each of these issues are discussed in more detail below.

Fitzsimons and Bargh (2003) suggest that behavioural goals can be activated unconsciously when using subliminal stimuli relevant to the goal itself. For instance,

in Strahan et al.'s (2002) research the subliminal prime words presented (e.g., 'thirst' and 'dry') were specific to the participants' goal with regard to quenching their thirst. Thus, when the primes were presented subliminally, they were thought to activate the goal-directed behaviour of reducing the individual's thirst. In Experiment 3 of the present thesis, whilst the participants were motivated to attain the goal of improving their working memory performance, the subliminal primes presented e.g., *cognitive* (i.e., intelligent, I am intelligent) and *affective* (i.e., one; mommy and I are one), were not directly associated to the goal itself. As such, they may have been insufficient to activate the goal and elicit the behaviour required to achieve an improvement in working memory performance. Such an idea would be consistent with the research of Mitchell et al. (2002) who reported successful subliminal priming of memory performance following the presentation of the Single-Word primes 'remember' and 'forget'. More specifically, they found that recollection of target stimuli followed by the subliminal Single-Word prime 'remember' was better than for items followed by the subliminal prime 'forget'. Whilst Mitchell et al. (2002) only tested Single-Word primes it is clear that the key word 'remember' is positively associated with memory improvement. As such, given that no change in working memory performance was elicited following exposure to intelligence-based and affective-based primes in Experiment 3, it may be that by changing the content of the primes to focus more on memory, utilising the key word 'remember', an effect on semantic working memory performance may be found. The inclusion of this key word in both subliminal Single-Word and Multiple-Word primes may be more likely to be unconsciously processed as relevant to the goal of improving working memory performance and therefore, enable the activation of such goal-directed behaviour. Hence, Experiment 4 shifts the focus of the subliminal primes from general positive stimuli (i.e., *cognitive*:

intelligent, I am intelligent; *affective*: one, mommy and I are one) to become more task-relevant and ‘*memory-specific*’ (e.g., remember, I can remember well).

A second issue that may have hampered the success of the subliminal stimuli presented in Experiment 3 was the possible lack of time for the individual to unconsciously process the subliminal stimuli. For instance, Sklar et al. (2012) have advocated the need for longer exposure durations in order for participants to unconsciously process subliminal stimuli, especially when dealing with more complex Multiple-Word primes. The previous experiments reported in this thesis presented the subliminal Single-Word and Multiple-Word primes for a duration of 14ms (after; Custers & Aarts, 2007; Dijksterhuis et al., 1998; Pichon et al., 2007; Wentura & Frings, 2005) and furthermore, the primes were immediately backward masked by the target stimuli from the lexical decision task (LDT), for which the participants were required to make a word/non-word decision. This procedure produces a short prime-target stimulus onset asynchrony (SOA), i.e., the amount of time between the onset of the subliminal stimulus and the onset of the lexical decision target stimulus the participant is required to respond to (Van den Bussche et al., 2009). Previous research has extended the prime-target SOA by applying an additional backward mask (e.g., between the subliminal prime and the target stimulus in the LDT) that was not relevant for the participant to respond to. For example, Strahan et al. (2002) presented participants with subliminal prime words for 16ms during a LDT that were immediately backward masked by a row of Xs for 102ms thus, producing an overall prime-target SOA of 118ms.

Currently there is no agreed upon duration for the prime-target SOA in subliminal priming experiments. Past research implementing the traditional backward masking procedure has reported successful subliminal priming following a range of

different prime-target SOA durations. For instance, 48-50ms (Custers & Aarts, 2007 Experiment 1; Radel et al., 2009), 100-250ms (Aarts et al., 2005; Aarts et al., 2007 Experiment 1; Custers & Aarts, 2005; Veltkamp et al., 2011), 300-550ms (Aarts et al., 2007 Experiment 2; Custers & Aarts, 2007 Experiment 2; Dijksterhuis & Smith, 2002; Dijksterhuis et al., 1998 Experiment 3; Karremans et al., 2006; Pichon et al., 2007), and 1020ms (Veltkamp et al., 2008). Nevertheless, due to the combination of the minimal exposure duration for the subliminal stimuli and the immediate backward masking using the LDT target letter strings in the current research, it is possible that the participants had insufficient time to adequately process the information as relevant. It is imperative for subliminally presented information to be processed as relevant to an existing goal to enable the activation of goal-directed behaviour (Aarts et al., 2005; Bermeitinger et al., 2009). Thus, subliminally presented information is more likely to be processed as relevant to the goal if unconscious processing is afforded a greater length of time with which to process the information (Sklar et al., 2012) before the participant is required to engage with other external task demands (e.g., LDT word/non-word decisions). Therefore, extending the prime-target SOA duration provides a longer duration for unconscious processing of the subliminal stimuli and this in turn may increase the likelihood of a behavioural response. Hence, in Experiment 4, an additional backward mask will be presented immediately after the subliminal stimuli and before the presentation of the LDT target letter string to extend the prime-target SOA duration whilst maintaining the traditional backward masking technique used in the previous experiments of this research.

One further possibility for the null results reported in Experiment 3 is that subliminal priming may be unable to improve semantic working memory performance. Semantic working memory performance, as measured using the CST,

was originally examined alongside a range of other cognitive measures i.e., Stroop Colour-Naming Task (selective attention), General Knowledge Test (intelligence); and affective measures i.e., SV-POMS (explicit mood) and SAS (state anxiety) in Experiment 1. Results from the post hoc tests for the CST in Experiment 1 indicated that participants who received positive content subliminal stimuli (e.g., *cognitive*: intelligent, I am intelligent; *affective*: one, mommy and I are one) significantly improved the number of words correctly recalled following subliminal stimulation compared to those who received the *neutral-control* (e.g., walking; people are walking) subliminal stimuli (see Figure 6, p. 111). However, the results from Experiment 2 and 3 failed to replicate this pattern and instead, only showed evidence of a practice effect. Thus, the question of whether positive content subliminal stimuli are able to improve semantic working memory performance remains unclear. Nevertheless, it would of course be very unlikely for the subliminal stimuli presented in this research to improve semantic working memory performance if participants' performance on the CST prior to subliminal stimulation was already at ceiling. However, the findings from Experiment 2 (see Table 20, p. 164) and Experiment 3 (see Table 25, p. 194) showed that participants' performance on the CST *did* improve over time, but that no interaction was found in relation to subliminal priming group. Additionally, previous research examining the CST has reported accuracy performance ranges from 58.95% (Haarmann et al., 2003) to 81.6% (Vernon et al., 2003). As such, performance on the CST task (Time 1) from the current research (i.e., ranging from 44.04%, Experiment 2 to 50.3%, Experiment 1) does not indicate that a possible ceiling effect had been reached.

As it is clear that participants' performance on the CST is not at ceiling, it is instead possible that subliminal priming is unable to improve general memory

performance. However, research has previously reported that subliminal priming has influenced performance on a range of different memory tasks, including the immediate recollection of just learnt information (Mitchell et al., 2002; DeVaul & Pentland, 2002; DeVaul et al., 2003; see also DeVaul, 2004 for further detail), auditory recall (Levy, 1996), photo recall (Levy, 1996; Levy & Leifheit-Limson, 2009; Stein et al., 2002), and free recall (Hess et al., 2004). However, the CST examined in the current research provides a measure of semantic working memory performance. Given that working memory is considered to be more complex than just short-term memory of information because it involves both online cognition and concurrent manipulation of information (see Baddeley, 1992; Baddeley & Logie, 1999), it is possible that subliminal priming is unable to elicit a change in working memory performance. Past research examining the effect of subliminal priming on working memory performance has been limited. However, there is some evidence to suggest that some aspects of working memory may be susceptible to subliminal priming.

In one experiment it was reported that elderly participants performance on a dot location task (Huttenlocher, Hedges, & Duncan, 1991)⁷⁰ was positively and negatively influenced following exposure to age-positive and age-negative subliminal primes respectively (Levy, 1996). Such a task is explained to utilise visual-spatial working memory and specifically taps into spatial coding in short-term memory (Fitting, Wedell, & Allen, 2005). However, such findings should be viewed with caution as Stein et al. (2002), failed to replicate the effects in a later experiment. Nevertheless, despite the inconsistency in the literature there is at least some evidence

⁷⁰ Participants are presented with seven dots on a grid for a duration of 10 seconds and once removed they are required to reproduce the location of the dots on an empty grid using nine dots provided.

(e.g., Levy, 1996) to suggest that working memory performance might be susceptible to subliminal priming.

However, the type of working memory performance examined in past research differs from the type of working memory assessed in the current research. In the working memory model, the central executive is thought to have two slave systems i.e., a visuo-spatial sketchpad that processes visual, spatial, and kinaesthetic information, and a phonological loop, explained to process verbal and acoustic information (Baddeley, 1992, 2000). As such, the spatial coding performance examined by Levy (1996) and Stein et al. (2002) is reliant upon the visuo-spatial sketchpad component of working memory, whereas performance on the CST is more reliant upon the phonological loop. Whilst the research undertaken for this thesis represents an extension to the field in the sense this is the first time that subliminal priming has been examined on this type of working memory; it is possible that subliminal priming may be unable to influence working memory that is reliant on the phonological loop. The phonological loop component of the working memory system is considered to have three different sub-components: the phonological store, the articulatory loop (Baddeley, 1992, 2000), and a semantic short-term memory (Haarmann & Usher, 2001; Haarmann et al., 2003). Each of the three sub-components plays a different role. For instance, the phonological store is the first storage system that holds verbal and speech-like information for a limited time, the articulatory loop is akin to subvocal speech and is used to process and transfer written information into the storage systems (Baddeley, 1992, 2003) and finally, semantic short-term memory is considered to be a second storage system that holds word meanings (Haarmann et al., 2003). As such, the CST is likely to utilise all three of these sub-components, as it requires the transfer of information, the storage of that information in memory and

additionally accessing the meaning of that information. Furthermore, it is possible that utilising all three sub-components may make the task more difficult, especially when a deeper level of processing is required (Craik & Lockhart, 1972). Such a notion is speculative, as the possible moderating effect of task difficulty has not been examined on subliminal priming, although previous research on conscious priming effects has shown that task difficulty can moderate the effects of priming (see Schacter, Cooper, & Delaney, 1990) and, as such, task difficulty may well moderate the effects of subliminal priming. With this in mind, a second working memory task (i.e., the Automated Operation Span Task, AOSPAN; Unsworth, Heitz, Schrock, & Engle, 2005) was examined alongside the CST that was reliant upon the phonological loop aspect of working memory, but does not require the use of all three sub-components, and as such, may be considered less difficult than the CST.

The AOSPAN task presents different letters between maths problems and requires the individual to recall the letters in their serial order (Unsworth et al., 2005). Therefore, the participant should transfer the letters using subvocalisation (articulatory loop) to the phonological store and maintain the order of these letters using subvocal repetition. As such, whilst the AOSPAN task does require the processing of written information, it does not require the participant to process the semantic meaning of such information heavily. As such, the AOSPAN task is similar to the CST in that it represents a measure of working memory performance that is reliant upon the phonological loop, but is distinguishable from the CST, as it does not heavily utilise the semantic short-term memory sub-component. Whilst there is a number of working memory tasks available in the literature, the AOSPAN task was chosen for a number of logistical reasons as it is easier to administer (i.e., computerised) compared to more classic working memory tasks (e.g., Operation Span

Task, OSpan; Turner & Engle, 1989), has high internal consistency ($\alpha = .78$), and holds a good test-re-test reliability (.83) (Unsworth et al., 2005).

In summary, Experiment 4 will again utilise the motivation manipulation to enhance participants' motivation to achieve the goal of improving their working memory. It will also alter the content of the subliminal stimuli from the general '*cognitive*' (i.e., intelligent, I am intelligent) and '*affective*' (i.e., one, mommy and I are one) primes to the '*memory-specific*' Single-Word (i.e., remember) and Multiple-Word (i.e., I can remember well) primes. Furthermore, the inclusion of an additional backward mask presented for 500ms (after; Aarts et al., 2007; Dijksterhuis & Smith, 2002; Dijksterhuis et al., 1998 Experiment 3; Karremans et al., 2006; Pichon et al., 2007) will be used to extend the prime-target SOA period from 14ms to 514ms. Finally, the experiment included a second working memory task (i.e., AOSPAN task; Unsworth et al., 2005). These refinements led to Experiment 4 testing three hypotheses (see Table 27, p. 215).

Table 27

The Hypotheses Tested in Experiment 4

Hypothesis	Prediction
H₁	Participants reported motivation to improve their working memory performance would significantly increase following the motivation enhancement strategy.
H₂	The <i>memory-specific</i> subliminal stimuli (i.e., remember, I can remember well) would produce significant improvements on working memory performance as measured by the CST and the AOSPAN task in comparison to subliminally presented <i>neutral-control</i> stimuli (i.e., walking, people are walking).
H₃	A differential prime type effect would be produced between the <i>Single-Word</i> prime (i.e., remember) and <i>Multiple-Word</i> prime (i.e., I can remember well) on working memory performance.

Method

Participants

Eighty-three⁷¹ students were recruited to participate in this experiment in return for course credit. The sample consisted of 68 females and 15 males that ranged from 18 to 38 years of age ($M = 19.21$, $SD = 2.43$). Recruitment was as outlined in Chapter 3 (p. 62).

⁷¹ Originally 85 participants took part in Experiment 4 however, one participant was removed due to technical issues with the computer that interfered with the presentation of the subliminal primes, and a second was removed for possible conscious awareness of the subliminal stimulus (see 7.7 *Threshold Testing*, p. 239)

7.1 Allocation to Subliminal Stimulus Group

Participants were allocated to one of the four subliminal stimuli groups meaning that each participant was shown only one of the four potential messages. Allocation was conducted to ensure an even number of participants were exposed to each subliminal stimulus. A Latin Square arrangement was utilised to ensure the rotation of subliminal stimuli conditions was even across other counterbalanced aspects of the experiments e.g., order of the CST. The first participant was randomly assigned to one of the subliminal stimulus conditions using a random number generator (<http://www.random.org/>) and each participant thereafter was assigned according to the Latin Square rotation.

Materials

Three tasks were performed during Experiment 4; the Conceptual Span Task (CST; as outlined in Chapter 3, p. 70), the Automated Operation Span Task (AOSPAN) and the Lexical Decision Task (LDT).

7.2 Automated Operation Span Task (AOSPAN)

The AOSPAN task (Unsworth et al., 2005) measures the general performance of the phonological loop component of working memory and requires participants to remember letters interspersed between simple mathematical problems. Additionally the participants are required to recall the letters in their serial order (i.e., the order they were presented; Unsworth et al., 2005). The AOSPAN task was adapted by Unsworth et al. (2005) to present letters instead of words, and by using programmed computer software to set a time limit individually for each participant to account for individual differences in the time taken to solve the maths operations (Unsworth et al.,

2005). Performance on the AOSPAN task is assessed using three measures. The first calculates participants' absolute AOSPAN score i.e., the number of complete letter-sets correctly recalled; the second calculates their serial recall score i.e., the number of correctly recalled letters in their correct position; and the third calculates the number of operation errors (i.e., maths errors) made.

The AOSPAN task was entirely controlled by the participant using the mouse and consisted of three different practice rounds and the main recorded trials. The first practice round focused on serial letter recall. Participants were presented with two sets of two letters (e.g., F, P; and Q, J) and one set of three letters (e.g., S, N, R) to recall. During the letter-set each letter was presented on screen for 800ms and after all letters had been shown a recall screen presenting a three by four letter grid of 12 letters (e.g., F, H, J, K, L, N, P, Q, R, S, T, and Y) was provided. Participants were told to click on the letters in the grid to select the ones they were just shown in the order they were presented. The recalled letters appeared at the bottom of the screen after they had been clicked, and if they could not remember one or more of the letters they were instructed to indicate its position in the string by clicking on the word 'blank' (e.g., S _ R) and if they needed to erase all letters and start again they clicked the word 'clear'. No time constraint was given for this recall stage and upon completion participants clicked on the word 'exit'. Feedback on serial recall performance was then provided whereby participants were informed how many letters they correctly recalled in their correct position (e.g., "You recalled 3 out of 3 correctly"). The second practice round introduced participants to the mathematics portion of the AOSPAN task and set the time limit for the maths problem presentation in the third maths and letter practice round and main recorded trials. The maths problem practice consisted of 15 simple maths operations (e.g., $(3 * 2) - 1 = ?$). Participants were

instructed to mentally solve the maths problem as quickly as they could and click the screen to move forward. Next participants were presented with a possible answer to the maths problem in number format with the words 'true' and 'false' beneath it. Participants clicked on the appropriate word depending on the answer of the preceding maths problem. For example, for the problem $(3 * 2) - 1 = ?$ if the number presented was '4' the participant should click on the word 'false' as the correct answer to the maths problem is five. Feedback on participants' performance (e.g., 'correct' or 'incorrect') was then presented at the bottom of the screen for 1000ms in blue. The time limit for the presentation of maths problems in the third maths and letter practice round and recorded trials were set to each participant's mean time to mentally solve the maths problems plus 2.5 standard deviations to "account for individual differences in the time required to solve maths operations" (Unsworth et al., 2005, p.500). The final maths and letter practice round served to emulate the recorded trials of the AOSPAN task. Participants were required to perform both serial letter recall *and* solve the maths operations. Participants were given the maths problem to mentally solve first then clicked the screen to move on to the true/false question. Participants answered the true/false question depending on the correct answer of the preceding maths problem and were then presented with a letter for 800ms. The maths problem remained on screen for their individually calculated time limit, if the participant took longer than this time limit the computer automatically 'timed out' and moved on to the letter presentation screen, and that maths problem was counted as an error. Participants completed two practice rounds of set sizes two and four e.g., two maths problems and two letters to remember. At the end of each set of maths problems and letters, participants were presented with the three by four letter grid and asked to click on the letters to indicate the letters presented in the preceding

set in the order they were presented. As in the serial recall practice round, letters appeared at the bottom of the screen and participants were instructed to use the words 'blank' and 'clear' when necessary, and to click the word 'exit' when satisfied with their letter selection in order to receive their performance feedback. Participants were provided with feedback for the number of correctly solved maths operations and recalled letters from that letter-set. They were also shown a red percentage score in the top right hand corner of the feedback screen which indicated their overall percentage of correctly solved maths operations across all sets completed up until that point, and they were told that they should aim to keep this score at 85 per cent or higher otherwise their data would not be useable. On completion of the final maths and letter practice round participants began the main recorded trials of the AOSPAN task. The procedure of the recorded trials was the same as the previous maths and letter practice round and consisted of three sets of each set size i.e., three sets of size three, four, five, six, and seven maths problems and letters, equalling a total of 75 maths problems and 75 letters. The order of these set sizes was randomly generated for each participant.

All written explanations provided on the information screens and the instructions provided on the letter recall and maths operation screens were presented in black, Courier New, point size 18 font. The letters in the letter grid, recalled letters and the words 'blank', 'clear', and 'exit' on the letter recall screen were presented in the same point size and font with additional bold font style. Instructions provided on all feedback screens (serial recall practice, maths and letter practice round, and main recorded trials) were presented in black Courier New, point size 24 font. Feedback on serial letter recall (serial recall practice; main recorded trials) and maths performance (maths and letter practice; main recorded trials) as well as the maths operations,

possible answers and the words ‘true’ and ‘false’ were presented in black, Courier New point size 30 font with bold style. The letters presented in the serial recall practice, maths and letter practice, and main recorded trials were presented in black, Courier New font with bold style. Finally, the maths practice feedback and maths percentage (maths and letter practice; main recorded trials) were presented in Courier New, point size 30 font with bold style in blue (EPrime RGB: 0, 0, 225) and red (EPrime RGB: 255, 0, 0) colour respectively. Additionally, each letter in the letter grid, and the words ‘blank’, ‘clear’, ‘exit’, ‘true’ and ‘false’ were outlined with a thin black line border with a width of 1 pixel. All information was presented on a white background. See Figure 15 for a diagram of the AOSPAN main task trial (p. 221).

7.3 Lexical Decision Task (LDT)

The LDT was altered in comparison to previous experiments (Experiments 1-3). The LDT⁷² continued to be used primarily to present the subliminal stimuli at 14ms once during each of its 30 trials. The aesthetics of the subliminal stimuli e.g., capital letters, point size, font type, font style, colour and position on screen remained the same as that outlined in Chapter 3 (3.2.5.2 *Lexical Decision Task LDT*, p. 74). The alteration of the LDT consisted of increasing the prime-target SOA. Subliminal stimuli presented in Experiment 4 were backward masked by a string of 19 Xs. The backward mask was presented in capital letters using black Courier New font, point size 70 and bold typeface to match the fixation cross and LDT target letter strings.

⁷² Data from the LDT was analysed however, results did not any yield significant interactions between time and prime type, or time and content of subliminal stimuli in response time and error data, and thus results are not reported.

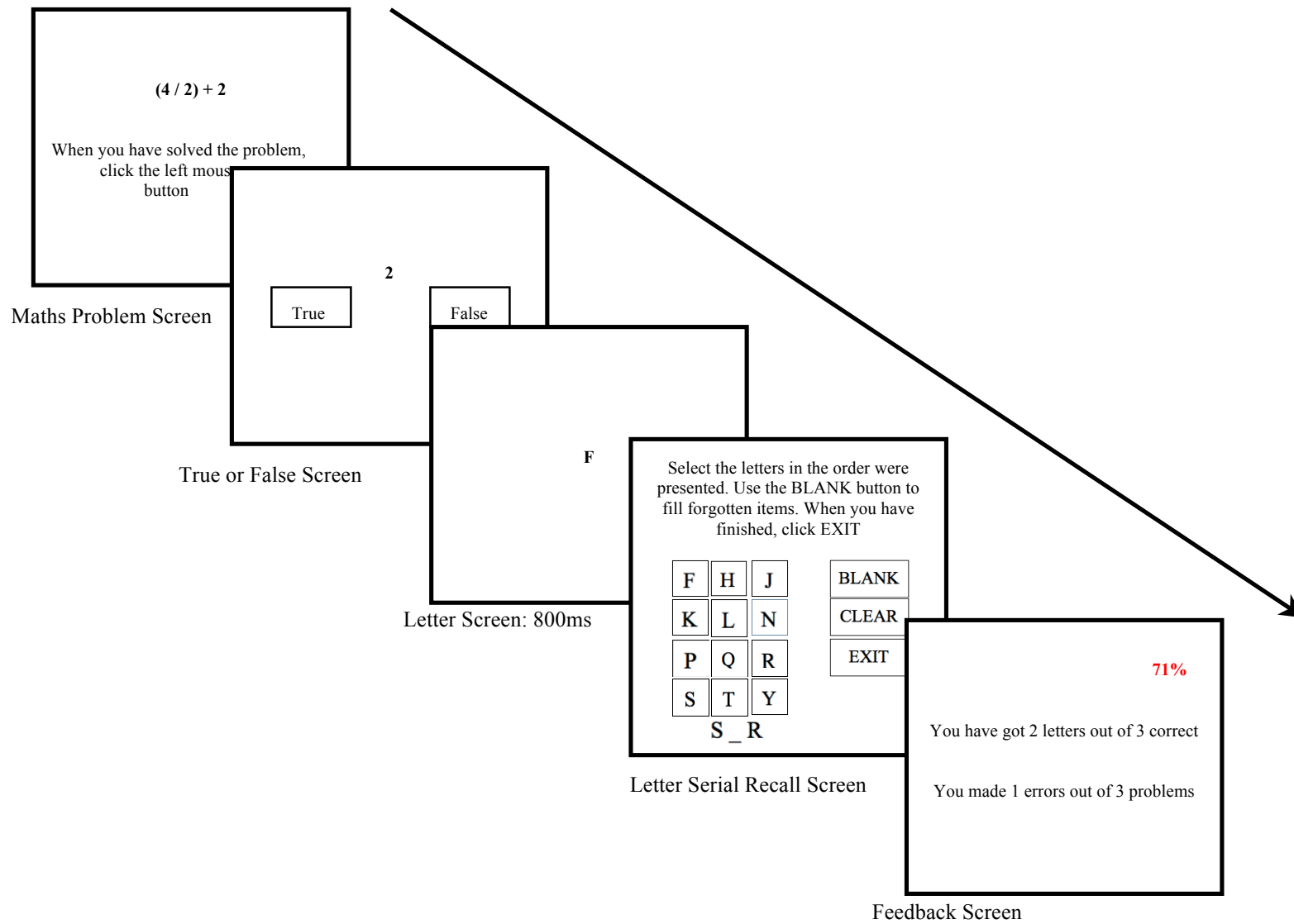


Figure 15: Trial procedure for the Automatic Operation Span main task.

The length of the backward mask was chosen for its suitability in masking the longest of the subliminal Multiple-Word primes (e.g., I can remember well) and remained on screen for 500ms extending the prime-target SOA from 14ms to 514ms. Following the backward mask a target letter string was presented and participants were instructed to make a word/non-word decision using button presses on the Cedrus Response Pad provided. The target letter strings presented and participants' instructions for the LDT were the same as outlined in Chapter 3 (see Figure 16, for a diagram of Experiment 4's LDT task, p. 223).

The CST and the AOSPAN were completed twice, once before the LDT and again after the LDT. The LDT was primarily used to present the subliminal stimuli, however, in Experiment 4 only four (instead of six) subliminal stimuli were presented; two Single-Word primes and two Multiple-Word primes. Two of the subliminal primes were *memory-specific* (e.g., *Single-Word*: remember; *Multiple-Word*: I can remember well) and the remaining two were the *neutral-control* primes (*Single-Word*: walking; *Multiple-Word*: people are walking). In addition to these two tasks, participants completed a short nine to 13 question 'motivation and memory questionnaire' three times during the experiment. The questionnaire was used to indicate how motivated participants were to improve their working memory performance, whereby participants rated the amount of effort they were willing to give to improve their working memory on a scale from zero to 100 percent, and secondly to rate how well the article they were given to read highlighted the benefits of working memory (Time 2: Post-Enhancement only). In accordance with the experiment's cover story the questionnaire also included filler questions concerning the participants' perception of their memory performance, motivation orientation

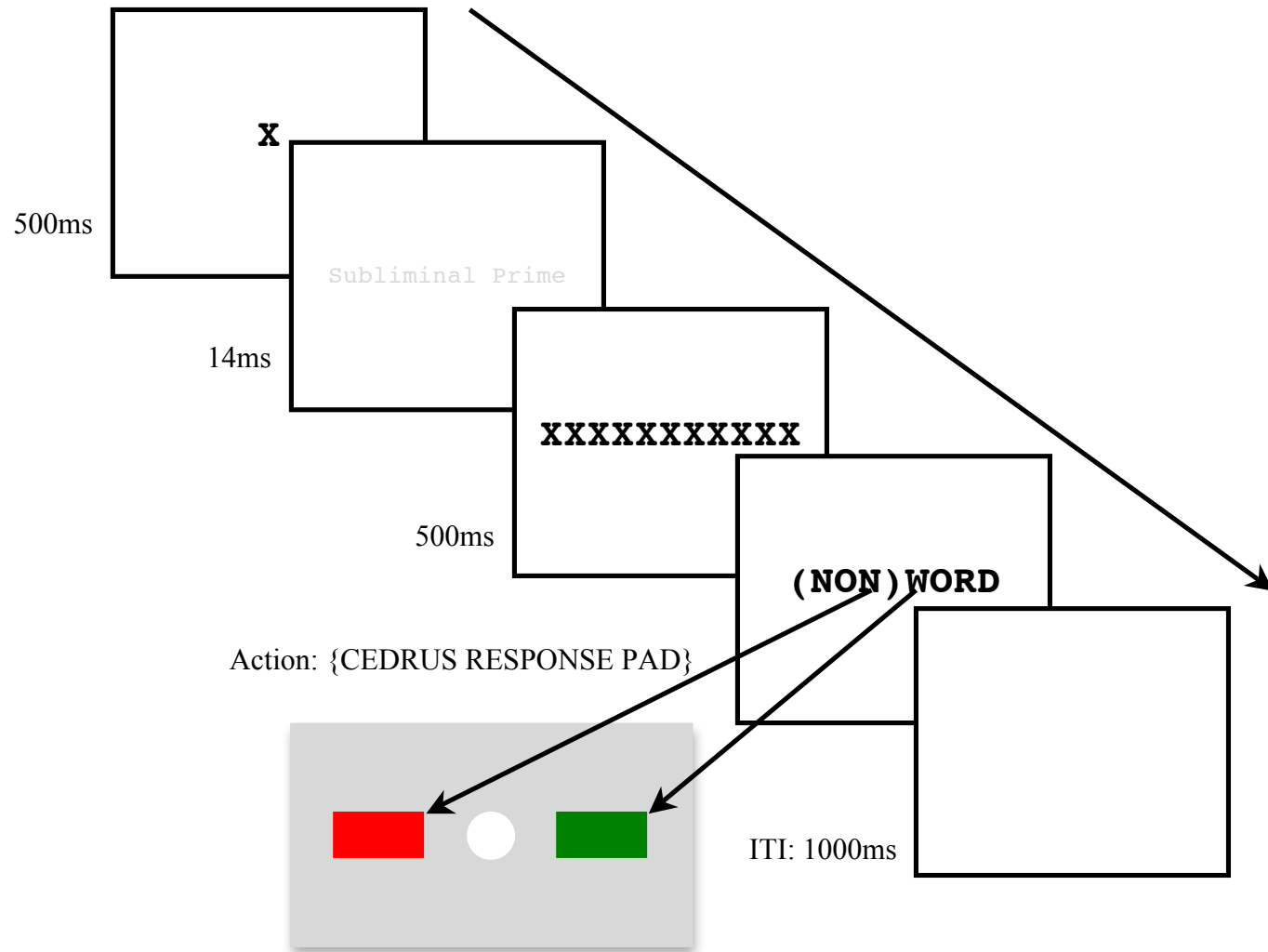


Figure 16: Trial procedure for the Lexical Decision Task used in Experiment 4.

(Time 1: Baseline only), and general interest to participate in the experiment as outlined in Chapter 6 (p.183-185).

Finally, a printed extract from a false article advocating the benefits of working memory (Appendix M, p. 371) was given to participants to read during the experiment as part of the motivation enhancement strategy and was the same as that described in Chapter 6 (p. 178). All other equipment and materials relevant to the experiment are as outlined in Chapter 3.

Procedure

The procedure of Experiment 4 was split into nine stages e.g., *Stage I* ‘informed consent’, *Stage II* ‘motivation and memory time 1’, *Stage III* ‘dependant measures time 1’, *Stage IV* ‘motivation enhancement strategy’, *Stage V* ‘motivation and memory time 2’, *Stage VI* ‘subliminal stimulation’, *Stage VII* ‘dependant measures time 2’, *Stage VIII* ‘motivation and memory time 3’, and *Stage IX* ‘debrief’. Each stage is outlined below.

Stage I: At the outset of the experiment participants were welcomed, seated at a desk and asked to read through the participant information sheet provided (Appendix S, p. 386). This gave an outline of the procedure of the experiment and participants gave informed consent by completing the screening and consent forms as outlined in Chapter 3 (p. 62).

Stage II: Participants completed the first short motivation and memory questionnaire (Time 1: Baseline; Appendix P, p. 379) as outlined in Chapter 6 (p. 183) to provide an initial indication of the percentage of effort they were willing to give to improve their working memory performance using a 10-point scale from zero to 100 per cent.

Stage III: Participants then completed the dependant measures e.g., the CST and AOSPAN (Time 1) the order of which was counter-balanced⁷³. The CST was completed as outlined in Chapter 3 (3.3.1 *Conceptual Span Task*, p. 75), and the AOSPAN task was entirely controlled by the participant using the mouse. Participants completed all three of the practice rounds of the AOSPAN before completing the recorded trials. Before each practice round a series of instruction screens were presented to explain the task and participants were encouraged to ask questions. Following the practice rounds, participants were shown further instruction screens to indicate the beginning of the recorded trials. They were reminded of their task aims i.e., to recall the letters presented in their serial order and to keep their maths solving performance at 85 per cent or higher. They were also reminded that feedback would be provided throughout the task to help them achieve these targets. After completion of the task participants were shown a final information screen to indicate the end of the task and to await further instruction from the experimenter.

Stage IV: To create the goal to improve working memory performance and enhance participants' motivation to achieve this goal a two-fold motivation enhancement strategy was employed as outlined in Chapter 6 (p. 184), although, false-positive feedback was only provided on the CST as participants' correct performance feedback was provided as part of the AOSPAN task.

Stage V: Participants were asked to complete the second motivation and memory questionnaire (Time 2: Post-Enhancement; Appendix Q, p. 382) used to assess any changes in the degree of effort they were willing to give to improve their working memory performance and how highly they rated the article at highlighting the usefulness of a proficient working memory.

⁷³ Forty-three participants completed the CST first and AOSPAN task second, and the remaining 42 participants completed the AOSPAN task first and the CST second.

Stage VI: Upon completion of the motivation and memory questionnaire, participants completed the LDT during which they were exposed to thirty presentations of their subliminal prime.

Stage VII: The LDT was immediately followed by the second attempt at the CST and AOSPAN tasks (Time 2) the order of which was again counter-balanced. The presentation order of the CST was counter-balanced across participants from Time 1 to Time 2⁷⁴, and the different set sizes of the AOSPAN task were presented in a randomised order.

Stage VIII: Participants were then asked to complete the last motivation and memory questionnaire (Time 3: Final; Appendix R, p. 384) to check whether their motivation e.g., percentage of effort, had changed after the motivation enhancement strategy.

Stage IX: Finally, after completing all the tasks, participants were debriefed using a funnel styled questionnaire as outlined (Appendix T, p. 387) to assess participants' level of subjective and objective awareness to subliminally presented stimuli (see Chapter 3; 3.2.4 *Subliminal Threshold Checks*, p. 72). See Figure 17 for a diagram of Experiment 4 procedure (p. 227).

⁷⁴ Forty-two participants completed CST A first and CST B second and 43 participants complete CST B first and CST A second.

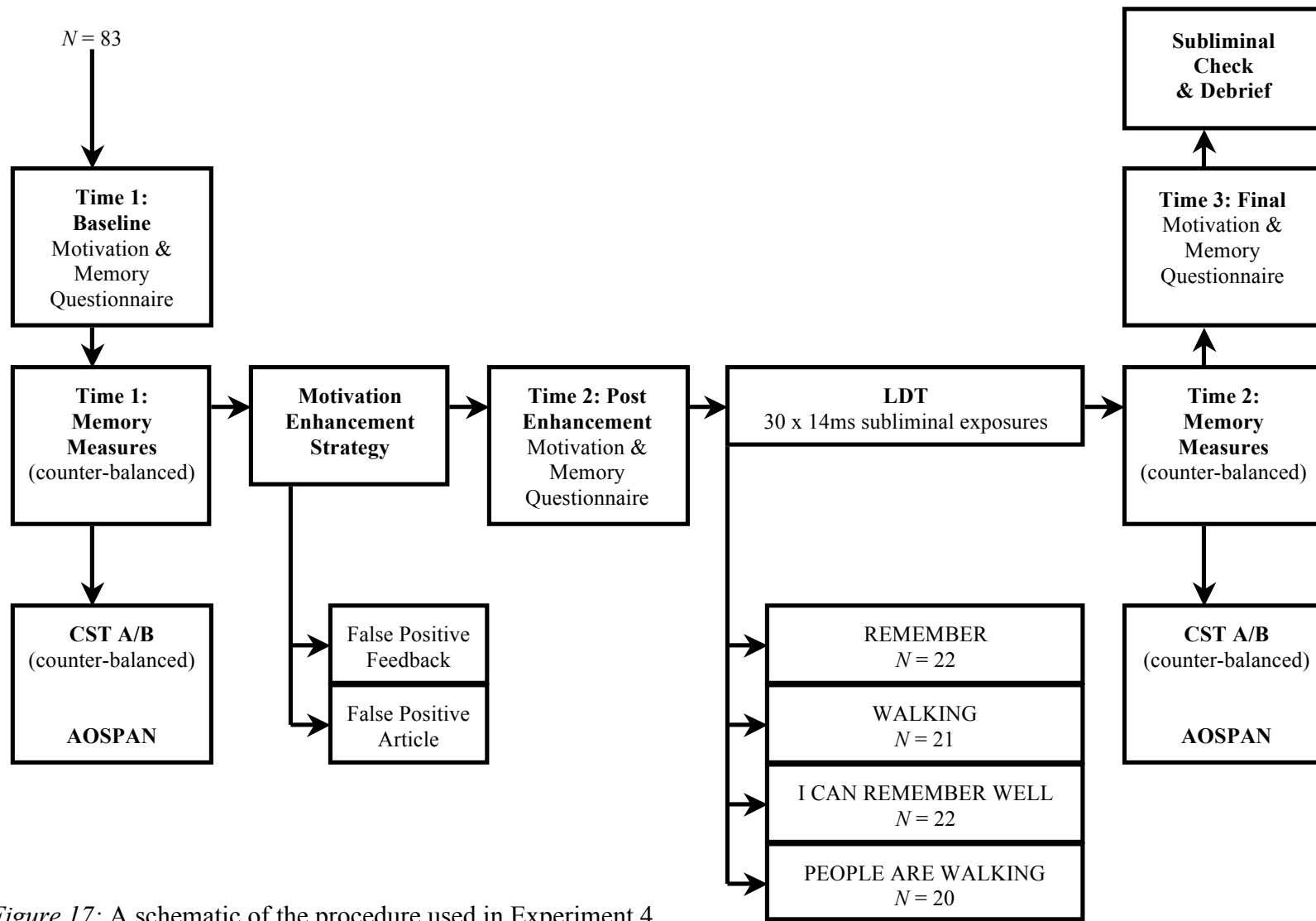


Figure 17: A schematic of the procedure used in Experiment 4.

Design

Experiment 4 utilised a 2 (Time: *Time 1* vs. *Time 2*) x 2 (Prime Type: *Single-Word* vs. *Multiple-Word*) x 2 (Prime Content: *Memory-Specific* vs. *Neutral-Control*) mixed design, with Time as a within-participants factor of two levels, and both Prime Type and Prime Content as between-participants factors both with two levels. The independent variables were the manipulation of stimuli Prime Type (Single-Word Prime vs. Multiple-Word Prime), and Prime Content (Memory-Specific vs. Neutral-Control). The dependant measures were the participants' accuracy (i.e., number of correctly recalled words) and intrusions (i.e., number of incorrectly recalled word) performance on the CST, and participants' absolute AOSPAN score (i.e., total of correctly recalled letter-sets), serial letter recall (i.e., number of letters recalled in their correct position) and number of maths operation errors (i.e., number of incorrectly answered or timed out maths problems) performance on the AOSPAN task.

Results

Data from the CST and the AOSPAN were analysed separately using a 2 (Time: *Time 1* vs. *Time 2*) x 2 (Prime Type: *Single-Word Prime* vs. *Multiple-Word Prime*) x 2 (Prime Content: *Memory-Specific* vs. *Neutral-Control*) mixed analysis of variance (ANOVA). Time was a within participants factor, and Prime Type and Prime Content were both between participants factors. In the eventuality of non-significant CST or AOSPAN⁷⁵ results, Bayes Factor analysis was conducted to assess whether data provides support for the alternative or null hypotheses, or whether the data were insensitive. Data from all measures are reported below.

⁷⁵ Bayes Factor Analysis was only calculated on CST accuracy data and calculated on AOSPAN absolute and serial recall data as experimental hypotheses were related to memory improvement.

7.4 Motivation

The amount of effort participants were willing to give to improve their working memory performance was measured on a scale from zero to 100% and was analysed using a repeated measures one-way ANOVA with a single factor of Effort compared across three time intervals with planned comparisons made between Time 1 and Time 2 and between Time 2 and Time 3.

7.4.1 Effort Percentage

The mean and the standard deviation (*SD*) of the percentage of effort participants specified they would be prepared to give to improve their working memory performance from each of the three questionnaires are provided in Table 28 (below). Higher percentages indicate a higher degree of motivation to improve working memory performance.

Table 28

Mean and SD Scores for the Percentage of Effort (Motivation) at Time 1, Time 2 and Time 3

	<u>Percentage of Effort</u>	
	Mean	<i>SD</i>
Time 1	71.08	17.39
Time 2	76.39	14.86
Time 3	76.39	15.51

Mauchly's test indicated that the assumption of sphericity was violated, $\chi^2(2)=10.990, p=.004$, hence the degrees of freedom were corrected using the Huynh-Feldt

estimate of sphericity ($\epsilon = .906$). The analysis showed a main effect of Effort, $F(1,811)=25.613, p<.001, MSE=33.518, \eta^2_p=.238$ (see Figure 18, below). Simple planned comparisons revealed an increase in motivation from Time 1 to Time 2 (71.08 and 76.39 respectively; mean difference=-5.301, $SE = .863, p<.001$). Although, no significant difference was found between Time 2 and Time 3 (76.39 and 76.39 respectively; mean difference=.000, $SE=.707, p=.1$).

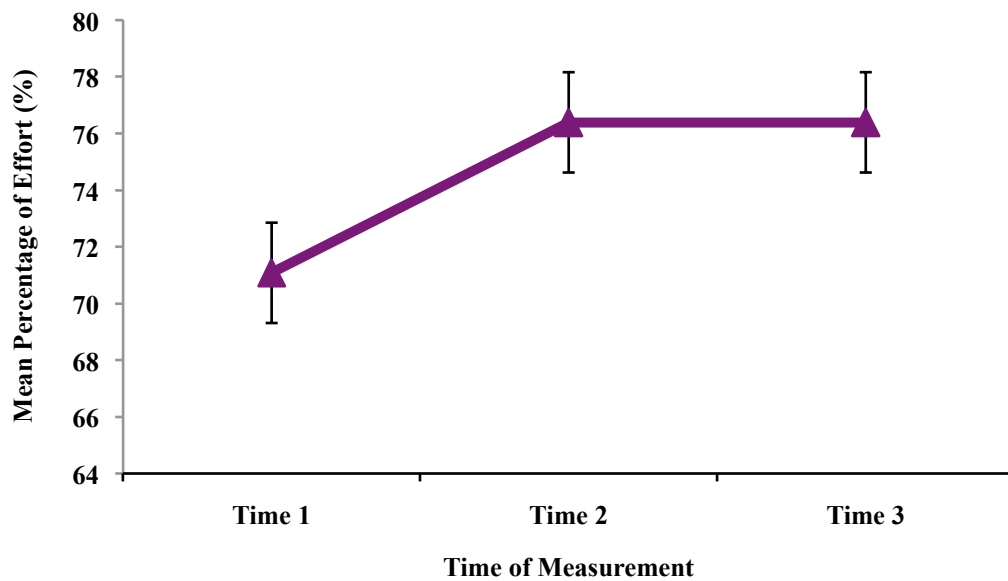


Figure 18: Showing the change in mean percentage of effort (with standard errors) from Time 1 to Time 3.

7.5 Conceptual Span Task (CST)

Accuracy (i.e., the number of words correctly recalled) and intrusion (i.e., the number of words incorrectly recalled) data were analysed separately and are reported below.

7.5.1 CST Accuracy

Mean accuracy scores (i.e., the number of correctly recalled words), and standard deviations (*SD*) for each condition are provided in Table 29 (below). Higher scores indicate more words correctly recalled.

Table 29

Mean and SD Scores for CST Accuracy at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	<i>SD</i>	Mean	<i>SD</i>
Single-Word	Memory	28.50	7.49	32.00	8.49
Single-Word	Neutral	31.75	7.69	34.90	5.51
Multi-Word	Memory	29.00	6.32	34.50	6.72
Multi-Word	Neutral	28.81	7.83	33.05	7.12

Note: Mean represents the number of correctly recalled words on the CST from a total of 63.

Analysis of the mean accuracy scores revealed a main effect of Time, $F(1,79)=35.738, p<.001, MSE=19.461, \eta^2_p=.311$, whereby participants' recall accuracy improved from Time 1 to Time 2 (29.48 and 33.57 respectively).

All other analyses which included: Prime Type, $F(1,79)=.098, p=.755, MSE=84.972, \eta^2_p=.001$, Prime Content, $F(1,79)=.619, p=.434, MSE=84.972, \eta^2_p=.008$, Time x Prime Type, $F(1,79)=1.269, p=.263, MSE=19.461, \eta^2_p=.016$, Time x Prime Content, $F(1,79)=.346, p=.558, MSE=19.461, \eta^2_p=.004$, Prime Content x Prime Type, $F(1,79)=1.851, p=.178, MSE=84.972, \eta^2_p=.023$, and Prime Type x Time x Prime Content, $F(1,79)=.111, p=.740, MSE=19.461, \eta^2_p=.001$, were not significant.

7.5.1.1 Bayes Factor Analysis

Due to the non-significant priming results reported in the orthodox analysis a Bayes Factor Analysis was used to assess whether the data provides evidence for the alternative hypothesis, the null hypothesis or whether the data was insensitive. Bayes Factor Analysis was first used to assess whether there was any evidence for a subliminal priming effect, and second to assess any differential effects between the two prime types.

To test whether there was a difference between the numbers of words correctly recalled on the CST following the *Memory-Specific* subliminal stimuli compared to *Neutral-Control* stimuli, the number of word correctly recalled by participants receiving the *Memory-Specific* stimuli at Time 1 and Time 2 was collapsed across stimulus Prime Type (e.g., Single-Word and Multiple-Word primes) to provide a mean improvement from Time 1 to Time 2 of 4.5. The mean improvement for the *Neutral-Control* group collapsed across stimulus Prime Type from Time 1 to Time 2 was 3.7, producing a raw effect of 0.8. The motivation enhancement strategy implemented during Experiment 3 and Experiment 4 provides an indication of a possible improvement, i.e., 3.23^{76} , that

⁷⁶ CST accuracy at Time 1 calculated by adding together the *Neutral-Control* conditions' Experiment 3, Time 1 score (28.54) and Experiment 4, Time 1 score (30.07) and dividing by 2 = 29.31. CST accuracy at Time 2 was calculated by adding together

can be achieved on the CST when motivation is increased. As such, the alternative hypothesis was represented as a half normal with a standard deviation of 3.23. The sample mean difference between the *Memory-Specific* and *Neutral-Control* conditions was .8 words ($SE= 1.36^{77}$) leading to a Bayes Factor of $B = .63$, indicating that the data are insensitive.

Secondly, to understand whether the data provides evidence for the alternative hypothesis exploring for differential effects between the *Memory-Specific* subliminal Prime Types, Single-Word Prime (i.e., remember) and Multiple-Word Prime (i.e., I can remember well) on CST accuracy performance a Bayes Factor Analysis was conducted. In the absence of any other suitable CST accuracy data, the difference in the number of incorrectly recalled words was used to predict possibility of a difference within the CST accuracy data. The difference in the number of incorrectly recalled words between the Single-Word and Multiple-Word prime groups of .44 was therefore identified as a reasonable expectation of the difference to be anticipated between the subliminal Prime Types in the CST recall accuracy data. As such, the alternative hypothesis was represented as a half-normal with a standard deviation of .44. The sample mean difference between the CST accuracy scores reported at Time 2 between the Single-Word and Multiple-Word prime type groups was 2.5 letters ($SE= 2.12^{78}$) leading to a Bayes Factor of $B = 1.20$, indicating the data is insensitive.

the *Neutral-Control* conditions' Experiment 3, Time 2 score (31.36) and Experiment 4, Time 2 score (33.72) and dividing by 2 = 32.54. Mean difference = $32.54 - 29.31 = 3.23$.

⁷⁷ SE was calculated using the F -value from the 2(Time: *Time 1* vs. *Time 2*) x 2(Prime Content: *Memory-Specific* vs. *Neutral-Control*) interaction of, $F=.346$; $\sqrt{.346} = t$ of .59. SE was then calculated (raw effect)/ t , i.e., $(.8)/ .59 = 1.36$.

⁷⁸ SE was calculated using the F -value from the 2(Time: *Time 1* vs. *Time 2*) x 2(Prime Type: *Single-Word* vs. *Multiple-Word*) interaction of, $F = 1.269$; $\sqrt{1.269} = t$ of 1.13. SE was then calculated by (raw effect)/ t , i.e., $(2.5)/ 1.13 = 2.12$.

7.5.2 CST Intrusions

The mean transformed⁷⁹ intrusion scores (i.e., the number of incorrectly recalled words), and standard deviations (*SD*) for each condition are provided in Table 30 (below). Higher scores indicate more words incorrectly recalled.

Table 30

Mean and SD Scores for CST Intrusions at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	<i>SD</i>	Mean	<i>SD</i>
Single-Word	Memory	2.12	1.14	2.35	1.06
Single-Word	Neutral	2.71	.87	2.84	1.17
Multi-Word	Memory	2.07	1.14	2.01	1.09
Multi-Word	Neutral	2.04	.92	2.07	1.00

Analysis of the mean number of incorrectly recalled words revealed a main effect of Prime Type, $F(1,79)=4.543$, $p=.036$, $MSE=1.916$, $\eta^2_p=.054$, whereby participants receiving the Single-Word primes recalled more words incorrectly compared to participants receiving the Multiple-Word primes (2.49 and 2.05 respectively).

All other analysis which included: Time, $F(1,79)=.960$, $p=.330$, $MSE=.298$, $\eta^2_p=.012$, Prime Content, $F(1,79)=1.655$, $p=.202$, $MSE=1.916$, $\eta^2_p=.021$, Time x Prime

⁷⁹ Data for incorrectly recalled words were transformed using a square-root transformation. Data were transformed as they did not meet the criteria for parametric testing for normality. See Chapter 3 for an outline of the procedure taken for broken parametric assumptions (3.5 *Data Preparation and Analysis*, p. 77). Square-root transformation improved normality to an acceptable level.

Type, $F(1,79)=1.304$, $p=.257$, $MSE=.298$, $\eta^2_p=.016$, Time x Prime Content, $F(1,79)=.000$, $p=.992$, $MSE=.298$, $\eta^2_p=.000$, Prime Content x Prime Type, $F(1,79)=1.459$, $p=.231$, $MSE=1.916$, $\eta^2_p=.018$, and Prime Type x Time x Prime Content, $F(1,79)=.334$, $p=.565$, $MSE=.298$, $\eta^2_p=.004$, were not significant.

7.5.3 Meta-Analysis of the Conceptual Span Task Accuracy Data

The aim of this section was to combine the accuracy⁸⁰ data from the Conceptual Span Task (CST) from the four previous experiments, as it was the only measure reported in this thesis that remained consistent throughout. A meta-analysis was then conducted to increase the statistical power of the analysis to further understand whether there is any evidence of subliminal priming following cognitive compared to neutral-control stimuli. It has been argued that although individual experiments might have been underpowered, a meta-analysis across a collection of underpowered experiments may be able to identify any modest but real effects (Vadillo et al., 2015). Furthermore, only the data from participants who received the subliminal primes that were cognitive in nature (cognitive-relevant), that is, the ‘intelligent’ and ‘memory-specific’ subliminal primes were compared to participants who received the ‘neutral-control’ subliminal primes. In total, data from 257 participants were used, consisting of 190 females and 67 males that ranged from 18 to 56 years of age ($M = 20.85$, $SD = 5.3$).

The CST data were analysed using a 2 (Time: *Time 1 vs. Time 2*) x 2 (Prime Type: *Single-Word Prime vs. Multiple-Word Prime*) x 2 (Prime Content: *Cognitive-Relevant vs. Neutral-Control*) mixed analysis of variance (ANOVA). Time was a within participants factor and Prime Type and Prime Content were both between participants

⁸⁰ Only the meta-analysis on the CST accuracy data was reported in this thesis as it was considered to better reflect memory improvement. A meta-analysis was conducted on the CST intrusions data and was found to show no significant changes in the number of words incorrectly recalled.

factors. In the eventuality of non-significant CST accuracy results, Bayes Factor analysis was conducted to assess whether data provides support for the alternative or null hypotheses or whether the data were insensitive.

Mean accuracy scores (i.e., the number of correctly recalled words), and standard deviations (*SD*) for each condition are provided in Table 31 (below). Higher scores indicate more words correctly recalled.

Table 31

Mean and SD Scores for CST Accuracy at Time 1 and Time 2 from all Four Experiments

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	<i>SD</i>	Mean	<i>SD</i>
Single-Word	Cognitive-Relevant	29.31	6.37	33.51	7.60
Single-Word	Neutral	29.86	7.21	33.06	6.61
Multi-Word	Cognitive-Relevant	28.86	7.18	32.52	8.23
Multi-Word	Neutral	29.86	7.49	32.32	7.42

Note: Mean represents the number of correctly recalled words on the CST from a total of 63.

Analysis of the mean accuracy scores revealed a main effect of Time, $F(1,253)=83.639, p<.001, MSE=17.560, \eta^2_p=.248$, whereby participants' recall accuracy improved from Time 1 to Time 2 (29.47 and 32.85 respectively).

All other analyses which included: Prime Type, $F(1,253)=.429, p=.513, MSE=88.579, \eta^2_p=.002$, Prime Content, $F(1,253)=.076, p=.783, MSE=88.579, \eta^2_p=.000$,

Time x Prime Type, $F(1,253)=.759, p=.384, MSE=83.639, \eta^2_p=.003$, Time x Prime Content, $F(1,253)=2.190, p=.140, MSE=83.639, \eta^2_p=.009$, Prime Content x Prime Type, $F(1,253)=.045, p=.832, MSE=88.579, \eta^2_p=.000$, and Prime Type x Time x Prime Content, $F(1,253)=.018, p=.892, MSE=83.639, \eta^2_p=.000$, were not significant.

7.5.3.1 Bayes Factor Analysis

Due to the non-significant priming results reported in the orthodox analysis a Bayes Factor Analysis was used to assess whether the data provides evidence for the alternative hypothesis, the null hypothesis or whether the data was insensitive. Bayes Factor Analysis was first used to assess whether there was any evidence for a subliminal priming effect and second to assess any differential effects between the two prime types.

To test whether there was a difference between the numbers of words correctly recalled on the CST following the *Cognitive-Relevant* subliminal stimuli compared to *Neutral-Control* stimuli, the number of words correctly recalled by participants receiving the *Cognitive-Relevant* stimuli at Time 1 and Time 2 was collapsed across stimulus Prime Type (e.g., Single-Word and Multiple-Word primes) to provide a mean improvement from Time 1 to Time 2 of 3.93. The mean improvement for the *Neutral-Control* group collapsed across stimulus Prime Type from Time 1 to Time 2 was 2.83, producing a raw effect of 1.1. The improvement noted by participants receiving the *Neutral-Control* prime provides an indication of a possible improvement, i.e., 2.83, that can be achieved on the CST through general practice and motivation. As such, the alternative hypothesis was represented as a half normal with a standard deviation of 2.83. The sample mean difference between the *Cognitive-Relevant* and *Neutral-Control*

conditions was 1.1 words ($SE = .74^{81}$) leading to a Bayes Factor of $B = 1.32$, indicating that the data are insensitive with weak support towards the alternative hypothesis.

Secondly, to understand whether the data provides evidence for the alternative hypothesis exploring for differential effects between the *Cognitive-Relevant* subliminal Prime Types, Single-Word Primes (i.e., intelligent, remember) and Multiple-Word Primes (i.e., I am intelligent, I can remember well) on CST accuracy performance a Bayes Factor Analysis was conducted. The difference in the number of incorrectly recalled words on the CST was used to predict possibility of a difference between the subliminal prime types (Single-Word and Multiple-Word) within the CST accuracy data collected from the previous four experiments. The difference in the number of incorrectly recalled words between the Single-Word and Multiple-Word prime groups of .17 and was therefore identified as a reasonable expectation of the difference to be anticipated between the subliminal Prime Types in the CST accuracy recall data. As such, the alternative hypothesis was represented as a half-normal with a standard deviation of .17. The sample mean difference between the CST accuracy scores reported at Time 2 between the Single-Word and Multiple-Word prime type groups was .87 letters ($SE = 1.00^{82}$) leading to a Bayes Factor of $B = 1.11$, indicating the data are insensitive with weak evidence towards the alternative hypothesis.

7.6 Automated Operation Span Task (AOSPAN)

Absolute AOSPAN score (i.e., number of complete letter-sets correctly recalled), serial letter recall accuracy (i.e., number of letters correctly recalled in their

⁸¹ SE was calculated using the F -value from the 2(Time: *Time 1 vs. Time 2*) x 2(Prime Content: *Cognitive-Relevant vs. Neutral-Control*) interaction of, $F = 2.190$; $\sqrt{2.190} = t$ of 1.48. SE was then calculated (raw effect)/ t , i.e., $(1.1)/ 1.48 = .74$.

⁸² SE was calculated using the F -value from the 2(Time: *Time 1 vs. Time 2*) x 2(Prime Type: *Single-Word vs. Multiple-Word*) interaction of, $F = .759$; $\sqrt{.759} = t$ of .87. SE was then calculated by (raw effect)/ t , i.e., $(.87)/ .87 = 1$.

correct position), and operation errors (i.e., number of incorrectly solved or timed out maths problems) were analysed separately and are reported below.

7.6.1 Absolute AOSPAN Score

The mean absolute AOSPAN scores (i.e., the number of correctly recalled letters-sets⁸³), and the standard deviations (*SD*) for each condition are provided in Table 32 (below). Higher scores indicate more letter-sets correctly recalled in their entirety.

Table 32

Mean and SD Scores for the Absolute AOSPAN Score at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	<i>SD</i>	Mean	<i>SD</i>
Single-Word	Memory	26.90	18.20	34.90	19.03
Single-Word	Neutral	21.00	17.94	27.58	17.08
Multi-Word	Memory	25.75	17.16	33.80	20.86
Multi-Word	Neutral	35.19	20.63	41.38	23.02

Analysis of the mean number of correctly recalled letter-sets revealed a main effect of Time, $F(1,77)=32.744$, $p<.001$, $MSE=64.096$, $\eta^2_p=.298$, whereby participants' absolute AOSPAN score improved from Time 1 to Time 2 (27.07 and 34.59 respectively).

⁸³ The absolute AOSPAN score is calculated by adding together the number of each letter-set recalled in its entirety. For example, if participants were presented with two sets of 3 letters and one set of 5 letters but only recalled *all* of the letters from the two size 3 letter-sets and only two letters correctly from the size 5 letter-set, then the participants' absolute AOSPAN score would be $3 + 3 + 0 = 6$. Because not all of the letters were recalled in their correct position for the size 5 letter-set, the score for that set size is zero.

All other analysis which included: Prime Type, $F(1,77)=2.433$, $p=.123$, $MSE=687.714$, $\eta^2_p=.036$, Prime Content, $F(1,77)=.053$, $p=.819$, $MSE=687.714$, $\eta^2_p=.001$, Prime Content x Prime Type, $F(1,77)=3.363$, $p=.071$, $MSE=687.714$, $\eta^2_p=.042$, Time x Prime Type, $F(1,77)=.005$, $p=.947$, $MSE=64.096$, $\eta^2_p=.000$, Time x Prime Content, $F(1,77)=.424$, $p=.517$, $MSE=64.096$, $\eta^2_p=.005$, and Prime Type x Time x Prime Content, $F(1,77)=.008$, $p=.931$, $MSE=64.096$, $\eta^2_p=.000$, were not significant.

7.6.1.1 Bayes Factor Analysis

Due to the non-significant priming results reported in the orthodox analysis a Bayes Factor Analysis was used to assess whether the data provides evidence for the alternative hypothesis, the null hypothesis or whether the data was insensitive. Bayes Factor Analysis was first used to assess whether there was any evidence for a subliminal priming effect and second, to assess any differential effects between the two prime types.

Bayes Factor Analysis was first used to assess whether the data provides evidence for or against the alternative hypothesis that there is a difference between the number of correctly recalled letter-sets on the AOSPAN following the *Memory-Specific* subliminal stimuli compared to *Neutral-Control* stimuli. For the *Memory-Specific* participants, the absolute AOSPAN score at Time 1 and Time 2 was collapsed across stimulus Prime Type (e.g., Single-Word and Multiple-Word primes) to provide a mean improvement from Time 1 to Time 2 of 8.02. The mean improvement for the *Neutral-Control* participants collapsed across stimulus Prime Type from Time 1 to Time 2 was 6.38, producing a raw effect of 1.64. The motivation enhancement strategy implemented during Experiment 4 provides an indication of a possible improvement

that can be expected on the AOSPAN when motivation is increased. As such, the alternative hypothesis was represented as a half-normal with the improvement reported by the *Neutral-Control* condition (i.e., 6.38) identified as the standard deviation. The sample mean difference between the *Memory-Specific* and *Neutral-Control* conditions was 1.64 words ($SE= 2.52^{84}$) leading to a Bayes Factor of $B = .64$, indicating that the data are insensitive.

Secondly, to understand whether the data provides evidence for the alternative hypothesis that there was a differential effect produced following the subliminal *Memory-Specific* Single-Word Prime (i.e., remember) and Multiple-Word Prime (i.e., I can remember well) a Bayes Factor Analysis was conducted. In the absence of any other suitable absolute AOSPAN data, the difference in the number of operation errors was used to predict the possibility of a difference within the absolute AOSPAN data. The difference in the number of operation errors made between the Single-Word and Multiple-Word prime groups of .04 was identified as a reasonable expectation of the difference to be anticipated between the subliminal Prime Type in the Absolute AOSPAN data. As such, the alternative hypothesis was represented as a half-normal with a standard deviation of .04. The sample mean difference between the Absolute AOSPAN scores reported at Time 2 between the Single-Word and Multiple-Word Prime groups was 1.1 letters ($SE= 15.71^{85}$) leading to a Bayes Factor of $B = 1.00$ indicating the data to be insensitive.

⁸⁴ *SE* was calculated using the square-root of the *F*-value from the 2(Time: *Time 1* vs. *Time 2*) x 2(Prime Content: *Memory-Specific* vs. *Neutral-Control*) interaction of $F=.424$; $\text{sqrt}(.424) = t$ of .65. *SE* was then calculated (raw effect)/ *t*, i.e., $(1.64)/ .65 = 2.52$.

⁸⁵ *SE* was calculated using the *F*-value from the 2(Time: *Time 1* vs. *Time 2*) x 2(Prime Type: *Single-Word* vs. *Multiple-Word*) interaction of, $F = .005$; $\text{sqrt}(.005) = t$ of .07. *SE* was then calculated by (raw effect)/ *t*, i.e., $(1.1)/ .07 = 15.71$.

7.6.2 AOSPAN Serial Recall Accuracy

The mean serial recall accuracy scores (i.e., the number of correctly recalled letters in their correct position), and the standard deviations (*SD*) for each condition are provided in Table 33 (below). Higher scores indicate more letters recalled in their correct position.

Table 33

Mean and SD Scores for AOSPAN Serial Recall Accuracy at Time 1 and Time 2

Prime Type	Prime Content	<u>Time 1</u>		<u>Time 2</u>	
		Mean	<i>SD</i>	Mean	<i>SD</i>
Single-Word	Memory	47.05	16.55	52.67	15.14
Single-Word	Neutral	42.68	16.13	46.79	16.57
Multi-Word	Memory	45.40	17.00	53.45	17.14
Multi-Word	Neutral	52.81	16.74	56.33	17.62

Note: Mean scores represent the number of letters correctly recalled in their correct position on the AOSPAN from a total of 75.

Analysis of the mean number of letters recalled in their correct position revealed a main effect of Time, $F(1,77)=21.566$, $p<.001$, $MSE=53.149$, $\eta^2_p=.219$, whereby participants significantly improved in their serial recall performance from Time 1 to Time 2 (46.73 and 52.43 respectively).

All other analyses which include: Prime Type, $F(1,77)=1.788$, $p=.185$, $MSE=499.767$, $\eta^2_p=.023$, Prime Content, $F(1,77)=.000$, $p=.997$, $MSE=499.767$, $\eta^2_p=.000$, Time x Prime Type, $F(1,77)=.163$, $p=.688$, $MSE=53.149$, $\eta^2_p=.002$, Time x Prime Content, $F(1,77)=1.734$, $p=.192$, $MSE=53.149$, $\eta^2_p=.022$, Prime Content x Prime

Type, $F(1,77)=2.132$, $p=.148$, $MSE=499.767$, $\eta^2_p=.027$, and Prime Type x Time x Prime Content, $F(1,77)=.431$, $p=.513$, $MSE=53.149$, $\eta^2_p=.006$, were not significant.

7.6.2.1 Bayes Factor Analysis

Due to the non-significant priming results reported in the orthodox analysis a Bayes Factor Analysis was used to assess whether the data provides evidence for the alternative hypothesis, the null hypothesis or whether the data were insensitive. Bayes Factor Analysis was first used to assess whether there was any evidence for a subliminal priming effect and second to assess any differential effects between the two prime types.

Bayes Factor Analysis was used to assess whether the data provides evidence for the alternative hypothesis that there is a difference between the serial recall performance on the AOSPAN following the *Memory-Specific* subliminal stimuli compared to *Neutral-Control* stimuli. For the *Memory-Specific* participants, serial recall performance at Time 1 and Time 2 was collapsed across stimulus Prime Type (e.g., Single-Word and Multiple-Word primes) to provide a mean improvement from Time 1 to Time 2 of 6.83. The mean improvement for the *Neutral-Control* participants collapsed across stimulus Prime Type from Time 1 to Time 2 was 3.81, producing a raw effect of 3.02. The motivation enhancement strategy implemented during Experiment 4 provides an indication of a possible improvement that can be achieved on the AOSPAN when motivation is increased. As such, the alternative hypothesis was represented as a half-normal with the improvement reported by the *Neutral-Control* condition (i.e., 3.81) identified as the standard deviation. The sample mean difference between the *Memory-Specific* and *Neutral-Control* conditions was 3.02 words ($SE=$

2.29⁸⁶) leading to a Bayes Factor of $B = 1.70$ indicating that the data is insensitive with increasing evidence towards the alternative hypothesis.

Secondly, to understand whether the data provide evidence for the alternative hypothesis that there is a difference between the effects produced following subliminal *Memory-Specific* Single-Word Prime (i.e., remember) and Multiple-Word Prime (i.e., I can remember well) a Bayes Factor Analysis was conducted. In the absence of any other suitable serial recall AOSPAN data, the difference in the number of operation errors was used to predict possibility of a difference within the serial recall AOSPAN data. The difference in the number of operation errors made between the Single-Word and Multiple-Word prime type groups of .04 was identified as a reasonable expectation of the difference to be anticipated between the subliminal Prime Type in the Serial Recall AOSPAN data. As such, the alternative hypothesis was represented as a half-normal with a standard deviation of .04. The sample mean difference between the Serial Recall AOSPAN scores reported at Time 2 between the Single-Word and Multiple-Word Prime groups was -.78 letters ($SE = 1.95$ ⁸⁷) leading to a Bayes Factor of $B = 1.00$, indicating the data to be insensitive.

⁸⁶ SE was calculated using the square-root of the F -value from the 2(Time: *Time 1* vs. *Time 2*) x 2(Prime Content: *Memory-Specific* vs. *Neutral-Control*) interaction of $F = 1.734$; $\sqrt{1.734} = t$ of 1.32. SE was then calculated (raw effect)/ t , i.e., $(3.02) / 1.32 = 2.29$.

⁸⁷ SE was calculated using the F -value from the 2(Time: *Time 1* vs. *Time 2*) x 2(Prime Type: *Single-Word* vs. *Multiple-Word*) interaction of, $F = .163$; $\sqrt{.163} = t$ of .40. SE was then calculated by (raw effect)/ t , i.e., $(.78) / .40 = -1.95$. The t -value was from the simple main effects analysis on the serial recall AOSPAN scores at Time 2 following Single-Word and Multiple-Word subliminal priming of, $t = 1.370$. SE was then calculated by (raw effect)/ t , i.e., $(.78) / 1.370 = .57$.

7.6.3 AOSPAN Operation Errors

Mean operation transformed⁸⁸ maths error scores (i.e., the number of incorrectly solved and timed-out maths problems), and the standard deviations (*SD*) for each condition are provided in Table 34 (below). Higher scores indicate more maths errors made.

Table 34

Mean and SD Scores for AOSPAN Operation Errors at Time 1 and Time 2

Prime Type	Prime Content	Time 1		Time 2	
		Mean	<i>SD</i>	Mean	<i>SD</i>
Single-Word	Memory	2.61	1.26	2.73	.90
Single-Word	Neutral	2.73	.93	2.45	.84
Multi-Word	Memory	2.41	1.02	2.13	1.02
Multi-Word	Neutral	2.12	.59	2.03	.53

Note: Mean scores represent the number of maths errors made on the AOSPAN from a transformed total of 8.66.

Analysis of the mean operation errors reveals a main effect of Prime Type, $F(1,77)=6.464, p=.013, MSE=1.313, \eta^2_p=.077$, whereby participants receiving the Single-Word primes made more operation errors compared to participants receiving the Multiple-Word primes (2.67 and 2.17 respectively).

All other analyses which included: Time, $F(1,77)=1.886, p=.174, MSE=.365, \eta^2_p=.024$, Prime Content, $F(1,77)=.607, p=.438, MSE=1.313, \eta^2_p=.008$, Time x Prime

⁸⁸ Data for AOSPAN operation errors were transformed using a square-root transformation. Data were transformed as they did not meet the criteria for parametric testing. See Chapter 3 for an outline of the procedure taken for broken parametric assumptions (3.5 *Data Preparation and Analysis*, p. 77).

Type, $F(1,77)=.319, p=.574, MSE=.356, \eta^2_p=.004$, Time x Prime Content, $F(1,77)=.301, p=.585, MSE=.356, \eta^2_p=.004$, Prime Content x Prime Type, $F(1,77)=.111, p=.740, MSE=1.313, \eta^2_p=.001$, and Prime Type x Time x Prime Content, $F(1,77)=2.443, p=.122, MSE=.356, \eta^2_p=.031$, were not significant.

7.7 Threshold Testing

Eight (9.41%) of the original 85 participants reported noticing something unusual during the experiment. When asked to elaborate, zero participants reported suspicion of the use of subliminal stimuli. All eight participants reported occurrences from either the CST (e.g., trial lists presenting the same words as shown in previous lists) or the LDT (e.g., resemblance of non-words to authentic words) as unusual. Additionally, five participants (5.88%) reported they noticed additional content flashing on the screen that was not a target word. When asked to elaborate participants did not report anything consistent with the subliminal stimuli used during the experiment. Instead participants reported the line of capital Xs presented prior to the LDT target word, or information relevant to one of the memory tasks (e.g., possibility of changing colour of the number zero in the AOSPAN task; use of the same words throughout the CST). As none of the participants mentioned the possible use of subliminal stimuli no participants were removed at this stage.

When informed of the use of subliminal stimuli during the experiment none of the participants were able to guess correctly the content of any of the stimuli used. The majority e.g., 34 participants (40%) answered ‘don’t know’ or left the question blank when asked to guess the content of the subliminal stimulus presented to them. Of the remaining 60% that attempted to guess the content of the stimulus, 20 participants (23.5%) suggested content consistent with the topic of ‘memory’ (e.g., “to encourage or not encourage memory”, “working memory is important”, “something to create false

memories”, “memory can be improved by doing tasks like this”). However, only 11 (55%) of these participants actually received the memory-specific subliminal primes, whereas the other nine (45%) were exposed to the neutral-control primes. This infers that the memory related suggestions given, concerning the guess of the content of the subliminal primes, may not have been aided by perception of the prime itself but more likely, by other factors such as the type of tasks completed during the experiment. Fourteen participants (16.5%) provided guesses that explained their perception of the aim of the experiment or tasks used (e.g., “does practicing memory improve over a short period of time”, “whether people are motivated to try harder to improve memory after difficult tasks and reading the article”, “does doing a numerical task distract you from remembering letters”). Twelve participants (14.1%) guessed words from, or related to the CST, AOSPAN, or LDT (e.g., “CST category words”, “maths answers/ numbers or letters”, “furniture”, “buy more vegetables”). The remaining five participants provided less common guesses (e.g., “motivation or to try hard at uni”, “red or green”, “positive or negative”, “change blindness” and “words that are not in the dictionary”). As none of the guesses matched the content of the subliminal stimulus participants were actually presented with, zero participants were removed at this stage.

Finally, when provided with the four subliminal stimuli used in Experiment 4, one participant was removed for guessing correctly and providing further information that they chose that stimulus, as it seemed familiar to them. For the remaining 84 participants, a chi-square analysis found that they were able to guess the content of their subliminal stimuli over and above chance success ($\chi^2(1) = 5.862, p = .015$); whereby 16 (19.3%) participants guessed the content of the *memory-specific* stimuli correctly and six (7.2%) participants guessed the content of the *neutral-control* stimuli correctly. However, when asked to explain the reason for their choice, the participants receiving

the *neutral-control* stimuli admitted to simply guessing, or made the choice based on categories used in the LDT e.g., ‘transport’. The participants who received the *memory-specific* stimuli who guessed correctly indicated they had made this decision based on the tasks they had completed during the experiment, i.e., CST and AOSPAN tasks as both measured memory, the memory and motivation questionnaire’s interest in perception of memory performance, a feeling of improvement, or simply guessing, therefore indicating that the visual presentation of the subliminal stimulus did not break their subjective, conscious awareness of the subliminal stimulus⁸⁹. Finally, one participant’s data were removed after experiencing severe technical difficulties with the computer interfering with the presentation of subliminal stimuli preventing them from completing the experiment.

Discussion

Experiment 4 explored the effect subliminal stimulation of *memory-specific* Single-Word and Multiple-Word primes had on working memory performance. Experiment 4 increased participants’ motivation to achieve their goal of improving working memory performance as well as focused the content of the subliminal stimuli to become more task specific. In addition, it provided an extended period of time for unconscious processing of the subliminal stimuli presented and utilised an additional working memory task. Results from Experiment 4 indicate that the motivation

⁸⁹ Analysis was conducted on only the participants who guessed the content of their subliminal stimuli incorrectly and the results remained the same for the CST accuracy and intrusions, and the AOSPAN’s absolute AOSPAN score and serial letter recall. Results for AOSPAN maths operation errors changed slightly, whereby the main effect of Time disappeared ($F(1,58)=.175, p=.677, MSE=.249, \eta^2_p=.003$) and the Main effect of Prime Type changed from being significant to marginally significant ($F(1,58)=3.937, p=.052, MSE=1.278, \eta^2_p=.064$).

enhancement strategy was successful. Participants rated the false-article highly with a score of 6.75 on a scale between zero (not at all useful) to nine (extremely useful) suggesting it did highlight the benefit of improving their working memory performance, and the degree of effort participants were willing to give to improve their working memory performance increased from Time 1 (Baseline) to Time 2 (Post-Enhancement). As such the first hypothesis that motivation to improve working memory performance would increase following the motivation enhancement strategy was supported.

During Experiment 4 participants completed two working memory tasks, the CST and the AOSPAN task. In relation to the second hypothesis tested, the results of Experiment 4 reveal an improvement over time in working memory performance on both the CST (i.e., number of words correctly recalled) and AOSPAN (i.e., absolute and serial recall) task regardless of the content of the subliminal primes and as such these differences are considered to reflect a simple practice effect. Furthermore, Bayes Factor Analysis indicates the data to be insensitive, hence the null hypothesis was neither rejected nor supported, and suggests that further research implementing a larger sample may be necessary. In addition, orthodox statistical analysis found no evidence of a differential effect elicited between the two subliminal prime types on either the CST or AOSPAN task, and Bayes Factor Analysis again identified the data to be insensitive. Hence, the third hypothesis explored was neither rejected nor supported.

However, in relation to the number of words incorrectly recalled on the CST and the number of errors made on the AOSPAN task, the results of Experiment 4 reveal that participants receiving Multiple-Word primes recalled fewer words incorrectly on the CST and made less operation errors on the AOSPAN task compared to participants receiving Single-Word primes. However, such results are not considered to clearly represent differential effects between the subliminal prime types, as the prime type was

not found to interact with either time of measurement or the content of subliminal stimuli. On examination of the descriptive statistics for both the CST intrusions data (see Table 30, p. 234) and AOSPAN operation errors (see Table 34, p. 245), there is a difference in the reported standard deviations for subliminal prime types indicative of a wider variation in the number of intrusions/errors made on each measure by participants receiving the Single-Word primes (see Table 35, below), although this variation is not considered to reflect any clear difference between the effects elicited by the subliminal prime types as the number of errors for both the CST and AOSPAN task was collected both prior to, and after exposure to subliminal priming. Hence, such an effect is more parsimoniously interpreted in terms of individual differences and as such, the third hypothesis exploring possible differences between subliminal primes types failed to be rejected.

Table 35

The Minimum, Maximum and Range for the Number of Incorrectly Recalled Words on the CST and Number of Operation Errors on the AOSPAN Task Collapsed Across Time

	<u>CST</u>			<u>AOSPAN</u>		
	Minimum	Maximum	Range	Minimum	Maximum	Range
Single-Word Primes	.00	4.24	4.24	1.37	4.90	3.53
Multiple-Word Primes	.00	4.13	4.13	1.00	4.40	3.40

Note: Values represent the transformed number of incorrectly recalled words on the CST and number of incorrect operation errors on the AOSPAN task.

In addition, a meta-analysis of the CST data was conducted to further examine for any evidence of subliminal priming effects following cognitive-related subliminal stimuli (i.e., *Single-Word*: intelligent, remember, *Multiple-Word*: I am intelligent, I can remember well) compared to the neutral-control subliminal stimuli (i.e., *Single-Word*: walking, *Multiple-Word*: people are walking) as the only measure that remained consistent across all four previous experiments. The result confirmed an improvement in participants' accuracy performance over time regardless of the content of the subliminal primes and as such, was considered to reflect a simple practice effect. Furthermore, Bayes Factor Analysis indicates the data to be insensitive hence the null hypothesis was neither rejected nor supported. Finally, in relation to the possible difference between the two subliminal prime types (i.e., Single-Word and Multiple-Word), orthodox statistical analysis found no evidence of a differential effect elicited between the two subliminal prime types on CST performance and Bayes Factor Analysis again identified the data to be insensitive.

In summary, orthodox statistical analysis and Bayes Factor Analysis conducted on both the CST and the AOSPAN task from Experiment 4 provide no clear support for the hypothesis that subliminal priming of memory-specific primes improves phonological working memory performance. Furthermore, no clear support was found for the third hypothesis exploring possible differential effects between subliminal Single-Word and Multiple-Word primes on the accuracy of word recall on the CST or letter recall on the AOSPAN task. Additionally, the differential effect found between subliminal prime type on the number of words incorrectly recalled on the CST and the number of operation errors on the AOSPAN task was considered to reflect a wider variation in the number of intrusions/errors made by participants on each task rather than an effect linked to the content of the subliminal primes presented. Such results

suggest that the subliminal primes presented in this research were unable to improve working memory performance as measured by a task that predominantly utilises the phonological loop (i.e., the AOSPAN task) or one that also relies more on the semantic short-term memory sub-component of the phonological loop (i.e., CST). Such a conclusion is supported by the findings of the meta-analysis conducted on the CST data collected across all four experiments that also found no evidence of subliminal priming on semantic working memory performance. Hence, it may only be possible for subliminal priming to influence visual-spatial working memory (see Levy, 1996). Alternatively, the lack of any subliminal priming effects may be the result of a number of other methodological factors, such as the delivery and duration of the subliminal primes and the possibility that the sample size was insufficient. Each of these factors are discussed below.

Performance on both the specific, semantic short-term memory sub-component of the phonological loop (CST; Experiment 2-4) and the more general phonological loop component (AOSPAN task; Experiment 4) improved over time but were not influenced by subliminal priming. As such, it is possible that working memory performance cannot be influenced by exposure to subliminal primes. However, previous research has reported that subliminal priming can influence visual-spatial working memory performance. For example, Levy (1996) examined the effect that subliminal age-related primes had on the performance of a dot location task and reported that both age-positive (e.g., wisdom) and age-negative (e.g., Alzheimer's) Single-Word primes automatically activated implicit self age-related stereotypes and moreover, elicited the performance appropriate to these self-stereotypes. However, Levy (1996) may have committed a Type I error when interpreting her results as it was noted that some of her findings disappeared following the application of a more

conservative post hoc correction. Most notably was the significant improvement reported on the dot location task following age-positive primes, although this was not taken into account in the interpretation of her findings. Furthermore, Stein et al. (2002) failed to replicate these results.

Stein et al. (2002) examined the same age-positive and age-negative subliminal primes in addition to age-neutral primes and examined elderly participants' performance on an adapted version of the dot location task⁹⁰. Stein et al. (2002) reported no changes in performance on the dot location task following any of the subliminal primes. Stein et al. (2002) suggested that the existing schematicity of age-related stereotypes may have impacted on the successfulness of the subliminal primes whereby, the age-negative primes (e.g., Alzheimer's, forgetful) might have been better able to influence memory performance on some types of memory tasks (e.g., photo recall task⁹¹) because they are more clearly associated with poorer memory performance. Whereas, the age-positive primes (e.g., wisdom, creative) were more representative of general positive beliefs about the elderly than their *memory* performance specifically. As such, Stein et al. (2002) suggested that the effects reported by Levy (1996) following the age-positive subliminal primes may have been attributable to factors other than subliminal priming (e.g., practice effects) especially as there was no comparative control condition. As such, consistent with the findings from Stein et al. (2002) and the current research, it seems as though subliminal priming is not able to influence working memory performance. Alternatively, some of Levy's (1996)

⁹⁰ Levy's (1996) version of the dot location task allowed for a possible range in scores from zero to seven points, whereas Stein et al. (2002) extended the task to allow for a wider range in points from zero to 12.

⁹¹ In both Stein et al. (2002) and Levy (1996) this task involved recalling the correct activity statement for picture of an elderly person e.g., "he likes to go hiking".

findings are still suggestive that subliming priming may be able to influence working memory performance that relies upon visuo-spatial processing.

Although it is not clear why working memory performance reliant upon the visuo-spatial sketchpad may be more susceptible to subliminal priming compared to working memory performance reliant upon the phonological loop, a speculative possibility relates to the impact of cognitive load. For instance, it has been argued that subliminal primes are processed by working memory (Greenwald et al., 1996) and in the case of written stimuli, by the phonological loop. Furthermore, it has been suggested that goal-directed behaviour may not occur if the individual's cognitive resources are depleted (Dijksterhuis & Bargh, 2001; Macrae & Johnston, 1998). Hence, because working memory is known to be a limited capacity system (Baddeley, 2003), it is plausible that the phonological loop component of working memory was not able to sustain the cognitive resources required for *both* the processing of the subliminal primes as well as the processing of written information presented during the CST and AOSPAN task. That is, cognitive load may inhibit subliminal priming.

Although memory performance has been influenced previously by subliminal primes (e.g., Chartrand & Bargh, 1996; Hess et al., 2004; Levy, 1996; Levy & Leifheit-Limson, 2009; Mitchell et al., 2002; Stein et al., 2002), the memory tasks were simpler and as such, may not have utilized all the individual's reservoir of cognitive resources. In contrast, more complex tasks such as the CST and the AOSPAN tasks that are heavily reliant upon the phonological loop may have drained all the individual's cognitive resources due to higher cognitive load. Therefore, the dot location task reliant upon the visuo-spatial sketchpad component of working memory, may be more susceptible to subliminal priming as it does not induce high cognitive load, hence the individual may still have some cognitive resources left in their reservoir to continue

processing the subliminal prime and implement the relevant behaviour. Hence, future research examining the effect of the memory-specific subliminal primes from the current research (i.e., remember, I can remember well) on the dot location task could extend previous the findings from past research (Stein et al., 2002) to provide evidence for whether visual-spatial memory can be positively influenced.

However, in relation to the other methodological issues, it could be that the delivery method used to present the subliminal primes was ineffective. During Experiment 4 (see also Experiment 1-3) an unrelated task (i.e., LDT) was completed prior to the CST and AOSPAN task. This raises two possible explanations for the null findings of Experiment 4. Firstly, that the subliminal primes activated goal-directed behaviour but that this activation was short-lived and did not extend beyond the LDT to the working memory tasks. Second, the completion of the LDT inhibited or interfered with the subliminal primes.

In relation to the first possibility, previous research examining the effect of memory-specific subliminal primes e.g., Mitchell et al. (2002 Experiment 1) presented the subliminal prime to 'remember' within the target-learning phase of their experiment (i.e., immediately following the target stimuli) and reported positive subliminal priming effects in a following surprise memory test. Hence, it is possible that the lack of any subliminal priming found in the current research may be due to this difference in the delivery of subliminal primes. That is, subliminal memory-specific primes may only be effective when embedded *within* the to-be-remembered items rather than separately presented within another task. Furthermore, Bargh and Morsella (2008) suggest that an activated goal will implement goal-relevant behaviour on whatever supraliminal information is available directly following the unconscious activation of the goal. This implies that subliminal priming by the memory-specific primes may have activated the

goal-directed behaviour to remember on the information presented within the LDT rather than the CST and AOSPAN task. As such, activation of goal-directed behaviour may not be durable over multiple-tasks. However such an idea is speculative as other researchers have shown subliminal priming effects for up to four days later (e.g., Lowery et al., 2007), suggesting that subliminal primes are capable of influencing behaviour beyond that in the current environment. Furthermore, memory for the target letter strings in the LDT was not examined and as such it is not known whether participants held an enhanced memory for these target letter strings following exposure to the memory-specific subliminal primes.

An alternative explanation is that the presentation of the subliminal primes during an unrelated task with a distinct goal (i.e., categorization of letter strings) may have depleted or interfered with the cognitive resources required to process the subliminal primes and activate the relevant goal-directed behaviour (see Dijksterhuis & Bargh, 2001; Macrae & Johnston, 1998). Overall, the findings from the current research are unable to clearly identify which of these two alternatives may account for the null findings of Experiment 4 and as such further research is needed. For instance, a surprise recollection memory task for the letter strings presented in the LDT performed after completion of the LDT (for similar see Mitchell et al., 2002) could provide evidence for one of these alternatives. That is whether there is any evidence for enhanced memory of the LDT letter strings. However, in relation to understanding whether subliminal memory-specific primes are able to improve phonological working memory performance, future research should consider presenting the subliminal primes embedded within the CST and AOSPAN task.

With regards to the duration of exposure to the subliminal primes Experiment 4 also lengthened the overall prime-target SOA period compared to that used during

Experiments 1-3. This consisted of an additional backward mask formed from a row of Xs presented immediately following the subliminal stimuli for 500ms extending the prime-target SOA from 14ms to 514ms (see also, Dijksterhuis & Smith, 2002; Dijksterhuis et al., 1998; Karremans et al., 2006; Pichon et al., 2007). However, whilst this provided more time to process the subliminally presented information, the exposure duration of the prime itself remained brief at 14ms. There is no reported optimal duration for the presentation of a subliminal prime and research has reported successful subliminal priming following a range of exposure durations from 8.5ms (Dijksterhuis & Smith, 2002) to 40ms (McKay et al., 2011). Although, others such as Klauer et al. (2007; see also Van den Bussche et al., 2009) have suggested that the strength of subliminal primes increases with exposure duration.

However, a concern with using a longer prime exposure duration is ensuring that the prime remains subliminal. For instance, Finkbeiner (2011) reported that longer prime exposure durations, such as 40ms or 50ms, could be used if presented in conjunction with a 'strong' backward mask. Finkbeiner (2011) explains that backward masks comprised of letters are considered *stronger* than backward masks composed of symbols (e.g., @@@@) due to their similarity (i.e., letters) to subliminal prime words (see also, Grainger et al., 2003; Kouider & Dehaene, 2007). Hence, the backward mask used in Experiment 4, comprised of string of capital Xs, fits into the category of a strong backward mask. As such, it should be possible to successfully mask the subliminal primes used in the current research for a longer duration than the 14ms used in this current research (see Finkbeiner, 2011). Furthermore, attempting to increase performance on a task involving complex cognition such as working memory performance may require a longer exposure duration of subliminal primes (see Klauer et al., 2007; Van den Bussche et al., 2009). As such, the subliminal prime exposure

duration could be lengthened to, for example, 34ms (see Mitchell et al., 2002). Although, due to the lack of an agreed optimal procedure concerning the specifications for the exposure duration of subliminal primes, masking stimuli and overall prime-target SOA duration in the field, the backward mask and the overall prime-target SOA could be adjusted in two ways. Firstly, the subliminal primes presented for 34ms could be backward masked using the same string of Xs presented for 500ms (as used in this current research) thus extending the overall prime-target SOA to 534ms (for similar procedure see Aarts et al., 2007 Experiment 2; Karremans et al., 2006; McKay et al., 2011). Alternatively, the backward mask duration could be reduced to 480ms (for similar procedure see Arndt et al., 1997) thus keeping the overall prime-target SOA at 514ms (the same as used in this current research). Both strategies allow for a longer duration for unconscious processing of the subliminal prime that may in turn, increase its strength (Klauer et al., 2007; Van den Bussche et al., 2009) and both also afford an extended period of time for the subliminal prime to be sufficiently processed (Sklar et al., 2012).

Finally, Bayes Factor Analysis indicated the data to be insensitive and as such a larger sample size may be required. A power analysis⁹² was conducted that suggested a sample of between 456 and 2,278 participants would be necessary to achieve a statistically significant three-way interaction between subliminal Prime Type (Single-Word vs. Multiple-Word), Prime Content (Memory-Specific vs. Neutral-Control), and Time (Time 1 vs. Time 2) to provide evidence for subliminal priming effects following memory-specific subliminal primes and differential effects elicited between the

⁹² Power analysis calculated using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) was used to estimate the required sample size to elicit statistically significant subliminal priming effects. The alpha (α) was set to .05, and the power was set to .80, and the effect size was calculated using the partial eta squared taken from the relevant three-way interaction from the CST accuracy and AOSPAN absolute and serial recall analyses.

subliminal prime types on the CST and AOSPAN tasks. As such, future research should aim to examine a larger sample of participants with a minimum of 456 participants. However, this range of participants (i.e., 456 and 2,278) is rather large and may be indicative that subliminal priming may not be able to improve phonological loop working memory performance.

To summarise, despite increased motivation to improve working memory performance no clear change in working memory performance, as measured by the CST or the AOSPAN task, was found following exposure to subliminal memory-specific primes (e.g., *Single-Word*: remember; *Multiple-Word*: I can remember well), instead improvements in performance accuracy are suggestive of a practice effect. Such a conclusion was supported by the results of the meta-analysis conducted on the CST collected data from all four experiments. Furthermore, Bayes Factor Analysis conducted on the data from Experiment 4 reveal that the data was insensitive, a conclusion that was also supported by the Bayes Factor Analysis conducted during the meta-analysis on the CST Accuracy data from all four experiments. Thus no clear conclusions can be made concerning the null or alternative hypotheses. However, several suggestions were made regarding these null results. First, it was suggested that subliminal priming is unable to improve phonological working memory performance, although suggestions for future research were provided as to how this speculative possibility could be addressed. Furthermore, reflections on the current methodology also led to other suggestions for future research. For instance, further assessing the nature of the delivery of the subliminal primes to reduce possible interference or inhibition effects, as well as strengthening the priming effects by lengthening the exposure duration of the subliminal primes. Finally, future research may wish to utilise a larger sample of participants based on the power analysis indicating that a minimum

of 456 participants is required to establish an interaction between subliminal prime type, prime content, and time. Implementing such suggestions could help clarify the effect subliminal stimuli may have on phonological working memory performance.

Chapter Eight: General Discussion

This chapter will begin with a review of the purpose and intention of this thesis and will then outline each of the four experiments conducted. For each experiment, a brief outline will be provided of their specific aims, methodological details, and key findings from the analysis followed by a brief account of the possible reasons for these findings. Then a general discussion of the findings from all four experiments will be provided. Following this general discussion, the theoretical considerations of this research will be presented in relation to the subliminal psychodynamic activation theory, automaticity theory and goal-directed behaviour theory. For each theory, the results from the relevant experiments will be explained as providing support or not, and highlight any potential implications this research may have. Finally, some discussion will be given concerning possible directions for future research. To conclude, this chapter will end with a brief summary and provide the final concluding remarks regarding the comparison between the subliminal prime types and the influence of subliminal priming on working memory performance.

8.1 Thesis Aim and Rationale

The main empirical purpose of this thesis was to compare the effects elicited by subliminally presented Single-Word and Multiple-Word primes on working memory performance. As discussed in Chapter 2 (2.4.1 *Single-Word Primes*, p. 43), research has shown Single-Word primes to be successfully processed unconsciously (see Cheesman & Merikle, 1986; Daza et al., 2002; Debner & Jacoby, 1994; Greenwald et al., 1995; Jacoby & Whitehouse, 1989; Marcel, 1983; Merikle & Joordens, 1997; Merikle et al., 1995; see also, Merikle & Daneman, 1998; Merikle et al., 2001 for a review).

Furthermore, Single-Word primes have been demonstrated to elicit a wide range of positive behavioural changes. For instance, exposure to Single-Word primes has been reported to improve a range of behaviours including memory performance (Chartrand & Bargh, 1996; Dijksterhuis et al., 2000; Levy, 1996; Levy & Leifheit-Limson, 2009; Mitchell et al., 2002), academic performance (Lowery et al., 2007; Radel et al., 2009; Shih et al., 2002 Experiment 2), and self-estimation (Dijksterhuis, 2004; Grumm et al., 2009; Jraidi & Frasson, 2010; Riketta & Dauenheimer, 2003). Hence, it is now widely communicated that unconscious processing is sophisticated enough to correctly process Single-Word primes and that such primes are capable of influencing behaviour that in some instances has been shown to be durable for up to four days (see Lowery et al., 2007).

Similarly, despite initial concerns regarding unconscious processing of more than one word (Draine, 1997; Greenwald, 1992; Greenwald & Liu, 1985), research examining the effects elicited by Multiple-Word primes has reported positive improvements in a wide range of behaviours. For instance, Chapter 2 (2.4.2 *Multiple-Word Primes*, p. 45) highlighted improvements in health-related behaviours such as smoking cessation and reduced drug use (Palmatier & Bornstein, 1980; Thornton et al., 1987), reduced anxiety (Orbach et al., 1994; Schurtman et al., 1982), increased implicit mood (Sohlberg, Billingham et al., 1998; Sohlberg et al., 1997; Sohlberg, Samuelberg, et al., 1998; Weinberger et al., 1997), increased feelings of trust (Légal et al., 2012), as well as improved academic performance (Ariam & Siller, 1982; Bryant-Tuckett & Silverman, 1984; Hudesman et al., 1992; Parker, 1982; Zuckerman, 1960). Additionally, recent research has supported the notion that unconscious processing *can* successfully process Multiple-Word primes (see Armstrong & Dienes, 2013, 2014). Hence, such evidence suggests that unconscious processing is indeed more

sophisticated than previously thought (see Loftus & Klinger, 1992) and provides further support for the wide array of past research reporting an influence on behaviour following the subliminal presentation of Multiple-Word primes.

Although both subliminal prime types have been shown to be successfully processed unconsciously and have been reported to influence behaviour, no comparison of the effectiveness of these two types of subliminal prime has yet been conducted. As such, it is not clear whether a Single-Word prime may elicit more or less robust effects relative to a Multiple-Word prime. Hence, the overarching aim of this thesis was to empirically address this issue by comparing the two subliminal prime types, Single-Word primes and Multiple-Word primes. The results of such an empirical test was considered to advance the understanding of subliminal priming in two ways. Firstly, to ascertain which subliminal prime type would be able to elicit the most robust change and secondly, to provide further detailed information concerning the subliminal priming procedure because as yet, there is no reported optimal procedure for the presentation of subliminal stimuli.

8.2 Experimental Aims, Methods and Results

8.2.1 Experiment 1

Experiment 1 (see Chapter 4) examined the difference between the two subliminal prime types (i.e., Single-Word and Multiple-Word) on both cognitive (i.e., semantic working memory, selective attention and intelligence) and affective (explicit mood and state anxiety) measures. Previous research has tended to examine the effects of Single-Word subliminal primes congruent in content to the intended cognitive or affective behaviour to be influenced. For instance, when testing for changes in memory performance, specific memory-related Single-Word primes were presented (Mitchell et

al., 2002) or when aiming to improve self-esteem, positive Single-Word primes such as ‘beautiful’ were presented (Dijksterhuis, 2004; see also Riketta & Dauenheimer, 2003). In contrast however, a large portion of research examining the effects of Multiple-Word primes on cognitive and affective measures has been mainly attributed to psychodynamic-based primes. For example, the commonly used Multiple-Word prime ‘mommy and I are one’ has been reported to improve both cognition i.e., academic performance (Ariam & Siller, 1982; Hudesman et al., 1992; Parker, 1982) as well as affective behaviours i.e., improved implicit mood (Sohlberg, Billingham et al., 1998; Weinberger et al., 1997) and reduced state-anxiety (Orbach et al., 1994). Hence, there has not been one specific Single-Word subliminal prime shown to elicit change across a variety of cognitive *and* affective measures unlike the Multiple-Word prime ‘mommy and I are one’.

As such, Experiment 1 additionally examined subliminal stimuli that aimed to differentially target either cognitive or affective behaviours within each prime type i.e., three Single-Word primes (e.g., *cognitive*: intelligent, *affective*: one, *neutral-control*: walking) and three Multiple-Word primes (e.g., *cognitive*: I am intelligent, *affective*: mommy and I are one, *neutral-control*: people are walking) on all measures. Hence, the effect of the three subliminal primes within each prime type were compared on both affective and cognitive measures to understand whether cognitive-based and affective-based subliminal stimuli were capable of eliciting change in measures congruent in nature (i.e., cognitive and affective measures respectively) as well as measures incongruent in nature (i.e., affective and cognitive measures respectively).

Ninety-six participants completed five tasks: a semantic working memory task (i.e., Conceptual Span Task; CST), a selective attention task (i.e., Stroop Colour Naming Task), an intelligence task (i.e., General Knowledge Test), an explicit mood

questionnaire (i.e., Short Version-Profile of Mood States; SV-POMS), and an anxiety questionnaire (i.e., State Anxiety Scale; SAS) before and after the Lexical Decision Task (LDT), which was used to present the subliminal stimuli. Results showed improved accuracy on the CST for those exposed to all positive content subliminal primes compared to those who received the neutral-control subliminal primes. No other subliminal priming effects were found for any of the other measures. These findings were considered to support past research showing that subliminal priming could improve memory performance (e.g., Chartrand & Bargh, 1996; Dijksterhuis et al., 2000; Hess et al., 2004 Experiment 2; Levy, 1996; Levy & Leifheit-Limson, 2009; Mitchell et al., 2002), but did not indicate any differential effects between the subliminal prime types. It was considered in Chapter 4 that the non-differential effect between the two subliminal prime types (i.e., Single-Word and Multiple-Word primes), evident in semantic working memory performance, might have been attributed to the differential delay between exposure to the subliminal prime and completion of the second CST. Additionally, the external goal to complete other tasks during this delay may have elicited an interference effect and reduced the impact of the subliminal primes (Dijksterhuis & Bargh, 2001; Macrae & Johnston, 1998; Mitchell et al., 2002).

8.2.2 Experiment 2

Experiment 2 continued to examine the effect of subliminal primes on semantic working memory as this task (i.e., the CST) was shown to be amenable to change following exposure to positive subliminal priming and as such, it was considered important to try and extend the findings from Experiment 1. Experiment 2 (see Chapter 5) explored the possibility that a delay and possible interference to the automatically primed behaviour between the initial exposure of the subliminal stimuli and the onset of

the CST may have contributed to the non-differential effects between the subliminal prime types. Hence, Experiment 2 addressed this issue by having participants complete the second CST *immediately* after the LDT.

Sixty participants completed Experiment 2 and were primed with one of the same six subliminal primes as used in Experiment 1. The analysis revealed that whilst the number of words correctly recalled increased over time, this was found to occur regardless of the content of the subliminal primes. Hence, the finding was considered to reflect a practice effect. Additionally, Bayes Factor Analysis provided further evidence towards the null hypothesis, that there was no difference between the effects elicited between the cognitive and the neutral control primes, or the affective and the neutral control primes. Furthermore, in relation to possible differential effects between the subliminal prime types, results showed that the number of words correctly recalled on the CST was higher for participants exposed to the Multiple-Word primes compared to the Single-Word primes. However, such a finding was not evidence for any difference between the subliminal prime types because the difference was not found to interact significantly with either the time of measurement or content of the subliminal stimuli. That is, the number of words correctly recalled was measured both before and after subliminal priming, and the content of the prime types was inclusive of both the positive experimental primes (e.g., cognitive and affective) as well as the neutral-control primes. Additionally, Bayes Factor Analysis found the data to be insensitive regarding the possible difference elicited between the different prime types, hence the null hypothesis could neither be rejected nor supported.

As such, the findings of Experiment 2 neither supported previous research (e.g., Mitchell et al., 2002) nor replicated the findings from Experiment 1. Whilst it is possible that subliminal primes are unable to improve semantic working memory,

Chapter 5 considered the possibility that participants may have lacked the appropriate goal to improve their working memory performance and sufficient motivation to attain this goal (see Strahan et al., 2002). Hence, Experiment 3 aimed to increase participants' motivation to achieve the goal of improving their working memory performance.

8.2.3 Experiment 3

Based on the goal-directed behaviour theory which stipulates the need for an existing goal (Aarts et al., 2005) and the relevant motivation to attain that goal (Strahan et al., 2002) for subliminal priming to influence behaviour, Experiment 3 (see Chapter 6) enhanced participants' motivation to improve their working memory performance whilst keeping all other aspects of the experiment consistent with Experiment 2. Experiment 3 adapted the procedure reported by Strahan et al. (2002) to include a strategy designed to increase participants' motivation to improve their working memory performance, and then presented the subliminal primes to activate this goal which in turn would activate the relevant goal-directed behaviour.

One hundred and six participants completed Experiment 3, which closely mirrored the design of Experiment 2. The only difference was that a two-fold motivation enhancement strategy was utilised to increase each participants' goal to improve his or her working memory performance. Results revealed that the motivation enhancement strategy was successful. The amount of effort participants were willing to give to improve their working memory performance increased during the course of the experiment indicating a higher degree of motivation to attain this goal. However, whilst participants' accuracy performance on the semantic working memory task (i.e., the number of correctly recalled words) was shown to increase over time, this effect occurred regardless of the type or content of the subliminal primes, and as such was

considered to reflect a practice effect. In addition, Bayes Factor Analysis found the data to either be insensitive (for the cognitive compared to neutral-control stimuli), or to provide evidence for the null hypothesis (for affective compared to neutral-control stimuli). In relation to a possible differential effect elicited by the two subliminal prime types, no difference was found using orthodox statistical analysis and Bayes Factor Analysis revealed the data to be insensitive. As such, no evidence was found to support previous research suggesting that subliminal priming improves memory performance (e.g., Mitchell et al., 2002) and further still, there was no differential effect between subliminal Single-Word and Multiple-Word primes. Additionally, the findings from Experiment 3 failed to support the notion that holding a goal prior to subliminal priming and being motivated to achieve that goal (e.g., Strahan et al., 2002) will be sufficient enough to produce successful subliminal priming effects. Whilst it is reasonable to suggest that subliminal priming may be unable to improve semantic working memory performance, several issues were raised that may have accounted for the null results. These included: the lack of specificity of the subliminal primes, the limited duration available for unconscious processing of the subliminal primes, and the specific nature of the working memory task used. Thus, Experiment 4 aimed to address each of these issues.

8.2.4 Experiment 4

Chapter 7 explored the possibility that the subliminal positive primes used during Experiments 1 to 3 (e.g., *cognitive*: intelligent, I am intelligent; *affective*: one, mommy and I are one) may not have sufficiently targeted the goal to improve working memory performance in order to activate the goal and the relevant goal-directed behaviour (Fitzsimons & Bargh, 2003). As such, Experiment 4 changed the content of

the subliminal stimuli to focus more specifically on memory (i.e., remember, I can remember well). Furthermore, it is possible that sufficient time was not afforded to enable the subliminal primes to be adequately processed unconsciously in order to elicit an effect due to the limited prime-target stimulus onset asynchrony (SOA) used in Experiments 1 to 3 (i.e., 14ms). Such a prime-target SOA is considerably shorter than the prime-target SOA used in some previous research that has shown subliminal priming effects (e.g., Aarts et al., 2007; Karremans et al., 2006; Pichon et al., 2007). Furthermore, it was suggested that this lack of time might have impaired the individual's ability to unconsciously process the subliminal primes, especially the more complex Multiple-Word primes (Sklar et al., 2012). Hence, an additional backward mask (e.g., a string of Xs) was presented between the subliminal prime and target stimulus in the LDT to increase the prime-target SOA from 14ms to 514ms.

Finally, the specific nature of the working memory task (i.e., the CST) used to assess the influence of subliminal priming on working memory performance was examined. In the working memory model, the phonological loop component is argued to have three sub-components: the phonological store, the articulatory loop (Baddeley, 1992, 2000), and the semantic short-term memory store (Haarmann & Usher, 2001; Haarmann et al., 2003). The CST is likely to utilise all three of these sub-components, but with specific reliance upon the semantic short-term store sub-component. As such, it was suggested that the CST may be a too complex a task to be influenced by subliminal priming. Such a notion is speculative, although previous research on conscious priming effects has shown that task difficulty can moderate the effects of implicit priming (see Schacter et al., 1990) and as such, task difficulty may also moderate the effects of subliminal priming. With this in mind a second working memory task (i.e., the Automated Operation Span Task; AOSPAN) was examined

alongside the CST that was also reliant upon the phonological loop component of working memory but that did not heavily utilise the semantic short-term memory sub-component, and therefore, may be considered less difficult than the CST.

Eighty-three participants completed both the CST and the AOSPAN task, once before and again after the LDT. During Experiment 4, participants received one of four subliminal primes during the LDT (i.e., *memory-specific*: remember, I can remember well; *neutral-control*: walking, people are walking), followed by an additional backward mask (i.e., row of Xs) to extend the prime-target SOA to 514ms (see Aarts et al., 2007; Karremans et al., 2006; Pichon et al., 2007 for a similar procedure). As in Experiment 3, participants' motivation was enhanced using the same two-fold strategy. Results from Experiment 4 indicated that the motivation enhancement strategy was again successful as the amount of effort participants were willing to give to improve their working memory performance increased over time. However, despite this increased motivation, participants' performance on the CST and the AOSPAN task both showed evidence of practice effects, but no evidence of subliminal priming effects. Furthermore, the Bayes Factor Analysis examining for evidence of a differential effect elicited by the memory-specific and neutral-control subliminal primes was found to be insensitive for both the CST and the AOSPAN task. Additionally, no evidence of differential effects were found between the effects elicited by the Single-Word and Multiple-Word primes on either the CST or AOSPAN task using orthodox statistical analysis, and Bayes Factor Analysis again found the data to be insensitive.

Overall, such results suggested that the subliminal primes presented in this research (i.e., *memory-specific*: remember, I can remember well) were unable to clearly influence working memory performance as measured by either the CST or AOSPAN task. Such a conclusion is supported by the findings of the meta-analysis conducted on

the CST data collected from all four previous experiments that was examined to assess whether there was any evidence of subliminal priming following the ‘cognitive-related’ subliminal stimuli (i.e., *Single-Word*: intelligent, remember, *Multiple-Word*: I am intelligent, I can remember well) compared to the ‘neutral-control’ subliminal stimuli (i.e., *Single-Word*: walking, *Multiple-Word*: People are Walking). The results confirmed a practice effect whereby participants improved in their CST accuracy performance over time regardless of the content of the subliminal primes and furthermore, the Bayes Factor Analysis indicates the data to be insensitive. Finally, orthodox statistical analysis found no evidence of a differential effect elicited between the two subliminal prime types (i.e., *Single-Word* and *Multiple-Word*) on CST performance and Bayes Factor Analysis again identified the data to be insensitive.

As such, it was considered in Chapter 7 that the nature of the working memory component being examined may explain the null results found in Experiment 4 (discussed further in *8.3 General Discussion of Experimental Findings*, p. 271). Alternatively, methodological factors such as the delivery of the subliminal stimuli, and the exposure duration of the subliminal primes (discussed further in *8.5 Directions for Future Research*, p. 291) were also considered as possible explanations for the lack of subliminal priming effects.

8.3 General Discussion of Experimental Findings

Previously it has been suggested that subliminal priming effects are ‘elusive’ (Greenwald et al., 1996), ‘fragile’ and ‘hard to replicate’ (Kouider & Dehaene, 2007). When taking all of the findings from the current research into account, it would seem that these statements may well be correct. The findings from this research indicate that subliminal priming does not readily influence affective behaviour (see Experiment 1),

cognition (see Experiment 1), and more specifically, working memory performance (Experiments 1-4). In relation to working memory performance, the findings from Experiment 1 provided some initial evidence that exposure to both cognitive and affective primes could improve semantic working memory performance. However, on reflection and taking into account the results from Experiments 2 to 4, it is possible that a Type II error may have been made during the interpretation of the analysis concerning the neutral-control group in Experiment 1. Following the marginal interaction between time and prime content, post hoc analysis revealed that only the participants receiving the cognitive (i.e., intelligent, I am intelligent) and affective primes (i.e., one, mommy and I are one) showed improved recall over time. However, as outlined in Chapter 3 (3.6.2.2.1 *Post hoc Tests*, p. 79), the post hoc analyses in this thesis were subjected to a conservative Bonferroni correction to limit the possibility of making a Type I error (Field, 2009; Howell, 2002). Hence, when assessing this time by prime content interaction, the alpha criterion was lowered from the conventional 0.05 to 0.017, and as such, the result for the neutral-control group was considered to be non-significant. Nevertheless, the *p*-value reported for the neutral-control condition (i.e., 0.042) could have been suggestive of a significant difference if a less conservative correction had been applied. Furthermore, consistent with previous research this result was not considered to reflect *marginal* significance, as outlined in Chapter 4, only *p*-values ranging from 0.051 to 0.069 were considered to reflect a marginally significant results (Iacobucci, 2005; Nickerson, 2000; Rosnow & Rosenthal, 1989). This range, when applied to the lower alpha criterion used following the Bonferroni correction, identified values from 0.018 to 0.036 to reflect marginal significance, hence the reported *p*-value (i.e., 0.042) was not reported as *marginally* significant.

However, the literature does not provide clear rules concerning what range of results can be considered as reflecting marginal significance. For instance, some suggest a more liberal range of results is suggestive of marginal significance. For example, Gelman (2013) explained that *p*-values between the wider range of 0.051 and 0.1 have been previously reported to reflect marginally significant findings. Hence, if this more liberal range was applied following the Bonferroni correction in Experiment 1 (e.g., from 0.018 to 0.067), the results of the neutral-control group would have been considered to reflect a marginally significant effect. If it was the case that a Type II error was made and the result of the neutral-control group was considered to have reflected a marginally significant difference, then the overall conclusion of the CST results from Experiment 1 would represent a practice effect whereby all participants showed improvement on the CST over time regardless of the content of the subliminal prime they were exposed too. Furthermore, this revised conclusion would more readily reflect the conclusions of the other three experiments reported in this thesis. Hence, when taking into consideration the results from Experiments 2 to 4, and the somewhat arbitrary nature of classifying marginal significance, the results from Experiment 1 are more suggestive of a Type II error and as such, cannot be clearly taken to represent any subliminal priming effects following exposure to cognitive and affective primes.

As such, taking the revised findings from Experiment 1 and those from Experiments 2 to 4 into account, there was no clear evidence that subliminal priming effects were elicited in any of the four experiments, despite attempts to control for a range of possible issues including the delay between subliminal priming and task measurement, possible interference effects, and levels of participant motivation (see Experiments 2-3). Furthermore, Experiment 4 also failed to find any improvement on a second working memory task despite participants' enhanced motivation to improve

their working memory performance, the presentation of more memory-specific subliminal primes, and the extended time period for unconscious processing of the subliminal stimuli. As such, this thesis found it was not possible to influence working memory performance, as measured by either the CST or AOSPAN task, following exposure to subliminally presented information. In addition, this thesis also found it was not possible to establish any differential effect between the two subliminal prime types of Single-Word versus Multiple-Word primes.

Although, it cannot be concluded with any certainty that there is *no* difference between the effectiveness of these subliminal prime types as no clear subliminal priming effects were found in the first instance. Previous research has shown that exposure to both subliminal prime types can improve a range of different behaviours (see Chapter 2 and Chapter 4) suggesting that both prime types can be effective. Hence, to examine if a difference between these prime types does exist, first a successful subliminal priming procedure must be established. Only after it is clear that the subliminal priming procedure chosen is successful can a robust test of strength and durability of the two subliminal prime types take place across a number of different behavioural measures. In the current research, it was not clear whether the null subliminal priming results were found because subliminal priming is not capable of eliciting a change on working memory performance, because participants were actually aware of the subliminal primes and ignored them, or because the procedure used to present the subliminal primes was not suitable and thus needs refining further, for example, by extending the subliminal prime exposure duration (see 8.5 *Directions for Future Research*, p. 291). It will now be discussed whether the null results from the current research offer evidence for the notion that subliminal priming is ineffective or more specifically, cannot influence phonological working memory performance.

Furthermore, it will also be discussed briefly whether the null results from the current research were achieved due to participants' possible awareness of the subliminal primes and the ineffectiveness of the funnel style questionnaire to detect this awareness or due to an ineffective method used to present the subliminal stimuli.

As discussed, the findings from the current research found no clear subliminal priming effects on affective measures, i.e., explicit mood (SV-POMS) and state anxiety (SAS; Experiment 1), cognitive measures such as selective attention (Stroop Colour Naming Task), intelligence (General Knowledge Test; Experiment 1), or working memory performance (CST, Experiments 1-4; AOSPAN task, Experiment 4). Such results could suggest that subliminal priming is an ineffective method for influencing behaviour, that is, put simply, subliminal priming does not work. However, there is a large body of literature that shows, on the contrary, that subliminal priming can be used to improve both affective behaviour and cognition (see Chapter 4). In relation to the current research, some of the measures (i.e., explicit mood, state anxiety, selective attention, and intelligence) were only examined once during Experiment 1. As discussed in Chapter 4, several limitations were highlighted that may explain why subliminal priming effects were not found. For example, the type or format of the measures used (mood and intelligence), type of sample examined (i.e., low state anxiety levels), or relevance of prime content presented (selective attention). As such, without addressing each of these limitations, firm conclusions concerning the effectiveness or ineffectiveness of subliminal priming as a method for influencing such behaviors, cannot be given. However, in relation to memory performance, this thesis provided a more robust examination of the possible effect subliminal priming has on the performance of working memory and as such, the null results found may provide evidence that subliminal priming is unable to improve working memory performance.

Previous literature has shown that subliminal priming can improve short-term recollection performance (Mitchell et al., 2002) and recall performance (Chartrand & Bargh, 1996) hence it is not suitable to conclude that subliminal priming cannot improve memory performance per se. Therefore, perhaps more specifically, it may be the case that subliminal priming is not able to influence working memory performance. It has been argued that working memory involves both online cognition and concurrent manipulation of information and is therefore more complex and cognitively demanding than short-term memory (Baddeley, 1992; Baddeley & Logie, 1999). Hence, it is possible that subliminal priming is less effective at enhancing the more complex cognitive processes involved in working memory. However, there is some evidence to suggest that exposure to subliminal primes can influence performance of the visuo-spatial sketchpad component of working memory. For example, Levy (1996) reported that age-related subliminal primes influenced performance on a visual-spatial working memory task. Although, such findings should be viewed with caution as Stein et al. (2002) failed to replicate this effect (see Chapter 7). Nevertheless, the current research extended previous work by examining the effects of subliminal priming on working memory tasks that were reliant upon the phonological loop component of working memory.

The present research examined performance of the phonological loop using the CST (i.e., a task specifically reliant on the semantic short-term memory sub-component of working memory; Haarmann et al., 2003), and the AOSPAN task (i.e., a task that does not heavily utilise the semantic short-term memory sub-component of working memory). Given that both tasks predominantly rely on the phonological loop component of working memory and that no subliminal priming effects were elicited in the current research, it is possible that performance reliant on the phonological loop

may not be susceptible to change following exposure to positive subliminal stimuli. Such a conclusion is further supported by the results of the meta-analysis that was conducted on the CST accuracy data⁹³ collected from Experiments 1 to 4. The meta-analysis represented a more sensitive examination of possible subliminal priming effects on the performance of semantic working memory following all cognitive-related (i.e., *Single-Word*: intelligent, remember, *Multiple-Word*: I am intelligent, I can remember well) subliminal primes compared to the neutral-control (*Single-Word*: walking, *Multiple-Word*: people are walking) primes and found no evidence of subliminal priming effects, confirming the conclusion that subliminal priming may not be capable of eliciting an improvement on working memory performance reliant on the phonological loop. Although, it is not yet clear why working memory performance reliant upon the phonological loop may not be susceptible to subliminal priming compared to working memory performance reliant upon the visuo-spatial sketchpad.

One speculative possibility is that subliminal priming is moderated by cognitive load, that is, the effectiveness of subliminal priming is depleted when cognitive load is high. Although previous research has shown subliminal primes can influence memory performance (e.g., Chartrand & Bargh, 1996; Hess et al., 2004; Levy, 1996; Levy & Leifheit-Limson, 2009; Mitchell et al., 2002), the tasks used to measure memory could be considered less demanding as they did not rely on the phonological loop in the same way that the CST and the AOSPAN task used in the current research did. For instance, when completing the CST, participants were required to access the semantic meaning of the words to enable the correct categorisation of them in addition to subvocalisation and repetition. In relation to the AOSPAN task, participants not only subvocalised and rehearsed the letters but also were simultaneously required to complete mental

⁹³ A meta-analysis was conducted only on CST accuracy data, as this measure was the only one that remained consistent throughout the four experiments.

arithmetic. Furthermore, whilst it has been argued that subliminal primes are processed by phonological working memory (Greenwald et al., 1996), if such processing is excessively demanding, goal-directed behaviour may not occur as there may be some competition for the same mechanism or insufficient cognitive resources available to process the subliminal primes and activate the relevant behaviour (Dijksterhuis & Bargh, 2001; Macrae & Johnston, 1998). For example, the higher cognitive load placed on the phonological loop during the completion of working memory tasks such as the CST and AOSPAN task may have utilised all of the individuals' limited cognitive resources and as such, inhibited any unconscious processing of the subliminal priming and therefore, the activation of goal-directed behaviour. Thus, it is possible that subliminal priming may be able to influence other aspects of working memory performance such as the visuo-spatial sketchpad, because the tasks used to measure its performance do not place a high cognitive load on the phonological loop component of working memory, which is used to process the subliminal primes. Therefore, leaving sufficient cognitive resources to process the subliminal primes and activate goal-directed behaviour.

Alternatively, it is possible that phonological working memory is susceptible to subliminal priming, but that no changes were found due to the possibility that participants were aware of the subliminal primes and potentially ignored them. If this was the case, such awareness and conscious decision to ignore the subliminal primes would have had a negative impact on the performance of the working memory tasks. However, participants' awareness to the subliminal primes was examined using a funnel-styled questionnaire in line with the social-cognitive methodology, the results of which concluded that participants were *not* aware of the subliminal primes presented to them. Although, it is possible that performance on the funnel-styled questionnaire was

influenced by forgetting, whereby participants may have consciously perceived the subliminal primes during the LDT but *forgot* them by time they completed the funnel-styled questionnaire, which was presented at the end of each experiment. Whilst forgetting the subliminal prime is possible, the notion is however, less likely had participants made a conscious decision to ignore them. Nevertheless, to better assess the awareness to the subliminal primes and tackle the potential issue of forgetting any conscious awareness to the subliminal primes, the threshold testing examination could be adapted in future experiments. For example, a measure of the participant's awareness could be taken directly after the LDT to reduce the possibility of forgetting or alternatively, an individual threshold testing technique could be employed. Such a technique would eliminate the possibility of forgetting awareness of subliminal primes, as the duration the prime would be presented at would be tailored to the individual's threshold level (see 2.2.1 *Measuring Conscious Awareness*, p. 17). A further possibility is that no changes in performance of phonological loop component of working memory were found due to an ineffective subliminal priming technique. For instance, methodological issues such as the exposure duration or the delivery of the subliminal primes may have also contributed to the null effects reported in the current research.

The social-cognitive methodology was utilised in the current research to present the subliminal primes. That is, all participants were exposed to the subliminal primes for a fixed duration of 14ms followed by a backward mask (row of Xs) for 500ms. Previous research has reported successful subliminal priming using similar short exposure durations. For instance, Dijksterhuis (2004) reported increased self-estimation and Pichon et al. (2007) reported increased religious prosociality. However, neither of these experiments can be categorised as influencing cognitive behaviour and as such, it

is possible that to influence the more complex cognitions involved in working memory, amendments to the subliminal priming procedure are required.

In the current research several amendments were made to the subliminal priming procedure used. For example, participants' motivation to improve their working memory performance was increased (see Experiments 3-4), the subliminal primes were changed to target memory performance more specifically, and the amount of time provided for unconscious processing of the subliminal primes was also extended (see Experiment 4). However, despite such amendments, no subliminal priming effects were elicited. Within the subliminal priming paradigm, no optimal priming procedure exists and as such, several aspects of the priming procedure can vary (see Chapter 2; 2.3.3: *Visual-Written Subliminal Stimuli*, p. 26). Therefore, it is possible that to influence working memory performance, further amendments to the priming procedure are required.

For instance, those that have reported changes in cognitive performance such as Lowery et al. (2007) reported increased academic performance using subliminal primes presented for a longer duration (i.e., 34ms) than the duration used in the current research. Furthermore, Mitchell et al. (2002) found subliminal primes presented for a longer duration (i.e., 34ms) and in closer temporal proximity to the items to be remembered influenced participants' recollection of those items. Hence, it is possible that altering the exposure duration and/or delivery of the subliminal prime may be necessary to elicit an influence on working memory performance (see 8.5 *Directions for Future Research*, p. 291).

Overall, previous research is inconsistent regarding the effect of subliminal priming on working memory performance (e.g., Levy, 1996; Stein et al., 2002).

However, the results from Experiments 1 to 4 and the meta-analysis conducted on the

CST data presented in this thesis demonstrate the ineffectiveness of subliminal priming at improving performance reliant upon the phonological loop component of working memory. It is possible that subliminal priming is moderated by high cognitive load. That is, tasks that are reliant upon the phonological loop place a higher cognitive load on this component and as such, may utilise all of the individual's limited cognitive resources, which in turn leaves little or no cognitive resources to process the subliminal primes and activate relevant behaviour required to complete such tasks. Alternatively, it is possible that participants may have been consciously aware of the subliminal primes and chosen to ignore them, impacting on the positive improvement of their performance on the working memory task, or the subliminal priming procedure used was ineffective. Whilst several amendments were made to the priming procedure used in the current research, it is possible that further amendments may be required. For example, an individual threshold technique could be employed to avoid any conscious detection and forgetting of the subliminal primes or a change in the exposure duration of the subliminal prime, and/or a change in the delivery of the prime may be required to elicit an influence on cognitive performance.

8.4 Theoretical Implications

The theoretical contributions of this thesis will now be discussed starting with contributions concerning the subliminal psychodynamic activation (SPA) theory, then the automaticity theory and finally, the goal-directed behaviour theory.

8.4.1 Subliminal Psychodynamic Activation Theory

Although originally the SPA theory explained changes in behaviour following symbiotic-like subliminal primes (e.g., mommy and I are one) as evidence of the

soothing of unconscious wishes (Silverman & Weinberger, 1985), the findings from this thesis were instead to be interpreted using Hardaway's (1990) cognitive account suggesting changes in behaviour were likely to be due to changes in positive mood and state variables (see Chapter 2; *2.5.1 Subliminal Psychodynamic Activation Theory*, p. 49). SPA research has not previously examined for cognitive behavioural changes following subliminal stimulation in conjunction with changes in positive mood and reductions in anxiety. For instance, although Ariam and Siller (1982) suggested that students' improved maths performance was due to reduced anxiety, they did not specifically test for changes in anxiety. Experiment 1 of this thesis, however, set out to examine the effects of subliminal priming across a range of affective and cognitive measures, hence could examine changes in experienced mood and anxiety as well as cognitive changes.

Given the reinterpretation of the results from Experiment 1 outlined above, the findings from Experiments 1 to 3 suggest that the affective subliminal primes (i.e., *Single-Word: one; Multiple-Word: mommy and I are one*) are limited at eliciting any improvements in either affect (see Experiment 1) or cognition (see Experiments 1-4). Such a conclusion is contrary to numerous SPA studies showing positive improvements in implicit mood, cognitive performance, and reductions in anxiety (see Hardaway, 1990 for a review). However, others have also reported no influence on behaviour following exposure to the Multiple-Word prime 'mommy and I are one' (e.g., phobic behaviour, Condon & Allen, 1980; depression, Oliver & Burkham, 1982), and as such this research may provide further evidence that SPA may not be capable of improving either affective behaviour (Experiment 1) or cognitive performance (Experiments 1-3). As discussed however, it is also possible that no subliminal priming effects were

elicited in the current research due to an inefficient priming procedure (see 8.5 *Directions for Future Research*, p. 291).

Furthermore, some methodological limitations highlighted in Chapter 4 may have also contributed to the null results found. For example, it may be more beneficial to examine for changes in explicit anxiety and/or mood using more sensitive scales compared to the SAS and SV-POMS used in the current research and similarly, it may be useful to examine possible changes in cognitive performance using exams/tests (see Ariam & Siller, 1982; Hudesman et al., 1992; Parker, 1982) rather than the selection of cognitive tasks used in this research (see Chapter 4 for more detail).

Alternatively, it is possible that the null results reported in Experiments 1 to 3 of the current research were found because the affective subliminal primes did not influence anxiety or positive mood (as evidenced in Experiment 1) and as such, no change in cognitive performance could be expected. This raises the issue that the individual's baseline level of experienced anxiety and/or mood may be important. According to the cognitive interpretation of the SPA paradigm, changes in experienced anxiety and/or mood must occur in order to mediate changes in cognitive performance (Hardaway, 1990). Previous research has shown that affective subliminal primes (e.g., mommy and I are one) have reduced state anxiety in a sample of participants whose anxiety levels were artificially increased prior to subliminal priming (see Orbach et al., 1994). As such, it is plausible that experienced levels of state anxiety were not reduced in the current research because the sample examined were not experiencing sufficiently high levels of anxiety prior to subliminal priming. As such, it is possible that subliminal affective stimuli may only provide an ameliorative effect on anxious behaviour that is excessive. The positive influence of subliminal affective primes on cognitive

performance such as academic success has however been reported previously in non-clinical samples.

For example, Ariam and Siller (1982), Hudesman et al. (1992) and Parker (1982) reported improved academic performance following exposure to the Multiple-Word primes ‘mommy and I are one’. In each of these experiments, participants were examined using academic tests/exams to measure performance and as such, it is possible that such upcoming exams heightened participants’ experienced feelings of anxiousness (Sarason, 1978). Whilst a reduction in anxiety was not measured in these experiments, it is possible however that the subliminal affective stimuli presented reduced the participants’ experienced levels of test anxiety and therefore, mediated an improvement in performance on the academic tests/exams (Ariam & Siller, 1982). Hence, future research may wish to examine the effect of the subliminal stimuli used in this current research on a clinically anxious or an anxiety-induced sample in order to reduce anxiety and therefore, mediate changes in cognition.

Overall, the theoretical implications from this thesis in relation to the SPA theory are that exposure to affective-orientated Single-Word and Multiple-Word primes are unable to provide any improvement in participants’ affect (e.g., anxiety, positive mood) or cognition (e.g., working memory, selective attention, intelligence). Such contribution provides further evidence in support of a minority of research showing that symbiotic-based subliminal priming does not elicit any behavioural effects (Condon & Allen, 1980; Oliver & Burkham, 1982). Although, such a conclusion is preliminary and should be interpreted with caution as further research could be conducted which addresses the limitations of the current research. For example, by examining for changes in anxiety/mood and cognitive performance using potentially more sensitive

measures, and by examining sample groups that exhibit higher levels of experienced anxiety.

8.4.2 Automaticity Theory

The automaticity theory (see Bargh, 2002) suggests that the subliminal presentation of stereotypical words, traits or concepts, automatically activates the relevant internal representation of a behaviour that is congruent with the stereotyped group, trait, or concept being primed (Bargh & Chartrand, 1999; Bargh & Ferguson, 2000). As the internal representation is activated so too are thoughts about the actions required to carry out these behaviours and as such, the behaviour itself is more likely to occur (Bargh & Chartrand, 1999; Bargh & Ferguson, 2000; see Chapter 2; 2.5.2 *Automaticity Theory*, p. 54). In relation to the current research, the cognitive-based primes of ‘intelligence’ and ‘I am intelligent’ and the memory-specific primes of ‘remember’ and ‘I can remember well’ were expected to automatically activate the traits of intelligence and memory respectively. Such activations were expected to elicit trait-relevant behaviour on the measures of intelligence, selective attention (Experiment 1) and phonological working memory (Experiments 1-4).

As discussed, the results of the current research found no subliminal priming effects and as such, no trait-directed behaviour was reported. Hence, such results provide no support for the automaticity theory in relation to subliminally presented ‘trait’ words. The automaticity theory stipulates that trait-congruent behaviour should occur given that the correct conditions for the behaviour to manifest are provided following exposure to subliminal primes (Bargh, 2005). However, the findings from Experiments 1 to 4 extends the automaticity theory to suggest that simply providing adequate conditions following subliminal priming may not be sufficient to elicit

subliminal priming effects. Although, it is possible that trait-relevant behaviour was not elicited because participants did not hold an adequate mental representation for the traits of intelligence and memory. However, as the samples examined during this research were all University students, this is doubtful because such participants are likely to have experienced behaviours relevant to both traits at academic establishments such as school, college/sixth form and whilst at University, that contribute to their mental representation of high intelligence and memory. It is possible then, that the subliminal primes presented during the current research did not successfully activate these traits due to a problematic subliminal priming procedure (see *8.5 Directions for Future Research*, p. 291). However, an alternative possibility is that the activation of these traits did occur, but that the spread of activation through the participants' semantic network was insufficient to elicit a cognitive behavioural change.

Spreading activation theories of human semantic processing suggest that conceptual information is organised into semantic networks and that memory search accesses this network when a concept is activated (Quillian, 1962, 1967). Quillian (1962, 1967; see also Collins & Loftus, 1975) explained that the network consists of 'nodes' which represent each concept and that various links (i.e., superordinate and subordinate links, modifier links, disjunctive and conjunctive set of links, and residual class of links) exist between these nodes. Although, a number of alterations have been made to this early version of the spreading activation theory of human semantic processing by Collins and Loftus (1975). For instance, they suggested that the number of links between concepts is higher when those concepts have more in common in terms of semantic similarity. Although speculative, spreading activation theory raises the possibility that the subliminal intelligence and memory-oriented primes may have activated the nodes for intelligence or memory in the individual's semantic network, but

that the activation of such 'single' nodes in the participant's semantic network was weak, and insufficient to activate the trait-related behaviour. Given this, it is possible that a higher number of semantically related trait words subliminally presented may activate an increased number of nodes and links between these nodes, and as such, may have a greater likelihood of activating the relevant trait-directed behaviour. That is, the presentation of more semantically similar trait words may be better able to activate a greater portion of the conceptual network, which may in turn increase the probability of activating the intelligence and memory representations and therefore, relevant thoughts of action that are considered to lead to the implementation of that behaviour (Bargh, 2002; Bargh & Ferguson, 2000).

Such a proposal is of course speculative, but there is support from previous research for such a notion. For example, Lowery et al. (2007) reported improved academic performance following exposure to 11 different subliminal primes semantically related to the trait of intelligence. Such a finding suggests that a greater number of words may have more adequately represented the trait of intelligence, leading to a more efficient spread of activation across the nodes, and thus activation of a larger portion of the participant's semantic conceptual network. Therefore, the findings from the current research could be taken to suggest that for a trait to be subliminally stimulated and successfully influence behaviour, the representation of that trait must be adequate to ensure the activation of a larger portion of the participant's semantic network. To address this further, research may wish to examine whether multiple words, for example, intelligent, smart, genius (see Lowery et al., 2007) or remember, recall, memory, provide a better representation of the traits of intelligence and memory respectively and elicit trait-relevant behaviour following greater activation of the participant's semantic network.

Overall, the subliminal trait-based primes (i.e., *Single-Word*: intelligent, memory *Multiple-Word*: I am intelligent, I can remember well) show no evidence in support of the automaticity theory (see Bargh, 2002). Such findings suggest that subliminal primes inclusive of trait-related words such as ‘intelligent’ or ‘remember’ may be unable to automatically activate behaviours associated with intelligence or memory and furthermore, that simply subliminally priming the trait and providing suitable circumstances afterwards for the behaviour to occur (Bargh, 2005) may be necessary, but not sufficient to elicit a subliminal priming effect. Whilst it is possible that the subliminal primes did not activate the traits of intelligence or memory, a speculative alternative is that the spread of activation (see Quillian, 1962, 1967; Collins & Loftus, 1975) following the subliminal primes was limited, and as such, was ineffective to elicit a cognitive behavioural effect. Future research may wish to address this by presenting a greater number of semantically similar trait words in order to activate a larger portion of the participants’ conceptual network, and in turn, increase the likelihood of activating trait-directed behaviour.

8.4.3 Goal-Directed Behaviour Theory

As an extension to the automaticity theory, goal-directed behaviour theory attempts to explain changes in behaviour following subliminal priming in terms of the activation of pre-existing social or interpersonal goals (Bargh, 1994; Hassin et al., 2005). Furthermore, some have expanded goal-directed behaviour theory to argue that the relevant goal-related behaviour may only occur if the situation allows for the exhibition of such behaviour (Bargh & Morsella, 2008; Bargh, 2005), and the individual is suitably *motivated* to achieve the goal (e.g., Karremans et al., 2006; Strahan et al., 2002; Velkamp et al., 2011 Experiment 1; see Chapter 2). As discussed

in Chapter 6, it was considered a possibility that participants did not exhibit any subliminal priming effects during Experiment 2 because they may not have held the goal of improving their working memory or they may not have been sufficiently motivated to achieve this goal. Hence, both Experiments 3 and 4 enhanced participants' motivation to improve their working memory performance (see Chapter 6). The findings show that the amount of effort participants were willing to give to attain the goal of improving their working memory performance increased following the motivation enhancement strategy employed.

However, despite the fact that participants exhibited increased motivation to improve their working memory, and were provided with an opportunity to improve their memory, no clear subliminal priming effects were found. As such, the findings from Experiments 3 and 4 do not provide support for the goal-directed behaviour theory. Interestingly, the findings from this research extend goal-directed behaviour theory to suggest that having the motivation to achieve a specific-goal (Strahan et al., 2002), priming this goal using relevant subliminal primes (Fitzsimons & Bargh, 2003), and providing an appropriate situation following subliminal priming to allow for the manifestation of the goal-directed behaviour (Bargh & Morsella, 2008; Bargh, 2005) whilst necessary, may not be sufficient to elicit subliminal priming effects.

As discussed, it is possible that the null results from the current research were found because the subliminal primes were ineffective at activating the goal of improving working memory performance, or because the procedure used to present the subliminal primes was ineffective (see *8.5 Directions for Future Research*, p. 291). However, a speculative alternative possibility relates to the nature of the goal being primed and the particular goal-directed behaviour that is being measured. Previous research has reported that physiological goals such as drinking (see Strahan et al.,

2002), calorie intake (Strahan et al., 2004, as cited in Kardes et al., 2005), increased physical pressure (Aarts et al., 2008), prosocial behavioural goals (see Aarts et al., 2005; Fitzsimons & Bargh, 2003), the “motivation for concentration enhancement” goal (see Bermeitinger et al., 2009, p.5), and achievement goals (Hart & Albarracín, 2009) can all be successfully primed. However, none of these past experiments examined goal-directed behaviours relevant to cognitive performance. For instance, although Bermeitinger et al. (2009) primed the goal of concentration, they measured goal-directed behaviour in relation to the physiological need to remain awake, and as such, measured participants’ consumption of energy pills rather than measuring for any change in cognitive performance reliant on concentration. Additionally, Hart and Albarracín (2009) primed an achievement goal and a fun goal in participants with high versus low achievement motivation and reported an influence of such goals on participants’ prioritisation of achieving compared to entertainment (Experiment 2) and their willingness to continue or disengage with an achievement-based task (e.g., word search). However, Hart and Albarracín (2009) did not measure for differential effects in cognitive performance on the achievement task following subliminal activation of the goal. As such, it is not clear whether cognitive goals and cognitive goal-directed behaviour can be subliminally primed using the goal-directed theory paradigm. However, this is a speculative suggestion and as such should be considered with caution, as further research is needed to address the limitations of this research.

In sum, Experiments 3 and 4 of the current research examined goal-directed behaviour theory by enhancing participants’ motivation to achieve the goal of improving their working memory performance. Results indicated that participants’ motivation to attain this goal increased over the course of the experiment, but that no clear subliminal priming effects were found in relation to improvement of working

memory performance, and as such did not provide any support for the goal-directed behaviour theory. However, findings from the current research may extend goal-directed behaviour theory by demonstrating that simply having the relevant motivation to attain a goal, subliminally priming such goal and providing a suitable situation to exhibit goal-directed behaviour may be necessary, but not sufficient to elicit subliminal priming effects. Whilst it is possible that the null results from this research were found due to ineffective subliminal primes or an insufficient subliminal priming procedure, a speculative alternative relates to the cognitive nature of the goal being primed and its goal-related behaviour being measured. It is possible that such cognitive goals and cognitive goal-directed behaviour may not be susceptible to subliminal priming. However, such an idea should be viewed with caution, as further research is required.

8.5 Directions for Future Research

As discussed, no differential effect was found between the two subliminal prime types examined (i.e., Single-Word and Multiple-Word). Although, it cannot be concluded with any certainty that there is *no* difference between these subliminal primes types as no clear subliminal priming effects were elicited. Hence, to examine if a difference between these prime types does exist, research should initially aim to establish a successful subliminal priming procedure *before* examining for possible differential effects between the different subliminal prime types. Only after it is clear that the subliminal priming procedure chosen is successful, can a robust test of possible differential effects occur. Hence, this section aims to address some possible amendments that could be made to the current procedure as a consideration for future research. For instance, the exposure duration of the subliminal primes will be discussed with consideration of procedures that could lengthen the exposure duration using

traditional social-cognitive methodology, individual threshold setting, as well as alternative delivery tasks that enable longer subliminal prime durations.

There are numerous methodological factors that should be considered when attempting to design the optimal procedure for the presentation of subliminal primes (see Chapter 2; 2.3.3 *Visual-Written Subliminal Stimuli*, p. 26). For example, the exposure duration and mode of delivery are two factors that may impact on the unconscious processing of the subliminal primes. In relation to the exposure duration of the subliminal primes, the presentation speed utilised in the current research was a factor that remained unchanged. The subliminal primes were presented for 14ms in each of the four experiments similar to previously successful subliminal priming experiments (e.g., Dijksterhuis, 2004; Pichon et al., 2007; Wentura & Frings, 2005). Although successful subliminal priming effects have been reported following a range of exposure durations from 8.5ms (Dijksterhuis & Smith, 2002) to 40ms (McKay et al., 2011), it is possible that in this instance, the exposure duration used was too conservative and as such, was too fast to elicit any influence on the complex cognitions involved in working memory. Previously it has been suggested that the *strength* of a subliminal prime increases with prime duration (Van den Bussche et al., 2009). As such, a longer exposure duration may be better able to improve working memory performance due to the increased strength of the subliminal primes.

In Experiment 4, the overall prime-target SOA duration was increased by presenting an additional backward mask, which in turn provided more time for the participant to unconsciously process the subliminal primes, without lowering the likelihood of consciously perceiving such primes. However, whilst the presentation of the additional backward mask extended the unconscious processing time available, the exposure duration of the subliminal prime itself remained unchanged and as such, the

strength of the subliminal prime did not change. Therefore, future research could consider lengthening the exposure duration of the subliminal primes to increase their strength (Van den Bussche et al., 2009) in *addition* to the measures already taken to lengthen the time available for unconscious processing of the subliminal primes. For example, past research examining the effect of subliminal priming on short-term memory using the social-cognitive methodology reported significant improvements in memory performance following exposure to primes presented for 34ms and replaced by a backward mask (Mitchell et al., 2002). As such, future research could expose participants to the subliminal primes from the current research for 34ms and immediately replace with a backward mask of a string of Xs for 500ms, thus increasing the strength of the subliminal prime in addition to providing an adequate amount of time for unconscious processing with an overall prime-target SOA of 534ms.

Alternatively, the subliminal primes could be presented to each participant at an individually tailored duration (see Armstrong & Dienes, 2013, 2014; Eckstein et al., 2011). The threshold for conscious awareness of information could be individually established prior to the subliminal priming task and used to ensure that the subliminal stimuli are presented for the longest possible duration without becoming visible to each participant. Individual threshold examinations are conducted by presenting the information at a set speed and gradually increasing or decreasing the exposure duration on each trial, after which the participant states what they saw or rates their confidence in their performance on the task (see Chapter 2; *2.1: Measuring Conscious Awareness*, p. 17). Although such a technique is considered more time-consuming to implement (Bargh & Chartrand, 2000), it does allow for the subliminal primes to be presented for the longest possible duration per participant without the participant becoming consciously aware of the subliminal stimuli. However, both solutions suggested (i.e.,

lengthened exposure duration for fixed-speed subliminally presented primes and individually tailored exposure durations), are both often used in conjunction with the traditional backward masking technique, a technique that has previously been criticised and suggested to reduce the effectiveness of the subliminal primes (Bargh & Chartrand, 2000; Enns & Oriet, 2007; Grainger et al., 2003; Greenwald et al., 1996; Jaśkowski, 2007; Jaśkowski & Przekoracka-Krawczyk, 2005; Lleras & Enns, 2006).

The traditional backward masking technique utilised in the current research was consistent with the social-cognitive methodology. For instance, during Experiments 1 to 3 the target letter strings (e.g., words and nonwords) presented during the LDT originally doubled up as backward masks for the subliminal primes. However, in Experiment 4, an additional backward mask (e.g., a string of Xs) was presented between the subliminal stimuli and the target letter strings to increase the amount of time available for unconscious processing of the primes. It has been suggested that the type of backward mask used may differentially affect the subliminally presented information. For example, Grainger et al. (2003; see also Enns & Oriet, 2007) suggested that backward masks comprised of letters may be more detrimental to the processing of the subliminal primes in comparison to backward masks comprised of symbols (Finkbeiner, 2011). Such information could be taken to suggest that the type of backward masks used throughout the duration of the current research may have contributed to the lack of subliminal priming effects as both types of backward masks utilised in the current research were composed of letters. As such, future research could replace such masks with a string of symbols such as a row of ampersands (e.g., &&&&). However, others have commented that the effect of backward masking of any kind is problematic as they may break the transfer of information from the sensory buffer to working memory thereby reducing the likelihood of the subliminal prime

being adequately processed (Bargh & Chartrand, 2000; Greenwald et al., 1996).

Alternatively, the initial activation of the subliminal prime may be inhibited following the sudden arrival of a backward mask (e.g., mask-triggered inhibition, see Jaśkowski, 2007; Jaśkowski & Przekoracka-Krawczyk, 2005; Lleras & Enns, 2006). Therefore, to avoid the possibility of reducing or inhibiting unconscious processing of the subliminal primes, future research could consider examining the effects of the subliminal primes using an alternative presentation method or delivery technique that does not require traditional backward masking.

For example, an alternative presentation method that could be incorporated into tasks such as the LDT that does not require backward masking is grey-scale colour contrasting (Lamy et al., 2008). Grey-scale colour contrasting essentially presents subliminal primes in a shade of grey that is minutely different to the background shade of grey. Hence, due to their non-obvious nature, the subliminal primes may be presented for a longer duration (see Figure 19, p. 296). For instance, Armstrong and Dienes (2013, 2014) reported average subliminal prime exposure durations of between 56ms (Armstrong & Dienes, 2013 Experiment 4) and 80ms (Armstrong & Dienes, 2014 Experiment 2). Such exposure durations are longer than those used from the current research (i.e., 14ms) and hence, could also be considered as potentially eliciting stronger effects (Van den Bussche et al., 2009). Furthermore, subliminal priming using grey-scale colour contrasting could be combined with the presentation of the stimuli at both fixed or individually tailored exposure durations, and because grey-scale colour contrasting removes the need for backward masking, the risk of inhibiting the cognitive processing of the subliminal primes is reduced (e.g., mask-triggered inhibition; Jaśkowski, 2007; Jaśkowski & Przekoracka-Krawczyk, 2005).

A further option however, is to consider the presentation of subliminal primes using continuous flash suppression (CFS; Tsuchiya & Koch, 2005). Here the subliminal primes are presented to the participant's left eye and gradually increased in colour contrast whilst a constantly changing image (changing every 100ms) is presented to their right eye, dominating conscious awareness (Sklar et al., 20012; see Figure 20, p. 297). Sklar et al. (2012) examined the length of time it took for the written subliminal stimuli to 'break through' into conscious awareness using the CFS technique and reported a range of exposure durations from 929ms (Experiment 1) to 1,108ms



Figure 19: An example of subliminal priming using the grey-scale colour contrasting technique. The image on the left is an example of a supraliminal prime and background contrast and the image on the right represents a subliminal prime and background contrast. Examples from Armstrong and Dienes (2013 Experiment 4).

(Experiment 2) indicating that such primes could remain non-conscious for considerably longer than those using the social-cognitive methodology and traditional backward masking techniques. Hence, far longer exposure durations can be achieved with such a technique, which may in turn increase the overall strength elicited by the subliminal primes (Van den Bussche et al., 2009). Furthermore, due to the nature of the task, mask-triggered inhibition (Jaśkowski, 2007; Jaśkowski & Przekoracka-Krawczyk,

2005; Lleras & Enns, 2006) is reduced, as no backward mask is required to replace the subliminal primes.

In summary, it is possible that the short exposure duration of the subliminal primes and/or the use of traditional backward masking techniques may have contributed to the null results reported in the current research. Previously, it has been suggested that the strength of a subliminal prime increases with exposure duration (Van den Bussche et al., 2009). Hence, future research may consider extending the exposure duration of the subliminal primes by increasing the fixed duration that it is presented

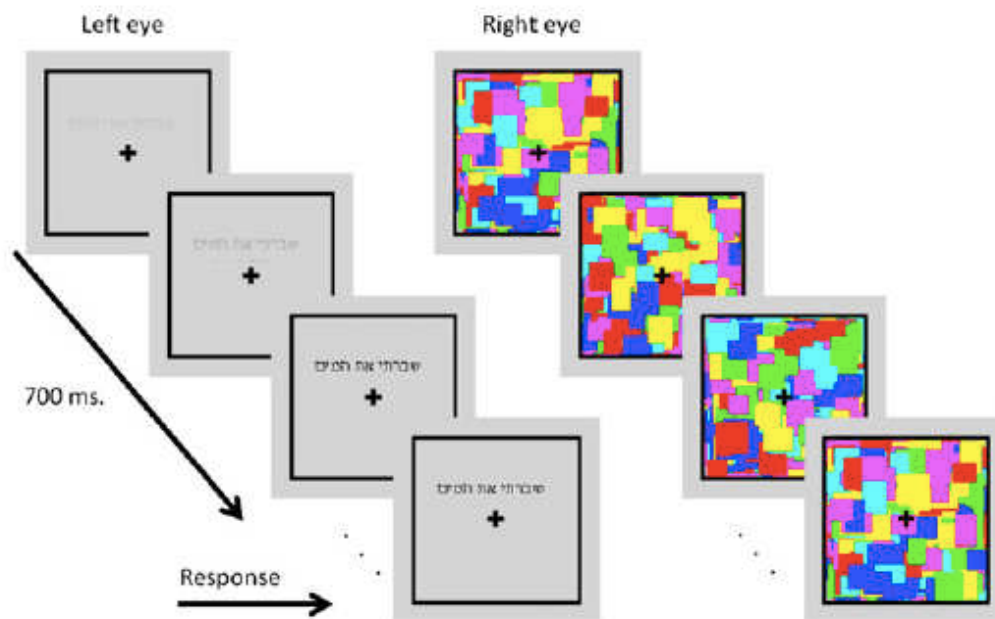


Figure 20: An example of subliminal priming using the continuous flash suppression technique. To the left eye the subliminal primes are gradually increased in contrast and to the right eye, colourful images are continually changed. Examples from Sklar et al. (2012 Experiment 1-2).

for, or individually tailoring the exposure duration for each participant (Armstrong & Dienes, 2013, 2014; Eckstein et al., 2011). Alternatively, the subliminal primes could be presented in the LDT using grey-scale colour contrasting (Lamy et al., 2008), or in a different task such as CFS (Tsuchiya & Koch, 2005), to both increase the exposure duration of the primes and remove the possible impact that traditional backward masking may have on the unconscious processing of the subliminal primes (Bargh & Chartrand, 2000; Greenwald et al., 1996; Jaśkowski, 2007; Lleras & Enns, 2006).

8.6 Discussion Summary

The aim of this thesis was to examine possible differences between the effects elicited following exposure to subliminal Single-Word and Multiple-Word primes. However, no subliminal priming effects and no differential effects between the subliminal prime types were found in any of the experiments or the meta-analysis conducted. Nevertheless, for the reasons outlined above, it cannot be concluded with any certainty that there is *no* difference between the subliminal prime types.

The subliminal prime types were initially compared across a range of affective and cognitive measures (Experiment 1), which initially suggested an effect for semantic working memory following exposure to the positive primes (i.e., cognitive and affective). However, repeated attempts to replicate this effect failed (see Experiments 2-4), and a re-examination of the data upon reflection of such findings suggested the possibility of a Type II error. As such, the results from Experiments 1 to 4 were concluded to reveal a practice effect. Such a conclusion was further supported by the results of the meta-analysis conducted on the CST data collected from all four experiments that also reported participants to improve over time, regardless of subliminal priming group. Hence, the findings from the current research suggest that

subliminal priming of either Single-Word or Multiple-Word primes may be unable to improve the complex cognitions involved in phonological working memory performance. It is possible that the higher cognitive load placed on the phonological loop by the working memory tasks (i.e., CST, AOSPAN task) utilise much of the individual's cognitive resources, which in turn, leaves insufficient cognitive resources left to process the subliminal primes and activate the relevant behaviour.

Furthermore, the results from this research were able to extend current theoretical knowledge. For example, the results from Experiments 3 and 4 extend goal-directed behaviour theory, demonstrating that it may be necessary but may not be sufficient to hold the motivation to achieve a goal, prime such a goal with relevant subliminal stimuli, and provide a suitable environment for goal-directed behaviour to manifest. It is also possible that the nature of that goal being primed, and its relevant goal-directed behaviour, should also be considered. Alternatively, it is possible that no subliminal priming effects were found due to an ineffective priming methodology. It is possible that the short exposure duration impacted on the strength of the subliminal primes (Van den Bussche et al., 2009), and/or the use of a backward mask inhibited unconscious processing of such primes (Greenwald et al., 1996; Jaśkowski, 2007). As such, future research may wish to extend the exposure duration of the subliminal primes by using a longer fixed duration or an individually tailored duration for each participant (see Armstrong & Dienes, 2013, 2014). Alternatively, grey-scale colour contrasting (Lamy et al., 2008) or CFS (Tsuchiya & Koch, 2005) could be used to enable a longer exposure duration, and reduce the risk of inhibiting the unconscious processing of the subliminal prime (Greenwald et al., 1996; Jaśkowski, 2007).

8.7 Final Concluding Remarks

With regards to the possible difference between subliminal Single-Word and Multiple-Word primes, this research reported no differential effect between the two prime types. However, before concluding that no difference exists, future research should *first* establish a successful subliminal priming procedure to ensure that any null results between the two prime types are not due to the possible ineffectiveness of the priming procedure utilised. For instance, future research should consider increasing the strength of the subliminal primes by increasing the exposure duration. Furthermore, this research found no subliminal priming effects following any of the subliminal primes and as such, suggests that subliminal priming may be unable to improve the complex cognitions involved in phonological working memory. It is possible that a high cognitive load placed on the phonological loop during the completion of phonological working memory tasks impairs the individual's ability to unconsciously process the subliminal primes.

References

- Aarts, H., Chartrand, T. L., Custers, R., Danner, U., Dik, G., Jefferis, V. E., & Cheng, C. M. (2005). Social stereotypes and automatic goal pursuit. *Social Cognition, 23*(6), 465-490. doi:10.1521/soco.2005.23.6.465.
- Aarts, H., Custers, R., & Holland, R. W. (2007). The nonconscious cessation of goal pursuit: When goals and negative affect are coactivated. *Journal of Personality and Social Psychology, 92*(2), 165-178. doi: 10.1037/00223514.92.2.165.
- Aarts, H., Custers, R., & Marien, H. (2008). Preparing and motivating behavior outside of awareness. *Science, 319*(5870), 1639-1639. doi: 10.1126/science.1150432.
- Aarts, H., Gollweizer, P. M., & Hassin, R. R. (2004). Goal contagion: Perceiving is for pursuing. *Journal of Personality and Social Psychology, 87*(1), 23-37. doi: 10.1037/0022-3514.87.1.23.
- Abrams, R. L., & Greenwald, A. G. (2000). Parts outweigh the whole (word) in unconscious analysis of meaning. *Psychological Science, 11*(2), 118-124, doi: 10.1111/1467-9280.00226.
- Abrams, R. L., Klinger, M. R., & Greenwald, A. G. (2002). Subliminal words activate semantic categories (no automated motor responses). *Psychonomic Bulletin & Review, 9*(1), 100-106. doi: 10.3758/BF03196262.
- Ackerman, P. L. (1996). A theory of adult intellectual development: Process, personality, interests, and knowledge. *Intelligence, 22*(2), 227-257. doi: 10.1016/S0160-2896(96)90016-1.
- Ackerman, P. L., & Rolfhus, E. L. (1999). The locus of adult intelligence: Knowledge, abilities, and nonability traits. *Psychology and Aging, 14*(2), 314-330. doi: 10.1037/0882-7974.14.2.314.

- Amabile, T. M. (1998). *How to kill creativity* (pp. 77-87). Boston, Massachusetts: Harvard Business School Publishing.
- Amabile, T. M., Hill, K. G., Hennessey, B. A., & Tighe, E. M. (1994). The work preference inventory: Assessing intrinsic and extrinsic motivational orientations. *Journal of Personality and Social Psychology, 66*(5), 950-967. doi: 10.1037/0022-3514.66.5.950.
- Anshel, J. (Ed.). (2005). *Visual ergonomics handbook*. Boca Raton, Florida: Taylor & Francis Group, CRP Press.
- Arditi, A., & Cho, J. (2005). Serifs and font legibility. *Vision Research, 45*, 2926-2933. doi: 10.1016/j.visres.2005.06.013.
- Ariam, S., & Siller, J. (1982). Effects of subliminal oneness stimuli in Hebrew on academic performance of Israeli high school students: Further evidence on the adaptation-enhancing effects of symbiotic fantasies in another culture using another language. *Journal of Abnormal Psychology, 91*(5), 343-349. doi:10.1037/0021-B43X.91.5.343.
- Armstrong, A. M., & Dienes, Z. (2013). Subliminal understanding of negation: Unconscious control by subliminal processing of word pairs. *Consciousness and Cognition, 22*(3), 1022-1040. doi: 10.1016/j.concog.2013.06.010.
- Armstrong, A. M., & Dienes, Z. (2014). Subliminal understanding of active versus passive sentences. *Psychology of Consciousness: Theory, Research, and Practice, 1*(1), 32-50. doi: 10.1037/css0000002.
- Arndt, J., Greenberg, J., Pyszczynski, T., & Solomon, S. (1997). Subliminal exposure to death-related stimuli increases defense of the cultural worldview. *Psychological Science, 8*(5), 379-385. doi: 10.1111/j.14679280.1997.tb00429.x.

- Aron, A. R., Schlaghecken, F., Fletcher, P. C., Bullmore, E. T., Eimer, M., Barker, R., ... & Robbins, T. W. (2003). Inhibition of subliminally primed responses is mediated by the caudate and thalamus: evidence from functional MRI and Huntington's disease. *Brain*, *126*(3), 713-723. Doi: 10.1093/brain/awg067.
- Asch, S. E. (1946). Forming impressions of personality. *The Journal of Abnormal and Social Psychology*, *41*(3), 258-290. doi: 10.1037/h0055756.
- Atas, A., Vermeiren, A., & Cleeremans, A. (2013). Repeating a strongly masked stimulus increases priming and awareness. *Consciousness and Cognition*, *22*(4), 1422-1430. doi: 10.1016/j.concog.2013.09.001.
- Avons, S. E., Russo, R., Cinel, C., Verolini, V., Glynn, K., McDonald, R., & Cameron, M. (2009). Associative and repetition priming with the repeated masked prime technique: No priming found. *Memory & Cognition*, *37*(1), 100-114. doi: 10.3758/MC.37.1.100.
- Baddeley, A. (1992). Working memory. *Science*, *255*(5044), 556-559. doi: 10.1126/science.1736359.
- Baddeley, A. (2000). The episodic buffer: A new component of working memory?. *Trends in Cognitive Science*, *4*(11), 417-423. doi: 10.1016/S1364-6613(00)01538-2.
- Baddeley, A. (2003). Working memory: Looking back and looking forward. *Nature Reviews*, *4*(10), 829-839. doi: 10.1038/nrn1201.
- Baddeley, A. D., & Logie, R. H. (1999). Working memory: The multiple-component model. In A. Miyake., & P. Shah. (Eds.), *Models of working memory. Mechanisms of active maintenance and executive control*. Cambridge: Cambridge University Press.

- Badgaiyan, R. D. (2000). Neuroanatomical organization of perceptual memory: An fMRI study of picture priming. *Human Brain Mapping, 10*(4), 197-203. doi: 10.1002/1097-0193(200008)10:4<197::AID-HBM50>3.0.CO;2-B.
- Balay, J., & Shevrin, H. (1988). The subliminal psychodynamic activation method: A critical review. *American Psychologist, 43*(3), 161-174. doi: 10.1037/0003-066X.43.3.161.
- Balconi, M., & Lucchiari, C. (2007). Consciousness and emotional facial expression recognition: Subliminal/supraliminal stimulation effect on n200 and p300 ERPs. *Journal of Psychophysiology, 21*(2), 100-108. doi: 10.1027/0269-8803.21.2.100.
- Balota, D. A., Tse, C. S., Hutchison, K. A., Spieler, D. H., Duchek, J. M., & Morris, J. C. (2010). Predicting conversion to dementia of the Alzheimer's type in a healthy control sample: The power of errors in Stroop color naming. *Psychology and Aging, 25*(1), 208-218. doi: 10.1037/a0017474.
- Bar, M., & Biederman, I. (1998). Subliminal visual priming. *Psychological Science, 9*(6), 464-468. doi: 10.1111/1467-9280.00086.
- Bargh, J. A. (1994). The four horsemen of automaticity: Intention, awareness, efficiency, and control as separate issues. In R. Wyer., & T. Scrull. (Eds.), *Handbook of social cognition* (pp. 1-40). Hillsdale, New Jersey Hove, United Kingdom: Lawrence Erlbaum Associates.
- Bargh, J. A. (2002). Losing Consciousness: Automatic influences on consumer judgment, behavior, and Motivation. *Journal of Consumer Research, 29*(2), 280-285. doi: 10.1086/341577.

- Bargh, J. A. (2005). Bypassing the will: Toward demystifying the nonconscious control of social behavior. In R. R. Hassin., J. S., Uleman., & J. A. Bargh. (Eds.), *The new unconscious* (pp. 37-58). New York: Oxford University Press.
- Bargh, J. A., Bond, R. N., Lombardi, W. J., & Tota, M. E. (1986). The additive nature of chronic and temporary sources of construct accessibility. *Journal of Personality and Social Psychology*, *50*(5), 869-878. doi: 10.1037/0022-3514.50.5.869.
- Bargh, J. A., & Chartrand, T. L. (1999). The unbearable automaticity of being. *American Psychologist*, *54*(7), 462-479. doi: 10.1037/0003-066X.54.7.462.
- Bargh, J. A., & Chartrand, T. L. (2000). The mind in the middle. A practical guide to priming and automaticity research. In H. Reis, & C. Judd. (Eds.), *Handbook of research methods in social psychology*, (pp. 253-285). New York: Cambridge University Press.
- Bargh, J. A., Chen, M., & Burrows, L. (1996). Automaticity of social behavior: Direct effects of trait construct and stereotype activation on action. *Journal of Personality and Social Psychology*, *71*(2), 230-244. doi: 10.1037/00022-3514.71.2.230.
- Bargh, J. A., & Ferguson, M. J. (2000). Beyond behaviorism: On the automaticity of higher mental processes. *Psychological Bulletin*, *126*(6), 925-245. doi: 10.1037/0033-2909.126.6.925.
- Bargh, J. A., & Morsella, E. (2008). The unconscious mind. *Perspectives on Psychological Science*, *3*(1), 73-79. doi: 10.1111/j.1745-6916.2008.00064.x.
- Bargh, J. A., & Pietromonaco, P. (1982). Automatic information processing and social perception: The influence of trait information presented outside of conscious

- awareness on impression formation. *Journal of Personality and Social Psychology*, 43(3), 437-449. doi: 10.1037/0022-3514.43.3.437.
- Bargh, J. A., Raymond, P., Pryor, J. B., & Strack, F. (1995). Attractiveness of the underling: An automatic power→ sex association and its consequences for sexual harassment and aggression. *Journal of Personality and Social Psychology*, 68(5), 768-781. doi: 10.1037/0022-3514.68.5.768.
- Bargh, J. A., Schwader, K. L., Hailey, S. E., Dyer, R. L., & Boothby, E. J. (2012). Automaticity in social-cognitive processes. *Trends in Cognitive Sciences*, 16(12), 593–605. doi: 10.1016/j.tics.2012.10.002.
- Barnes, L. L., Harp, D., & Jung, W. S. (2002). Reliability generalization of scores on the Spielberger state-trait anxiety inventory. *Educational and Psychological Measurement*, 62(4), 603-618. doi: 10.1177/0013164402062004005.
- Basden, B. H., & Basden, D. R. (1998). Directed forgetting: A contrast of methods and interpretations. In J. M. Golding., & C. M. MacLeod. (Eds.), *Intentional forgetting: Interdisciplinary approaches* (pp. 139-172). Mahwah, New York: Lawrence Erlbaum Associates Publishers.
- Benjamin, L. S. (1974). Structural analysis of social behavior. *Psychological Review*, 81(5), 392–425. doi: 10.1037/h0037024.
- Benjamin, L. S. (1996a). *Interpersonal diagnosis and treatment of personality disorder* (2nd ed.). New York: Guilford.
- Benjamin, L. S. (1996b). Introduction to the special section on structural analysis of social behavior. *Journal of Consulting and Clinical Psychology*, 64(6), 1203–1212. doi: 10.1037/0022-006X.64.6.1203.

- Bennett, J. D., Lleras, A., Oriet, C., & Enns, J. T. (2007). A negative compatibility effect in priming of emotional faces. *Psychonomic Bulletin & Review*, *14*(5), 908-912. doi: 10.3758/BF03194120.
- Bermeitinger, C., Goelz, R., Johr, N., Neumann, M., Ecker, U. K., & Doerr, R. (2009). The hidden persuaders break into the tired brain. *Journal of Experimental Social Psychology*, *45*(2), 320-326. doi: 10.1016/j.jesp.2008.10.001.
- Bermeitinger, C., Wentura, D., Koppermann, C., Hauser, M., Grass, B., & Frings, C. (2012). The direction of masked auditory category priming correlates with participants' prime discrimination ability. *Advances in Cognitive Psychology*, *8*(3), 210-217. doi: 10.2478/v10053-008-0116-6.
- Bernard, M., Lida, B., Riley, S., Hackler, T., & Janzen, K. (2002, January 10). A comparison of popular online fonts: Which size and type is best. *Usability News*, *4*(1). Retrieved from <http://usabilitynews.org/a-comparison-of-popular-online-fonts-which-size-and-type-is-best/>.
- Bijleveld, E., Custers, R., & Aarts, H. (2011). Once the money is in sight: Distinctive effects of conscious and unconscious rewards on task performance. *Journal of Experimental Social Psychology*, *47*(4), 865-869. doi: 10.1016/j.jesp.2011.03.002.
- Birgegård, A. (2003). *Producing, preventing, and explaining persistent complex subliminal stimulation effects*. (Doctoral thesis, Uppsala University, Uppsala, Sweden). Retrieved from <http://www.diva-portal.org/smash/get/diva2:163823/FULLTEXT01.pdf>.

- Blu. (Producer). (2010). *Big bang big boom – the new wall-painted animation* [ONLINE]. Available from <https://www.youtube.com/watch?v=sMoKcsN8wM8>.
- Blu, & Ellis, D. (Producers). (2009). *COMBO a collaborative animation* [ONLINE]. Available from <https://www.youtube.com/watch?v=uad17d5hR5s>.
- Bodner, G. E., & Masson, M. E. (1997). Masked repetition priming of words and nonwords: Evidence for a nonlexical basis for priming. *Journal of Memory and Language, 37*(2), 268-293. doi: 10.1006/jmla.1996.2507.
- Bornstein, R. F., Leone, D. R., & Galley, D. J. (1987). The generalizability of subliminal mere exposure effects: Influence of stimuli perceived without awareness on social behavior. *Journal of Personality and Social Psychology, 53*(6), 1070-1079. doi: 10.1037/0022-3514.53.6.1070.
- Bos, M. W., Dijksterhuis, A., & Baaren, R. B. V. (2008). On the goal-dependency of unconscious thought. *Journal of Experimental Social Psychology, 44*(4), 1114-1120. doi: 10.1016/j.jesp.2008.01.001.
- Bower, G. H. (1981). Mood and memory. *American Psychologist, 36*(2), 129-148. doi: 10.1037/0003-066X.36.2.129.
- Boy, F., & Sumner, P. (2010). Tight coupling between positive and reversed priming in the masked prime paradigm. *Journal of Experimental Psychology: Human Perception and Performance, 36*(4), 892-905. doi: 10.1037/a0017173.
- Brockner, J. (1983). Low self-Esteem and behavioral plasticity: Some implications. In L. Wheeler & P. Shaver (Eds.), *Review of personality and social psychology* (pp. 237-271). Beverly Hills: Sage.

- Bronstein, A. A., & Rodin, G. C. (1983). An experimental study of internalization fantasies in schizophrenic men. *Psychotherapy: Theory, Research & Practice*, 20(4), 408-416. doi: 10.1037/h0088501.
- Bry, C., Follenfant, A., & Meyer, T. (2008). Blonde like me: When self-construals moderate stereotype priming effects on interlectual performance. *Journal of Experimental Social Psychology*, 44(3), 751-757. doi: 10.1016/j.jesp.2007.06.005.
- Bryant-Tuckett, R., & Silverman, L. H. (1984). Effects of the subliminal stimulation of symbiotic fantasies on the academic performance of emotionally handicapped students. *Journal of Counseling Psychology*, 31(3), 295-305. doi: 10.1037/0022-0167.31.3.295.
- Bryk, A. S., & Raudenbush, S. W. (1988). Heterogeneity of variance in experimental studies: A challenge to conventional interpretations. *Psychological Bulletin*, 104(3), 196-404. doi: 10.1037/0033-2909.104.3.396.
- Cabeza, R., Kapur, S., Craik, F. M. I., McIntosh, A. R., Houle, S., & Tulving, E. (1997). Functional neuroanatomy of recall and recognition: A PET study of episodic memory. *Journal of Cognitive Neuroscience*, 9(2), 245-265. doi:10.1162/jocn.1997.9.2.254.
- Campbell, K. W., & Sedikides, C. (1999). Self-threat magnifies the self-serving bias: A meta-analytic integration. *Review of General Psychology*, 3(1), 23-34. doi: 10.1037/1089-2680.3.1.23.
- Cesario, J. (2014). Priming, replication, and the hardest science. *Perspectives on Psychological Science*, 9(1), 40-48. doi: 10.1177/1745691613513470.

- Chakalis, E., & Lowe, G. (1992). Positive effects of subliminal stimulation on memory. *Perceptual and motor skills*, 74(3), 956-958. doi: 10.2466/pms.1992.74.3.956.
- Chalfoun, P., & Frasson, C. (2008). Subliminal priming enhances learning in a distant virtual 3D Intelligent Tutoring System. *IEEE Multidisciplinary Engineering Education Magazine: Special Issue on Intelligent Tutoring Systems*, 3(4), 125-130.
- Chalfoun, P., & Frasson, C. (2009). Optimal affective conditions for subconscious learning in a 3D intelligent tutoring system. In J. A. Jacko (Ed.), *Human-Computer Interaction. Interacting in Various Application Domains. 13th International Conference, HCI International 2009 San Diego, CA, USA, July 2009 proceedings, Part IV* (pp. 39-48). doi: 10.1007/978-3-642-02583-9_5.
- Chalfoun, P., & Frasson, C. (2011). Subliminal cues while teaching: HCI technique for enhanced learning. *Advances in Human-Computer Interaction*, 2011(2), 1-15. doi:10.1155/2011/968753.
- Chartrand, T. L., & Bargh, J. A. (1996). Automatic activation of impression formation and memorization goals: Nonconscious goal priming reproduces effects of explicit task instructions. *Journal of Personality and Social Psychology*, 71(3), 464-478. doi: 10.1037/0022-3514.71.3.464.
- Cheesman, J., & Merikle, P. M. (1984). Priming with and without awareness. *Perception & Psychophysics*, 36(4), 387-395. doi: 10.3758/BF03202793.
- Cheesman, J., & Merikle, P. M. (1986). Distinguishing conscious from unconscious perceptual processes. *Canadian Journal of Psychology/Revue Canadienne de Psychologie*, 40(4), 343-367. doi: 10.1037/h0080103.

- Cohen, J., MacWhinney, B., Flatt, M., & Provost, J. (1993). PsyScope: An interactive graphic system for designing and controlling experiments in the psychology laboratory using Macintosh computers. *Behavior Research Methods, Instruments, & Computers*, 25(2), 257-271. doi: 10.3758/BF03204507.
- Collins, A. M., & Loftus, E. F. (1975). A spreading-activation theory of semantic processing. *Psychological Review*, 82(6), 407-428. doi: 10.1037/0033-295X.82.6.407.
- Colom, R., Abad, F., Rebollo, I., & Shih, P. C. (2005). Memory span and general intelligence: A latent-variable approach. *Intelligence*, 33(6), 623-642. doi: 10.1016/j.intell.2005.05.006.
- Colom, R., Jung, R. E., & Haier, R. J. (2007). General intelligence and memory span: evidence for a common neuroanatomic framework. *Cognitive Neuropsychology*, 24(8), 867-878. doi: 10.1080/02643290701781557.
- Condon, T. J., & Allen, G. J. (1980). Role of psychoanalytic merging fantasies in systematic desensitization: A rigorous methodological examination. *Journal of Abnormal Psychology*, 89(3), 437-443. doi: 10.1037/0021-843X.89.3.437.
- Cook, D. R. (1994). *Internalized Shame Scale – Professional manual*. Menomonie, WI: Channel Press.
- Cook, D. R. (1996). Empirical studies of shame and guilt: The Internalized Shame Scale. In D. L. Nathanson (Ed.), *Knowing feeling: Affect, script and psychotherapy*. New York: Norton.
- Costello, P., Jiang, Y., Baartman, B., McGlennen, K., & He, S. (2009). Semantic and subword priming during binocular suppression. *Consciousness and Cognition*, 18(2), 375-382. doi: [10.1016/j.concog.2009.02.003](https://doi.org/10.1016/j.concog.2009.02.003).

- Costin, D. (1988). MacLab: A Macintosh system for psychology labs. *Behaviour Research Methods, Instruments, & Computers*, 20(2), 197-200. doi: 10.3758/BF03203834.
- Craig, J., Scala, I. K., & Bevington, W. (2006). *Designing with type. The essential guide to typography* (5th ed.). New York: Watson-Guptill publications.
- Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of verbal learning and verbal behavior*, 11(6), 671-684. doi: 10.1016/S0022-5371(72)80001-X.
- Crawley, S. E., French, C. C., & Yesson, S. A. (2002). Evidence for transliminality from a subliminal card-guessing task. *Perception*, 31(7), 887-892. doi: 10.1068/p3186.
- Curran, S. L., Andrykowski, M. A., & Studts, J. L. (1995). Short Form of the Profile of Mood States (POMS-SF): Psychometric information. *Psychological Assessment*, 7(1), 80-83. doi: 10.1037/1040.3590.7.1.80.
- Custers, R., & Aarts, H. (2005). Positive affect as implicit motivator: On the nonconscious operation of behavioral goals. *Journal of Personality and Social Psychology*, 89(2), 129-142. doi: 10.1037/0022-3514.89.2.129.
- Custers, R., & Aarts, H. (2007). In search of the nonconscious sources of goal pursuit: Accessibility and positive affective valence of the goal state. *Journal of Experimental Social Psychology*, 43(2), 312-318. doi: 10.1016/j.jesp.2006.02.005.
- Custers, R., & Aarts, H. (2010). The unconscious will: How the pursuit of goals operates outside of conscious awareness. *Science*, 329(5987), 47-50. doi: 10.1126/science.1188595.

- Daltrozzo, J., Signoret, C., Tillmann, B., & Perrin, F. (2011). Subliminal semantic priming in speech. *PloS one*, *6*(5), e20273. doi: 10.1371/journal.pone.0020273.
- Damian, M. F. (2001). Congruity effects evoked by subliminally presented primes: Automaticity rather than semantic processing. *Journal of Experimental Psychology: Human Perception and Performance*, *27*(1), 154-165. doi: 10.1037/0096-1523.27.1.154.
- Dannlowski, U., Kersting, A., Lalee-Mentzel, J., Donges, U. S., Arolt, V., & Suslow, T. (2006). Subliminal affective priming in clinical depression and comorbid anxiety: A longitudinal investigation. *Psychiatry Research*, *143*(1), 63-75. doi: 10.1016/j.psychres.2005.08.002.
- Dauber, R. B. (1984). Subliminal psychodynamic activation in depression: On the role of autonomy issues in depressed college women. *Journal of Abnormal Psychology*, *93*(1), 9-18. doi: 10.1037/0021-843X.93.1.9.
- Daza, M. T., Ortells, J. J., & Fox, E. (2002). Perception without awareness: Further evidence from a Stroop priming task. *Perception & Psychophysics*, *64*(8), 1316-1324. doi: 10.3758/BF03194774.
- de Gelder, B. D., Meeren, H. K., Righart, R., Stock, J. V. D., van de Riet, W. A., & Tamietto, M. (2006). Beyond the face: Exploring rapid influences of context on face processing. *Progress in Brain Research*, *155*, 37-48. doi: 10.1016/S0079-6123(06)55003-4.
- Debner, J. A., & Jacoby, L. L. (1994). Unconscious perception: Attention, awareness, and control. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*(2), 304-317. doi: 10.1037/0278-7393.20.2.304.
- DeCarlo, L. T. (1997). On the meaning and use of kurtosis. *Psychological methods*, *2*(3), 292-307. doi: 10.1037/1082-989X.2.3.292.

- Deci, E. L. (1972). Intrinsic motivation, extrinsic reinforcement, and inequity. *Journal of Personality and Social Psychology*, 22(1), 113-120. doi: 10.1037/h0032355.
- Deci, E. L., Koestner, R., & Ryan, R. M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychological Bulletin*, 125(6), 627-668. doi: 10.1037/0033-2909.125.6.627.
- Deci, E. L., & Ryan, R. M. (1985). The general causality orientations scale: Self-determination in personality. *Journal of Research in Personality*, 19(2), 109-134. doi: 10.1016/0092-6566(85)90023-6.
- Dehaene, S., Naccache, L., Le Clec'H, G., Koechlin, E., Mueller, M., Dehaene-Lambertz, G., ... & Le Bihan, D. (1998). Imaging unconscious semantic priming. *Nature*, 395(6702), 597-600. doi: 10.1038/26967.
- Dehaene, S., Naccache, L., Cohen, L., Le Bihan, D., Mangin, J. F., Poline, J. B., & Rivière, D. (2001). Cerebral mechanisms of word masking and unconscious repetition priming. *Nature Neuroscience*, 4(7), 752-758. doi: 10.1038/89551.
- Dehaene, S., Changeux, J. P., Naccache, L., Sackur, J., & Sergent, C. (2006). Conscious, preconscious, and subliminal processing: A testable taxonomy. *Trends in Cognitive Sciences*, 10(5), 204-211. doi: 10.1016/j.tics.2006.03.007.
- Dell'Acqua, R., & Grainger, J. (1999). Unconscious semantic priming from pictures. *Cognition*, 73(1), B1-B15. doi: 10.1016/S0010-0277(99)00049-9.
- Delord, S. (1998). Which mask is the most efficient: A pattern or a noise? It depends on the task. *Visual Cognition*, 5(3), 313-338. doi: 10.1080/713756789.
- DeVaul, R. W. (2004). *Memory glasses: Wearable Computing for just-in-time memory support*. (Doctoral Dissertation, Massachusetts Institute of Technology). Retrieved from <http://pubs.media.mit.edu/pubs/papers/DeVaul.pdf>

- DeVaul, R. W., & Pentland, A. S. (2002). Towards the zero attention interface: Wearable subliminal cuing for short term memory support. *Proceedings of the 6th International Symposium on Wearable computers, Institute of Electrical and Electronic Engineers Press*. p.141.142. doi: 10.1109/ISWC.2002.1167234.
- DeVaul, R. W., Pentland, A., & Corey, V. R. (2003). The memory glasses: Subliminal vs. overt memory support with imperfect information. *Proceedings of the 7th International Symposium on Wearable Computers, Institute of Electrical and Electronic Engineers Press*. p.146-153. doi: 10.1109/ISWC.2003.1241404.
- Devine, P. G. (1989). Stereotypes and prejudice: Their automatic and controlled components. *Journal of Personality and Social Psychology*, 56(1), 5-18. doi: 10.1037/0022-3514.56.1.5.
- Dienes, Z. (2004). Assumptions of subjective measures of unconscious mental states: Higher order thoughts and bias. *Journal of Consciousness Studies*, 11(9), 25-45.
- Dienes, Z. (2008). *Understanding psychology as a science: An introduction to scientific and statistical inference*. Hampshire, England: Palgrave Macmillan.
- Dienes, Z. (2011). Bayesian versus orthodox statistics: Which side are you on?. *Perspectives on Psychological Science*, 6(3), 274-290. doi: 10.1177/1745691611406920.
- Dienes, Z. (2014). Using Bayes to get the most out of non-significant results. *Frontiers in Psychology*, 5, 781. doi: 10.3389/fpsy.2014.00781.
- Dienes, Z. (2015). How Bayesian statistics are needed to determine whether mental states are unconscious. In M. Overgaard (Ed.), *Behavioral methods in consciousness research*. Oxford: Oxford University Press.

- Dijksterhuis, A. (2004). I like myself but I don't know why: Enhancing implicit self-esteem by subliminal evaluative conditioning. *Journal of Personality and Social Psychology*, 86(2), 345-355. doi: 10.1037/0022-3514.86.2.345.
- Dijksterhuis, A. (2013). Reproducibility: Priming-effect author responds. *Nature*, 498(7454), 299-299. doi:10.1038/498299e.
- Dijksterhuis, A. (2014). Welcome back theory!. *Perspectives on Psychological Science*, 9(1), 72-75. doi: 10.1177/1745691613513472.
- Dijksterhuis, A., Aarts, H., Bargh, J. A., & van Knippenberg, A. (2000). On the relation between associative strength and automatic behavior. *Journal of Experimental Social Psychology*, 36(5), 531-544. doi: 10.1006/jesp.2000.1427.
- Dijksterhuis, A., & Bargh, J. A. (2001). The perception-behavior expressway: Automatic effects of social perception on social behavior. *Advances in Experimental Social Psychology*, 33, 1-40. doi: 10.1016/S0065-2601(01)80003-4.
- Dijksterhuis, A., Preston, J., Wegner, D. M., & Aarts, H. (2008). Effects of subliminal priming of self and God on self-attribution of authorship for events. *Journal of Experimental Social Psychology*, 44(1), 2-9. doi: 10.1016/j.jesp.2007.01.003.
- Dijksterhuis, A., & Smith, P. K. (2002). Affective habituation: Subliminal exposure to extreme stimuli decreases their extremity. *Emotion*, 2(3), 203 –214. doi: 10.37/1528-3542.2.3.203.
- Dijksterhuis, A., & Van Knippenberg, A. (1998). The relation between perception and behavior, or how to win a game of trivial pursuit. *Journal of Personality and Social Psychology*, 74(4), 865-877. doi: 10.1037/0022-3514.74.4.865.
- Dijksterhuis, A., van Knippenburg, A., & Holland, R. W. (2014). Evaluating behavior priming research: Three observations and a recommendation. In D. C. Molden

- (Ed.), *Understanding priming effects in social psychology* (pp. 205-217). New York: The Guilford Press.
- Dijksterhuis, A., Spears, R., Postmes, T., Stapel, D., Koomen, W., Knippenberg, A. V., & Scheepers, D. (1998). Seeing one thing and doing another: Contrast effects in automatic behavior. *Journal of Personality and Social Psychology*, *75*(4), 862-871. doi: 10.1037/0022-3514.75.4.862.
- Dixon, R., Hultsch, D., & Hertzog, C. (1988). The Metamemory in Adulthood Questionnaire. *Psychopharmacology Bulletin*, *24*, 671-688.
- Doyen, S., Klein, O., Pichon, C. L., & Cleeremans, A. (2012). Behavioral priming: It's all in the mind, but whose mind. *PloS one*, *7*(1), e29081. doi: 10.1371/journal.pone.002908.
- Draine, S. C. (1997). *Analytic limitations of unconscious language processing* (Doctoral dissertation). Available from ResearchWorks Archive. (UMI No. 9736260).
- Draine, S. (1999). Inquisit [Computer software]. Seattle, WA: Millisecond Software.
- Draine, S. C., & Greenwald, A. G. (1998). Replicable unconscious semantic priming. *Journal of Experimental Psychology: General*, *127*(3), 286-303. doi: 10.1037/0096-3445.127.3.286.
- Druckman, D., & Bjork, R. A. (1991). *In the mind's eye: Enhancing human performance*. Washington DC: National Academy Press.
- Dupoux, E., de Gardelle, V., & Kouider, S. (2008). Subliminal speech perception and auditory streaming. *Cognition*, *109*(2), 267-273. doi: 10.1016/j.cognition.2008.06.012.

- Dupoux, E., & Mehler, J. (1990). Monitoring the lexicon with normal and compressed speech: Frequency effects and the prelexical code. *Journal of Memory and Language*, 29(3), 316-335. doi: 10.1016/0749-596X(90)90003-I.
- Eckstein, D., Kubat, M., & Perrig, W. J. (2011). Visible homonyms are ambiguous, subliminal homonyms are not: A close look at priming. *Consciousness and Cognition*, 20(4), 1327-1343. doi: 10.1016/j.concog.2011.05.010.
- Egermann, H., Kopiez, R., & Reuter, C. (2006). Is there an effect of subliminal messages in music on choice behavior. *Journal of Articles in Support of the Null Hypothesis*, 4(2), 29-45.
- Elliott, A. C., & Woodward, W. A. (2007). *Statistical analysis quick reference guidebook: With SPSS examples*. Thousand Oaks, Calif: Sage Publications.
- Endler, N. S., & Kocovski, N. L. (2001). State and trait anxiety revisited. *Journal of Anxiety Disorders*, 15(3), 231-245. doi: 10.1016/S0887-6185(01)00060-3.
- Enns, J. T., & Oriet, C. (2007). Visual similarity in masking and priming: The critical role of task relevance. *Advances in Cognitive Psychology*, 3(1-2), 211-226. doi: 10.2478/v10053-008-0026-z.
- Erdley, C. A., & D'Agostino, P. R. (1988). Cognitive and affective components of automatic priming effects. *Journal of Personality and Social Psychology*, 54(5), 741-747. doi: 10.1037/0022-3514.54.5.741.
- Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, 39, 175-191.
- Field, A. (2009). *Discovering statistics using SPSS* (3rd ed.). London: SAGE Publications.

- Finkbeiner, M. (2011). Subliminal priming with nearly perfect performance in the prime-classification task. *Attention, Perception, & Psychophysics*, 73(4), 1255-1265. doi: 10.3758/s13414-011-0088-8.
- Finkbeiner, M., & Forster, K. I. (2008). Attention, intention and domain-specific processing. *Trends in cognitive sciences*, 12(2), 59-64. doi: 10.1016/j.tics.2007.11.003.
- Fitting, S., Wedell, D. H., & Allen, G. L. (2005). Memory for spatial location: Influences of environmental cues and task field rotation. In A. G. Cohen, & D. M. Mark, (Eds.), *Spatial information theory. International conference, COSIT 2005, Ellicottville, NY, USA, September 14-18, 2005. Proceedings* (pp. 459-474). doi: 10.1007/11556114_29.
- Fitts, P. M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. *Journal of Experimental Psychology*, 47(6), 381-391. doi: 10.1037/h0055392.
- Fitzsimons, G. M., & Bargh, J. A. (2003). Thinking of you: Nonconscious pursuit of interpersonal goals associated with relationship partners. *Journal of Personality and Social Psychology*, 84(1), 148-164. doi: 10.1037/0022-3514.84.1.148.
- Fitzsimons, G. M., Chartrand, T. L., & Fitzsimons, G. J. (2008). Automatic effects of brand exposure on motivated behavior: How apple makes you “think different”. *Journal of Consumer Research*, 35(1), 21-35. doi: 10.1086/527269.
- Fleming, J. S., & Courtney, B. E. (1984). The dimensionality of self-esteem: II. Hierarchical facet model for revised measurement scales. *Journal of Personality and Social Psychology*, 46(2), 404-421. doi: 10.1037/0022-3514.46.2.404.

- Flowers, J. H., & Stoup, C. M. (1977). Selective attention between words, shapes and colors in speeded classification and vocalization tasks. *Memory & Cognition*, 5(3), 299-307. doi: 10.3758/BF03197574.
- Forster, K. I., & Davis, C. (1984). Repetition priming and frequency attenuation in lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 10(4), 680-698. doi: 10.1037/0278-7393.10.4.680.
- Förster, J., Liberman, N., & Friedman, R. S. (2007). Seven principles of goal activation: A systematic approach to distinguishing goal priming from priming of non-goal constructs. *Personality and Social Psychology Review*, 11(3), 211-233. doi: 10.1177/1088868307303029.
- Frauman, D. C., Lynn, S. J., Hardaway, R., & Molteni, A. (1984). Effect of subliminal symbiotic activation on hypnotic rapport and susceptibility. *Journal of Abnormal Psychology*, 93(4), 481-483. doi: 10.1037/0021-843X.93.4.481.
- Frings, C., & Wentura, D. (2005). Negative priming with masked distractor-only prime trials: awareness moderates negative priming. *Experimental Psychology*, 52(2), 131-139. doi: 10.1027/1618-3169.52.2.131.
- Froufe, M., & Schwartz, C. (2001). Subliminal messages for increasing self-esteem: Placebo effect. *The Spanish Journal of Psychology*, 4(01), 19-25. doi: 10.1017/S1138741600005618.
- Gaillard, R., Del Cul, A., Naccache, L., Vinckier, F., Cohen, L., & Dehaene, S. (2006). Nonconscious semantic processing of emotional words modulates conscious access. *Proceedings of the National Academy of Sciences*, 103(19), 7524-7529. doi: 10.1073/pnas.0600584103.
- Gelman, A. (2013). *P* values and statistical practice. *Epidemiology*, 24(1), 69-72.

- Gelman, A., & Stern, H. (2006). The difference between “significant” and “not significant” is not itself statistically significant. *The American Statistician*, 60(4), 328-331. doi: 10.1198/000313006X152649.
- Ghasemi, A., & Zahediasl, S. (2012). Normality tests for statistical analysis: A guide for non-statisticians. *International Journal of Endocrinology Metabolism*, 10(2), 486-489. doi: 10.5812/ijem.3505.
- Girden, E. R. (Ed.). (1992). *ANOVA: Repeated measures* (No. 84). California, USA: Sage Publications Inc.
- Glassman, N. S., & Andersen, S. M. (1999). Activating transference without consciousness: Using significant-other representations to go beyond what is subliminally given. *Journal of Personality and Social Psychology*, 77(6), 1146-162. doi: 10.1037/0022-3514.77.6.1146.
- Golegogo Animation. (Producer). (2007). *Game over – THE LEGO PacMan (RETRO)* [ONLINE]. Available from <https://www.youtube.com/watch?v=TqXiPYjFZ5g>.
- Graham, S., & Lowery, B. S. (2004). Priming unconscious racial stereotypes about adolescent offenders. *Law and Human Behavior*, 28(5), 483-504. doi: 10.1023/B:LAHU.0000046430.65485.1f.
- Grainger, J., Diependaele, K., Spinelli, E., Ferrand, L., & Farioli, F. (2003). Masked repetition and phonological priming within and across modalities. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 29(6), 1256-1269. doi: 10.1037/0278-7393.29.6.1256.
- Grainger, J., & Frenck-Mestre, C. (1998). Masked priming by translation equivalents in proficient bilinguals. *Language and Cognitive Processes*, 13(6), 601-623. doi: 10.1080/016909698386393.

- Green, D. M., & Swets, J. A. (1966). *Signal detection theory and psychophysics*. New York: Wiley.
- Greenwald, A. G. (1992). New Look 3: Unconscious cognition reclaimed. *American Psychologist*, 47(6), 766-779. doi: 10.1037/0003-066X.47.6.766.
- Greenwald, A. G., Abrams, R. L., Naccache, L., & Dehaene, S. (2003). Long-term semantic memory versus contextual memory in unconscious number processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 29(2), 235-247. doi: 10.1037/0278-7393.29.2.235.
- Greenwald, A. G., Draine, S. C., & Abrams, R. L. (1996). Three cognitive markers of unconscious semantic activation. *Science*, 273(5282), 1699-1702. doi: 10.1126/science.273.5282.1699.
- Greenwald, A. G., & Farnham, S. D. (2000). Using the implicit association test to measure self-esteem, and self-concept. *Journal of Personality and Social Psychology*, 79(6), 1022-1038. doi: 10.1037//0022-3514.79.6.1022.
- Greenwald, A. G., Gonzales, R., Harris, R. J., & Guthrie, D. (1996). Effect sizes and *p* values: What should be reported and what should be replicated?. *Psychophysiology*, 33(2), 175-183. doi: 10.1111/j.1469-8986.1996.tb02121.x.
- Greenwald, A. G., Klinger, M. R., & Schuh, E. S. (1995). Activation by marginally perceptible ("subliminal") stimuli: Dissociation of unconscious from conscious cognition. *Journal of Experimental Psychology: General*, 124(1), 22-42. doi: 10.1037/0096-3445.124.1.22.
- Greenwald, A. G., & Liu, T. J. (1985). Limited unconscious process of meaning. *Bulletin of the Psychonomic Society*, 23(4), 292-298.

- Greenwald, A. G., Spangenberg, E. R., Pratkanis, A. R., & Eskenazi, J. (1991). Double-blind tests of subliminal self-help audiotapes. *Psychological Science*, 2(2), 119-122. doi: 10.1111/j.1467-9280.1991.tb00112.x.
- Groeger, J. A. (1984). Evidence of unconscious semantic processing from a forced error situation. *British Journal of Psychology*, 75(3), 305-314. doi: 10.1111/j.2044-8295.1984.tb01902.x.
- Grumm, M., Nestler, S., & Von Collani, G. (2009). Changing explicit and implicit attitudes: The case of self-esteem. *Journal of Experimental Social Psychology*, 45(2), 327-335. doi: 10.1016/j.jesp.2008.10.006.
- Gupta, N., Khera, S., Vempati, R. P., Sharma, R., & Bijlani, R. L. (2006). Effect of yoga based lifestyle intervention on state and trait anxiety. *Indian Journal of Physiology and Pharmacology*, 50(1), 41-47.
- Haarmann, H. J., Davelaar, E. J., & Usher, M. (2003). Individual differences in semantic short-term memory capacity and reading comprehension. *Journal of Memory and Language*, 48(2), 320-345. doi: 10.1016/S0749-596X(02)00506-5.
- Haarmann, H., & Usher, M. (2001). Maintenance of semantic information in capacity-limited item short-term memory. *Psychonomic Bulletin & Review*, 8(3), 568-578. doi: 10.3758/BF03196193.
- Harris, C. R., Coburn, N., Rohrer, D., & Pashler, H. (2013). Two failures to replicate high-performance-goal priming effects. *PloS one*, 8(8), e72467. doi: 10.1371/journal.pone.0072467.
- Hamilton, D. L., Katz, L. B., & Leirer, V. O. (1980). Cognitive representation of personality impressions: Organizational processes in first impression formation. *Journal of Personality and Social Psychology*, 39(6), 1050-1063. doi: 10.1037/h0077711.

- Hardaway, R. A. (1990). Subliminally activated symbiotic fantasies: Facts and artifacts. *Psychological Bulletin*, *107*(2), 177-195. doi: 10.1037/0033-2909.107.2.117.
- Hart, W., & Albarracín, D. (2009). The effects of chronic achievement motivation and achievement primes on the activation of achievement and fun goals. *Journal of Personality and Social Psychology*, *97*(6), 1129–1141. doi:10.1037/a0017146.
- Hassin, R. R., Uleman, J. S., & Bargh, J. A. (2005). *The new unconscious*. New York: Oxford University Press.
- Heatherton, T. F., & Polivy, J. (1991). Development and validation of a scale for measuring state self-esteem. *Journal of Personality and Social Psychology*, *60*(6), 895-910. doi: 10.1037/0022-3514.60.6.895.
- Hermans, D., Spruyt, A., De Houwer, J., & Eelen, P. (2003). Affective priming with subliminally presented pictures. *Canadian Journal of Experimental Psychology/Revue Canadienne de Psychologie Expérimentale*, *57*(2), 97-114. doi: 10.1037/h0087416.
- Hertzog, C., Dixon, R., & Hultsch, D. (1990). Relationships between metamemory, memory predictions and memory task performance in adults. *Psychology and Aging*, *5*, 215-227. doi: 10.1037/0882-7974.5.2.215.
- Hess, T. M., Hinson, J. T., & Statham, J. A. (2004). Explicit and implicit stereotype activation effects on memory: Do age and awareness moderate the impact of priming?. *Psychology and Aging*, *19*(3), 495-505. doi: 10.1037/0882-7974.19.3.495.
- Hill, A., & Scharff, L. V. (1997). Readability of websites with various foreground/background color combinations, font types and word styles. *Proceedings of 11th National Conference in Undergraduate Research*, *2*, 742-746.

- Holender, D. (1986a). Conceptual, experimental, and theoretical indeterminacies in research on semantic activation without conscious identification. *Behavioral & Brain Sciences*, 9(01), 50-66. doi: 10.1017/S0140525X00021543.
- Holender, D. (1986b). Semantic activation without conscious identification in dichotic listening, parafoveal vision, and visual masking: A survey and appraisal. *Behavioral & Brain Sciences*, 9(01), 1-23. doi: 10.1017/S0140525X00021269.
- Holender, D. (1987). Semantic activation without conscious identification: Can progress be made? *Behavioral & Brain Sciences*, 10(04), 768-773. doi: 10.1017/S0140525X00055746.
- Holender, D., & Duscherer, K. (2004). Unconscious perception: The need for a paradigm shift. *Perception & Psychophysics*, 66(5), 872-881. doi: 10.3758/BF03194980.
- Howell, D. C. (2002). *Statistical methods for psychology* (5th ed.). [Online Resource]. Belmont, CA: Duxbury Press. Retrieved from https://www.uvm.edu/~dhowell/StatPages/More_Stuff/RepMeasMultComp/RepMeasMultComp.html#Howell.
- Howell, D. C. (2013). *Statistical methods for psychology* (8th ed.). Belmont, CA: Wadsworth.
- Hudesman, J., Page, W., & Rautiainen, J. (1992). Use of subliminal stimulation to enhance learning mathematics. *Perceptual and Motor Skills*, 74(3c), 1219-1224. doi: 10.2466/PMS.74.4.1219-1224.
- Hull, J. G., Slone, L. B., Meteyer, K. B., & Matthews, A. R. (2002). The nonconsciousness of self-consciousness. *Journal of Personality and Social Psychology*, 83(2), 406-424. doi: 10.1037/0022-3514.83.2.406.

- Huttenlocher, J., Hedges, L. V., & Duncan, S. (1991). Categories and particulars: Prototype effects in estimating spatial location. *Psychological Review*, *98*(3), 352-376. doi: 10.1037/0033-295X.98.3.352.
- Iacobucci, D. (2005). On p-values. *Journal of Consumer Research*, *32*(1), 6-11. doi: 10.1086/430648.
- Izquierdo, E., Saal, A., & Page, R. (2010). An accrual model for primed digit classification. *Canadian Journal of Experimental Psychology/ Revue Canadienne de Psychologie Expérimentale*, *64*(1), 3-16. doi: 10.1037/a0016790.
- Jacoby, L. L., & Whitehouse, K. (1989). An illusion of memory: False recognition influenced by unconscious perception. *Journal of Experimental Psychology: General*, *118*(2), 126-135. doi: 10.1037/0096-3445.118.2.126.
- Jaśkowski, P. (2007). The effect of nonmasking distractors on the priming of motor responses. *Journal of Experimental Psychology: Human Perception and Performance*, *33*(2), 456- 468. doi: 10.1037/0096-1523.33.2.456.
- Jaśkowski, P., & Przekoracka-Krawczyk, A. (2005). On the role of mask structure in subliminal priming. *Acta Neurobiologiae Experimentalis*, *65*, 409–417.
- Jefferys, H. (1961). *Theory of probability: Oxford classic texts in the physical sciences* (3rd ed.). New York, United States: Oxford University Press.
- Johnson, M. K., Rowatt, W. C., & LaBouff, J. (2010). Priming Christian religious concepts increases racial prejudice. *Social Psychological and Personality Science*, *1*(2), 119-126. doi: 10.1177/1948550609357246.
- Jostmann, N. B., Koole, S. L., van der Wulp, N. Y., & Fockenberg, D. A. (2005). Subliminal affect regulation: The moderating role of action vs. state orientation. *European Psychologist*, *10*(3), 209-217. doi: 10.1027/1016-9040.10.3.209.

- Jraidi, I., & Frasson, C. (2010). Subliminally enhancing self-esteem: Impact on learner performance and affective state. In V. Aleven, J. Kay, & J. Mostow, (Eds.), *Intelligent Tutoring Systems* (pp. 11-20). Berlin Heidelberg: Springer. doi: 10.1007/978-3-642-13437-1_2.
- Kaiser, C. R., Vick, S. B., & Major, B. (2006). Prejudice expectations moderate preconscious attention to cues that are threatening to social identity. *Psychological Science, 17*(4), 332-338. doi: 10.1111/j.1467-9280.2006.01707.x.
- Kane, M. J., Hambrick, D. Z., & Conway, A. R. (2005). Working memory capacity and fluid intelligence are strongly related constructs: Comment on Ackerman, Beier, and Boyle (2005). *Psychological Bulletin, 131*(1), 66-71. doi: 10.1037/0033-2909.131.1.66.
- Kaplan, R., Thornton, P., & Silverman, L. (1985). Further data on the effects of subliminal symbiotic stimulation on schizophrenics. *The Journal of Nervous and Mental Disease, 173*(11), 658-706.
- Kardes, F. R., Herr, P. M., & Nantel, J. (Eds.). (2005). *Applying social cognition to consumer-focused strategy*. Mahwah, New Jersey: Lawrence Erlbaum Associates.
- Karremans, J. C., Stroebe, W., & Claus, J. (2006). Beyond Vicary's fantasies: The impact of subliminal priming and brand choice. *Journal of Experimental Social Psychology, 42*(6), 792-798. doi: 10.1016/j.jesp.2005.12.002.
- Kherif, F., Josse, G., & Price, C. J. (2011). Automatic top-down processing explains common left occipito-temporal responses to visual words and objects. *Cerebral Cortex, 21*(1), 103-114. doi: 10.1093/cercor/bhq063.

- Kiefer, M., & Martens, U. (2010). Attentional sensitization of unconscious cognition: task sets modulate subsequent masked semantic priming. *Journal of Experimental Psychology: General*, *139*(3), 464-489. doi: 10.1037/a0019561.
- Kiesel, A., Kunde, W., Pohl, C., Berner, M. P., & Hoffmann, J. (2009). Playing chess unconsciously. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *35*(1), 292-298. doi: 10.1037/a0014499.
- Kiesel, A., Kunde, W., & Hoffmann, J. (2007). Mechanisms of subliminal response priming. *Advances in Cognitive Psychology*, *3*(1-2), 307-315. doi: 10.2478/v10053-008-0032-1.
- Kiyonaga, K., Grainger, J., Midgley, K., & Holcomb, P. J. (2007). Masked cross-modal repetition priming: An event-related potential investigation. *Language and Cognitive Processes*, *22*(3), 337-376. doi: 10.1080/01690960600652471.
- Kjaer, T. W., Nowak, M., Kjaer, K. W., Lou, A. R., & Lou, H. C. (2001). Precuneus-prefrontal activity during awareness of visual verbal stimuli. *Consciousness and Cognition*, *10*, 356-365. doi: 10.1006/ccog.2001.0509.
- Klapp, S. T., & Hinkley, L. B. (2002). The negative compatibility effect: Unconscious inhibition influences reaction time and response selection. *Journal of Experimental Psychology: General*, *131*(2), 255- 269. doi: 10.1037/0096-3445.131.2.255.
- Klatzky, R. L., & Creswell, J. D. (2014). An intersensory interaction account of priming effects—and their absence. *Perspectives on Psychological Science*, *9*(1), 49-58. doi: 10.1177/1745691613513468.
- Klauer, K. C., Eder, A. B., Greenwald, A. G., & Abrams, R. L. (2007). Priming of semantic classifications by novel subliminal prime words. *Consciousness and Cognition*, *16*(1), 63-83. doi: 10.1016/j.concog.2005.12.002.

- Kouider, S., de Gardelle, V., Dehaene, S., Dupoux, E., & Pallier, C. (2010). Cerebral bases of subliminal speech priming. *Neuroimage*, *49*(1), 922-929. doi: 10.1016/j.neuroimage.2009.08.043.
- Kouider, S., & Dehaene, S. (2007). Levels of processing during non-conscious perception: A critical review of visual masking. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *362*(1481), 857-875. doi: 10.1098/rstb.2007.2093.
- Kouider, S., & Dupoux, E. (2001). A functional disconnection between spoken and visual word recognition: Evidence from unconscious priming. *Cognition*, *82*(1), B35-B49. doi: 10.1016/S0010-0277(01)00152-4.
- Kouider, S., & Dupoux, E. (2005). Subliminal speech priming. *Psychological Science*, *16*(8), 617-625. doi: 10.1111/j.1467-9280.2005.01584.x.
- Kouider, S., Dehaene, S., Jobert, A., & Le Bihan, D. (2007). Cerebral bases of subliminal and supraliminal priming during reading. *Cerebral Cortex*, *17*(9), 2019-2029. doi: 10.1093/cercor/bhl110.
- Kunimoto, C., Miller, J., & Pashler, H. (2001). Confidence and accuracy of near-threshold discrimination responses. *Consciousness and cognition*, *10*(3), 294-340. doi: 10.1006/ccog.2000.0494.
- Langer, E., Rodin, J., Beck, P., Weinman, C., & Spitzer, L. (1979). Environmental determinants of memory improvement in late adulthood. *Journal of Personality and Social Psychology*, *37*, 2003-2013. doi: 10.1037/0022-3514.37.11.2003.
- Larson, K. (2007). The technology of text. *IEEE Spectrum (INT)*, *5*, 20-25.
- Lamy, D., Mudrik, L., & Deouell, L. Y. (2008). Unconscious auditory information can prime visual word processing: A process-dissociation procedure study.

- Consciousness and Cognition*, 17(3), 688-698. doi:
10.1016/j.concog.2007.11.001.
- Légal, J. B., Chappé, J., Coiffard, V., & Villard-Forest, A. (2012). Don't you know that you want to trust me? Subliminal goal priming and persuasion. *Journal of Experimental Social Psychology*, 48(1), 358-360. doi:
10.1016/j.jesp.2011.06.006.
- Lemay, S., Bédard, M. A., Rouleau, I., & Tremblay, P. L. (2004). Practice effect and test-retest reliability of attentional and executive tests in middle-aged to elderly subjects. *The Clinical Neuropsychologist*, 18(2), 284-302. doi:
10.1080/13854040490501718.
- Levene, H. (1960). Robust tests for equality of variances. In I. Olkin, S. G. Ghurye, W. Hoeffding, W. G. Madow, & H. B. Mann (Eds.), *Contributions to probability and statistics: Essays in honor of Harold Hotelling*, (pp. 278-292). Standard, California: Stanford University Press.
- Leventhal, A. M., Waters, A. J., Breitmeyer, B. G., Miller, E. K., Tapia, E., & Li, Y. (2008). Subliminal processing of smoking-related and affective stimuli in tobacco addiction. *Experimental and Clinical Psychopharmacology*, 16(4), 301-312. doi: 10.1037/a0012640.
- Levy, B. (1996). Improving memory in old age through implicit self-stereotyping. *Journal of Personality and Social Psychology*, 71(6), 1092- 1107. doi:
10.1037/0022-3514.71.6.1092.
- Levy, B. R., & Leifheit-Limson, E. (2009). The stereotype-matching effect: Greater influence on functioning when age stereotypes correspond to outcomes. *Psychology and Aging*, 24(1), 230- 233. doi: 10.1037/a0014563.

- Levy, B. R., Hausdorff, J. M., Hencke, R., & Wei, J. Y. (2000). Reducing cardiovascular stress with positive self-stereotypes of aging. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 55(4), P205-P213. doi: 10.1093/geronb/55.4.P205.
- Lezak, M. (1983). *Neuropsychological assessment*. New York: Oxford University Press.
- Li, W., Zinbarg, R. E., Boehm, S. G., & Paller, K. A. (2008). Neural and behavioral evidence for affective priming from unconsciously perceived emotional facial expressions and the influence of trait anxiety. *Journal of Cognitive Neuroscience*, 20(1), 95-107. doi: 10.1162/jocn.2008.20006.
- Lie, I., & Watten, R. G. (1994). VDT work, oculomotor strain, and subjective complaints: An experimental and clinical study. *Ergonomics*, 37(8), 1419-1433. doi: 10.1080/00140139408964919.
- Linehan, E., & O'Toole, J. (1982). Effect of subliminal stimulation of symbiotic fantasies on college student self-disclosure in group counseling. *Journal of Counseling Psychology*, 29(2), 151-157. doi: 10.1037/0022-0167.29.2.151.
- Lleras, A., & Enns, J. T. (2006). How much like a target can a mask be? Geometric, spatial, and temporal similarity in priming: A reply to Schlaghecken and Eimer (2006). *Journal of Experimental Psychology: General*, 135(3), 495-500. doi: 10.1037/0096-3445.135.3.495.
- Loftus, E. F., & Klinger, M. R. (1992). Is the unconscious smart or dumb?. *American Psychologist*, 47(6), 761- 765. doi: 10.1037/003-066X.47.6.761.
- Lowery, O. M. (1992). *U.S. Patent No. 5,159,703*. Washington, DC: U.S. Patent and Trademark Office.

- Lowery, B. S., Eisenberger, N. I., Hardin, C. D., & Sinclair, S. (2007). Long-term effects of subliminal priming on academic performance. *Basic and Applied Social Psychology, 29*(2), 151-157. doi: 10.1080/01973530701331718.
- Lucas, M. (2000). Semantic priming without association: A meta-analytic review. *Psychonomic Bulletin & Review, 7*(4), 618-630. doi: 10.3758/BF03212999.
- MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin, 109*(2), 163-203. doi: 10.1037/0033-2909.109.2.163.
- Mahler, M. S. (1952). On child psychosis and schizophrenia: Autistic and symbiotic infantile psychoses. *The Psychoanalytic Study of the Child, 7*, 286-305.
- Mandler, G., Pearlstone, Z., & Koopmans, H. S. (1969). Effects of organization and semantic similarity on recall and recognition. *Journal of Verbal Learning and Verbal Behavior, 8*(3), 410-423. doi: 10.1016/S0022-5371(69)80134-9.
- Marcel, A. J. (1983). Conscious and unconscious perception: Experiments on visual masking and word recognition. *Cognitive Psychology, 15*(2), 197-237. doi: 10.1016/0010-0285(83)90009-9.
- Marien, H., Custers, R., Hassin, R. R., & Aarts, H. (2012). Unconscious goal activation and the hijacking of the executive function. *Journal of Personality and Social Psychology, 103*(3), 399-415. doi: 10.1037/a0028955.
- Marzouki, Y., Grainger, J., & Theeuwes, J. (2007). Exogenous spatial cueing modulates subliminal masked priming. *Acta Psychologica, 126*(1), 34-45. doi: 10.1016/j.actpsy.2006.11.002.

- Mayer, B., & Merckelbach, H. (1999). Unconscious processes, subliminal stimulation, and anxiety. *Clinical Psychology Review, 19*(5), 571-590. doi: 10.1016/S0272-7258(98)00060-9.
- Macrae, C. N., & Johnston, L. (1998). Help, I need somebody: Automatic action and inaction. *Social Cognition, 16*(4), 400-417. doi: 10.1521/soco.1998.16.4.400.
- McKay, R., Efferson, C., Whitehouse, H., & Fehr, E. (2011). Wrath of God: Religious primes and punishment. *Proceedings of the Royal Society B: Biological Sciences, 278*(1713), 1858-1863. doi: 10.1098/rspb.2010.2125.
- McNair, P. M., Lorr, M., & Droppleman, L. F. (1981). *POMS manual* (2nd ed.). San Diego: Educational and Industrial Testing Service.
- Mehler, J., Sebastian, N., Altmann, G., Dupoux, E., Christophe, A., & Pallier, C. (1993). Understanding compressed sentences: The role of rhythm and meaning a. *Annals of the New York Academy of Sciences, 682*(1), 272-282. doi: 10.1111/j.1749-6632.1993.tb22975.x.
- Melara, R. D., & Mounts, J. R. (1993). Selective attention to Stroop dimensions: Effects of baseline discriminability, response mode, and practice. *Memory & Cognition, 21*(5), 627-645. doi: 10.3758/BF03197195.
- Mendelsohn, E. M. (1981). The effects of stimulating symbiotic fantasies on manifest pathology in schizophrenics: A revised formulation. *The Journal of Nervous and Mental Disease, 169*(9), 580-590.
- Merikle, P. M. (1988). Subliminal auditory messages: An evaluation. *Psychology & Marketing, 5*(4), 355-372. doi: 10.1002/mar.4220050406.
- Merikle, P. M., & Cheesman, J. (1987). Current status of research on subliminal perception. *Advances in Consumer Research, 14*(1), 298-302.

- Merikle, P. M., & Daneman, M. (1998). Psychological investigations of unconscious perception. *Journal of Consciousness Studies*, 5(1), 5-18.
- Merikle, P. M., & Joordens, S. (1997). Parallels between perception without attention and perception without awareness. *Consciousness and Cognition*, 6(2), 219-236. doi: 10.1006/ccog.1997.0310.
- Merikle, P. M., Joordens, S., & Stolz, J. A. (1995). Measuring the relative magnitude of unconscious influences. *Consciousness and Cognition*, 4(4), 422-439. doi: 10.1006/ccog.1995.1049.
- Merikle, P. M., & Skanes, H. E. (1992). Subliminal self-help audiotapes: A search for placebo effects. *Journal of Applied Psychology*, 77(5), 772-776. doi: 10.1037/0021-9010.77.5.772.
- Merikle, P. M., Smilek, D., & Eastwood, J. D. (2001). Perception without awareness: Perspectives from cognitive psychology. *Cognition*, 79(1), 115-134. doi: 10.1016/S0010-0277(00)00126-8.
- Meyer, D. E., & Schvaneveldt, R. W. (1971). Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental Psychology*, 90(2), 227-234. doi: 10.1037/h0031564.
- Meyer, C., & Waller, G. (1999). The impact of emotion upon eating behavior: The role of subliminal visual processing of threat cues. *International Journal of Eating Disorders*, 25(3), 319-326.
- Miettinen, I., Alku, P., Yrttiaho, S., May, P. J. C., & Tiitinen, H. (2012). Cortical processing of degraded speech sounds: Effects of distortion type and continuity. *Neuroimage*, 60(2), 1036-1045. doi: 10.106/j.neuroimage.2012.01.085.

- Milgram, P. (1987). A spectacle-mounted liquid-crystal tachistoscope. *Behavior Research Methods, Instruments, & Computers*, *19*(5), 449-456. doi: 10.3758/BF03205613.
- Mills, C. B., & Weldon, L. J. (1987). Reading text from computer screens. *ACM Computing Surveys (CSUR)*, *19*(4), 329-357.
- Mitchell, J. P., Macrae, C. N., Schooler, J. W., Rowe, A. C., & Milne, A. B. (2002). Directed remembering: Subliminal cues alter nonconscious memory strategies. *Memory*, *10*(5-6), 381-388. doi: 10.1080/09658210244000207.
- Mogg, K., Bradley, B. P., Williams, R., & Mathews, A. (1993). Subliminal processing of emotional information in anxiety and depression. *Journal of Abnormal Psychology*, *102*(2), 304-311. doi: 10.1037/0021-843X.102.2.304.
- Mogg, K., Bradley, B. P., & Williams, R. (1995). Attentional bias in anxiety and depression: The role of awareness. *British Journal of Clinical Psychology*, *34*(1), 17-36. doi: 10.1111/j.2044-8260.1995.tb01434.x.
- Moore, T. E. (1995). Subliminal self-help auditory tapes: An empirical test of perceptual consequences. *Canadian Journal of Behavioural Science/Revue Canadienne des Sciences du Comportement*, *27*(1), 9-20. doi: 10.1037/008-400X.27.1.9.
- Morris, R. A., Aquilante, K., Yager, D., & Bigelow, C. (2002, May). P-13: Serifs Slow RSVP Reading at Very Small Sizes, but Don't Matter at Larger Sizes. In *SID Symposium Digest of Technical Papers* (Vol. 33, No. 1, pp. 244-247). Blackwell Publishing Ltd. doi: 10.1889/1.1830242.
- Naccache, L., & Dehaene, S. (2001). Unconscious semantic priming extends to novel unseen stimuli. *Cognition*, *80*(3), 215-229. doi: 10.1016/S0010-0277(00)00139-6.

- Naccache, L., Gaillard, R., Adam, C., Hasboun, D., Clémenceau, S., Baulac, M., ... & Cohen, L. (2005). A direct intracranial record of emotions evoked by subliminal words. *Proceedings of the National Academy of Sciences of the United States of America*, *102*(21), 7713-7717. doi: 10.1073/pnas.0500542102.
- Newell, B. R., & Shanks, D. R. (2012). Unconscious influences on decision making: A critical review. *Behavioral and Brain Sciences*, *37*(01), 1-19. doi: 10.1017/S0140525X12003214.
- Nickerson, R. S. (2000). Null hypothesis significance testing: A review of an old and continuing controversy. *Psychological Methods*, *5*(2), 241-301. doi: 10.1037/1082-989X5.2.241.
- Nuttin, J. M. (1987). Affective consequences of mere ownership: The name–letter effect in twelve European languages. *European Journal of Social Psychology*, *17*(4), 381-402. doi: 10.1002/ejsp.2420170402.
- Oliver, J. M., & Burkham, R. (1982). Subliminal psychodynamic activation in depression: A failure to replicate. *Journal of Abnormal Psychology*, *91*(5), 337-342. doi: 10.1037/0021-843X.91.5.337.
- Orbach, I., Shopen-Kofman, R., & Mikulincer, M. (1994). The impact of subliminal symbiotic vs identification messages in reducing anxiety. *Journal of Research in Personality*, *28*(4), 492-504. doi: 10.1006/jrpe.1994.1035.
- Ortigue, S., Bianchi-Demicheli, F., Hamilton, A. D. C., & Grafton, S. T. (2007). The neural basis of love as a subliminal prime: An event-related functional magnetic resonance imaging study. *Journal of Cognitive Neuroscience*, *19*(7), 1218-1230. doi:10.1162/jocn.2007.19.7.1218.

- Palmatier, J. R., & Bornstein, P. H. (1980). Effects of subliminal stimulation of symbiotic merging fantasies on behavioral treatment of smokers. *The Journal of Nervous and Mental Disease, 168*(12), 715-720.
- Parker, K. A. (1982). Effects of subliminal symbiotic stimulation on academic performance: Further evidence on the adaptation-enhancing effects of oneness fantasies. *Journal of Counseling Psychology, 29*(1), 19- 28. doi: 10.1037/0022-0167.29.1.19.
- Pashler, H., Rohrer, D., & Harris, C. R. (2013). Can the goal of honesty be primed?. *Journal of Experimental Social Psychology, 49*(6), 959-964. doi: 10.1016/j.jesp.2013.05.001.
- Peirce, C. S., & Jastrow, J. (1884). On small differences of sensation. *Proceedings of the National Academy of Sciences, 3*(1), 75-83.
- Perfetti, C. A., & Bell, L. (1991). Phonemic activation during the first 40ms of word identification: Evidence from backward masking and priming. *Journal of Memory and Language, 30*(4), 473-485. doi: 10.1016/0749-596X(91)90017-E.
- PES Film. (Producer). (2008). *Game over* [ONLINE]. Available from <https://www.youtube.com/watch?v=Ovvk7T8QUIU>.
- Pichon, I., Boccato, G., & Saroglou, V. (2007). Nonconscious influences of religion on prosociality: A priming study. *European Journal of Social Psychology, 37*(5), 1032-1045. doi: 10.1002/ejsp.416.
- Plant, R. R. (2003). Black Box ToolKit [software for millisecond timing accuracy]. Sheffield, UK.
- Qiao, E., Vinckier, F., Szwed, M., Naccache, L., Valabrègue, R., Dehaene, S., & Cohen, L. (2010). Unconsciously deciphering handwriting: Subliminal

- invariance for handwritten words in the visual word form area. *Neuroimage*, 49(2), 1786-1799. doi: 10.1016/j.neuroimage.2009.09.034.
- Quillian, R. (1962). A revised design for an understanding machine. *Mechanical Translation*, 7(1), 17-29.
- Quillian, R. (1967). Word concepts: A theory and simulation of some basic semantic capabilities. *Behavioural Science*, 12(5), 410-430. doi: 10.1002/bs.3830120511.
- Radel, R., Sarrazin, P., Legrain, P., & Gobancé, L. (2009). Subliminal priming of motivational orientation in educational settings: Effect on academic performance moderated by mindfulness. *Journal of Research in Personality*, 43(4), 695-698. doi: 10.1016/j.jrp.2009.02.011.
- Radel, R., Sarrazin, P., & Pelletier, L. (2009). Evidence of subliminally primed motivational orientations: The effects of unconscious motivational processes on the performance of a new motor task. *Journal of Sport & Exercise Psychology*, 31, 657-674.
- Rastle, K., Harrington, J., & Coltheart, M. (2002). 358-534 nonwords: The ARC nonword database. *The Quarterly Journal of Experimental Psychology*, 55A(4), 1339-1362.
- Ratcliff, R. (1993). Methods for dealing with reaction time outliers. *Psychological Bulletin*, 114(3), 510- 532. doi: 10.1037/0033-2909.114.3.510.
- Rayner, K. (1978). Foveal and parafoveal cues in reading. In J. Requin (Ed.), *Attention and performance VII* (pp. 149-161). Hillsdale, NJ: Erlbaum.
- Razali, N. M., & Wah, Y. B. (2011). Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests. *Journal of Statistical Modeling and Analytics*, 2(1), 21-33.

- Rehak, K. M. (2010). *Native and non-native processing of morphologically complex English words: Testing the influence of derivational prefixes* (Unpublished master's thesis). Retrieved from <http://d-scholarship.pitt.edu/7520/>.
- Reuter, F., Del Cul, A., Audoin, B., Malikova, I., Naccache, L., Ranjeva, J. P., ... & Pelletier, J. (2007). Intact subliminal processing and delayed conscious access in multiple sclerosis. *Neuropsychologia*, *45*(12), 2683-2691. doi: 10.1016/j.neuropsychologia.2007.04.010.
- Riketta, M., & Dauenheimer, D. (2003). Manipulating self-esteem with subliminally presented words. *European Journal of Social Psychology*, *33*(5), 679-699. doi: 10.1002/ejsp.179.
- Roberts, M. S., Crooks, W., Kolody, T. J., Pavlovic, T., Rombola, K. J., & Standing, L. G. (2013, January 01). Does Priming with a personality trait or a stereotype influence general knowledge test scores? An attempt to replicate the results of Dijksterhuis and van Knippenberg (1998). Retrieved July 29, 2015 from <http://www.PsychFileDrawer.org/replication.php?attempt=MTQz>.
- Robertson, I. H., Ward, T., Ridgeway, V., & Nimmo-Smith, I. (2001). Test reviews: The test of everyday attention (TEA). *The Application of Occupational Psychology to Employment and Disability*, *4*(1), 51-55.
- Rosnow, R. L., & Rosenthal, R. (1989). Statistical procedures and the justification of knowledge in psychological science. *American Psychologist*, *44*(10), 1276-1284. doi: 10.1037/0003-066X.44.10.1276.
- Rouder, J. N., & Morey, R. D. (2009). The nature of psychological thresholds. *Psychological Review*, *116*(3), 655-660. doi: 10.1037/a0016413.

- Sarason, I. G. (1978). The test anxiety scale: Concept and research. In C. D. Spielberger, & I. G. Sarason (Eds.), *Stress and anxiety* Vol 5 (pp. 194-216). New York: Halstead-Wiley.
- Saroglou, V., Corneille, O., & Van Cappellen, P. (2009). "Speak, Lord, your servant is listening": Religious priming activates submissive thoughts and behaviors. *The International Journal for the Psychology of Religion*, *19*(3), 143-154. doi: 10.1080/10508610902880063.
- Sato, W., & Aoki, S. (2006). Right hemispheric dominance in processing of unconscious negative emotion. *Brain and Cognition*, *62*(3), 261-266. doi: 10.1016/j.bandc.2006.06.006.
- Schacter, D. L., Cooper, L. A., & Delaney, S. M. (1990). Implicit memory for unfamiliar objects depends on access to structural descriptions. *Journal of Experimental Psychology: General*, *119*(1), 5-24. doi: 10.1037/0096-3445.119.1.5.
- Schacter, D., Kaszniak, A., & Kihlstrom, J. (1991). Models of memory and the understanding of memory disorders. In T. Yanagihara & R. Petersen (Eds.), *Memory disorders: Research and clinical practice* (pp. 111-133). New York: Marcel Dekker.
- Schlaghecken, F., & Eimer, M. (2001). Partial response activation to masked primes is not dependent on response readiness. *Perceptual and Motor Skills*, *92*(1), 208-222. doi: 10.2466/pms.2001.92.1.208.
- Schlaghecken, F., & Eimer, M. (2002). Motor activation with and without inhibition: Evidence for a threshold mechanism in motor control. *Perception & Psychophysics*, *64*(1), 148-162. doi: 10.3758/BF03194564.
- Schlaghecken, F., & Eimer, M. (2004). Masked prime stimuli can bias "free" choices

- between response alternatives. *Psychonomic Bulletin & Review*, *11*(3), 463-468. doi: 10.3758/BF03196596.
- Schlaghecken, F., Rowley, L., Sembi, S., Simmons, R., & Whitcomb, D. (2007). The negative compatibility effect: A case for self-inhibition. *Advances in Cognitive Psychology*, *3*(1-2), 227-240. doi: 10.2478/v10053-008-0027-y.
- Schneider, W. (1988). Micro experimental laboratory: An integrated system for IBM PC compatibles. *Behaviour Research Methods, Instruments, & Computers*, *20*, 206-217. doi: 10.3758/BF03203833.
- Schurtman, R., Palmatier, J. R., & Martin, E. S. (1982). On the activation of symbiotic gratification fantasies as an aid in the treatment of alcoholics. *Substance Use & Misuse*, *17*(7), 1157-1174.
- Schweizer, K., & Moosbrugger, H. (2004). Attention and working memory as predictors of intelligence. *Intelligence*, *32*(4), 329-347. doi: 10.1016/j.intell.2004.06.006.
- Severance, L. J., & Dyer, F. N. (1973). Failure of subliminal word presentations to generate interference to color naming. *Journal of Experimental Psychology*, *101*(1), 186-189. doi: 10.1037/h0035768.
- Shacham, S. (1983). A shortened version of the Profile of Mood States. *Journal of Personality Assessment*, *47*(3), 305-306. doi: 10.1207/s15327752jpa4703_14.
- Shanks, D. R., Newell, B. R., Lee, E. H., Balakrishnan, D., Ekelund, L., Cenac, Z., ... & Moore, C. (2013). Priming intelligent behavior: An elusive phenomenon. *PLoS One* *8*(4): e56515. doi: 10.1371/journal.pone.0056515.
- Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality. *Biometrika*, *52*(3/4), 591-611.

- Sheedy, J. E., Subbaram, M. V., Zimmerman, A. B., & Hayes, J. R. (2005). Text legibility and the letter superiority effect. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 47(4), 797-815. doi: 10.1518/001872005775570998.
- Simmons, J. P., Nelson, L. D., & Simonsohn, U. (2011). False-positive psychology undisclosed flexibility in data collection and analysis allows presenting anything as significant. *Psychological Science*, 22(11), 1359–1366. doi:10.1177/0956797611417632.
- Shih, M., Ambady, N., Richeson, J. A., Fujita, K., & Gray, H. M. (2002). Stereotype performance boosts: The impact of self-relevance and the manner of stereotype activation. *Journal of Personality and Social Psychology*, 83(3), 638- 647. doi: 10.1037/0022-3514.83.3.638.
- Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending and a general theory. *Psychological Review*, 84(2), 127- 190. doi: 10.1037/0033-295X.84.2.127.
- Silva, R., & Clahsen, H. (2008). Morphologically complex words in L1 and L2 processing: Evidence from masked priming experiments in English. *Bilingualism: Language and Cognition*, 11(02), 245-260. doi: 10.1017/S1366728908003404.
- Silverman, L. H. (1966). A technique for the study of psychodynamic relationships: The effects of subliminally presented aggressive stimuli on the production of pathological thinking in a schizophrenic population. *Journal of Consulting Psychology*, 30(2), 103-111. doi: 10.1037/h0023177.

- Silverman, L. H. (1982). A comment on two subliminal psychodynamic activation studies. *Journal of Abnormal Psychology, 91*(2), 126-130. doi: 10.1037/0021-843X91.2.126.
- Silverman, L. H., Bronstein, A., & Mendelsohn, E. (1976). The further use of the subliminal psychodynamic activation method for the experimental study of the clinical theory of psychoanalysis: On the specificity of the relationship between symptoms and unconscious conflicts. *Psychotherapy: Theory, Research & Practice, 13*(1), 2-16. doi: 10.1037/h0086477.
- Silverman, L. H., & Candell, P. (1970). On the relationship between aggressive activation, symbiotic merging, intactness of body boundaries, and manifest pathology in schizophrenics. *The Journal of Nervous and Mental Disease, 150*(5), 387-399.
- Silverman, L. H., Candell, P., Pettit, T. F., & Blum, E. A. (1971). Further data on effects of aggressive activation and symbiotic merging on ego functioning of schizophrenics. *Perceptual and Motor Skills, 32*(1), 93-94.
- Silverman, L. H., Frank, S. G., & Dachinger, P. (1974). A psychoanalytic reinterpretation of the effectiveness of systematic desensitization: Experimental data bearing on the role of merging fantasies. *Journal of Abnormal Psychology, 83*(3), 313-318. doi: 10.1037/h0036733.
- Silverman, L. H., Martin, A., Ungaro, R., & Mendelsohn, E. (1978). Effect of subliminal stimulation of symbiotic fantasies on behavior modification treatment of obesity. *Journal of Consulting and Clinical Psychology, 46*(3), 432-441. doi: 10.1037/0022-006X.46.3.432.
- Silverman, L. H., & Silverman, S. E. (1967). The effects of subliminally presented drive stimuli on the cognitive functioning of schizophrenics. *Journal of*

- Projective Techniques and Personality Assessment*, 31(1), 78-85. doi: 10.1080/0091651X.1967.10120347.
- Silverman, L. H., & Spiro, R. H. (1967). Further investigation of the effects of subliminal aggressive stimulation on the ego functioning of schizophrenics. *Journal of Consulting Psychology*, 31(3), 225- 232. doi: 10.1037/h0020998.
- Silverman, L. H., & Spiro, R. H. (1968). The effects of subliminal, supraliminal and vocalized aggression on the ego functioning of schizophrenics. *The Journal of Nervous and Mental Disease*, 146(1), 50-61.
- Silverman, L. H., Spiro, R. H., Weisberg, J. S., & Candell, P. (1969). The effects of aggressive activation and the need to merge on pathological thinking in schizophrenia. *The Journal of Nervous and Mental Disease*, 148(1), 39-51.
- Silverman, L. H., & Weinberger, J. (1985). Mommy and I are one: Implications for psychotherapy. *American Psychologist*, 40(12), 1296-1308. doi: 10.1037/0003-066X.40.12.1296.
- Skandrani-Marzouki, I., & Marzouki, Y. (2010). Subliminal emotional priming and decision making in a simulated hiring situation. *Swiss Journal of Psychology/Schweizerische Zeitschrift für Psychologie/Revue Suisse de Psychologie*, 69(4), 213-219. doi: 10.1024/1421-0185/a000025.
- Sklar, A. Y., Levy, N., Goldstein, A., Mandel, R., Maril, A., & Hassin, R. R. (2012). Reading and doing arithmetic nonconsciously. *Proceedings of the National Academy of Sciences*, 109(48), 19614-19619. doi: 10.1073/pnas.1211645109.
- Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory*, 6(2), 174-215. doi: 10.1037/0278-7393.6.2.174.

- Sohlberg, S., Arvidsson, M., & Birgegård, A. (1997). Stroop and mood/memory measures in the study of unconscious 'oneness'. *Perceptual and Motor Skills*, 85(1), 81-82. doi: 10.2466/pms.1997.85.1.81.
- Sohlberg, S., Billinghamurst, A., & Nylén, S. (1998). Moderation of mood change after subliminal symbiotic stimulation: Four experiments contributing to the further demystification of Silverman's "mommy and I are one" findings. *Journal of Research in Personality*, 32(1), 33-54. doi: 10.1016/jrpe.1997.2199.
- Sohlberg, S., & Birgegård, A. (2003). Persistent complex subliminal activation effects: First experimental observations. *Journal of Personality and Social Psychology*, 85(2), 302- 316. doi: 10.1037/0022-3514.85.2.302.
- Sohlberg, S., Claesson, K., & Birgegård, A. (2003). Memories of mother, complementarity and shame: Predicting response to subliminal stimulation with "mommy and I are one". *Scandinavian Journal of Psychology*, 44(4), 339-346. doi: 10.1111/1467-9450.00353.
- Sohlberg, S., Samuelberg, P., Sidén, Y., & Thörn, C. (1998). Caveat medicus--let the subliminal healer beware: Two experiments suggesting conditions when the effects of Silverman's mommy and I are one phrase are negative. *Psychoanalytic Psychology*, 15(1), 93-114. doi: 10.1037/0736-9735.15.1.93.
- Spencer, S. J., Fein, S., Strahan, E. J., & Zanna, M. P. (2005). The role of motivation in the unconscious: How our motives control the activation of our thoughts and shape our actions. In J. P. Forgas, K. D. Williams, & S. M. Laham (Eds.), *Social motivation: Conscious and unconscious processes* (pp. 113-129). New York: Cambridge University Press.
- Spielberger, C. D. (1983). *Manual for the State-Trait Anxiety Inventory (STAI)*. Palo Alto, CA: Consulting Psychologists Press.

- Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1970). *Manual for the State–Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.
- Spiro, R. H., & Silverman, L. H. (1969). Effects of body awareness and aggressive activation on ego functioning of schizophrenics. *Perceptual and motor skills*, 28(2), 575-585.
- Stajkovic, A. D., & Luthans, F. (2001). Differential effects of incentive motivators on work performance. *Academy of Management Journal*, 44(3), 580-590. doi: 10.2307/3069372.
- Stein, R., Blanchard-Fields, F., & Hertzog, C. (2002). The effects of age-stereotype priming on the memory performance of older adults. *Experimental Aging Research*, 28(2), 169-181. doi: 10.1080/03610730252800184.
- Strahan, E. J., Spencer, S. J., & Zanna, M. P. (2002). Subliminal priming and persuasion: Striking while the iron is hot. *Journal of Experimental Social Psychology*, 38(6), 556-568. doi: 10.1016/S0022-1031(02)00502-4.
- Strahan, E. J., Spencer, S. J., & Zanna, M. P. (2005). Subliminal priming and persuasion: How motivation affects the activation of goals and the persuasiveness of messages. In F. R. Kardes, P. M. Herr, & J. Nantel (Eds.), *Applying social cognition to consumer-focused strategy* (pp. 267-280). , Mahwah, New Jersey: Lawrence Erlbaum Associates.
- Stroebe, W., & Strack, F. (2014). The alleged crisis and the illusion of exact replication. *Perspectives on Psychological Science*, 9(1), 59-71. doi: 10.1177/1745691613514450.
- Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, 18(6), 643- 662. doi: 10.1037/h0054651.

- Subbaram, V. M. (2004). *Effect of display and text parameters on reading performance* (Doctoral dissertation). Retrieved from <http://www.ohiolink.edu/etd/>.
- Tabachnick, B. G., & Fidell, L. S. (2014). *Using multivariate statistics* (6th ed.). Harlow, Essex: Pearson Education Limited.
- Tamietto, M., & de Gelder, B. (2010). Neural bases of the non-conscious perception of emotional signals. *Nature Reviews Neuroscience*, *11*(10), 697-709. doi: 10.1038/nrn2889.
- Thornton, P. I., Igleheart, H. C., & Silverman, L. H. (1987). Subliminal stimulation of symbiotic fantasies as an aid in the treatment of drug abusers. *Substance Use & Misuse*, *22*(8), 751-765.
- Tsuchiya, N., & Koch, C. (2005). Continuous flash suppression reduces negative afterimages. *Nature Neuroscience*, *8*(8), 1096-1101. doi: 10.1038/nn1500.
- Turner, M. L., & Engle, R. W. (1989). Is working memory capacity task dependent? *Journal of Memory & Language*, *28*(2), 127-154. doi: 10.1016/0749-596X(89)90040-5.
- Unsworth, N., Heitz, R. P., Schrock, J. C., & Engle, R. W. (2005). An automated version of the operation span task. *Behavior Research Methods*, *37*(3), 498-505. doi: 10.3758/BF03192720.
- Urban, M. J. (1992). Auditory subliminal stimulation: A reexamination. *Perceptual and Motor Skills*, *74*, 515-541. doi: 10.2466/pms.1992.74.2.515.
- Vadillo, M. A., Konstantinidis, E., & Shanks, D. R. (2015). Underpowered samples, false negatives, and unconscious learning. *Psychonomic Bulletin & Review*, *1-16*. doi: 10.3758/s13423-015-0892-6.

- Van den Bussche, E., & Reynvoet, B. (2007). Masked priming effects in semantic categorization are independent of category size. *Experimental Psychology (formerly Zeitschrift für Experimentelle Psychologie)*, *54*(3), 225-235. doi: 10.1027/1618-3169.54.3.225.
- Van den Bussche, E., Van den Noortgate, W., & Reynvoet, B. (2009). Mechanisms of masked priming: A meta-analysis. *Psychological Bulletin*, *135*(3), 452- 477. doi: 10.1037/a0015329.
- Van den Bussche, E., Smets, K., Sasanguie, D., & Reynvoet, B. (2012). The power of unconscious semantic processing: The effect of semantic relatedness between prime and target on subliminal priming. *Psychologica Belgica*, *52*(1), 59-70.
- Van Opstal, F., Reynvoet, B., & Verguts, T. (2005a). How to trigger elaborate processing? A comment on Kunde, Kiesel, and Hoffmann (2003). *Cognition*, *97*(1), 89-97. doi: 10.1016/j.cognition.2004.12.001.
- Van Opstal, F., Reynvoet, B., & Verguts, T. (2005b). Unconscious semantic categorization and mask interactions: An elaborate response to Kunde et al. (2005). *Cognition*, *97*(1), 107-113. doi: 10.1016/j.cognition.2005.04.005.
- Van Opstal, F., Gevers, W., Osman, M., & Verguts, T. (2010). Unconscious task application. *Consciousness and Cognition*, *19*(4), 999-1006. doi: 10.1016/j.concog.2010.05.002.
- Veltkamp, M., Aarts, H., & Custers, R. (2008). On the emergence of deprivation-reducing behaviors: Subliminal priming of behavior representations turns deprivation into motivation. *Journal of Experimental Social Psychology*, *44*(3), 866-873. doi: 10.1016/j.jesp.2007.08.005.
- Veltkamp, M., Custers, R., & Aarts, H. (2011). Motivating consumer behavior by subliminal conditioning in the absence of basic needs: Striking even while the

- iron is cold. *Journal of Consumer Psychology*, 21(1), 49-56. doi: 10.1016/j.jcps.2010.09.011.
- Vernon, D. (2009). *Human potential: Exploring techniques used to enhance human performance*. Hove, East Sussex: Routledge.
- Vernon, D., Egner, T., Cooper, N., Compton, T., Neilands, C., Sheri, A., & Gruzelier, J. (2003). The effect of training distinct neurofeedback protocols on aspects of cognitive performance. *International Journal of Psychophysiology*, 47(1), 75-85. doi: 10.1016/S0167-8760(02)00091-0.
- Vohs, K. D., Mead, N. L., & Goode, M. R. (2006). The psychological consequences of money. *Science*, 314(5802), 1154-1156. doi: 10.1126/science.1132491.
- Vokey, J. R., & Read, J. D. (1985). Subliminal messages: Between the devil and the media. *American Psychologist*, 40(11), 1231-1239. doi: 10.1037/0003-066X.40.11.1231.
- Walker, M. W. (1987). How to produce forward/backward recordings (without supernatural guidance). *Popular Music & Society*, 11(2), 1-3. doi: 10.1080/03007768708591272.
- Weibel, S., Giersch, A., Dehaene, S., & Huron, C. (2013). Unconscious task set priming with phonological and semantic tasks. *Consciousness and Cognition*, 22(2), 517-527. doi: 10.1016/j.concog.2013.02.010.
- Weinberger, J. (1992). Validating and demystifying subliminal psychodynamic activation. In R. F. Bornstein, & T. S. Pittman, (Eds.), *Perception without Awareness* (pp. 170–190). New York: Guilford Press.
- Weinberger, J., Kelner, S., & McClelland, D. (1997). The effects of subliminal symbiotic stimulation on free-response and self-report mood. *Journal of Nervous & Mental Disease*, 185(10), 599–605.

- Weinberger, J., & Silverman, L. H. (1990). Testability and empirical verification of psychoanalytic dynamic propositions through subliminal psychodynamic activation. *Psychoanalytic Psychology, 7*(3), 299-339. doi: 10.1037/h0079214.
- Weinberger, J., & Smith, B. (2011). Investigating merger subliminal psychodynamic activation and oneness motivation research. *Journal of the American Psychoanalytic Association, 59*(3), 553-570. doi: 10.1177/0003065111411481.
- Wentura, D., & Degner, J. (2010). Automatic evaluation isn't that crude! Moderation of masked affective priming by type of valence. *Cognition & Emotion, 24*(4), 609-628. doi: 10.1080/02699930902854587.
- Wentura, D., & Frings, C. (2005). Repeated masked category primes interfere with related exemplars: new evidence for negative semantic priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31*(1), 108-120. doi: 10.1037/0278-7393.31.1.108.
- Wentura, D., Moritz, S., & Frings, C. (2008). Further evidence for “hyper-priming” in thought-disordered schizophrenic patients using repeated masked category priming. *Schizophrenia Research, 102*(1), 69-75. doi: 10.1016/j.schres.2008.04.016.
- Wickelgren, W. A. (1977). Speed-accuracy tradeoff and information processing dynamics. *Acta Psychologica, 41*(1), 67-85. doi: 10.1016/0001-6918(77)90012-9.
- Wickens, D. D. (1972). Characteristics of word encoding. In A. W. Melton, & E. Martin, (Eds.), *Coding processes in human memory* (pp. 191-215). Washington DC: Winston.
- Wickens, D. D. (1973). Some characteristics of word encoding. *Memory & Cognition, 1*(4), 485-490.

- Williams, J. M. G., Watts, F. N., MacLeod, C., & Mathews, A. (1988). *Cognitive psychology and emotional disorders*. New York: Wiley.
- Winkielman, P., Berridge, K. C., & Wilbarger, J. L. (2005). Unconscious affective reactions to masked happy versus angry faces influence consumption behavior and judgments of value. *Personality and Social Psychology Bulletin*, *31*(1), 121-135. doi: 10.1177/0146167204271309.
- Winkielman, P., & Zajonc, R. B., & Schwarz, N. (1997). Subliminal affective priming resists attributional interventions. *Cognition & Emotion*, *11*(4), 433-465. doi: 10.1080/026999397379872.
- Wrightman, L. S., Jr. (1960). Effects of waiting with others on changes in level of felt anxiety. *The Journal of Abnormal and Social Psychology*, *61*(2), 216-222. doi: 10.1037/h0040144.
- Wyer, N. A., & Calvini, G. (2011). Don't sit so close to me: Unconsciously elicited affect automatically provokes social avoidance. *Emotion*, *11*(5), 1230-1234. doi: 10.1037/a0023981.
- Yang, Z., & Tong, E. M. (2010). The effects of subliminal anger and sadness primes on agency appraisals. *Emotion*, *10*(6), 915-922. doi: 10.1037/a0020306.
- Yong, E. (2012). In the wake of high profile controversies, psychologists are facing up to problems with replication. *Nature*, *483*, 298-300.
- Zeijlmans Van Emmichoven, I. A., van Ijzendoorn, M. H., de Ruiter, C., & Brosschot, J. F. (2003). Selective processing of threatening information: Effects of attachment representation and anxiety disorder on attention and memory. *Development and Psychopathology*, *15*(01), 219-237. doi: 10.1017.S0954579403000129.

- Zemack-Rugar, Y., Bettman, J. R., & Fitzsimons, G. J. (2007). The effects of nonconsciously priming emotion concepts on behavior. *Journal of Personality and Social Psychology*, *93*(6), 927–939. doi: 10.1037/0022-3514.93.6.927.
- Zuckerman, M. (1960). The effects of subliminal and supraliminal suggestion on verbal productivity. *The Journal of Abnormal and Social Psychology*, *60*(3), 404-411. doi: 10.1037/h0046319.

*Appendix A -
An example of the consent form (Experiment 3)*



Dept of Applied Social Sciences
Laud
Canterbury Christ Church
University
Canterbury,
Kent, CT1 1QU

Participant Copy

Participant Consent Form

Study: Investigating the conscious processing of cognitive and motivational states on rapid decision-making.

I confirm that I have read and understand the information sheet for the above study Yes No

Have you had the opportunity to ask questions and discuss the study? Yes No

Have you received satisfactory answers to all your questions? Yes No

To whom have you spoken? (write name)

Do you understand that you are free to withdraw from the study at any time, without having to give a reason? Yes No

I understand that any personal information that I provided to the researcher will be kept strictly confidential Yes No

Do you understand that this form may be examined by an Ethics Committee as part of the monitoring process Yes No

Do you agree to take part in this study? Yes No

Your Name in Block Capital Letters:

Signature

Date

Name of person obtaining consent

Signature

Date

*Appendix C -
Conceptual Span Task (CST) Response Sheet A*

Conceptual Span Task Response Sheet

A

Trial No.	Recall Cue	Correct	Responses	Answers	Extra words/Slips
1	Vegetable	Potato	Mushroom	Lettuce	
2	Fruit	Lemon	Strawberry	Peach	
3	transport	Train	Motorcycle	Bicycle	
4	Clothing	Coat	Jacket	Mitten	
5	Fruit	Grapes	Pear	Apple	
6	Musical	Harp	Accordion	Guitar	
7	Animal	Elephant	Goat	Tiger	
8	Clothing	Sweater	Vest	Hat	
9	Animal	Swan	Gorilla	Deer	
10	Electrical	Telephone	Lamp	Toaster	
11	Fruit	Banana	Cherry	Orange	
12	Musical	Piano	French Horn	Flute	
13	Electrical	Computer	Iron	Fridge	
14	Clothing	Glove	Dress	Sock	
15	Vegetable	Onion	Pumpkin	Corn	
16	Transport	Bus	Sailboat	Truck	
17	Electrical	Record Player	Kettle	Television	
18	Transport	Helicopter	Airplane	Wagon	
19	Musical	Violin	Drum	Trumpet	
20	Vegetable	Pepper	Carrot	Asparagus	
21	Animal	Rabbit	Pig	Eagle	

*Appendix D -
Conceptual Span Task (CST) Response Sheet B*

Conceptual Span Task response Sheet

B

Trial No.	Recall Cue	Correct	Responses	Answers	Extra words/Slips
1	Musical	Flute	French horn	Piano	
2	Electrical	Iron	fridge	Computer	
3	Fruit	Pear	apple	Grapes	
4	Electrical	Television	Record player	Kettle	
5	Vegetable	Pepper	Carrot	Asparagus	
6	Fruit	Lemon	Strawberry	Peach	
7	Musical	Guitar	Harp	Accordion	
8	Fruit	Banana	Cherry	Orange	
9	Transport	Wagon	Airplane	Helicopter	
10	Musical	Violin	Drum	Trumpet	
11	Clothing	Hat	Sweater	Vest	
12	Animal	Rabbit	Pig	Eagle	
13	Clothing	Coat	Sock	Mitten	
14	Clothing	Dress	Jacket	Glove	
15	Animal	Tiger	Elephant	Goat	
16	Electrical	Telephone	Lamp	Toaster	
17	Vegetable	Potato	Mushroom	Lettuce	
18	Animal	Deer	Swan	Gorilla	
19	Vegetable	Corn	Onion	Pumpkin	
20	Transport	Train	Motorcycle	Bicycle	
21	Transport	Truck	Bus	Sailboat	

*Appendix E -
Short Version-Profile of Mood States (SV-POMS)*

SV – POMS

Participant no: _____

Date: _____

Time: 1, 2, (circle one)

Task: Please indicate, by circling the relevant number, how much each of the following adjectives applies to you at this moment in time.

T_A

1. Tense

0	1	2	3	4
Not at all				Extremely

2. On edge

0	1	2	3	4
Not at all				Extremely

3. Uneasy

0	1	2	3	4
Not at all				Extremely

4. Restless

0	1	2	3	4
Not at all				Extremely

5. Nervous

0	1	2	3	4
Not at all				Extremely

6. Anxious

0	1	2	3	4
Not at all				Extremely

D_D

7. Unhappy

0	1	2	3	4
Not at all				Extremely

8. Sad

0	1	2	3	4
Not at all				Extremely

9. Blue

0 Not at all	1	2	3	4 Extremely
10. Hopeless				
0 Not at all	1	2	3	4 Extremely
11. Discouraged				
0 Not at all	1	2	3	4 Extremely
12. Miserable				
0 Not at all	1	2	3	4 Extremely
13. Helpless				
0 Not at all	1	2	3	4 Extremely
14. Worthless				
0 Not at all	1	2	3	4 Extremely
A_H				
15. Angry				
0 Not at all	1	2	3	4 Extremely
16. Peeved				
0 Not at all	1	2	3	4 Extremely
17. Grouchy				
0 Not at all	1	2	3	4 Extremely
18. Annoyed				
0 Not at all	1	2	3	4 Extremely
19. Resentful				
0 Not at all	1	2	3	4 Extremely
20. Bitter				
0 Not at all	1	2	3	4 Extremely
21. Furious				
0 Not at all	1	2	3	4 Extremely

V_A

22. Lively					
0	1	2	3	4	
Not at all				Extremely	
23. Active					
0	1	2	3	4	
Not at all				Extremely	
24. Energetic					
0	1	2	3	4	
Not at all				Extremely	
25. Cheerful					
0	1	2	3	4	
Not at all				Extremely	
26. Full of pep					
0	1	2	3	4	
Not at all				Extremely	
27. Vigorous					
0	1	2	3	4	
Not at all				Extremely	

F_I

28. Worn out				
0	1	2	3	4
Not at all				Extremely
29. Fatigued				
0	1	2	3	4
Not at all				Extremely
30. Bushed				
0	1	2	3	4
Not at all				Extremely
31. Exhausted				
0	1	2	3	4
Not at all				Extremely
32. Weary				
0	1	2	3	4
Not at all				Extremely

*Appendix F -
State Anxiety Scale (SAS)*

State Trait Anxiety Inventory

Read each statement and select the appropriate response to indicate how you feel right now, that is, at this very moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	1 Not at all	2 A little	3 Somewhat	4 Very Much So
1. I feel calm	1	2	3	4
2. I feel secure	1	2	3	4
3. I feel tense	1	2	3	4
4. I feel strained	1	2	3	4
5. I feel at ease	1	2	3	4
6. I feel upset	1	2	3	4
7. I am presently worrying over possible misfortunes	1	2	3	4
8. I feel satisfied	1	2	3	4
9. I feel frightened	1	2	3	4
10. I feel uncomfortable	1	2	3	4
11. I feel confident	1	2	3	4
12. I feel nervous	1	2	3	4
13. I feel jittery	1	2	3	4
14. I feel indecisive	1	2	3	4
15. I am relaxed	1	2	3	4
16. I feel content	1	2	3	4
17. I am worried	1	2	3	4
18. I feel confused	1	2	3	4
19. I feel steady	1	2	3	4
20. I feel pleasant	1	2	3	4

**Appendix G -
General Knowledge Test A**

Quiz A

1) What ocean goes the deepest depths?	
2) Who was known as “Old Blue Eyes”?	
3) When the cow jumped over the moon, what ran away with the spoon?	
4) What is the chemical symbol for Zinc?	
5) How many is a bakers dozen?	
6) Which famous painter painted the ceiling of the Sistine Chapel?	
7) Who wrote the Canterbury Tales?	
8) In what year did the National Lottery start?	
9) What is the Worlds largest snake?	
10) What is the colour of Yaks milk?	
11) Who directed “Star Wars”?	
12) In what year was the death penalty abolish in Britain?	
13) What is the cube root of 64?	
14) What is the largest planet in the Solar System?	
15) What was Henry VIII’s fifth wife called?	
16) Who set sail in a beautiful pea green boat?	
17) What does the cockney rhyming slang ‘Cain and Able’ represent?	
18) Name the Roman God of the sea.	
19) Which of Disney’s seven dwarfs wore glasses?	
20) How many years have you been married for your Diamond anniversary?	
21) By what name is the Central Criminal Court in London better known by?	
22) Where on the body is the Thyroid gland?	

**Appendix H -
General Knowledge Test B**

Quiz B

1) What is the name of England's largest National Park?	
2) Which singer is known as "The Queen of Soul"?	
3) Mondays child is fair of face, Tuesday's child is _____?	
4) Name the chemical symbol for Iron.	
5) How many equal angles are there in an Isosceles Triangle?	
6) Which famous artist painted the Mona Lisa?	
7) Which Shakespeare play begins with "If music be the food of love, play on"?	
8) What does 'BBC' stand for?	
9) What is the UK's most venomous snake?	
10) What is the worlds largest lizard?	
11) What type of creature was Chewbacca in "Star Wars"?	
12) What year did the Berlin Wall finally come down?	
13) What is the square of 13?	
14) What planet has rings around it?	
15) Name the French port the evacuation on 4 th June 1940, took place from.	
16) What did the three little kittens lose?	
17) Do seagulls drink seawater?	
18) Name the one-eyed giant in Greek mythology.	
19) What is the name of Donald Ducks girlfriend?	
20) How many years are you celebrating when you reach your Silver wedding anniversary?	
21) What is the name of the oldest surviving British Sunday newspaper?	
22) Where on the body is the Patella?	

***Appendix I -
Experiment 1 Participant Information Sheet***



Participant Information Sheet

Study: An investigation into the conscious processing of cognitive and affective states on rapid decision-making.

You are invited to participate in a study exploring the processes involved in rapid decision-making in relation to changes in cognitive and affective states.

As part of the procedure, you will be required to complete a series of measurements looking to gauge your Mood, Memory, Anxiety, Attention and Intelligence levels prior to, and after the completion of a lexical decision task. The task consists of the presentation of a letter string on a computer screen and involves you making word (poster) / non-word (gawhe) judgements as quick and as accurately as you can, indicating your answer with a button press on the button box provided.

The scales for Mood, Anxiety and Intelligence will be measured via paper-based questionnaires. The measurements require you to indicate on a numbered scale the extent to which you either agree or disagree with the given statements (Anxiety); or the extent to which your present mood incorporates the listed mood options (Mood). The Intelligence task requires you to fill out a general knowledge questionnaire with open-ended answers.

Measurement for Memory and Attention will both be a computerised. The 'Conceptual Span Task' will be used to assess, short-term working memory. The task will present a list of words, one at a time for one second each and at the end will ask for you to recall the words relating to a specified category, for example, the computer presents the words: zebra; leg; thimble; turtle; eye; ring; arm; wrench; and screw individually, and then presents 'Body Part?' to indicate for you to recall out loud to the experimenter any words from the list which represent a body part (e.g. leg, eye, and arm). The Stroop Task will be used to assess attention. The aim is to press the colour button on the button box provided which matches with the colour the words shown on screen are written in. The aim is to complete this task in the quickest possible time with the highest level of accuracy.

Any information collected from you will be coded so as to maintain your anonymity. Furthermore, it should be highlighted that this study is entirely voluntary and you are free to withdraw at any time without giving a reason if you so wish. The results from the study are expected to be disseminated via international conference and refereed journal publications. If you have any further questions/queries about this study you are welcome to contact me at the following:

Samantha Reeves

PhD Researcher

Dept of Applied Social Sciences

Canterbury Christ Church University

Canterbury, Kent, CT1 1QU: Email: ssr3@canterbury.ac.uk

*Appendix J -
Experiment 1 Debrief Funnel-Styled Questionnaire*

-End of Study Questionnaire and Debrief-

-Subliminal Check-

Thank you for participating in this study, your time has been very much appreciated. Having completed the study, I just have a few questions to ask regarding the procedure.

Did you notice anything unusual during the lexical decision task?

Please Circle:

YES

NO

Did you see any words (other than the target words) flashing up on the computer screen?

Please Circle:

YES

NO

If yes, can you elaborate on what you saw? Please state anything at all that you feel was not strictly apart of the lexical decision task.

.....
.....
.....
.....
.....
.....

* This study that you have participated in today had a subliminal element to it. If you had to guess at the subliminal message presented to you, what would your guess be?

.....
.....
.....
.....

This study that you have taken part in involves six different conditions. Participants that have taken part in this study have all been distributed evenly across the six conditions and these conditions only differ in the message content that is presented. Below is a list of ALL the Subliminal Messages used throughout this study. Please could you indicate which one you believe you were exposed to.

MOMMY AND I ARE ONE

I AM INTELLIGENT

PEOPLE ARE WALKING

ONE

INTELLIGENT

WALKING

The message that you received was : **--PLEASE ASK EXPERIMENTER!--**

Why do you think you received this message?

.....
.....
.....
.....

-Emotional Check-

Now you know which subliminal stimulus you received, I just want to check how you feel about this.

Firstly, do you have any comments you would like to make regarding any aspect of this study or the message that you received?

.....
.....
.....
.....

How does the thought of receiving a subliminal message make you feel, even if it is designed to generate positive effects?

.....
.....
.....
.....

Has this study had any impact on any previous perceptions you held about the use of, and/or effects of subliminal message presentations?

.....
.....
.....

-Break Check-

Finally, due to the length of the study a break period was implemented to ensure that participants taking part would not suffer from fatigue.

* One of the study aims was to measure your mood. Our moods can be quite sensitive, therefore I would like to ask if during the break period of this study you experienced any strong emotion which affected your mood.

Please Circle:

YES

NO

Was this a negative or positive emotion?

.....
.....

Do you feel this emotion affected your mood at all during the second half of this experiment?

Please Circle:

YES

NO

That is the end of the study, just to reiterate, none of your personal information will be disseminated and will be kept anonymous in storage at CCCU in accordance with the Data Protection Act 1998, and the universities own data protection guidelines. If you have any questions regarding any aspect of this study, please do not hesitate to ask, or to contact me at a later date.

Kind Regards,

Samantha Reeves
PhD Researcher
Dept. Applied Social Science
Canterbury Christ Church University
Email: ssr3@canterbury.ac.uk

*Appendix K -
Experiment 2 Participant Information Sheet*



Participant Information Sheet

Study: An investigation of the conscious processing of working memory and lexical decision making skills.

You are invited to participate in a study exploring the speed of cognitive processing in relation to rapid decision-making and memory recall ability.

As part of the procedure, you will be required to complete two tasks, the Conceptual Span Task and the Lexical decision Task.

The Lexical Decision Task consists of the 30 presentation of letter strings shown on a computer screen. You will be required to make a decision as to whether it is a **word** (e.g. 'poster') or a **non-word** (e.g. 'grawhe'). The aim of the task is to make these decisions as accurately as you can, in the quickest possible time. You will need to indicate your answer with the press of a button on the button pad provided, where **Green** = WORD and **Red** = NON-WORD.

The Conceptual Span Task will be used to assess short-term working memory. The task consist 21 trials. Each trial will present a list of 9 words; each word is shown to you on the computer screen for one second. At the end of the list, you will be prompted by a category cue to recall only the words from that specific category. For example: If the computer presented the words: zebra; leg; thimble; turtle; eye; ring; arm; wrench; screw, and then presented the prompt 'BODY-PART' you would recall the words 'leg', 'eye' and 'arm'.

The aim is to recall as many words from that category, shown in the list prior to it within 5 seconds. Recall is done by saying the words aloud to the experimenter.

Any information collected from you will be coded to maintain your anonymity. Furthermore, it should be highlighted this study is entirely voluntary and you are free to withdraw at any time, without providing a reason.

The results from the study are expected to be disseminated via international conference and refereed journal publications. If you have any further questions/queries about this study you are welcome to contact me at the following:

Samantha Reeves
PhD Researcher
Dept of Applied Social Sciences
Canterbury Christ Church University
Canterbury, Kent,
CT1 1QU:
Email: ssr3@canterbury.ac.uk

*Appendix L -
Experiment 2 and 3 Debrief Funnel-Styled Questionnaire*

**End of Study Questionnaire and Debrief-
-Subliminal Check-**

Thank you for participating in this study, your time has been very much appreciated. Having completed the study, I just have a few questions to ask regarding the procedure.

* Did you notice anything unusual during the lexical decision task?

Please Circle:

YES

NO

* Did you see any words (other than the target words) flashing up on the computer screen?

Please Circle:

YES

NO

* If yes, can you elaborate on what you saw?

Please state anything at all that you feel was not strictly part of the lexical decision task.

.....
.....
.....
.....

* This study you have participated in today had a *subliminal* element to it. If you had to guess at the content of the subliminal message presented to you, what would your guess be?

.....
.....
.....
.....

* This study you have taken part in involves six different groups. Participants who have taken part in this study have all been distributed evenly across the six groups, and these groups only differ in the message content that is presented.

Below is a list of ALL the Subliminal Messages used in this study. Please indicate which one you believe you were exposed to.

MOMMY AND I ARE ONE

I AM INTELLIGENT

PEOPLE ARE WALKING

ONE

INTELLIGENT

WALKING

* Why do you think you received this message?

.....
.....
.....
.....

The message that you received was : **--PLEASE ASK EXPERIMENTER!--**

-Emotional Check-

Now you know which subliminal stimulus you received, I just want to check how you feel about this.

* Firstly, do you have any comments you would like to make regarding the use of subliminal messaging?

.....
.....
.....
.....

* How does the thought of receiving a subliminal message make you feel?

.....
.....
.....
.....

* Even if it is designed to generate positive effects?

.....
.....
.....
.....

* Has this study had any impact on any previous perceptions you held about the use of, and/or effects of subliminal message presentations?

.....
.....
.....
.....

Thank you very much for your time and participation in this study!

If you have any questions regarding the procedure or the results of this study, please feel free to contact the researcher:

Samantha Reeves (PhD Student; Supervisor, Dr. David Vernon)

ssr3@canterbury.ac.uk

***Appendix M -
False Article Extract***

The new Scientist magazine
Issue number: 2808
Author: Joseph Anslow
April edition, 2011
Article title: "It pays to work at training working memory"

...Intriguing research by psychologist Sophie Ingold-Read (2010) reports on the benefits of working memory for successful progression in the workplace. This large longitudinal study (N=172) followed students for five years after leaving University and showed that those with a good working memory had gained better promotions and earned, on average, higher salaries. Why? It seems that having a good working memory boosted individual's progression in their chosen career, which in turn led to the higher salaries.

Psychologists have long since been aware of the links between better working memory in children and higher levels of comprehension and numeracy skills, which in turn facilitate exam performance leading to better academic grades. Now Ingold-Read's research suggests that having a good working memory not only benefits academic schooling but can also improve your prospects in the work place. For example, when asked by an employer to conduct a specific series of tasks, those with good working memory skills seem able to process the instructions more easily and efficiently making them quicker to initiate actions and complete the tasks in less time and with a greater degree of accuracy.

It is not surprising that such employees appear more effective at their jobs, which in turn leads to a greater possibility of promotions within the company. It's clear from the findings of this research that a good working memory can benefit your academic schooling as well as your academic career. However, not everyone has a good working memory. Fear not, Professor Alan Baddeley, an expert in memory research, has massed quite a compendium of research showing that it is possible to improve working memory with practice. Research from Baddeley's lab has found that practicing tasks designed to test our working memory actually benefit our ability to use it. For example, such tasks can improve our ability to hold and process new information, a primary function of working memory...

*Appendix N -
Motivation and Memory Questionnaire Pilot Survey*



Pilot:
Memory and Motivation Questionnaire

Hello!

Thank you for agreeing to take part in this pilot study! The aim of a pilot study is to ensure that certain components of my 3rd experiment (due to go live in October) are effective at measuring what I would like them to – and that they are not too long-winded from the perspective of the participant!

For this pilot, you will be required to complete the following questionnaire on the perception of your motivation and memory ability. Having completed the questionnaire, you are also required to complete a few questions about the questionnaire itself.

If you have any questions, please feel free to contact me prior to completing the study (Samantha.reeves@canterbury.ac.uk).

Participant Consent Form

I confirm that I have read and understood the information given for the pilot study	Yes	No
I understand that this form may be examined by an Ethics Committee as part of the monitoring process	Yes	No
Do you agree to take part in this study?	Yes	No

YOUR FULL NAME (Block Capital Letters):

Signature:

Date:

0 1 2 3 4 5 6 7 8 9
 Completely Disagree Completely Agree

[6] I am [was] strongly motivated by the RPS credits I receive[d] in return for completing this study

0 1 2 3 4 5 6 7 8 9
 Completely Disagree Completely Agree

[7] Enjoyment in taking part is what matters most

0 1 2 3 4 5 6 7 8 9
 Completely Disagree Completely Agree

[8] I have to feel that I am earning something in return for what I do

0 1 2 3 4 5 6 7 8 9
 Completely Disagree Completely Agree

-General-

This final set of questions relate to the study as a whole. Please answer honestly on the 9-point scales provided.

[9] How interested are [were] you in completing this study?

0 1 2 3 4 5 6 7 8 9
 Not at all Very much

[10] How much effort will [did] you give to today's tasks?

0 1 2 3 4 5 6 7 8 9
 No effort High effort

[11] To you, how important is [was] it to perform successfully on these tasks?

YES

NO

[b] Do you have any further comments regarding this subsection?

.....
.....
.....

Thank you for your time and responses in this pilot study!

If you have any further questions about your participation or about the study itself, please feel free to email me on the email address at the top of this form.

Kind regards,

Miss Samantha Reeves
PhD Researcher
Department of Applied Social Sciences
Canterbury Christ Church University

*Appendix O -
Experiment 3 Participant Information Sheet*



Participant Information Sheet

Study: Investigating the conscious processing of cognitive and motivational states on rapid decision-making.

You are invited to participate in a study exploring the processes involved in rapid decision-making in relation to changes in cognitive and motivational states.

As part of the procedure, you will be required to complete a series of measurements looking to gauge your perceived Motivation and Memory levels prior to, and after the completion of a lexical decision task (LDT). The LDT consists of the presentation of a letter string on a computer screen and involves you making word (poster) / non-word (gawhe) judgements as quick and as accurately as you can, indicating your answer with a button press on the button box provided.

Perceived motivation and memory will be measured at three points during the study. For this measure, you will be asked to complete a short paper-based questionnaire with questions answered on a 10-point scale.

A computerised measure of your working memory ability will be taken at 2 stages during the study. This measure, the 'Conceptual Span Task' will present a list of words, with each word shown one at a time for one second, finally prompting you to recall the words relating to a specified category. For example, if the computer presents the words: Indigo; Fork; Liquorish; Gobstopper; Knife; Yellow; Smarties; Orange; and Spoon; and then presents the category word, 'Sweets?' It is indicating to you to recall out loud to the experimenter, any words from the list, which represent a sweet (e.g. Liquorish; Gobstopper and Smarties).

Any information collected from you will be coded to maintain your anonymity. Furthermore, it should be highlighted this study is entirely voluntary and you are free to withdraw at any time without giving a reason if you so wish. Completing this study automatically enters you into a cash prize draw, for the chance to win £100. All participants will be contacted at the close of the draw in a group email, whereby email addresses will be made anonymous. However, should you be the winner your full name will be published in this email. If you do not want to enter the prize draw please inform the experimenter.

The results from the study are expected to be disseminated via international conference and refereed journal publications. If you have any further questions/queries about this study you are welcome to contact me at the following:

Samantha Reeves

PhD Researcher - Department of Applied Social Sciences
Canterbury Christ Church University - Canterbury, Kent, CT1 1QU:
Email: ssr3@canterbury.ac.uk

[6] Curiosity is the driving force behind taking part in this study

0 1 2 3 4 5 6 7 8 9
Completely Disagree Completely Agree

[7] I am strongly motivated by the RPS credits/entry into the cash prize draw I receive in return for completing this study

0 1 2 3 4 5 6 7 8 9
Completely Disagree Completely Agree

[8] Enjoyment in taking part is what matters most

0 1 2 3 4 5 6 7 8 9
Completely Disagree Completely Agree

[9] I have to feel that I am earning a reward in return for what I do

0 1 2 3 4 5 6 7 8 9
Completely Disagree Completely Agree

-General-

This final set of questions relate to the study as a whole. Please answer honestly on the 10-point scales provided.

[10] How interested are you in completing this study?

0 1 2 3 4 5 6 7 8 9
Not at all Maximum

[11] How much effort will you give to all of today's tasks? E.g. The CST and LDT tasks.

0 1 2 3 4 5 6 7 8 9
No effort Maximum effort

**Appendix S –
Experiment 4 Participant Information Sheet**



Study: Investigation of the conscious processing of working memory and lexical decision skills.

You are invited to participate in a study exploring the conscious processes involved in working memory and lexical decision skills.

During the experiment you will be required to complete two tasks measuring your working memory performance and one task measuring your lexical decision skills.

Memory tasks:

1) Conceptual Span Task – In each trial of this task you will be shown a list of nine words to read. You will then be asked to recall words from that list that relate to a specific category. For example, the computer presents the words ‘Smarties, Oak, Football, Willow, Snickers, Hockey, Netball, Birch, Fruit Tellers’ then the category ‘TREE?’. The correct answers are ‘Oak, Willow, and Birch’. You will be asked to complete this task twice, once before the Lexical Decision Task and again after the Lexical Decision Task.

2) Automated Operation Span Task – During this task you will be required to calculate simple maths problems, for example $(3*2) + 1 = ?$. After mentally solving the problem the computer will then show you an answer and you will need to indicate whether that answer is true or false. On answering this question you will be shown a letter to remember. You will be asked to complete this procedure between three to seven times in each ‘set’. At the end of each set you will need to recall the letters shown to you in the order they were presented. You will be asked to complete this task twice, once before the Lexical Decision Task and again after the Lexical Decision Task.

Lexical Decision Task:

This task will be completed once in the middle of the experiment. For this task you will be shown a letter string on the computer screen and will be asked to make a decision about this letter string as *quick* and as *accurately* as you can. The decision is whether that letter string spells a ‘word’ or ‘nonword’ i.e., is part of the English dictionary (Word = Comb) or is not a real word (Nonword = Fong).

Any information collected from you will be coded to maintain your anonymity. Furthermore, it should be highlighted that this study is entirely voluntary and you are free to withdraw at any time without giving a reason if you so wish. It is expected that the results from this experiment will be disseminated via international conference and refereed journal publications. If you have any further questions/queries about this study you are welcome to contact me at the following:

Samantha Reeves

PhD Researcher

Department of Applied Social Sciences

Canterbury Christ Church University

Canterbury, Kent, CT1 1QU: Email: samantha.reeves@canterbury.ac.uk

*Appendix T –
Experiment 4 Debrief Funnel-Style Questionnaire*

**-End of Study Questionnaire and Debrief-
-Subliminal Check-**

Thank you for participating in this study your time has been very much appreciated.

Please complete the following questions:

* Did you notice anything unusual during the **Lexical Decision Task**?

Please Circle:

YES

NO

* Did you see any words (other than the target words) flashing up on the computer screen?

Please Circle:

YES

NO

* If yes (to any of the above), can you elaborate on what you saw?

Please state anything at all that you feel was not strictly part of the Lexical Decision Task.

.....
.....
.....
.....
.....
.....

* This study you have participated in today had a *subliminal* element to it.

If you had to guess at the content of the subliminal message presented to you, what would your guess be?

.....
.....
.....
.....

* This study you have taken part in involves four different groups. Participants who have taken part in this study have all been distributed evenly across the four groups, and these groups only differ in the message content that is presented to them.

Below is a list of ALL the subliminal messages used in this study. Please indicate which one you think you were exposed to (please circle).

I CAN REMEMBER WELL

PEOPLE ARE WALKING

REMEMBER

WALKING

* Explain why you think you received this message?

.....
.....
.....
.....

The message that you received was : **--PLEASE ASK EXPERIMENTER!--**

-Emotional Check-

Now you know which subliminal stimulus you received, I just want to check how you feel about this.

* Firstly, do you have any comments you would like to make regarding the use of subliminal messaging?

.....
.....
.....
.....

* How does the thought of receiving a subliminal message make you feel?

.....
.....
.....
.....

* Do your thoughts change if you knew the subliminal messages were designed to generate positive effects?

.....
.....

.....
.....

* Has this study had any impact on any previous perceptions you held about the use of, and/or effects of subliminal message presentations?

.....
.....
.....
.....

Thank you very much for your time and participation in this study!

If you have any questions regarding the procedure or the results of this study, please feel free to contact the researcher:

Samantha Reeves (PhD Student; Supervisor, Dr. David Vernon)
Samantha.reeves@canterbury.ac.uk