FALSE RECALL SERIAL POSITION EFFECTS

A Thesis Submitted to the College of

Graduate Studies and Research

In Partial Fulfillment of the Requirements

For the Degree of Doctor of Philosophy

In the Department of Psychology

University of Saskatchewan

Saskatoon

By

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ABSTRACT

A series of 5 experiments investigated whether false memory in associated word lists present with *serial position effects* (SPE) and how any such effects behave in response to manipulations of true recall SPE. Recall for a series of events is typified by SPE such that items nearer the beginning, *primacy effect*, and end, *recency effect*, of a series are remembered better than middle items. Recall is also typified by the intrusion of falsely remembered information. Word-lists segmented into trimesters of either semantically (e.g., *hot, snow, warm.../ bed, rest, awake.../ looking, lens, shatter...*) or phonologically (e.g., *code, called, fold.../ sweep, sleet, steep.../ class, grass, glad...*) associated words produced false recall (e.g., *cold, sleep, glass*), allowing for the simultaneous investigation of SPE for true and false recall. Typical SPE for true recall were observed for each of the five Experiments. For immediate free recall, semantic false recall declined from early to late study trimesters whereas phonological false recall displayed a false primacy and recency effect similar to true recall SPE. Phonological false recall was significantly reduced when a 15 second distractor task was implemented during the retention interval. Dividing attention during study using a concurrent handwriting task reduced true recall whereas semantic false recall increased at primacy and phonological false recall increased at recency. This suggests distinct processes underlying the two forms of false recall. Dividing attention using an articulatory suppression task produced less true recall and less false recall than using concurrent handwriting. This research indicates that false recall SPE exist and that the semantic and phonological forms of false recall SPE are distinct. Current theories of false memory and of true recall SPE are considered.

ACKNOWLEDGMENTS

The production of this document has involved the efforts of too many people to list. In general, I feel fortunate to have been a part of the University of Saskatchewan academic community. I would like to thank in particular my supervisor, Dr. Tammy A. Marche, and my Advisory Committee members, Dr. Jim Cheesman, Dr. Andrew Kirk and Dr. Valerie Thompson, for their expertise and wisdom in helping to prepare this thesis. My external examiner, Professor Michael P. Toglia, provided thoughtful comments and questions that will undoubtedly positively impact future development of this dissertation research. The funding and education provided by a Graduate Teaching Fellowship and also through working with Dr. Tammy Marche, Dr. Valerie Thompson and Dr. Jamie Campbell, are greatly appreciated. I wish to also extend thanks to my colleagues affiliated with the Cognitive Science Lab at the College of Arts and Science and with the Cognitive Development Lab at St. Thomas More College. Jody Shynkaruk and Lynette Epp, among others, were very helpful in early collection and editing. My lab mates Thomas Phenix, Eyvind Ohm, Arron Metcalfe and visiting professor Orlando Espino, were key figures in my graduate school experience. Much thanks to my former Honours Student Johnna Mooney for showing confidence in me as a mentor. Special thanks to my former Honours Student Jennifer Briere for her continued collegiality and support.

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CHAPTER 1: FALSE MEMORY AND SERIAL POSITION EFFECTS

When a series of events are experienced and subsequent memory for those events is measured, two signatures of human memory are typically found; the location in the series impacts memory retention, and secondly, memories contain information over and above that which was initially experienced. Since the late 19th century, experimental psychologists have used lists of words to study human memory (see Crowder & Greene, 2000 for a discussion). An early finding that has remained of enduring interest is that the serial location at which list words are initially studied influences memory for those words (see Glanzer, 1972 for a discussion). For immediate free recall and other experimental paradigms, memory presents with a *serial position curve* in which items nearer the beginning and end of a series have a higher probability of being remembered than middle items, respectively termed the *primacy effect* and the *recency effect,* and are together referred to as *serial position effects* (SPE; see Crowder, 1976; 2000 for discussions). SPE have been observed in a remarkable variety of contexts and have been a hallmark in the development of true memory theory (e.g., see Brown & Lamberts, 2003; Davelaar, Goshen-Gottstein, Ashkenazi, Haarmann & Usher, 2005; Healy & McNamara, 1996; Howard & Kahana, 1999; 2002a; 2002b for discussions). Interest in SPE for list memory continues to the present time (e.g., Haarmann & Usher, 2001; Howard & Kahana, 1999) and like other memory effects, are typically assessed in terms of the quantity of correctly remembered items. However, in more recent times (Bruce & Winnograd, 1998), theorists have come to recognize that falsely remembered list items are essential to describing memory (e.g., Brainerd, Payne, Wright & Reyna, 2003; Deese, 1959; Koriat, Goldsmith & Pansky, 2000; Kronlund & Whittlesea, 2005). It was recognized at the outset of this research initiative that false memory may very well be impacted by serial position just as is true memory, and furthermore that this impact may be different for false than for true memory.

SPE and false memory in associated word-lists has been given little experimental consideration (however see Read, 1996). Based on previous cued recall research (Kintsche & Buschke, 1969), Read correctly predicted that semantic false recall (Deese, 1959) would be associated with early study position in terms of participants' subjective judgments. This successful line of prediction was founded on classical dual store theory of SPE (e.g., Atkinson & Shiffrin, 1968) which suggests that the primacy effect is supported by a long-term semantically coded memory store (Glanzer, 1972). Although more recent research suggests limitations to this view (see Glanzer, 1972 for a discussion), findings consistent with dual store memory theory continue to demand attention from memory theorists (Baddeley, 1990; Healy & MacNamara, 1996; Kimball, Smith & Kahana, 2007; Radvansky, 2005). This present thesis draws on the classical dual store framework in advancing a series of experiments aimed at attaining some degree of experimental control and understanding of false recall and SPE in relation to true recall SPE. Whereas the dimensions of semantics and phonology have received considerable focus in research on true recall SPE (see Baddeley, 2004; Crowder & Greene, 2000; Glanzer, 1972; Haarmann & Usher, 2001 for discussions), research on false recall in associated word-lists has only begun to explore differences between these dimensions (e.g., Ballou & Sommers, 2008; McDermott & Watson, 2001; Roediger, Watson, McDermott & Gallo, 2001; Watson, Balota & Roediger, 2003).

The existence of false recall SPE would have relevance to several specific current investigations in the false memory literature. If different serial position regions produce more or less false recall, it may impact assessment of the relative co-occurrence of true and false recall within the context of single lists (Robinson & Roediger, 1997). Specifically, if the overall power of associated word-lists (Deese, 1959; Sommers & Lewis, 1999) to produce false recall is dependent on the serial position region at which associated word items are clustered, then the factor of serial position must be considered in understanding the role of associative processes in the context of a larger event. Similarly, research simultaneously investigating semantic and phonological false recall (Budson, Sullivan, Kirk & Schacter, 2003; McDermott & Watson, 2001) has measured true and false recall in terms of entire word-lists when serial position may be affecting true and false recall differently at different serial positions. If serial position impacts false memory, it may alter the empirical definitions of theoretical memory parameters calculated on the basis of true and false recall response probabilities which are formed from responses throughout the entire serial position curve (Brainerd et al., 2003). Furthermore, false recall SPE may figure in assessing factors affecting false recall generally (Roediger et al., 2001) just as research into SPE has figured in research on factors affecting true memory (Glanzer, 1972).

In summary, the principle motivation of this thesis was to investigate the possibility that false recall SPE exist and to relate any such findings to current issues in the associated false memory literature. Because true and false memories are typical aspects of memory reports, the question as to the relationship between these forms of memory is of special interest (e.g., Toglia, Neuschatz & Goodwin, 1999). Patterns of false SPE may vary from true SPE and this may be applicable in attempting to distinguish true from false memory. Does false memory produce unique SPE from that of true memory? Furthermore, does false memory arising from semantic association (Deese, 1959) produce a different pattern of SPE than false memory arising from phonological association (Sommers & Lewis, 1999)? What consequences might false recall SPE have for theoretical interpretation (Brainerd, Wright, Reyna & Payne, 2002; Roediger et al., 2001) and for the empirical assessment of memory accuracy generally (Koriat et al., 2000; Kronlund & Whittlesea, 2005; Toglia et al., 1999)?

The following dissertation provides a brief history of false memory research turning to a focus on false memory in list learning paradigms and finally to discussion of the relevance of SPE to false memory in associated word-lists and vice versa. SPE in list memory and their impact on theory will be discussed and related to current issues in the false memory literature. In endeavoring to understand the relationship between true and false memory, scientists often produce both true and false memories under similar conditions in order to observe and predict their mutual behaviors (e.g., Brainerd et al., 2003; Kronlund & Whittlesea, 2005; Seamon et al., 2003; Toglia et al., 1999). In this tradition, manipulations of the normal serial position curve are undertaken in the present thesis in an experimental paradigm designed to simultaneously produce true and false memory as a function of different serial position regions, and as a function of either semantic or phonological word association. This research aimed to produce data pertinent to the issue of how serial position of initial encounter impacts false recall in associated word-lists. Much research has been conducted in which true recall SPE have been strategically manipulated (e.g., see Glanzer, 1972). In order for a complete understanding of list memory to emerge, research must be conducted on how false recall SPE vary in relation to true recall SPE.

False Memory

The term *false memory* refers to memory that does not accurately correspond to the circumstances that produced it (Koriat et al., 2000). False memory is often referred to as *memory illusion* or *memory distortion* (Schacter, Fischbach, Mesulam & Sullivan, 1995). The term false memory implies that events which are believed to have occurred were never experienced or are remembered incorrectly in relation to the actual event. False memory sometimes involves active errors of commission, distinct from passive forgetting (Roediger & McDermott, 2000a). Schacter

(1999) concludes that memory distortions may be seen as involving both commission and omission errors. This thesis is concerned with active commission errors. False memory is also distinct from intentional false reporting because it does not imply intent. Distinguishing true memory from false memory is more difficult than distinguishing true memory from intentional false reporting because false memory may be completely indistinguishable from true memory from either the perspective of the experimental participant (Payne, Elie, Blackwell & Neuschatz, 1996) or from subtle methods of experimental detection into memory phenomenology (Brainerd et al., 2003). A large body of scientific research now exists demonstrating that people can easily be induced to falsely remember (Brainerd & Reyna, 2002; Brown, Goldstein & Bjorklund, 2000; Koriat et al., 2000; Roediger & McDermott, 2000a; Schacter et al., 1995).

A brief history of false memory research

The first experimental research into false memory was conducted by European experimental psychologists often acting in the interest of the law (Brown et al., 2000). These researchers were concerned with the authenticity of testimony, particularly that of children (Brown et al., 2000; Ceci & Bruck, 1993; Roediger & McDermott, 2000a; Schacter et al., 1995). According to Ceci and Bruck (1993), children's testimony was held in very tenuous regard by legal scholars for three centuries following the spectacular 17th century witch trials in Salem USA, and other cases in Europe, where legally sanctioned executions were undertaken on the basis of children's testimony, and where this testimony was later recanted. Contrary to the North American adversarial legal process where a jury has been viewed as adequate in discerning questions of memory veracity, European inquisitorial legal procedure saw judges regularly seeking experimental psychologists' input into decision making (Ceci & Bruck, 1993; 2000).

In an effort to inform the courts about memory veracity with experimental evidence, early European experimental psychologists developed paradigms intended to capture the essential features of circumstances believed to produce false memory reports. Binet (1900; as cited in Roediger & McDermott, 2000a), for example, recognized the influence of suggestion, particularly that of an authority figure on children. Binet founded an experimental paradigm based on line-length judgments that is often cited (e.g., Roediger & McDermott, 2000a) because it is particularly illustrative of how suggestion can create false memories. *Misinformation* designs such as Binet's line judgment experiments demarcate the beginning of experimental research into false memory (Brown et al., 2000; Schacter et al., 1995) and continue to be a powerful source of knowledge about the nature of false memory (Loftus, 1997). In Binet's experiments, children were misled regarding line length judgments. The experimenter, or a confederate participant, would motion toward an incorrect response as children were matching lines to a sample. This drew the participants to either agree with the suggestion or use their own judgment. Children often reported false line lengths in accordance with suggestion. Although children were sometimes simply complying, Binet identified instances where participants falsely remembered selecting the correct response. Later research identified similar effects in adults (Ashe, 1956; Bond & Smith, 1996). While it is certainly the case that adults are susceptible to suggestion (Risinger, Sachs, Thompson & Rosenthal, 2002), modern memory research continues to support the view that children are more suggestible than adults (Ceci, Bruck & Battin, 2000), and furthermore, that older adults may also be more susceptible to false memory than younger adults (e.g., Balota et al., 1999).

Bartlett (1932) is typically given credit for elucidating the fact that human memory is an active process of interpretation (Brown et al., 2000; Koriat et al., 2000; Reyna & Lloyd, 1997; Roediger & McDermott, 2000a; Schacter et al., 1995). In Bartlett's most celebrated study, he had participants listen to a story, *The War of Ghosts*, and at several later points in time asked participants to recount the story. He found that the story was altered in systematic ways. Order and sense were often given to the rather vague story; he referred to this constructive process of remembering as *rationalization*. In the process of rationalizing, or *schematizing* as it has often been referred to, the true story was to some extent falsified from its initial form. Bartlett made clear that memory is not simply a storehouse of mental representations; but rather memories are active interpretations.

Bartlett's (1932) book *Remembering* was not noticed much for decades, however, his constructionist concept of rationalized memory fit perfectly with the views contained in Neisser's (1967) watershed textbook publication *Cognitive Psychology* (Roediger & McDermott, 2000a). What was pivotal about Bartlett's view was that the human mind became an active agent in shaping memory and this was shared with other perspectives from within the emerging cognitive revolution. Linguistics, contrary to behaviorist thinking, proposed that the human brain contained functional organs of language (Chomsky, 1957). Viewing human memory as being comprised of functional components was also occurring in neuropsychology where medical and psychological researchers were collaborating in attempting to understand functional brain anatomy (Scoville & Milner, 1957). Bartlett's work was the subject of large increases in citations in the 1970s (Roediger & McDermott, 2000a) and continues 35 years later to be regarded as highly influential. Bransford and Franks (1971), for example, using a sentence memory paradigm, found that participants were more likely to falsely remember complex sentences that contained the meanings that were actually expressed in different shorter sentences. This suggested that meaningful representations were formed in memory that produced different surface forms at retrieval, some of which did not precisely accord with the circumstances that initially produced them.

Another line of influential false memory research arising from constructionist thinking on memory involves the *misinformation* paradigm or variants of it (Loftus, 1997; 2004). Loftus and her colleagues have conducted many experiments in which misleading suggestions have led to false memories. In a classic example of the misinformation paradigm (Loftus, Miller & Burns, 1978), a series of slides depicting a car accident is shown after which the experimenter might ask participants 'what happened after the car drove though the yield sign?' when in fact a stop sign had been presented in the original slide show. Many people later confidently remembered a yield sign rather than a stop sign as a result of this surreptitiously placed misinformation. The misinformation seems to interfere or integrate with the initial memory (see Koriat et al., 2000 for theoretical discussion). Similar experimentation expanded this reasoning to include circumstances potentially more informative to the clinical or forensic settings. For example, complex false memories for mildly traumatic events have been produced through a form of suggestion paradigm. Loftus and Pickrell (1996), using repeated suggestion, and employing parents as confederates, evoked false memories of being lost in a shopping mall and being rescued by an elderly man. Other research has shown that merely imagined, as compared to non-imagined, events are sometimes seen by experimental participants as having actually occurred at later testing (Garry, Manning, Loftus & Sherman, 1996; Goff & Roediger, 1998; Kassin & Gudjonsson, 2004; Thomas & Loftus, 2002), a phenomena referred to as *imagination inflation*.

In Bartlett's (1932) *War of Ghosts* research discussed above, no suggestion or misinformation was explicitly provided by the experimenter to the participants. Suggestion of misinformation need not come directly from the experimenter, but may simply be implied by the experimental situation or materials. In Binet's (1900, as cited in Roediger & McDermott, 2000a) line length experiments discussed above, participants would often make incorrect line-length judgments if the lines were generally presented in progressing order of length. The presentation order suggests that each successive line should be longer or shorter than the previous one, whether or not it actually is. Suggestion is provided only by participants interpretation of the study materials. It is this more subtle and insidious form of false memory production that is of particular interest because it speaks to the issue of how false memory may take root without intention (e.g., Marche, Brainerd, Lane & Loehr, 2005). Word-list memory experimentation, which forms the experimental content of this dissertation, also inevitably directs the memory of the experimental participants by suggesting various meanings through the experimental setting and materials.

Experimentation into the basic processes of false memory production using word-list research was slower to take hold than false memory created by other memory paradigms (Bruce & Winograd, 1998; Roediger, McDermott & Robinson, 1998). However, beginning in the mid-1990s (Read, 1996; Roediger & McDermott, 1995) word-lists became utilized in attempting to understand basic false memory processes. Just as social circumstances spawned interest in false memory at the turn of the last century, social circumstance again spawned basic scientific research into false memory, and this has brought false memory in associated word-lists into the current scientific spotlight (Brainerd & Reyna, 2005). Formal legal proceedings, including some involving the practice of therapeutic psychology in which recovered traumatic memories were later determined false, created resurgence in false memory research (Brainerd & Reyna, 2005; Loftus, 2004; Peters, 2001).

The fact that the law is demanding reliable and verifiable psychological practices underscores the need for an experimental foundation in upholding psychology in the larger social context. From the first scientific studies of false memory to the present, psychology and the law have shared a special relationship due to legal interest in scientific perspectives on memory reliability

(Otto & Heilbrun, 2002). The continuing need to understand the psychology of false memory could not be more poignantly stated in contemporary terms than by the now accepted fact of 253 wrongfully convicted people who have been exonerated by highly reliable DNA evidence (see http://www.innocenceproject.org/). In over two thirds of these cases, false person-identification memory was involved, and numerous cases of other erroneous memory have been implicated, including false confessions of guilt that were falsely believed by the confessor (Kassin & Gudjonsson, 2004; Loftus, 2004). Studies of false memory through DNA exoneration cases are confirming concerns surrounding the reliability of testimony that experimental psychologists have expressed for years (Wells & Olson, 2003). Testimonies obtained in legal investigations or during psychological therapy are coming under increasing scrutiny by courts as to the scientific validity and reliability of methods used in attaining statements from memory (Saunders, 2001) and in the assessment of memory authenticity (Bekerian & Dennett, 1993; Yarmey, 2001). Courts (Risinger et al., 2002) and other social interest groups (see Brainerd & Reyna, 2005 for a discussion) increasingly require that psychological practice be nested within a scientific epistemology.

As they had at the turn of the last century, late in the 20th century influential legal cases again arose in which the reliability of witnesses' or therapy clients' memory came under suspicion (Brown et al., 2000; Bruce & Winograd, 1998; Lindsay & Read, 1995). The false memory literature is now large and diverse and continues to be considered of special interest to forensic testimony and clinical histology (Otto & Heilbrun, 2002; Read, 1999), but is also equally important for all aspects of social and experimental psychology. Just as the stakeholders in false memory issues are diverse, so too are the scientific methodologies used to investigate them. Each methodology arises from the perspective of investigation. Neuroscientists study false memory from the standpoint of functional brain anatomy (Squire, 2000) including computational models of neurobiological process (McClelland, 1995) and neuropsychology (Schacter, Verfaellie & Pradere, 1996). Researchers study the impact of authority (Schacter et al., 1995; Memon, Vrij & Bull, 2004) and social contagion (Meade & Roediger, 2002) on the veracity of memory. Others examine individual differences factors that may be predictive of false memory (e.g., Ballou & Sommers, 2008; Mather, Henkel & Johnson, 1997). Autobiographical researchers study false memory from the perspective that our pasts are reshaped from their original form by expectations, fears and desires; this perspective has impacted clinical psychology from Freud to the present day (see Schacter et al., 1995, Introduction).

Cognitive psychologists draw from lab based paradigms such as list learning experiments in order to conduct controlled studies searching for the basic factors that impact false memory and to formulate basic level theories and models (e.g., Anisfeld & Knapp, 1968; Deese, 1959; Brainerd et al., 2003; Kintsch & Bushke, 1969, Roediger & McDermott, 1995; Sommers & Lewis, 1999). It is this latter laboratory experimental approach that forms the focus of the following thesis experiments. The present dissertation falls in the genre of list learning paradigms. For just over the past decade, an intense interest has existed in understanding false memory for reasons discussed above. This research is motivated by the belief that understanding false memory will be aided by the controlled experimentation that list learning paradigms afford. Furthermore, a substantial portion of what is known about memory has been learned from list learning paradigms. Now that false memory has become recognized as an essential aspect of memory, its study in relation to the basic effects typically measured by true memory is necessary.

False memory in associated word-lists

Paradigms involving false memory in associated word-lists have played an essential role in facilitating the current multidisciplinary interest in false memory because they easily and reliably produce samples of false memory for analysis under reasonably controlled experimental conditions (see Schacter & Slotnick, 2004 for a discussion). List memory paradigms have a history dating back to the beginning of the scientific study of memory (Ebbinghaus, 1885). The role of false memory in the context of list learning research is highly elucidative of a shift in zeitgeist concerning the status of false memory as a legitimate object of scientific interest. Intrusions into word-list memory had been noted by a number of researchers in different contexts during behaviorist dominated years between about 1920 and 1970 (see Read, 1996; Roediger & McDermott, 2000a for discussions). Rather than instances of false memory being viewed as a potential dependent variable, they were regarded as undesirable distortion from proper memory function. In fact, what are now referred to as false memories in list learning paradigms were often called *false intrusions* into memory (e.g., Deese, 1959).

List learning paradigms were so steeped in stimulus-response behaviorist tradition that even throughout the 1970s and 80s, as constructionist false memory research using misinformation paradigms flourished (e.g., see Loftus, 1993 for a review), systematic intrusions into word-list memory that were discovered in the middle of the century (e.g., Anisfeld & Knapp, 1968; Deese, 1959; Kintsch & Buschke, 1969; Underwood, 1965) did not make much of an impression on list memory researchers. The most classic example of mainstream nonchalance toward systematic false intrusions into word-list memory (Koriat et al., 2000; Roediger & McDermott, 2000a) is that of Deese's research (Deese, 1959) into word-lists produced using associated items. Deese's false memory research did not make the reference sections of many research publications until the mid-1990s (Bruce & Winograd, 1998). Deese's true memory research from the same time period (e.g., Deese & Kaufman, 1957) was successful in attracting citations throughout the following three decades. It was not until the 1990s that Deese's work on memory intrusions was fully appreciated (Read, 1996; Roediger & McDermott, 1995). His work on false intrusions into memory is now far more commonly cited than his other research from the same time period. The paradigm that Deese devised has proven to be an efficient way to produce convincing samples of false memory that can easily be used by researchers from various disciplines (e.g., see Schacter & Slotnick, 2004 for a discussion).

Deese's (1959) procedure typically involves participants studying lists of 12 or 15 associated words (*e.g., hard, light, pillow...etc.)* where each word is associated to an unpresented target item (*e.g., soft*). The presentation lists developed by Deese were constructed by asking a large sample of people to report the first word that came to mind in response to various target items. These lists were then presented to experimental participants. Using Deese's procedure, participants routinely report the unpresented item, including that they *remember* (Tulving, 1985) the context in which it arose and often are willing to identify the speaker (Payne et al., 1996). This paradigm of presenting associated word-lists for the purpose of producing falsely remembered words has become known as the DRM, or *dream*, paradigm arising from the acronym for Deese (1959), and from Roediger and McDermott (1995) who adopted the paradigm (e.g., Bruce & Winograd, 1998; Roediger et al., 2001).

A seemingly behaviorist paradigm focusing on stimulus-response and on associationist thinking (Roediger & McDermott, 1995; Schacter et al., 1995), Deese's paradigm has been rather difficult for modern constructionist thinking memory scientists to embrace. Even the popular use of the terms *memory distortion*, *false memory* or *tricks of memory* (Roediger & McDermott, 2000b) entails the ethic of a true normative memory based on an objective independent account of that which was encountered. It assumes that because the veridical event to be remembered can be known through some form of archival evidence, that a deviation from this known truth is not a measure of the memory function, but rather of memory dysfunction. This view of false memory is still not uncommon. Bower (2000), for example, in discussing the history of memory research, remarks that false intrusions into memory constitute “forgetting via errors of commission” (p. 10). In fact, forgetting per se is not necessarily evident at all in errors of commission. For example, when a participant reports an unpresented word in a list learning paradigm (e.g., Deese, 1959) it could be said that the source of the memory was forgotten and then misplaced (Roediger et al. 2001). However, research suggests that many false intrusions have not come to mind prior to recall (Seamon, Lee, Toner, Wheeler, Goodkind & Birch, 2002), in which case forgetting of the source no longer provides an explanation. False recall as a detraction from proper memory function is also suggested in the terminology *more is less* (Toglia et al., 1999) referring to experimental findings in which true memory is sometimes accompanied by higher DRM false memory. False recall in associated word-lists represents more complex phenomena than simply forgetting. Consider for example that false recall under some conditions is accompanied by *higher* levels of true recall (e.g., Thapur & McDermott, 2001; Toglia et al., 1999) and is considered an indication of normal activation in the lexicon (Buchanan et al., 1999; Hancock, Hicks, Marsh & Ritschel, 2003).

Inaccurate responses of experimental participants have often been treated by researchers as irrelevant to the simple question of how *much* of studied lists can be remembered correctly (Bruce & Winograd, 1998; Roediger et al., 1998; Roediger & McDermott, 2000a for discussions). The growing scientific literature on false memory in associated word-lists attests to the fact that output intrusions are accepted as a natural aspect of list memory (see below for a discussion of false memory). As has been noted in other areas of memory research for some time (Loftus, 1997), the accuracy of any memory report is accompanied by falsely remembered aspects of that memory. The realization of this in list memory research has been slower to take hold (Roediger et al., 1998). Any complete theoretical model of memory must include explanation of all regularities including false memory, not just the quantity of the originally studied items correctly remembered (Brainerd & Reyna, 2003; Koriat et al., 2000). Now that false intrusions are recognized as a systematic feature of memory output (Bruce & Winograd, 1998; Roediger & McDermott, 2000a) it is important to understand the place of false memory as a measure of normal memory performance, and not only as detraction from verbatim event replication.

Deese (1959) was fully aware that false intrusions into memory were not simply noise; otherwise he would have had no interest in intentionally producing and manipulating them. In fact, Deese's methodology produced predicted false memory at levels approaching true recall levels. In was in the context of a strong associationist tradition in memory research that Deese manipulated the associative strength of study items in order to produce false intrusions into memory. An associationist tradition still exists in modern memory research which continues to employ Deese's method today (e.g., Robinson & Roediger, 1997; Watson et al., 2003). Other researchers of Deese's era were also struck by the regularity of false intrusions observed in list memory experiments (Anisfeld & Knapp, 1968; Baddeley, 1968; Baddeley & Dale, 1966; Underwood, 1965; Kintsch & Bushke, 1971). As will be discussed below, Underwood in particular became of interest to modern memory theorists (e.g., Seamon et al., 1998; Roediger & McDermott, 1995) because he made the leap from interference to activation based explanation of false intrusions into memory. Rather than viewing false intrusions into memory in terms of interference causing mistakes (e.g., Conrad, 1964), Underwood thought that false intrusions into memory were implicit associated responses that came to mind as if they were actually studied word items.

Theories of false memory in associated word-lists

Since the rebirth of interest in false recall in associated word lists in the 1990s (Roediger & McDermott, 1995; Sommers & Lewis, 1999) considerable effort has been undertaken in developing scientific theories of these effects (see Brainerd & Reyna, 2005; Gallo, 2006 for recent reviews). The researchers who brought false memory in associated word-lists to the forefront (Roediger & McDermott, 1995) have developed a line of theoretical interpretation which arises in part from the *implicit associated response* hypothesis suggested by Underwood (1965). This hypothesis holds that semantically associated intrusions into memory are the result of conscious activation of the false items during study. This use of *implicit* is rather opposite to the more modern usage which connotes cognition that is not open to conscious reflection (e.g., Squire, 1995). Underwood intended that *implicit associated responses* were responses that came to consciousness during study and were later erroneously recalled as if they were actually studied items (e.g., Robinson & Roediger, 1997; Seamon, Luo & Gallo, 1998). Seamon and colleagues (1998) have referred to Underwood's hypothesis as the *implicit activated response* hypothesis, reflecting a shift of theoretical perspectives based on the cognitive metaphor of neural activation (e.g., McClelland, 1995). In lexical decision studies, which are thought to indicate level of lexical activation, false DRM memories are recognized quickly as if they have been repeatedly self-generated prior to response (Hancock et al., 2003). However, research in which participants are instructed to verbalize aloud during study indicates that about half of all false recalls are vocalized, suggesting that implicit associated responses may account for only part of the false recall effect (Seamon, Lee et al., 2002).

Underwood's (1965) implicit associated response hypothesis has been adapted into an activation/monitoring approach to understanding false memory in associated word-lists (e.g., Lindsay & Johnson, 2000; Roediger et al., 2001). If a critical false response comes to mind any time prior to responding, the source of that signal may not be monitored successfully resulting in a false memory. The activation/monitoring framework posits that false items may be activated, consciously or not, any time during study or test (Roediger et al., 2001). Consequently, source monitoring failure (i.e., confusion as to whether an item was experienced at study or came to mind but was not studied) is the mechanism producing false memory. Activation/monitoring theorists interpret the fact that under some conditions higher false recall co-occurs with lower true recall as evidence for the view that success in source monitoring, resulting from success in encoding, allows participants to distinguish correct from semantically similar but false candidates (Roediger et al., 2001). However, theorists also acknowledge that veridical and false recall co-occur at high levels where semantic processing is encouraged (e.g., Thapar & McDermott, 2001). Without specifying the expected relative levels of these opponent processes, virtually any result can be predicted or explained by appeal to dominance of either one process or the other.

Fuzzy-trace theory (e.g., Brainerd et al., 2002) is another central theory invoked to explain false memory including false memory in associated word-lists (e.g., Roediger et al., 2001; Thapar & McDermott, 2001). Fuzzy-trace theory holds that memory involves the parallel formation of dissociated verbatim and gist memory representations (e.g., Brainerd & Reyna, 2002a; Brainerd & Reyna, 2002b; Brainerd, Payne et al., 2003). *Gist traces* are described as global representations invoking meaning related to many specific associated items. *Verbatim traces* are characterized as being feature-specific and less stable than gist traces. The theory explains false memory in terms of an accrual of gist memory trace strength which creates strong familiarity for critical false items. Fuzzy-trace theory posits that gist processing is encouraged by conditions that make associated meanings most apparent. Like activation/monitoring theory, fuzzy-trace theory also includes an opponent process, referred to as *recollection rejection*, whereby verbatim traces, largely indexed by veridical recall levels, provide comparison traces through which associated false responses can be rejected (Brainerd, Reyna, Wright & Mojardin, 2003). Returning to the issue of the relative levels of true and false recall mentioned above in connection with activation/monitoring, depending on whether gist strength or recollection rejection processes are assumed to be dominant, fuzzy-trace theory may be interpreted accordingly. If false memory rates are relatively higher or lower under a given experimental manipulation, this may be accounted for by invoking the involvement of either one or the other process.

It is difficult to disambiguate predictions generated from the current central theories of false memory (also see Gallo, 2006; Hancock et al., 2003; Koriat et al., 2000; Roediger et al., 2001; Seamon et al., 2003; Thapar & McDermott, 2001 for similar comments). Conditions producing higher true recall may be seen as indicative of strong signal (Miller & Wolford, 1999), strong activation (Roediger et al., 2001), strong verbatim trace formation (Brainerd et al., 2002), and furthermore higher true recall may attenuate false recall through a procedure of comparison of false to true memory. While high true recall may reduce false recall, high true recall may also be seen as indicative of conditions producing high false recall through strong meta-knowledge, semantic knowledge, or gist memory. Principle proponents of activation/monitoring theory (Roediger et al., 2001) have suggested that what their theory calls semantic activation may be empirically synonymous with gist memory in fuzzy-trace theory. A similar state of affairs exists concerning the concepts of success in monitoring as compared to verbatim trace availability. If these are different concepts, they need to be specifically distinguished.

The above discussion of theory pertains almost exclusively to semantic false recall. False recall produced by phonologically associated word-lists was initially studied by different researchers (Sommers & Lewis, 1999) than those studying the semantic false recall in associated word lists (Deese, 1959; Roediger & McDermott, 1995), however, this is changing (e.g., Ballou & Sommers, 2008; Gallo, 2006). As mentioned above, word-lists comprised of phonologically similar items (e.g., *bold, scold, mold, colt… etc.)* produce robust false recall for phonologically similar items (e.g., *cold)*. For both the DRM and the phonological forms of associated false memory, Sommers and Lewis (1999) have advanced a *Criterion Shift Theory*, which holds that false memories occur because participants' response criterion shifts toward liberal acceptance when highly familiar critical items come to mind at study. They postulate that meta-knowledge of list words contributes to a procedure whereby self-generated candidate responses are tested by comparative signal strength as to their veracity. The theory assumes that criterion shift, and not activation of the false item, causes false memory in associated word-lists. This line of reasoning has been further developed by theorists studying semantic false memory who couch false recall in terms of familiarity at retrieval (Whittlesea & Masson, 2005).

Watson et al. (2003) discovered over-additive false recall effects using *hybrid* lists comprised words that were both semantically associated (e.g., *hot*) and phonologically associated (e.g., *bold*) to the same critical false items (e.g., *cold*). The authors aligned activation/monitoring theory with a phonological-semantic interactive activation account of false memory, similar to a theory of speech production errors (Dell & O'Seaghdha, 1992). Watson and colleagues remarked that activation/monitoring and interactive activation theories share the "fundamental assumption" of independent phonological and semantic networks (Watson et al., 2003, p. 113). No reference is provided for this claim and no allusion to this fundamental assumption in the false memory literature was noticed during the literature review for this present thesis. The authors recognize the application of a semantic/phonological distinction and predict that dissociable effects are possible as a result of independent phonological/semantic processes. This dissertation research addressed the possibility of an empirical distinction between semantic and phonological false recall in terms of false recall SPE. This was not motivated on the basis of dissociable remember/know judgment responses (Watson et al., 2003), but on the basis of a fundamental distinction in the literature between phonological and semantic aspects of memory (e.g., Baddeley, 1966; Hoffman, Jefferies, Ehsan, Jones & Lambon, 2009; Kintsch & Buschke, 1969; Price, 2000).

The experimentation comprising the core of this present thesis explores how the conceptual framework for the phenomena of false memory in associated word-lists might be informed by research into SPE for true memory which makes a fundamental distinction between phonological and semantic coding (see Hoffman et al., 2009 for a recent discussion). Given that true and false memories are necessarily products of the same memory system, similarities in expression likely exist between true and false memory. However, any differences observed may be useful in distinguishing true from false memory, and between semantic rather than phonological false recall.

Serial Position Effects in Free Recall

SPE were first described by Francis Nipher in 1878, and were later re-described by Ebbinghaus in 1902 (in Crowder & Greene, 2000). SPE have been studied extensively, are robust to a wide range of materials and test types, and have exerted a large influence on models of memory (e.g., see Davelaar, Goshen-Gottstein, Ashkenazi, Haarmann & Usher, 2001; Howard

& Kahana, 1999, for discussions). SPE have often been studied using lists of words, but have also been observed using seriated materials spanning much longer terms and for more ecologically persuasive materials. For example, SPE have been observed in memory for opposing rugby teams played over a season (Baddeley & Hitch, 1977), hymn verses (Maylor, 2002), and parking lot locations (Pinto & Baddeley, 1991). Besides the ubiquitous nature of these effects, SPE are of special scientific interest because the pattern of recall for the final few, or recency, items is impacted by different conditions or manipulations than is memory for the earlier studied or *pre-recency* items (see Carlesimo, Marfia, Loasses & Caltagirone, 1996; Haarmann & Usher, 2001; Howard & Kahana, 1999; Glanzer 1972 for discussions).

The classical explanation of the recency effect is that the last few items of a study list are still active in a short-term store and are immediately offloaded at test (Craik, 1970; Glanzer & Cunitz, 1966). Key evidence for this view is that the implementation of a delay between study and test (Glanzer & Cunitz, 1966) or requesting that lists be recalled in the same order as they were presented (Dalezman, 1976) will remove the recency effect but preserve the pattern of recall for the pre-recency items, including the primacy effect. The pre-recency region of the serial position curve is often described as being supported by long-term semantic memory and is selectively sensitive to various encoding manipulations that presumably impact the ability to form semantic associations such as rehearsal (see Carlesimo et al., 1996; Glanzer, 1972; Haarmann & Usher, 2001; Howard & Kahana, 1999, for discussions). Conversely, recency memory does not seem to be impacted by rehearsal, but rather by interference, such as a post-test distractor task. The memory stores account of dissociable SPE has formed a substantive part of textbook descriptions despite the known shortcomings of such descriptions (Healy & McNamara, 1996). Effects typically cited in support of stores models (e.g., Atkinson & Shiffrin;

Waugh & Norman, 1965) continue to require explanation by modern memory theories, whether these theories are dual or single process theories (e.g., Brown & Lamberts, 2003; Davelaar et al., 2005; Healy & McNamara, 1996).

Cognitive researchers have in recent years tended toward single process explanations of SPE (e.g., Howard & Kahana, 1999; Neath & Surprenant, 2003). Rather than manipulations of true SPE being produced by the interaction of long and short-term stores, theorists have suggested single factors including the position of first study in relation to retrieval (e.g., Nairne, 2002), the distinctiveness of the to be remembered items (Murdock, 2001), the temporal relationship between encoding and retrieval (Glenberg & Swanson, 1986), and temporal combined with contextual factors (Howard & Kahana, 1999). However, cognitive neuropsychological research is particularly persuasive in suggesting the existence of relatively independent short-term/long-term stores involved in the production of SPE. Some neuropsychological patients have selectively impaired recall for primacy list region (Baddeley & Warrington, 1970) while others have selectively impaired recall for recency (Shallice & Warrington, 1970). Neuroimaging research indicates that memory for the primacy and recency aspects of the serial position curve involves qualitatively different brain regions, rather than the two aspects being a matter of degree of activation within the same regions (Talmi et al., 2005). The concept of somewhat independent long-term and short-term operations continues to compel theorists of SPE (Haarmann & Usher, 2001; Talmi et al., 2005). Howard and Kahana (1999) have suggested that dual process theories or variants of them have provided the only successful models of the free recall serial position curve.

Serial position effects and false recall

False memory researchers often manipulate variables known to impact true recall, such as word frequency (see Roediger et al., 2001), in associated word-lists in order to compare the simultaneous impact of the manipulation on true and false memory (see Koriat et al., 2000 for a discussion). As the discussion above illustrated, SPE represent a fundamental intrinsic aspect of memory, however, SPE have been given little empirical consideration in connection with false memory. Classical memory stores logic appears not to have made an especially clear impact on false memory research involving associated word-lists. Consider, for example, research examining DRM false memory as a function of the number of associated items presented at study (Goodwin, Meissner & Ericsson, 2001; Robinson & Roediger, 1997). The logic of separately coded long-term and short-term stores suggests that additional semantic associates should impact pre-recency and recency regions differently (Read, 1996), with greater impact of additional semantic associates on earlier study positions and greater impact of additional phonological associates on recency list region. Brainerd, Wright, Reyna and Mojardin (2001) observed that forward list presentation, which clusters the strongest associates nearer primacy list region, produces more false recall than backward list presentation, and attribute this finding to a gist processing advantage enjoyed at early study positions. However, they do not relate semantic false memory to other semantic manipulations that selectively impact pre-recency serial positions (Glanzer, 1972). If DRM false memory is a typical output of semantic memory, then stronger semantic associates to the target unpresented item would be expected to interact with earlier study positions that are more representative of long-term memory than later items. The absence of consideration of serial position in associated word-lists is also evident in research that compares semantic and phonological false recall (Budson, Sullivan, Daffner & Schacter, 2003; McDermott & Watson, 2001; Roediger et al., 2001; Watson et al., 2003). No specific consideration is given to serial position and phonological as opposed to semantic association. The presentation of semantic associates at primacy would enhance semantic associative processes far more than if items were presented at recency. Conversely, for phonological confusions, data exist that are consistent with the view that short-term processes are coded phonologically (e.g., Conrad, 1964; Kintsch & Buschke, 1969) and may therefore be impacted by serial position differently than semantic confusions.

McDermott and Watson (2001) compared semantic and phonological associated false recall and noticed evidence of earlier output for false memory arising from phonological as compared to semantic association. The authors suggested that this indicated possible subtle differences between the two forms of associated false memory. As with the research mentioned above, no reference is made to evidence suggesting short-term phonological and long-term semantic coding in memory. If phonological false recall is the product of such a short-term store, then phonological false recall may be offloaded relatively earlier than semantic false recall. Watson et al. (2003) combined phonological and semantic associates in the same study lists and found over-additive false recall effects, suggesting that somewhat distinct networks of activation act on the critical lexical item. The authors did not consider the possibility that the outcome of their experiments may have been systematically impacted by the study positions at which associates were clustered. Hence, despite the influence of the memory stores "notion" (Glanzer, 1972) of separate long-term semantic and short-term phonological stores on theories of SPE in word-lists, this influence has not been extended to false memory research.

In other research comparing semantic and phonological false recall, Watson and colleagues (2003) observed differences in phenomenology between the two forms of false recall. In the remember/know procedure (Tulving, 1985), responses are judged as to whether participants remember context at encoding, termed *remember* judgment, or whether they know the memory is correct but do not remember its physical context, termed *know* judgment (Tulving, 1985).

Several variables that are semantic in nature selectively impact remember judgments whereas perceptual variables selectively impact know judgments (Rajaram, 1993). The remember/know procedure has become something of an initial assay of potential experimental dissociations. If manipulations impact remember/know judgments differently, it suggests that different processes may underlie the manipulations. Watson and colleagues found that semantic intrusions were associated with a higher rate of remember judgment than know judgment whereas phonological false recall was split roughly evenly between remember and know judgments. Hence Watson et al.'s (2003) results indicate possible differences between the semantic (Deese, 1959) and phonological (Sommers & Lewis, 1999) forms of false memory in associated word-lists. McDermott and Watson's (2001) research, mentioned above, while recognizing the necessity of embracing the semantic/phonological dimension, does not bridge the connection to true SPE and the semantic to phonological transition in processing which some research suggests they represent (e.g., Kintsch & Bushke, 1969).

Read (1996) was the first researcher to specifically notice the connection between previous research on confusions in short-term memory and Deese's (1959) false recall effect. In Read's research, participants studied Deese's 12-word associated lists (e.g., *bed, rest, awake, tired, dream…etc.*), in which each item was semantically associated to the non- presented word (e.g., *sleep*). Participants falsely recalled the non-studied word *sleep* 55% of the time. People who reported *sleep* tended to judge its having occurred early in study and furthermore were more likely to respond with *remember* judgments (Tulving, 1985) of first person experience when false words were perceived as having occurred early in study lists. Read recognized a parallel between semantic false recall and research such as that of Kintsch and Buschke (1969) who discovered that in a paired associate recall task synonym confusions tended to occur most often when they were related to early study items. Kintsch and Buschke specifically predicted this pattern of synonym errors based on the theory that the earlier study region produces output reflective of secondary memory, coded semantically, whereas recency memory is reflective of primary memory, coded acoustically.

This dissertation sought to directly test Read's (1996) hypothesized parallel between semantic false recall (Deese, 1959; Roediger & McDermott, 1995) and effects such as Kintsch and Buschke's (1969) synonym confusions. When using single 15-word study lists segmented into trimesters of associated words (Deese, 1959) semantic false recall declined with advancing study trimester; more false recall was observed for the pre-recency study region than for the recency trimester. If the recency effect in immediate free recall is the result of activation of a short-term phonological store, and activation of the phonological store also results in phonological false recall, then phonological false recall should present with SPE that are distinct from semantic false recall which is a semantic manipulation. Phonological false recall may present with a recency effect reflecting processes underlying a fleeting, short-term memory store. Just like true memory, false memory in associated word-lists may be the result of processes related to a short-term phonological and long-term semantic store.

Scientific opinion (however see Watson et al., 2003) has leaned toward thinking that both semantic and phonological false recall are mediated by similar processes (McDermott & Watson, 2001; Sommers & Lewis, 1999). Because evidence exists that different processes appear to underlie phonological and semantic dimensions of true memory (e.g., Glanzer, 1972), semantic and phonological forms of associated false memory may also be sensitive to different manipulations. In particular, semantic coding and DRM lists are associated with *secondary* memory and are often seen as being comprised of semantic associates whereas acoustic or phonological coding is associated with *primary* memory (Waugh & Norman, 1965). This distinction between short-term and long-term memory stores remains a contentious and informative point of discussion (e.g., see Haarmann & Usher, 2001; Neath & Surprenant, 2003 for discussions). Current research on false memory in associated word-lists is now wading into issues surrounding semantics and phonology (Ballou & Sommers, 2008; McDermott & Watson, 2001; Roediger et al., 2001; Watson et al., 2003). Indeed Ballou and Sommers (2008) have recently found that the forms of associated false recall do not correlate as would not be expected if the same processes drove both effects. This dissertation specifically sought to examine whether false memory differentiates along the dimension of semantic-phonological word association in terms of the signature left by patterns of false SPE.

The Present Experiments

The purpose of the following series of Experiments was to explore false memory on the dimension of serial position of study, a dimension that entails the issue of semantic and phonological processes as it relates to traditional true memory research on SPE. Any memory, due to it being acquired through time, has a serial aspect. Furthermore any verbal memory entails both semantic and phonological properties. The regularity with which SPE are observed suggests that the serial position curve reflects essential underlying properties of memory generally. Because it is now known that false memory is a typical aspect of normal memory function with empirical and theoretical consequences, it is necessary to work toward understanding how false memory fits into the serial position pattern expressed by true memory in the hope that this type of controlled investigation might generalize to ecologically valid contexts in the future. True memory for studied items provides only part of the information necessary to evaluate memory performance (see Kronlund & Whittlesea, 2005 for a discussion). The approach taken in this thesis is distinct from treating false memory as detraction from memory. The perspective taken here is aligned with thinking that considers predicted false intrusions into memory as a typical expression of memory (e.g., Buchanan et al., 1999; Roediger et al., 2001). Consideration of memory accuracy is of interest to any false memory research; however the present focus is on what false SPE have to say about normal memory function more so than memory accuracy (Koriat et al., 2000), although these issues are not entirely separate. For example, the relative levels of true and false memory have a bearing on the estimation of theoretical parameters from both true and false empirical data (Brainerd, Payne et al., 2003) and furthermore the relative levels of true and false memory also impact how accurately a memory represents the past (Koriat et al., 2000).

A dual short-term phonological/long-term semantic store explanation of SPE has little evidence in its support and was recognized years ago as being a "popular generalization" that is "incorrect" or at best "oversimplified" (Glanzer, 1972, p. 176). However, interest in distinct semantic/phonological representational networks and whether they are associated with early or late aspects of SPE persists in present theories of and research on verbal short-term memory (see Hoffman et al., 2009 for a recent discussion). The central current false memory theories discussed above did not make specific predications or generate distinct hypotheses concerning the existence of false recall SPE or about differences between semantic and phonological false recall. However, as noted by (Read, 1996), the notion of SPE being supported by separately coded semantic/phonological memory stores, even with its limited empirical support, did make specific predictions concerning SPE for false recall in associated word-lists. Namely, manipulations impacting semantic association selectively alter true memory for the pre-recency serial position region, whereas phonological manipulations sometimes selectively impact recency (Glanzer, 1972). Hypotheses emanating from the oversimplified dual-store explanation of SPE formed the only tenable starting point in attempting to provide some theoretical framework in which testable hypotheses could be formed. However oversimplified this model may be, it continues to be debated and drives testable and interpretable research hypotheses concerning semantic compared to phonological coding in the production of true SPE (Hoffman et al., 2009). Neuroimaging evidence suggests the involvement of dual semantic/phonological representational networks underlying SPE (Talmi et al., 2005) and current theories of verbal short-term memory often share the assumption of interactive activation between a long-term semantic neural network and a temporary phonological neural network (see Hoffman et al., 2009 for a discussion).

As described above, the present research paradigm involved segmenting word-lists into trimesters of either semantically or phonologically associated words rather than presenting lists comprised of words associated to single critical unpresented item (Deese, 1959; Sommers & Lewis, 1999). What is informative about the use of these list constructions is that the first and last categories are associated uniquely to the primacy and recency items respectively, while the middle study category is associated only to the asymptotic region of the serial position curve. Furthermore, the first two regions are more representative of pre-recency than the final trimester, and, as discussed above, some manipulations impact memory differently for items falling in these general regions of the serial position curve. If dual stores logic is of predictive value to research involving false memory in associated word-lists, then the serial position signatures for phonological and semantic false recall should be dissociable from each other on the basis of their distinct coding. Such findings may help to characterize false recall in associated word-lists more precisely by attempting to empirically differentiate semantic and phonological false recall and by forming a bridge from recent false memory theory to key findings relating to true memory SPE. Specifically, and as is beginning to emerge in the literature through other research (see Ballou &

Sommers, 2008, for a discussion), the semantic and phonological forms of associated false recall in word-lists are not entirely similar effects and this may necessitate that false memory theory include additional assumptions.

Phonological false recall and SPE had not been studied prior to the onset of this dissertation. Various outcomes were possible other than that suggested by the simple stores rationale discussed above (see Experiment 1 introduction for further discussion). It was recognized as possible from the outset that false recall may remain stable over serial positions or present with any other possible pattern of false SPE. The priority of this thesis was to present a basic description of false SPE in the context of known serial position effects in list memory (Glanzer, 1972). Due to the continued influence of the dual semantic/phonological store explanation of short-term true recall SPE and the contemporary issue of semantic and phonological association in false recall, this inquiry into false SPE naturally led to an extension of classic manipulations of the short-term SPE whereby delayed recall eliminates the recency effect (e.g., Glanzer & Cunitz, 1966; Waugh & Norman, 1965) whereas list study with divided attention selectively reduces true recall at middle and especially primacy list regions (e.g., Richardson & Baddeley, 1975).

The dual store metaphor has been helpful in generating meaningful hypotheses for true memory and was seen as having potential utility in developing predictions for false recall. The paradigm used sought to produce empirical evidence for Read's (1996) hypothesis that semantic effects are associated with earlier study positions and the dual store corollary prediction that phonological false recall may be associated with recency. Distinct patterns of SPE for semantic compared to phonological false recall would suggest that the processes underlying these effects may be distinct and therefore modern theories of false memory would have to accommodate this by including distinct theoretical parameters for phonology in empirical models of false memory

(Brainered, Reyna et al., 2003) or by specifying how activation/monitoring processes (Roediger et al., 2001) can accommodate distinct SPE for semantic and phonological false recall.

CHAPTER 2: DO FALSE RECALL SERIAL POSITION EFFECTS EXIST?

Experiments 1 and 2 investigated false recall SPE using a paradigm designed to produce false recall based on both semantic (Deese, 1959) and phonological (Sommers & Lewis, 1999) word association. This thesis further advances other research aimed at understanding the relationship between false recall and serial position (Read, 1996). It was expected that the semantic false recall would produce a primacy effect based on Read's (1996) successful prediction of where participants subjectively judged predicted false intrusions to have occurred. A pattern of decline with advancing serial position has been observed for true recall under delayed recall conditions (Craik, 1970) therefore a parallel finding for false recall is consistent with the view that semantic false recall is a typical outcome of long-term memory processes. A question exists as to the relationship between long-term memory and short-term memory on the one hand, and semantic and phonological word association on the other (Glanzer, 1972), which persists into modern discussions of free recall SPE (Hoffman et al., 2009).

According to some interpretations of dual store memory theory (Glanzer, 1972), at the onset of recall the decision to output responses is based on phonological aspects of recently heard list items, that is, on the basis of quickly decaying short-term phonological information. If phonological false recall occurs in the context of short-term processes, then phonological false recall (Sommers & Lewis, 1999) may present with a rather opposite pattern of SPE to those of semantic false recall (Deese, 1959). If the same processes that support the recency effect support phonological false recall, then false recall would be highest for the recency serial position region, opposite to the pattern expected for semantic false recall (Read, 1996). A short-term store explanation of a phonological false recall recency effect would also suggest that false recall output position may be relatively earlier for phonological than for semantic false recall. Word items studied at recency positions are outputted earlier (Deese & Kaufman, 1957). If the bases for recall changes from offloading a short-term phonological store to retrieval from long-term semantic memory, then it may be that phonological false recall would be outputted relatively earlier than semantic false recall in terms of total output.

While preliminary work on semantic false recall SPE had begun (Read, 1996), at the outset of this dissertation, no reports of serial position analysis for phonological false recall in associated word-lists (Sommers & Lewis, 1999) have been found in the literature. Several patterns of phonological false SPE were possible using the current paradigm. Although the word items used in these Experiments are phonologically associated, they are also semantically meaningful words in the English language, and therefore complex interactions between serial position and list-type were recognized as possible. It was also possible that phonological false recall would follow the same pattern of true recall SPE expressing both a primacy effect and a recency effect. This pattern would not provide identifying information in terms of patterns of SPE with which to distinguish it from true recall, but this pattern would be distinct from semantic false recall SPE. It was possible that phonological false recall would present with a declining pattern of false recall from early to late study regions as semantic false recall does. If this were the case, then parallel interpretations of semantic and phonological false SPE could be advanced; the nature of the two types of associated false memory effects could be regarded as similar in so far as false recall SPE are concerned.

An absence of SPE for false recall in associated word-lists was a tenable outcome. This would be consistent with previous findings in which semantic false recall appears to be mediated by automatic processes (e.g., Seamon et al., 2003). Seamon et al. (2003) consider this conclusion after reviewing and conducting research showing that dividing or distracting attention during list study does not generally reduce the effect, which suggests that intentional processing is not necessary. It was also tenable that phonological false recall would show signs of being mediated by automatic processes to a greater extent than semantic false memory. Phonological false recall, being based on association of physical sound properties, may be a more perceptual effect and semantic false recall a more conceptually based effect (Ballou & Sommers, 2008), and this may have consequences for SPE as it appears to for true recall SPE (Glanzer, 1972). Higher false recall for the recency list region may suggest implicit processing in so far as both associated semantic false recall (Tse & Neely, 2005) and the recency effect (Baddeley & Hitch, 1993) are known to be influenced by priming manipulations. Another possible outcome for phonological false recall was that the middle study trimester would produce the highest level of false recall. Low true recall is typically expected for middle list region; perhaps phonological false recall is prevalent under conditions of low true recall as semantic false recall sometimes is (Brainerd et al., 2002; Roediger et al., 2001). Such findings would be suggestive of the involvement of false memory editing processes that operate through subjective comparison of false candidate responses to correctly recalled items.

In summary, the various potential outcomes of the introductory Experiment each provided theoretically and empirically important information. The theoretical framework guiding the research was couched in terms of classical stores theory that has generated so much attention in the true memory literature on SPE (e.g., Healey & McNamara, 1996). This view, in a strict form, would suggest that phonological false recall would be associated to recency on the basis of the short-term phonological rather than the long-term semantic processes that are sometimes thought to characterize the pre-recency list region (Glanzer, 1972). The specific intention was to extend the logic of earlier experimentation that helped to classify semantic false memory as being predominantly mediated by processes captured by the pre-recency serial position region, which is often thought to represent long-term semantic memory (Glanzer, 1972). If phonological false recall is mediated by short-term phonological processes, then evidence of a phonological false recall recency effect should appear in the data.

Experiment 1

In Experiment 1, lists segmented into trimesters of either semantically (Deese, 1959) or phonologically (Sommers & Lewis, 1999) associated words were presented to participants. Both list-types produce false recall of certain unpresented associated false words. Both true recall and associated false recall were then available for analysis as a function of serial position trimesters. The central dependent variables of interest were the probabilities of true recall and predicted false recall. Previous research has shown that semantically associated lists produce more true recall than phonologically associated lists (Baddeley, 1966). Poorer memory for phonologically similar items is one of the key effects cited in support of the existence of a short-term phonologically coded store in working memory (Baddeley, 2004). False recall levels for semantic and phonological list-types were expected to be similar based on data from previous research involving single-theme lists (Roediger & McDermott, 1995; Sommers & Lewis, 1999; Watson et al., 2003), however, the present paradigm is unique and so comparison to previous research is tentative.

It was of interest to give some appraisal of the output position at which critical false items occur. Different patterns of output may provide further evidence for distinct properties for the two forms of associated false recall. Research in which both phonological and semantic false recall output orders have been compared (McDermott & Watson, 2001) tentatively suggested relatively earlier output position of false recall for phonologically as opposed to semantically associated materials. Phonological false recall may be outputted at a relatively earlier stage (i.e., at a stage when short-term phonological information is still available). McDermott and Watson (2001) observed different output distributions for the two forms of false recall and suggested that this indicated "subtle" (p. 168) differences between the effects. The authors did not speculate about differences between long-term semantic and short-term phonological coding which is the discussion of much list memory research (Glanzer, 1972) which may have application to the general issue of how the two effects are related to each other and to true recall.

Method

Participants

Experiment 1 involved 48 undergraduate university student volunteer recruits from a participant pool. An optional informational debriefing was offered in lieu of participation. No one took the alternative option. The sample contained only six males reflecting the disproportionately high enrollment of women in introductory psychology courses. Ages ranged from 18-26 years (M = 19.31; SD = 1.77). None of the participants reported knowing the experimental paradigm and three reported English as a second language.

Materials

Experiment 1 employed 36 pairs of associated word-lists from the research of Watson et al. (2003; Appendix A). For each of 36 target unpresented items there were corresponding lists of phonological and semantic associates. For both list-types, the first 8 words from each list were combined into single 24 words lists thus forming trimesters of associated words expected to produce specific predicted false items. The following is an example of a single presentation list: *hound, puppy, bite, mutt, pet, beware, bone, tail / good, rotten, harmful, worse, villain, severe, trouble, awful / bounce, throw, basket, bowling, golf, play, tennis, soccer*. Each trimester is formed of the primary associates of the critical unpresented items *dog*, *bad*, and *ball*, respectively. Similarly blocked lists were also constructed using phonologically related materials, for example, *log, dodge, dug, hog, bog, doff, daub, cog / had, lad, bat, bag, bud, band, dad, bide / doll, bile, bail, balk, wall, fall, bald, pall,* where blocks contain items differing from critical unpresented items by a single phoneme, *dog, bad* and *ball*, respectively. These lists allowed for the observation of semantic and phonological false recall as a function of primacy, middle, and recency serial position trimesters. Materials were counterbalanced such that half of the participants received the semantic lists first, and half received the phonological lists first. List construction involved the random assignment of all sub-lists into positions within the blocked presentation lists for each participant. Hence each participant received a unique set of lists.

Participants wrote down their responses on provided answer sheets that included a general demographics questionnaire requesting age, gender, whether English was their first language, and whether or not the participant was aware of the false memory experimental paradigm. Participants were required to sign a pre-test consent form that included a brief description of the procedure. Post-test debriefing forms provided a specific explanation of the experimental purpose and researcher contact information.

Design and procedure

The above-described materials were designed to provide data for a 3 (study-position; primacy, middle, recency) × 2 (list-type; semantic, phonological) completely within-subjects factorial design experiment. The dependent variables of interest were true recall and also predicted false recall for both list-types. It was furthermore of interest to examine characteristics of output position for the two types of false recall in order to garner evidence for the hypothesis that phonological false recall occurs relatively earlier than semantic false recall. Unpredicted levels were of interest for comparisons in subsequent planned experiments. If unpredicted false recall levels were to change under different manipulations it would suggest response bias as a possible confound (Dewhurst, Barry, Swannell, Holmes & Bathurst, 2007; Peréz-Mata, Read & Diges, 2002).

Participants were tested individually in an environment of minimal distraction during 30-minute sessions. They received a consent form that included written experimental instructions. Lists were read aloud by the experimenter from a computer screen not visible to the participant at a rate of about 1.5s per word using a metronome to keep time. Participants were presented with either six phonological lists followed by six semantic lists, or vice versa, alternating for each participant. Participants were instructed to recall only items they were sure they heard and to not guess. In order to alleviate experimental demand to respond, it was explained that it was not a memory intelligence test and that accuracy in response was the most important consideration. At the metronome beat after the last word from each list, the experimenter instructed the participant to 'go ahead' after which they were given 1 minute to respond. This procedure was repeated 12 times in total, 6 for semantically associated lists and 6 for phonologically associated lists.

When all lists were complete, participants were thanked and the experimenter discussed their debriefing forms with them prior to departure. The form included discussion of the specific purposes of the experiment. It was explained that associated false responses are typical and normal. Participants were offered an opportunity to view the results of the entire study at a later date.

Results and Discussion

True recall analyses

As can be seen in Figure 1-1, the segmented lists produced normal serial position curves for true recall. As in previous serial recall research, semantically associated lists were recalled with a higher probability than phonologically associated lists (Baddeley, 1966). The overall pattern of recall for the blocked lists represents typical SPE. Notably, the recency item is clearly higher than the primacy item for these lists. In the typical DRM procedure using single theme lists, the primacy items appear to be elevated to roughly the same extent as the recency item (Roediger & McDermott, 1995). The blocked list design used in this research produced the typical recency advantage seen using lists of unrelated materials (e.g., Glanzer, 1972).

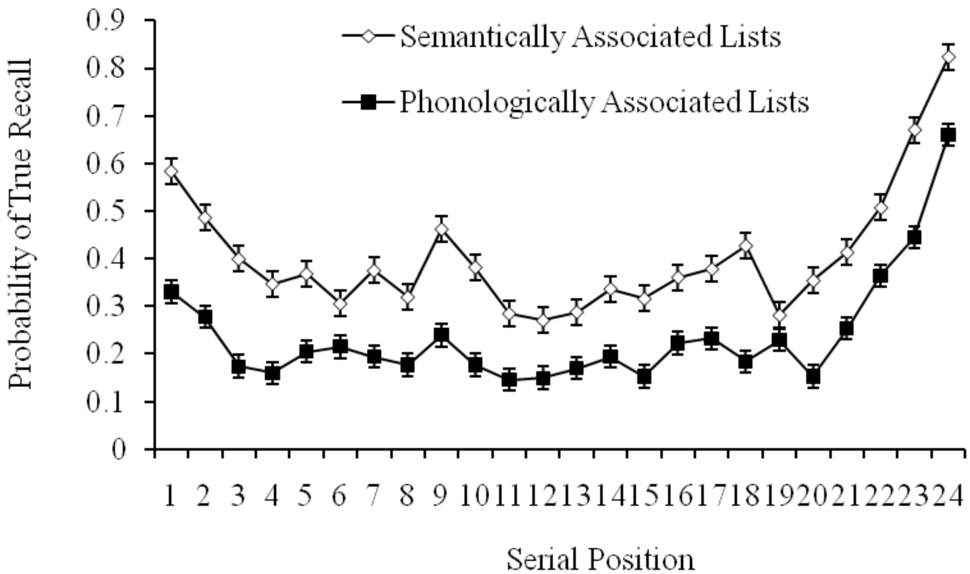

Figure 1-1. True recall as a function of serial position and list-type in Experiment 1. Error bars represent standard error of the mean.

A 3 (study-position; primacy, middle, recency) × 2 (list-type; semantic, phonological) repeated measures analysis of variance (ANOVA) of true recall probabilities indicated an expected main effect of list-type, $F(1, 47) = 232.28$, $MSE = 2.04$, $p < .001$, in which the probability of true recall for the phonologically associated lists was generally lower ($M = .24$; $SD = .06$) than for the semantically associated lists ($M = .41$; $SD = .09$).

There was also a significant main effect of position (see Figure 1-2), $F(1, 59) = 52.04$, $MSE = .48$, $p < .001$. More items were correctly recalled from both primacy ($M = .40$; $SD = .12$) and recency ($M = .48$; $SD = .11$) trimesters than from middle ($M = .34$; $SD = .02$), $t(47) = 3.04$, $SEM = .03$, $p = .004$ and $t(47) = 7.27$, $SEM = .02$, $p < .001$ respectively. The lack of interaction between list-type and serial position indicates that blocking lists into trimesters of associated words did not impact one type of word association differently than the other in terms of patterns of SPE. The pattern of results indicate that for both list-types this method captures the essential dynamics of the normal free recall serial position curve, with higher recall for categories nearer the beginning and end of the lists compared to the middle list region.

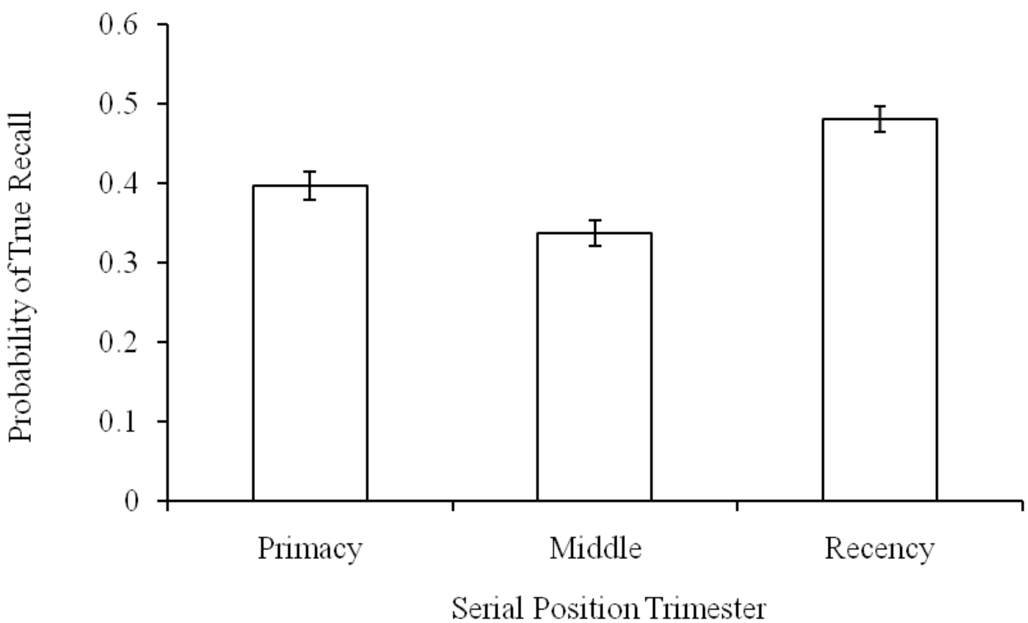

Figure 1-2. True recall as a function of serial position trimester in Experiment 1. Error bars represent standard error of the mean.

False recall analyses

A 3 (study-position; primacy, middle, recency) × 2 (list-type; semantic, phonological) ANOVA was conducted on the false recall data. Only the interaction was significant, $F(2, 94) = 7.20$, $MSE = .02$, $p < .001$. The interaction suggests that unlike true recall SPE, false recall SPE are impacted differently by list-type.

Semantic false recall was higher for primacy ($M = 16$; $SD = .19$) than for recency ($M = .08$; $SD = .11$) study trimester, $t(47) = 3.04$, $MSE = .03$, $p = .004$. Middle trimester also produced reliably more false recall ($M = .15$; $SD = .18$) than recency, $t(47) = 2.29$, $SEM = .03$, $p = .030$. The primacy and middle regions did not differ reliably. This pattern of decline is similar to that of true recall after a delay (Craik, 1970) and therefore consistent with the idea that semantic false recall is associated with long-term memory and therefore also associated with the earlier aspect of the serial position curve (Read, 1996).

Phonological false recall showed a strikingly different pattern of SPE. False recall was higher for recency ($M = .15$; $SD = .14$) than for middle ($M = .07$; $SD = .09$) study position, $t(47) = 3.07$, $MSE = .02$, $p = .004$, consistent with the hypothesis that phonological false recall is associated with the same short-term processes that appear under some conditions to support the true recall recency effect (Atkinson & Shiffrin, 1968). A strict short-term phonological/long-term semantic stores interpretation, discussed in the thesis introduction, predicts that recency should also produce more false recall than primacy. The fact that recency did not produce more false recall than primacy trimester weakens the straightforward interpretation that phonological false recall would be specifically associated to short-term phonological processes captured by the recency study region.

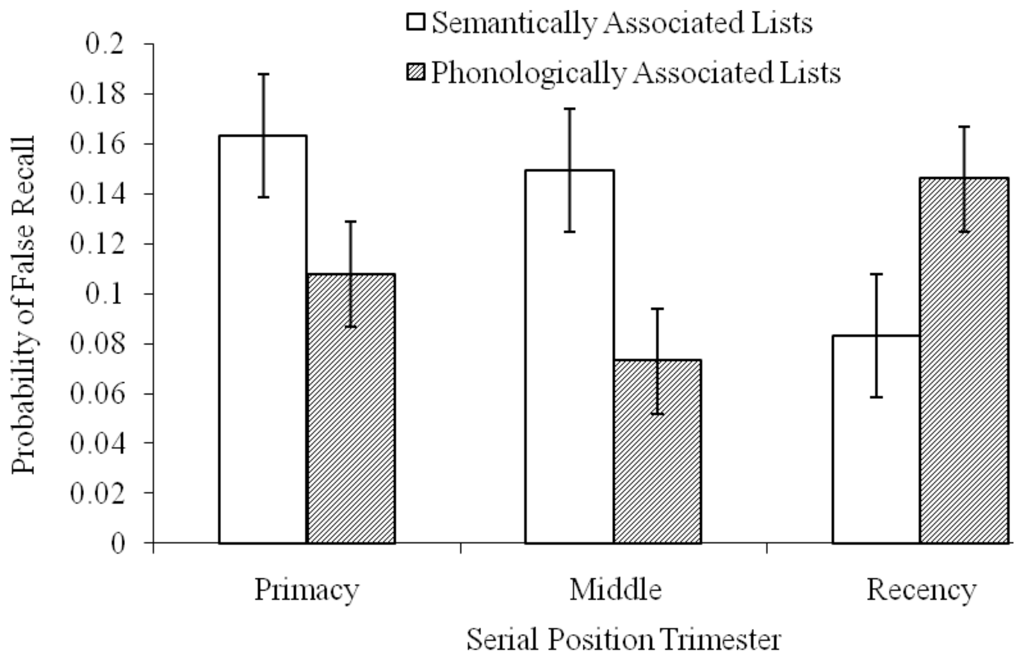

Figure 1-3. False recall as function of serial position trimester and list-type in Experiment 1. Error bars represent standard error of the mean.

Unpredicted false recall

The probability of unpredicted false recall in this paradigm was high for both list-types. The mean probability of a participant producing an unpredicted false intrusion in response to a list was .66 for the semantically associated lists and .97 for the phonologically associated lists. Other research using associated word-lists have also produced similar high levels of unpredicted intrusions (e.g., Watson et al., 2003). Associated false memory paradigms may considerably underestimate systematic intrusions into memory (Toglia et al., 1999). Many of the unpredicted intrusions in Experiment 1 were associated to one or more studied themes. Toglia et al. (1999) observed higher rates of unpredicted intrusions under conditions where themes were blocked as opposed to being interleaved with other category items. Peréz-Mata et al. (2002) observed a high probability of unpredicted intrusions (.92) in research where four semantic list themes were studied in a single study presentation and also noted elevated levels of unpredicted intrusions under conditions of divided attention during study. Higher unpredicted false intrusions are a possible indication of guessing. The hypothesis that divided attention at encoding increases unpredicted false recall will discussed further in the Experiment 2 materials section and in Experiments 4 and 5.

Output position analyses

In free recall, output position is under the control of the participant. Output interference is a potential mechanism mediating false memory (Roediger & McDermott, 1995). It is typical that some analyses on the output protocol are conducted in order to evaluate the possible impact of output position in explaining the experimental results. Output position may be indicative of the involvement of time and/or interference encountered between encoding and retrieval in producing any observed effects. In previous research (e.g., Roediger & McDermott, 1995), the output position of critical false items appears systematically late in output; this is perhaps more so for semantic than for phonological false recall (McDermott & Watson, 2001). As discussed in the introduction to Experiment 1 above, McDermott and Watson (2001) speculated about apparent differences in output distributions of phonological and semantic false recall.

If semantic and phonological false recall engage different processes whereby phonological false recall is influenced by short-term-phonological rather than long-term-semantic memory operations, then phonological false recall may be outputted relatively earlier than semantic false recall. Recency list items are typically outputted early in immediate free recall (Deese & Kaufman, 1957). If the same processes mediate the true recency effect and phonological false recall, then phonological false recall may tend to be outputted earlier also. The average output position of semantic false recall was 8.3 out of an average total recall of 10.8 items. False phonological recall was outputted at an average of 4.6 out of 7.0 total recalls. Hence, for

Experiment 1, semantic false recall appeared on average at about 70% of the way through total output and phonological false recall just under 62%. As in previous research (McDermott & Watson, 2001; Roediger & McDermott, 1995) output position was appraised in terms of the ratio of absolute output position to total number of items outputted. If the relative output position of either semantic or phonological false recall is earlier or later, then these ratios would differ accordingly. The output ratios for critical false items were summed and expressed as the proportion of total false recall per each quintile of recall output (McDermott & Watson, 2001; Roediger & McDermott, 1995). This was done in order to further assess if there was any indication that false items were outputted systematically at any output stage (see Figure 1-4). If output was not systematic, then a straight line would be produced indicating that predicted false intrusions do not tend to be outputted at any particular stage. As can be seen, there is some indication that false recall tends to occur later than chance in output, and that this is slightly more the case for semantic than for phonological false recall, therefore replicating McDermott and Watson's (2001) observations. McDermott and Watson did not report a comparison of the output ratios.

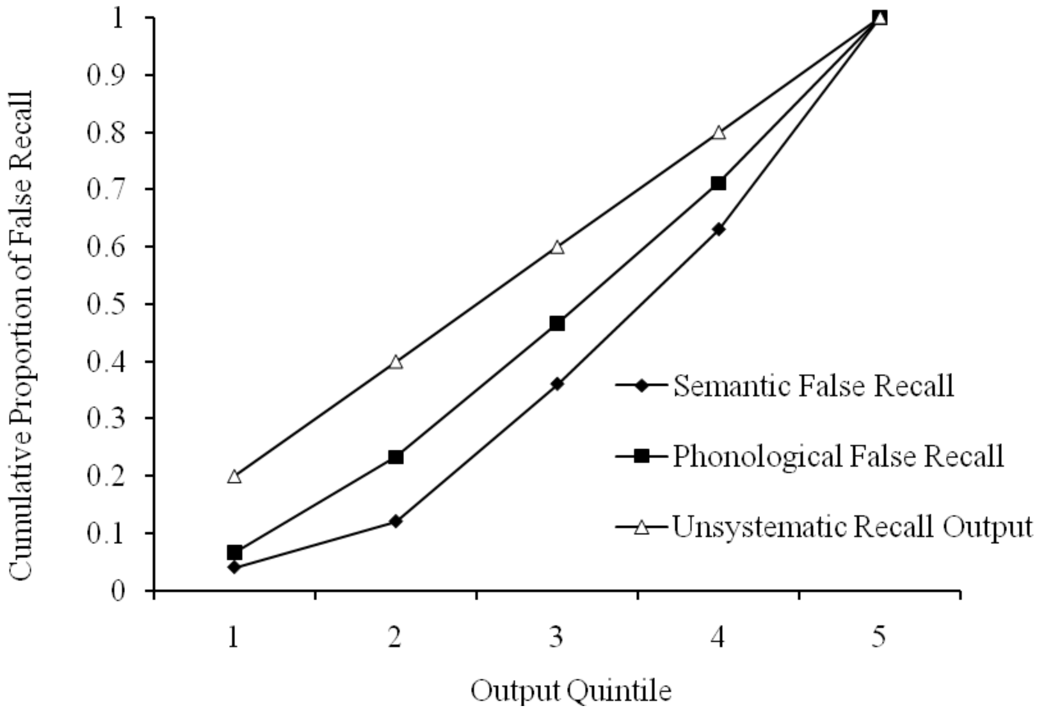

Figure 1-4. Probability of false recall as a function of output quintile in Experiment 1.

If phonological false recall were the product of a short-term phonological store, then it should be outputted relatively earlier than semantic false recall. In order to investigate this possibility, the relative output positions of predicted intrusions for the two list-types were compared for each participant who produced at least one of each type of false recall. For each list-type, a measurement of output position was determined for each participant using a ratio calculated by dividing the output position of predicted false recall by the total number of items outputted. Where more than one false recall was produced on a given list-type, the average output position was taken. For the 35 participants that produced a sample of both types of false recall, the semantic false recall output ratio was .33 compared to .21 for phonological false recall, a significant difference, $t(34) = 22.89$, $MSE = .03$, $p < .001$. Based on this selected set from the data, some evidence was obtained consistent with the idea that compared to semantic false recall, phonological false recall may be more influenced by short-term resources available only immediately at the onset of list recall.

Conclusions

Experiment 1 provided evidence that there are SPE for false recall in associated word-lists and that these effects differ depending on the type of word association used to produce false recall. Consistent with a dual semantic-phonological store theory of SPE, semantically associated lists produced more false recall in the pre-recency list region and phonologically associated lists produced a false recall recency effect. However, phonological false recall at recency was not significantly higher than at false recall primacy, which it would be if phonological false recall were especially associated with a short-term phonological store in a straightforward way.

It was noticed during collection that some lists (Watson et al., 2003) contained words that were both phonologically and semantically associated. For example, in the list designed to produce the false response *cat* the word *fat* appears. Together they form the semantically meaningful association *fat-cat*. It was thought possible that the phonological false recall primacy effect observed in Experiment 1 may have been due to such doubly associated materials. Namely, semantic association may have produced the primacy effect in the phonologically associated lists. *Hybrid* lists comprised of both semantically and phonologically associated words are known to produce over-additive levels of false recall in comparison to either effect in isolation (Watson et al., 2003). Hybrid list-types was a possible reason that phonological false recall was not isolated to recency memory. Lists used in Experiment 1 that contained items that are both semantically and phonologically associated may have simultaneously produced both of the associated false recall effects. This concern was given some further validation in so far as when the phonological *cat* list and semantic *rough* list were removed from Experiment 1 data, the false recall patterns more closely approximated the stores predicted pattern. It was concluded that another Experiment was required using materials cleared of hybrid semantic/phonological associates.

While a follow-up Experiment was clearly needed using altered materials, certain other important conclusions can be drawn from the results of Experiment 1. Evidence was obtained that distinct patterns of SPE are produced depending on word association type. Furthermore, evidence of a false recency effect for phonologically associated lists was found and is consistent with the theory that the recency advantage is supported by a short-term phonological store. It was clearly suggested by the data that the two forms of false memory effect are impacted differently by serial position. If the two false recall effects were driven by gist processing combined with trace decay (Brainerd, Reyna et al., 2003) or monitoring failure (Roediger et al., 2001), why would one false effect behave so differently compared to the other under these experimental conditions? Clearly the dimensions of semantics and phonology have a bearing on the false recall SPE produced using the two types of associated word-lists.

Experiment 2

Experiment 2 provided a replication of Experiment 1 with Watson et al.'s (2003) materials altered so as to address the issue of cross contamination of study list materials discussed above, and generally to improve the power of the experimental design to detect effects. It was important to obtain clear effects early in the research project because later studies were planned requiring meaningful comparisons across experiments. Some further alterations were made to materials at this time as discussed below and the sample size was increased in order to provide greater statistical power to detect effects. An idealized short-term phonological/long-term semantic stores interpretation of SPE predicts that only recently experienced words should be especially subject to phonologically associated false recall. If contaminated materials were the reason that elevated phonological false recall was not clearly confined to recency serial position trimester in Experiment 1, then the materials used in Experiment 2 may produce a solitary recency effect for phonological false recall. If on the other hand a false phonological primacy effect was in fact emerging in Experiment 1, then the methodology used in Experiment 2 should detect and solidify this finding.

Method

Participants

Sixty University of Saskatchewan undergraduate students from a participant pool received course credit for volunteering. There were 41 females representative of the disproportionately higher number of female psychology students. Ages of participants ranged from 17 to 42 years (*M* = 20.05; *SD* = 5.94). An optional informational debriefing was offered in lieu of participation, which none of the students exercised. The sample size was increased over Experiment 1 in order to improve the chances of detecting effects and for providing stable results for the purposes of comparison to later experimentation. None of the participants reported English as a second language and none reported knowing the experimental paradigm.

Materials

As discussed in Experiment 1 above, for Experiment 2, Watson et al.'s (2003) materials were cleared of items that were hybrid semantic/phonological associates to the target false response items (Appendix B). Watson et al.'s presentation lists were sixteen words long, and the present methodology required only eight words for each list trimester. As hybrid words were removed from Watson et al.'s lists, new words were selected from the remaining list items in ascending order of their occurrence in the original materials. As new lists were being formed, potentially confounding words were vetted by circulating new lists among lab colleagues who were asked to note any words in the lists that they felt were both semantically and phonologically associated to the critical target responses. This helped to detect words that were specific to different English dialects; such as with the word *lad* in the list designed to elicit *bad* together form the components of the common British English phrase *bad-lad*.

It was further reasoned that semantic associative processes would be minimized in the phonological lists by excluding associated words from within lists. Therefore, words from the phonologically associated lists that were semantic associates of each other were also removed. Furthermore, the Watson et al. (2003) materials contained several double entries that were removed. In Watson et al.'s research, double entries were likely not of much consequence because single theme lists were presented. However, in the present paradigm, where three themes per list are presented, double entries for different themes made it possible that the same word might be randomly assigned to the same list.

Non-words, or words so rare they may be perceived as non-words, were also removed from the phonological study materials. This was done in an effort to limit the high level of unpredicted intrusion errors in the phonological condition in Experiment 1 (also see Watson et al., 2003). It was further thought that if non-words, or rare words that may be perceived as non-words, from Watson et al.'s (2003) lists (i.e., *tup, blass*), were included, that participants may feel more licensed to produce random responses that sounded similar to words rather than focusing on remembering actual words. Removing such words further equated the conditions between list-types because the semantically associated lists contained clearly meaningful English words.

Design and procedure

The design and procedure for Experiment 2 were largely the same as for Experiment 1, with the exception that the materials were altered as discussed above (refer to Appendix B). Lists were segmented into trimesters of associated words to accord with a 3 (study-position; primacy, middle, recency) × 2 (list-type; semantically associated, phonologically associated) completely within-subjects factorial design experiment. The central dependent variables of interest were the probability of true and false recall for both semantically and phonologically associated list-types. Probabilities of unpredicted false recall and the output position were also of interest.

Participants were tested individually during 30-minute sessions. Lists were read aloud by the experimenter from a computer screen at about 1.5s per word using a computer metronome to keep a pace of approximately 1.5s per word. Order of list-type presentation was alternated for each new participant. Participants were instructed to recall only items they were sure they heard and to not guess. It was explained that it was not a memory intelligence test but a test of how people respond to certain word-lists and furthermore that only accurate responses were of interest. At the metronome beat after the last word from each list, the Experimenter instructed the participant to “go ahead and write down the words you are *sure* you can recall” and were then given up to 1 minute to respond. The additional instruction at test was included in order to focus the participants’ attention on accurate responding in light of the high rates of unpredicted intrusions in Experiment 1. The above described procedure was repeated 12 times in total for each participant. When all lists were complete the experimenter discussed the experiment. The debriefing form included discussion of the specific purposes of the experiment and paradigm.

Results and Discussion

True recall analyses

Normal SPE were observed for true recall in Experiment 2 (see Figure 2-1). Clear evidence can be seen of a primacy and recency effect for both the semantically and phonologically associated lists. The true recall serial position curves are similar to those of Experiment 1 showing the typical primacy and recency aspects. It is also evident that the recency aspects of the curves for both list-types are more prominent than the primacy aspects. This is typical of serial position effects generally (Glanzer, 1972), however using single theme semantically associated lists researchers have noted that there is no difference in the primacy and recency advantages (e.g. Roediger & McDermott, 1995).

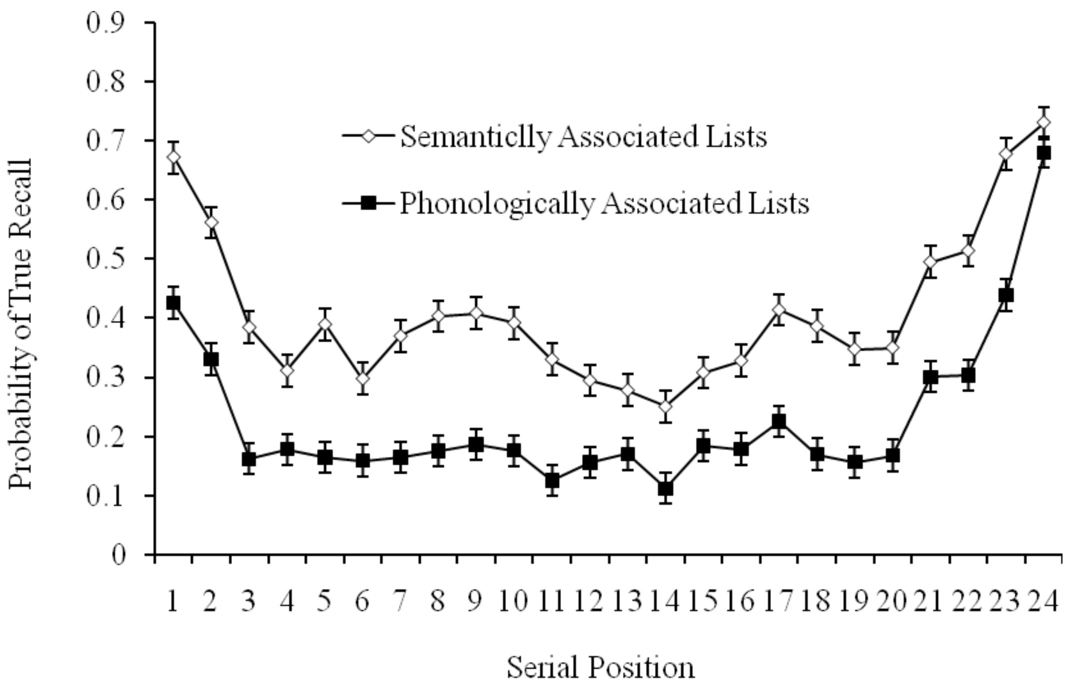

Figure 2-1. True recall as a function of serial position and list-type in Experiment 2. Error bars represent standard error of the mean.

A 3 study-position (primacy, middle, recency) × 2 list-type (semantic, phonological) repeated measures ANOVA of true recall probabilities was conducted. The results indicate a main effect of list-type, $F(1, 59) = 332.34$, $MSE = 2.90$, $p < .001$. There was also a main effect of position, $F(1, 59) = 90.58$, $p < .001$, $MSE = .95$, $p < .001$, but no interaction of the factors was observed, therefore giving no indication that the two forms of associated word-lists produce different patterns of true recall SPE.

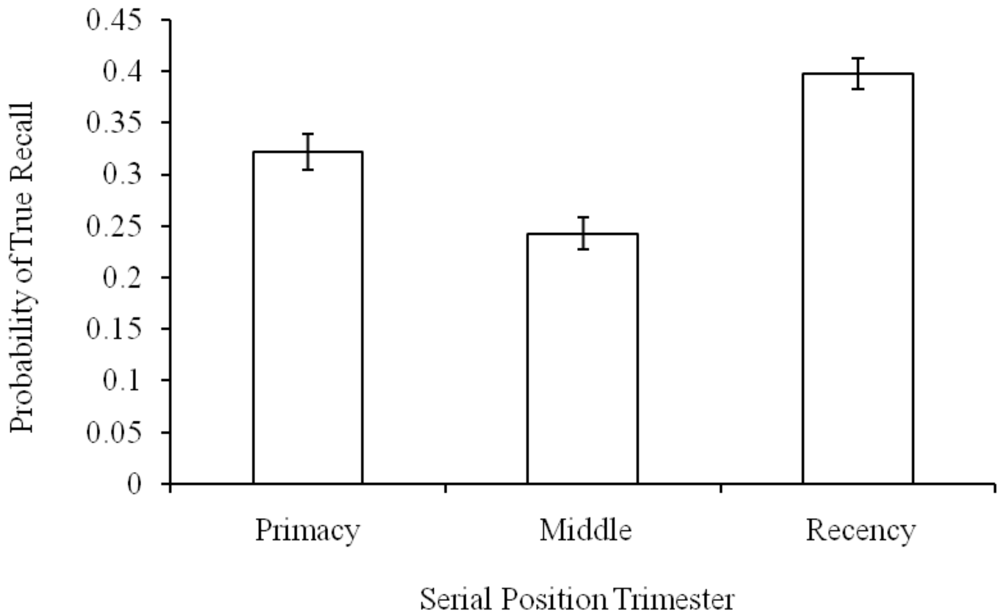

Figure 2-2. True recall as a function of serial position trimester. Error bars represent standard error of the mean.

More items were correctly recalled from the primacy trimester (*M* = .32; *SD* = .01) than from the middle trimester (*M* = .24; *SD* = .01), *t*(59) = 7.38, *SEM* = .01, *p* < .001, and more items from recency trimester (*M* = .40; *SD* = .01) than from middle, *t*(59) = 14.43, *SEM* = .01, *p* < .001. Therefore, the 8-item blocks captured the essential dynamics of normal free recall serial position curve. There was also greater recall for recency trimester than for primacy, *t*(59) = 5.85, *SEM* = .01, *p* < .001, which is typical for true recall for lists of unrelated words (Glanzer, 1972). This overall recency advantage was found in Experiment 1 also and stands in contrast to single theme semantically associated lists in which the recency advantage has not appeared more pronounced than the primacy advantage (Roediger & McDermott, 1995).

False recall analyses

A 3 (study-position; primacy, middle, recency) × 2 (list-type; semantic, phonological) within-subjects ANOVA replicated a similar interaction to that observed in Experiment 1; $F(2, 118) = 8.41$, $MSE = .17$, $p < .001$ (see Figure 2-3). The interaction of the factors was due to the distinct SPE produced by the two different list-types.

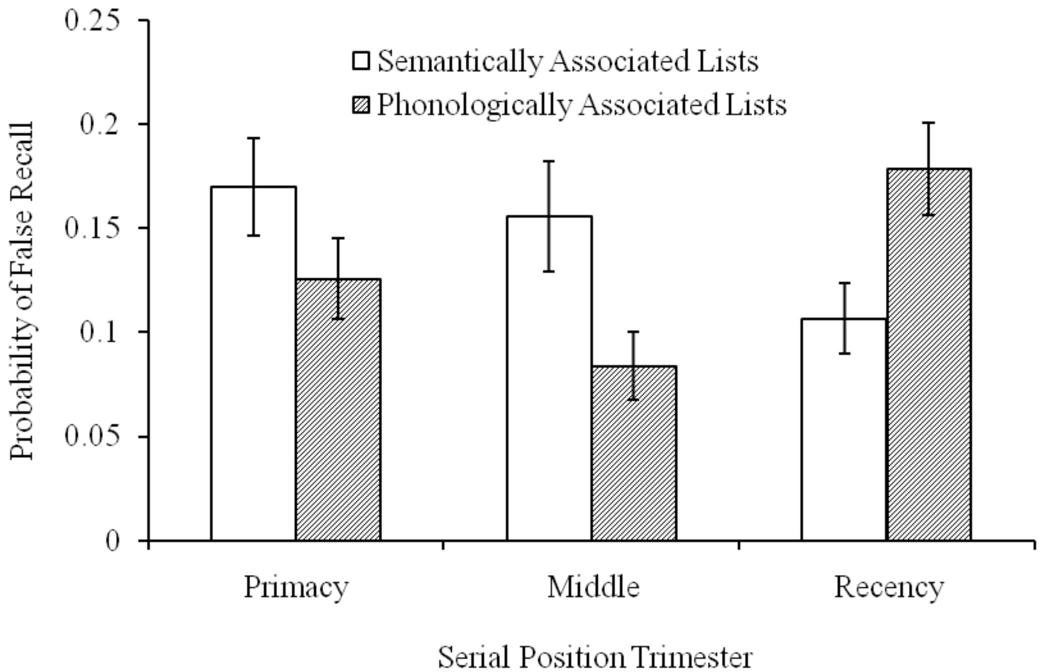

Figure 2-3. False recall as a function of list-type and serial position trimester. Error bars represent standard error of the mean.

For semantically associated lists, false recall significantly declined from primacy (*M* = 17; *SD* = .18) to recency (*M* = .11; *SD* = .13) trimesters, $t(59) = 2.68$, $SEM = .02$, $p = .009$. In contrast to semantic false recall, phonological false recall presented with a recency effect. Recency trimester produced more false recall (*M* = .18; *SD* = .17) than middle trimester (*M* = .08; *SD* = .12), $t(59)$ =

3.30, *SEM* = .02, *p* = .002. As in Experiment 1, and despite efforts to reduce the possibility that semantic associative processes were not contaminating the results for phonologically associated lists, primacy (*M* = .13; *SD* = .15) and recency trimesters did not produce reliably different levels of false recall. Higher false recall for primacy than for middle trimester was marginally significant, *t*(59) = 1.93, *SEM* = .02, *p* = .06.

False recall output analyses

As was noted in Experiment 1 above and in other research (McDermott & Watson, 2001; Roediger & McDermott, 1995), there appeared in Experiment 2 to be a tendency for false recall to be outputted later than a completely unsystematic output pattern indicates (see Figure 2-4). The average output position of semantic false recall was 7.22 out of an average of 11.38 total items recalled, or about 63% of the way through total recall output. For phonological false recall the average total number of outputted items was 8.14. False recall was outputted at an average position of 4.89, or about 60% of the way through total output.

Further analyses were undertaken to analyze the relative output positions of false recall for both list-types. Cases were selected in which there were samples of false recall from both semantically and phonologically associated lists. For these 38 selected cases, the ratio between average output position of false recall and average total response output was calculated for each list-type. The output ratio for semantically associated lists (.64) indicated later output than for the phonologically associated lists (.55), *t*(37), *SEM* = .03, *p* = .02. Earlier output of phonologically associated false recall is consistent with the theory that this type of false recall reflects an aspect of the same short-term memory processes that support the true recall recency effect, which is supported by early outputted items (Deese & Kaufman, 1957). It is also consistent with the theory of a phonologically coded short-term store inclined to produce phonologically associated false recall.

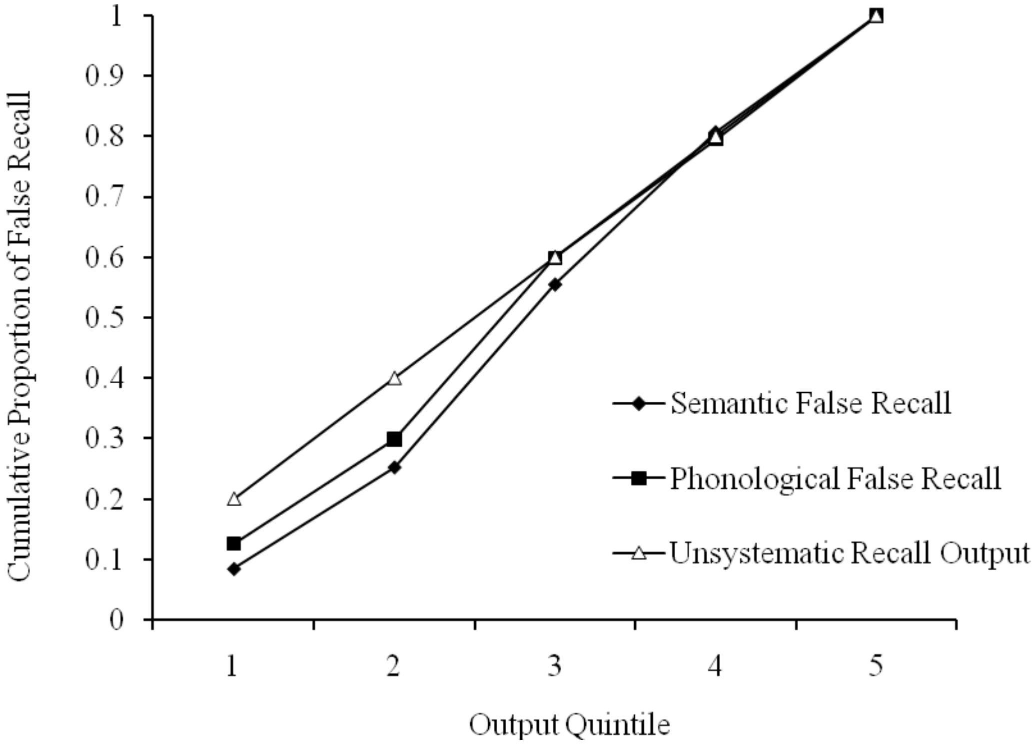

Figure 2-4. Semantic and phonological false recall as a function of output quintile.

Conclusions

Experiment 2 provided an important replication of the newly described false recall SPE. A phonological false recall recency effect was clearly observed. A phonological false recall primacy effect also appeared to emerge, which is not simply explained on the basis of decaying short-term phonological activation. However, as discussed above, neither is it necessarily the case that either phonological or semantic processes are exclusively restricted to impacting either the recency or pre-recency region of the serial position curve (e.g., see Glanzer, 1972; Haarmann & Usher, 2001 for discussions). The uniform impact of phonological association on recall performance is suggested in the serial position curves for true recall in the first two Experiments;

phonologically associated lists consistently produced less true recall throughout serial positions compared to semantically associated lists.

Also inconsistent with a simple semantic/phonological stores interpretation of the data is the possible emergence of a false recall primacy effect for the phonologically associated materials. The true primacy effect is robust, particularly for the first study item itself (Howard & Kahana, 1999). The phonological false recall primacy effect appears to be less pronounced than the phonological false recency effect, the typical pattern for true recall SPE. A simple semantic/phonological dual store interpretation would suggest that phonological false recall should principally be confined to the recency region. The possible existence of a phonological false recall primacy effect contradicts this suggestion. It is possible that different processes support the primacy and recency aspects of the false SPE in the phonologically associated lists. Under conditions of long-term learning, phonological similarity improves rather than impairs memory (e.g., Copeland & Radvansky, 2001), and therefore it is possible that the phonological false primacy effect is the result of long-term phonological processes that are relatively distinct from the short-term processes that support the true recall recency effect and the phonological false recall recency effect. To further complicate interpretation, long-term recency effects have been observed which are sensitive to acoustic manipulations (Jones, Macken & Nicholls, 2004). The false phonological recency effect observed in the above Experiments may also persist over longer terms. The present research does not address long-term recency effects, but this an important avenue for future research for false SPE.

Despite the fact that phonological false SPE did not clearly present with a simple recency effect, short-term phonological processes may still be involved in the production of phonological false SPE. It is possible that the marginal phonological false primacy effect observed in

Experiment 2 was due to earlier studied categories being rehearsed more fully (Rundus, 1971) and consequently reemerging in short-term phonological operations at recall where they were erroneously outputted. In other words, both phonological false primacy and recency effects could be mediated by a phonological store, but at different stages of list recall. The phonological false recency effect may result from the echo of recently presented words in a short-term store whereas the phonological false primacy effect may arise because sounds experienced at primacy are more active in the short-term store during the recall test.

Regardless of the abovementioned limitations of a simple semantic/phonological dual store theory of false recall SPE, some interesting consistencies with this theory emerged in the data. The semantically associated materials produced SPE such that the predominance of false recall was observed in the earlier two trimesters, which is consistent with other findings suggesting that pre-recency true recall is especially sensitive to manipulations that impact semantic long-term memory (Glanzer, 1972). Secondly, the phonologically associated material did produce a recency effect which is consistent with the theory that such false recall arises from a short-term phonologically coded store. Finally, the relatively earlier output of false recall for the phonological list-type is consistent with the idea that false recall for recency is supported by a short-term phonological store whereas the later outputted semantic false recall is supported by a long-term semantic store.

CHAPTER 3: FALSE RECALL AND SHORT-TERM MEMORY

As introduced earlier in this dissertation, errors in recall for lists of words have been studied by experimental psychologists in order to make inferences about coding in long-term and short-term memory (e.g., Baddeley, 1966; Kintsch & Buschke, 1969). A generalization (Glanzer, 1972) arising from such research that continues to influence modern thinking on list memory, including false memory in associated list words, is that semantic errors are supported by long-term semantic processes and phonological errors are supported by short-term phonological processes (Read, 1996). Manipulations of the true recall serial position curve that are thought to exemplify dual memory stores have provided mixed evidence for such a view (Glanzer, 1972; Haarman & Usher, 2001). In the present Experiments where SPE for semantic (Deese, 1959) and phonological (Sommers & Lewis, 1999) forms of false recall are being studied, hypothesizing from the vantage of dual store theory provided a starting point that has proven useful in traditional experimentation using true recall as the dependent measure of memory capacity. Furthermore, because much of what is understood about SPE has been couched in terms of dual process theory (see Brainerd & Reyna, 2005; Radvansky, 2005 for discussions), an understanding of how false memory is related to true memory at a basic level cannot be attained without addressing their relationship in terms of basic memory effects such as SPE.

When a distractor filled delay is interposed in the retention interval between the end of study lists and the onset of recall, the true recall recency effect is eliminated (e.g., Glanzer & Cunitz, 1966; Waugh & Norman, 1965). This is evidence that the terminal aspect of the serial position curve is supported by the residual availability of a short-term memory store which is depleted during the distractor task phase (e.g., Atkinson & Shiffrin, 1968). It is typically the case in immediate free recall that the final few list items are the first offloaded at test (Deese & Kaufman, 1957) as if participants are aware that these final words are only temporarily available for recall. According to this explanation of the recency advantage in list recall, immediate offloading of short-term memory cannot happen when a delay is introduced, and so recency words are lost from memory. The question that arises in the context of this present research paradigm concerns how delay will impact false recall. If the processes that support the true recall recency effect are the same processes that support the phonological false recall recency effect, then false recall at recency should decline after a delay. Differences in the way that semantic and phonological false recall SPE respond to a delay may provide further evidence of the distinct nature of the two forms of associated false memory effect.

Considering the short-term phonological/long-term semantic store rationale suggested above, the hypothesis emerges that phonological false recall for the recency study region may selectively decline after a delay (i.e., as a result of the purported reliance on short-term phonological representations for recency recall). This rationale is inconsistent with the finding of a primacy effect for phonological false recall in Experiment 2, which does not support a straightforward phonological/semantic stores interpretation of false recall SPE. Other outcomes relating to phonological false recall SPE were certainly recognized as possible heading into Experiment 3. Phonologically associated lists may continue to promote higher levels of false recall for primacy than for middle study positions after a delay. Perhaps higher phonological false recall at primacy was observed in Experiment 2 because primacy categories were rehearsed to a relatively greater extent and hence the primacy categories were more likely to reemerge in short-term memory during recall. False intrusions may then be encoded at test or may be retained from the study phase and retrieved at test. Under the above interpretation, delayed recall would not prevent the phonological false primacy effect from occurring but would remove the phonological false recency effect. Evidence may be produced by Experiment 3 indicating that phonologically associated lists produce independent primacy and recency effects.

Recency list items in delayed recall conditions, contrary to immediate free recall, are not outputted relatively earlier (Deese & Kaufman, 1957). This may be interpreted as an indication that the contents of a short-term phonological store are no longer available and hence no advantage for early output exists. If this were the case using delayed recall with the present experimental paradigm, a short-term phonological store may not be available to support the phonological false recall recency effect after a delay either. If phonological false recall is supported by short-term processes available immediately at test, it is reasonable to predict that it would be outputted relatively earlier than semantic false recall, which would be more reliant on long-term semantic processes. Therefore another important aspect of Experiment 3 hypotheses involves the relative output positions of the two forms of associated false recall. If phonological false recall is especially supported by a short-term phonological store which is depleted using delayed recall, then, contrary to immediate free recall, there is no basis on which to hypothesize that the output position of phonological false recall relative to total list output should be any earlier for phonological than for semantic false recall.

Experiment 3

Higher levels of the semantically based DRM false recall were expected to predominate in primacy and middle (i.e., pre-recency) compared to recency regions of the serial position curve as have other effects measured by true recall that impact semantic elaboration (Glanzer, 1972). However, if dual store theory has application in forming predictions concerning the distinct nature of the semantic and phonological forms of false recall under investigation, the same pattern would not be expected for phonological false recall. If phonological false recall is a product of the same short-term phonological processes that appear to underlie the true recall recency effect, and these processes are removed by a delay, then false phonological recall should decline after a delay along with the true recency effect. Declining phonological false recall after a short delay runs contrary to semantic DRM false recall which is known to remain stable over delays (McDermott, 1996; Payne et al., 1996; Toglia et al., 1999) even for days and weeks (Thapar & McDermott, 2001; Toglia et al., 1999).

No research currently exists on phonological false recall (Sommers & Lewis, 1999) under delayed recall conditions using associated word-lists such as those used in this research (see Experiment 2 Method section & Appendix B). However, considerable research has been conducted examining the impact of delay on memory for phonologically similar materials in order to better understand the nature of coding in short-term memory (see Nairne & Kelley, 1999 for a discussion). Some of this research has involved the evaluation of errors in memory (e.g., Kintsch & Bushke, 1969). Estes (1973) found that phonological errors were reduced to chance levels after a 14s digit shadowing task consistent with the concept of a fading short-term phonological store. A *phonological similarity effect* exists such that phonologically associated list words reduce success at serial recall in comparison to semantically associated words or non-associated word-lists (Baddeley, 1966). On the basis of their review, Nairne and Kelley (1999) suggest that the relationship between the phonological similarity effect and delayed response is complex, and furthermore that recall paradigms other than free recall do not necessarily produce parallel results in terms of consistency with dual store memory logic. Fournet, Juphard, Monnier and Roulin (2003) experimented using free recall for 5-item lists of phonologically similar words and observed that under short delays of 2s, 8s or 24s that the advantage in true recall for phonologically similar compared to dissimilar lists remained roughly equal. If this latter finding has any application in forming hypotheses about the phonologically associated lists used in this research (Deese, 1959; Sommers & Lewis, 1999) then after a delay there could continue to be a main effect of greater recall for the semantically associated word lists than for the phonologically associated word-lists.

Other outcomes than those implied by stores theory outlined above were certainly possible. If the phonological false SPE observed in Experiment 2 were due to similar processes that underlie semantic false recall (McDermott & Watson, 2001), then the pattern of phonological false recall SPE may remain stable under delayed conditions. However, as discussed above, it is also possible that preferred rehearsal for primacy categories into long-term memory supports the reintroduction of phonological themes or associated false intrusions into working memory during the recall phase. If this were the case, there would be no reason to assume that a short delay would impact the phonological false recall primacy effect, even though the phonological false recall recency effect may be attenuated due to the abolition of short-term phonological activation.

Method

The method and materials in Experiment 3 were matched to those used in Experiment 2 for the purpose of comparing immediate to delayed free recall. The only difference between the method for Experiment 2 and the present Experiment was the introduction of a distractor filled delay between the end of study and the beginning of recall which is discussed in the procedure section below.

Participants

Experiment 3 involved 60 university undergraduate students from a participant pool, 53 were female. The average age was 21.23 years (*SD* = 6.44). Participation was for course credit. It was explicitly stated to participants that credit would be received whether or not they chose to volunteer; they had the option of leaving after listening to a description of the research being conducted. One participant took this option, and so another participant from the pool replaced that person. Three participants reported English as a second language and none reported previous knowledge of the experimental paradigm.

Materials

The stimuli (Appendix B), and the method by which they were assigned to conditions, were the same as for Experiment 2.

Procedure and design

All aspects of the procedure were the same as in Experiment 2 with the exception that a distractor-filled delay was implemented between study and test. After each list was read, and prior to the instruction to recall, participants were instructed to count backwards in steps of three starting from a random three digit number. At the end of each word list the Experimenter read a three digit number aloud. Participants were instructed to write down that number and immediately begin performing subtractions of three and writing down the results. Random numbers were greater than 200 to avoid the possibility of fast subtraction leading to negative numbers. After 15s of backwards counting, timed by the Experimenter using a stopwatch, participants were instructed to write down the words recalled. Research has shown that a 15s distractor filled delay will abolish the recency effect for true recall (Glanzer & Cunitz, 1966; Postman & Phillips, 1965).

Results and Discussion

True recall analyses

In order to assess the impact of delayed recall in Experiment 3 in comparison to immediate free recall conditions of Experiment 2, direct comparisons were made between Experiments 2 and 3. A mixed factor ANOVA of true recall probabilities was conducted with the between-subjects factor of recall condition (immediate free recall, delayed free recall) mixed with the two within-subjects factors of study-position (primacy, middle, recency) and list-type (phonological, semantic). The analyses indicated a main effect of recall condition whereby immediate free recall produced more true recall (M = .32; SEM = .01) than delayed recall (M = .27; SEM = .01), $F(2, 118) = 93.31$, MSE = .67, $p < .01$. This main effect was qualified by a significant interaction with recall condition, $F(2, 118) = 32.09$, $p < .01$, MSE = .23, $p < .01$ (see Figure 3-1). For recency trimester, true recall was reduced for the delayed recall condition (M = .28; SEM = .01) compared to the immediate recall condition (M = .40; SEM = .01), $t(118) = 7.83$, SED = .02, $p < .01$, whereas no reliable difference in true recall was observed for primacy or middle trimesters between immediate and delayed recall conditions. As was expected on the basis of previous research (Glanzer & Cunitz, 1966), true recall at recency position was selectively reduced by the delayed recall manipulation. Therefore evidence was obtained consistent with dual store theory that a distrator-filled delay depletes the short-term store.

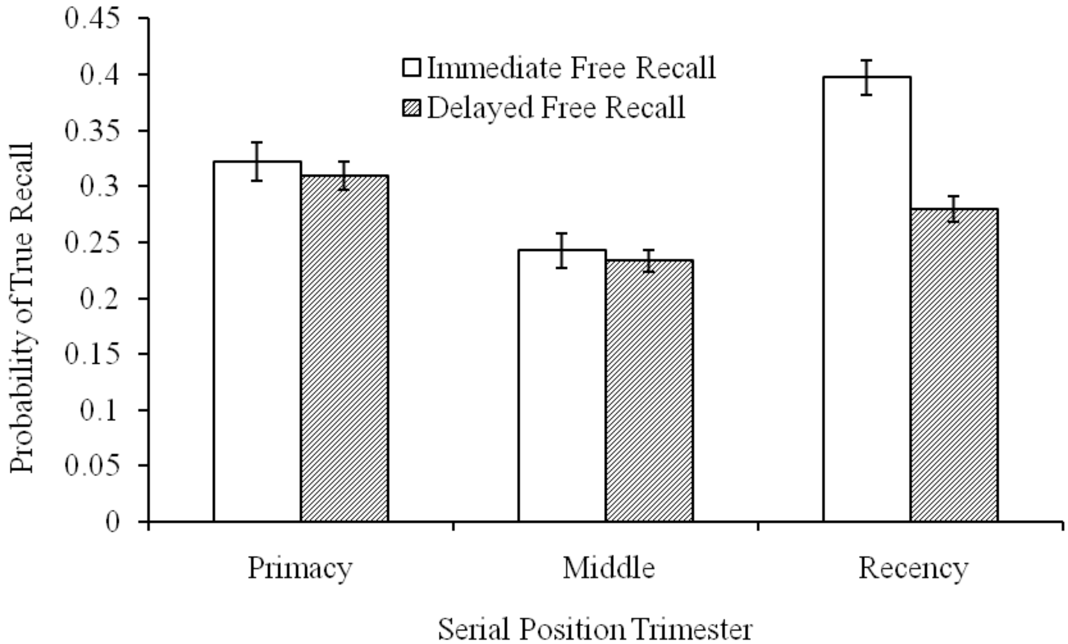

Figure 3-1. True recall as a function of recall condition and serial position trimester. Error bars represent the standard error of the mean.

A significant interaction between list-type and position was also observed, *F*(1, 118) = 6.56, *p* < .01, *MSE* = .04, *p* < .01 (see Figure 3-2). Semantically associated lists produced more true recall (*M* = .38; *SEM* = .01) than phonologically associated lists (*M* = .21; *SEM* = .01), *F*(1, 118) = 643.92, *p* < .01, *MSE* = 5.38, *p* < .001. Furthermore, both list-types produced typical patterns of SPE with the primacy and recency trimesters producing higher true recall than middle trimester. The interaction was due to differences in the pattern of SPE between list-types. The semantically associated lists produced a pattern of SPE similar to that of single theme semantically associated lists (Deese, 1959; Roediger & McDermott, 1995) with primacy (*M* = .41; *SEM* < .01) and recency (*M* = .41; *SEM* < .01) trimesters producing non-significantly different probabilities of true recall. This single non-significant pair wise comparison underlies the interaction between list-type and serial position. For the phonologically associated lists, the recency effect for the phonological materials is more pronounced than primacy, which is typically the case for true recall SPE (e.g., Glanzer, 1972).

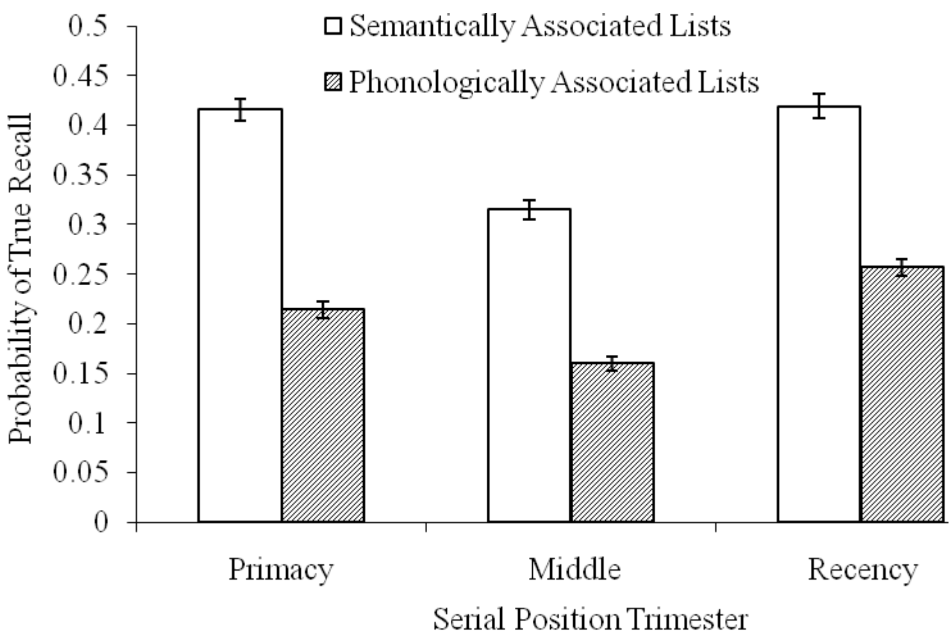

Figure 3-2. True recall as a function of list-type and serial position trimester. Error bars represent the standard error of the mean.

False recall analyses

In order to compare false recall between Experiment 2 immediate free recall conditions and Experiment 3 delayed free recall conditions, a 3 within-subjects (position; primacy, middle, recency) × 2 within-subjects (list-type; phonological, semantic) × 2 between-subjects (recall condition; immediate free recall, delayed free recall) mixed factor ANOVA was conducted. The analyses of false recall produced main effects of list-type and position. The main effect of list-type was qualified by significant two-way interactions with position and with recall condition.

Semantically associated lists produced more false recall (*M* = .15; *SD* = .01) than the phonologically associated lists (*M* = .10; *SD* = .01), *F*(1, 118) = 11.61, *MSE* = .37, *p* = .001. List-type interacted with study-position (see Figure 3-4), *F*(1, 118) = 11.83, *MSE* = .25, *p* < .001, reflecting the same distinct semantic-phonological patterns of false recall SPE seen in Experiments 1 and 2. Semantic false recall declined reliably from primacy (*M* = .19; *SD* = .19) to recency (*M* = .12; *SD* = .15) study trimesters, *t*(119) = 3.88, *SEM* = .02, *p* < .001, and from middle (*M* = .16; *SEM* = .19) to recency, *t*(119) = 2.37, *SEM* = .02, *p* = .019. Contrary to semantically associated lists, the phonologically associated lists produced a pattern of SPE similar to true recall with higher probabilities observed at primacy (*M* = .14; *SD* = .16) and recency (*M* = .15; *SD* = .16) than for middle (*M* = .07; *SD* = .11), *t*(119) = 2.40, *SEM* = .02, *p* < .001 and *t*(119) = 3.88, *SEM* = .02, *p* < .001, respectively. Furthermore the recency trimester produced reliably more phonological false recall than the primacy trimester, *t*(119) = 1.00, *SEM* = .18, *p* = .048.

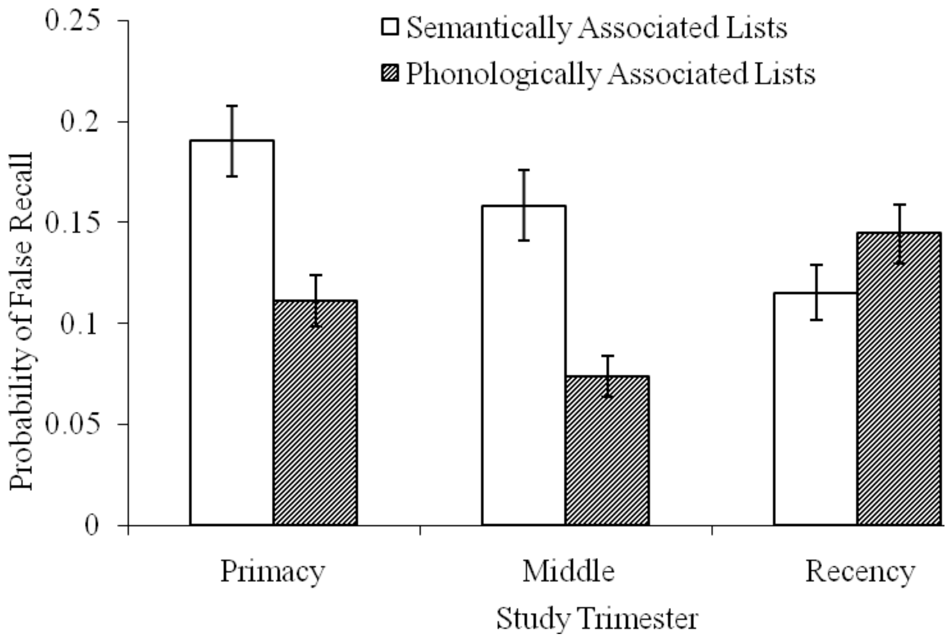

Figure 3-3. False recall as a function of list-type and serial position trimester. Error bars represent standard error of the mean.

The ANOVA also indicated a reliable interaction between recall condition and list-type (see Figure 3-4), $F(1, 118) = 5.59$, $MSE = .18$, $p = .020$. False recall for the phonologically associated lists declined from immediate recall ($M = .13$; $SD = .13$) to delayed recall ($M = .09$; $SD = .08$) conditions, $t(118) = 2.48$, $SD = .02$, $p = .015$, whereas no significant decline in false recall was noted for the semantically associated lists. These findings map nicely on to the interpretation that phonological false recall is supported by a short-term store and semantic false recall by a long-term store.

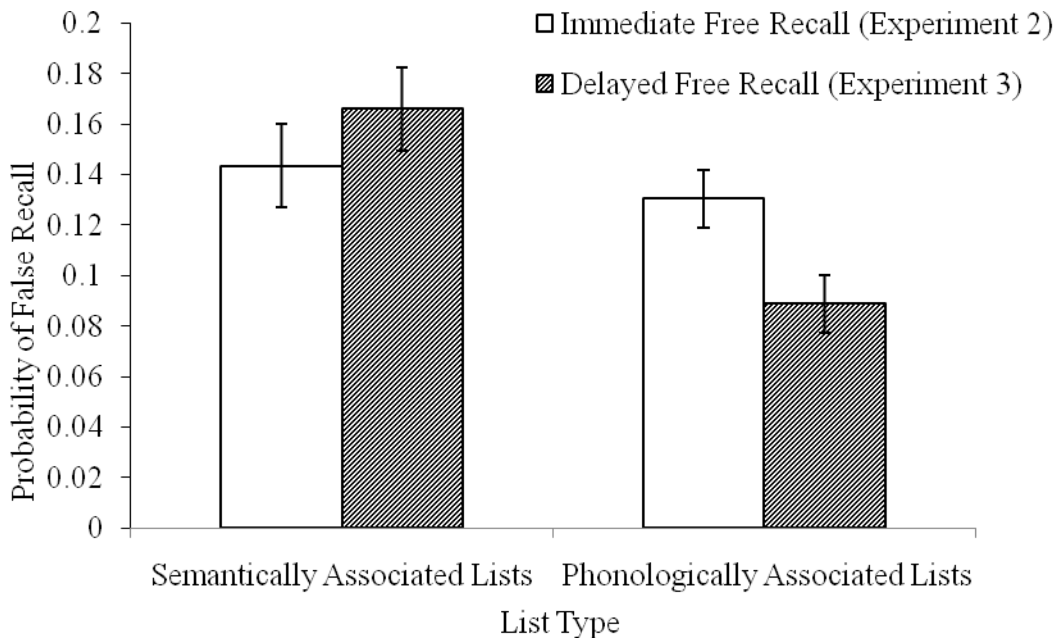

Figure 3-4. False recall as a function of recall condition and list-type. Error bars represent the standard error of the mean.

A simple long-term-semantic/short-term-phonological store interpretation of false recall SPE would suggest that a three-way interaction should have occurred in which recency study position in particular produced less phonological false recall after a delay. This interaction was not observed. Therefore the data are most consistent with the view that the depleting of short-term resources affected false recall throughout the serial position curve, rather than just for the most recently studied phonologically associated category.

False recall output position analyses

In terms of dual store theory, there appears to be an advantage to dumping the contents of short-term memory immediately at recall (Deese & Kaufman, 1957). It was found in Experiment 2 above that phonological false recall was outputted relatively earlier than its semantic counterpart, perhaps suggesting it is reliant on short-term phonological rather than long-term semantic processes. After a distractor-filled delay, no such advantage is available due to short-term memory depletion, and therefore there is no reason to assume that phonological false recall should be outputted relatively earlier than semantic false recall. McDermott and Watson (2001) reported analyses suggesting that false semantic recall may be outputted less systematically late after a delay. A similar analysis was undertaken here in order to assess output of false recall, and to see if McDermott and Watson's findings replicate under the present experimental conditions.

For Experiment 3, the average output position of semantic false recall was 6.28 out of an average of 9.45 total words recalled, or 62% of the way through output. The average position of phonological false recall was 3.51 out of an average of 6.13 items recalled, or 60% of total output. When the cumulative probability of false recall was plotted as a function of output quintile similar patterns were found to those reported in the Experiments above and in other previous research (McDermott & Watson, 2001). However, after the delay, just as McDermott and Watson (2001) found, phonological false recall appears to be completely unsystematically outputted, and the semantic false recall perhaps somewhat systematically later. McDermott and Watson attributed this difference to possible subtle differences between the effects.

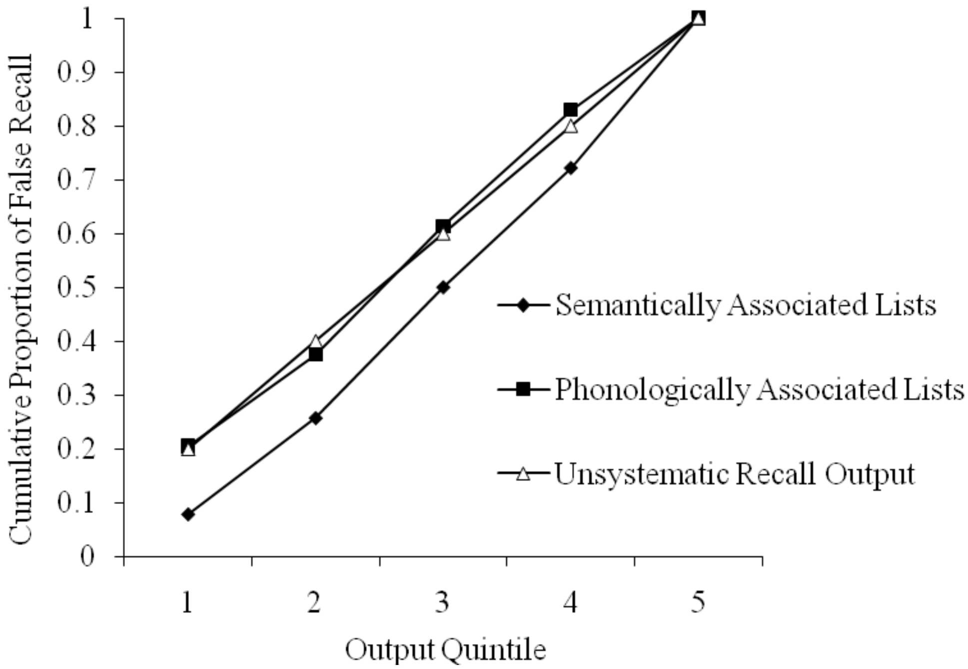

Figure 3-5. False recall as a function of output quintile.

Further analyses were undertaken in order to examine the relative output positions of false recall from the two list-types. It was hypothesized above that a delay might remove the tendency for phonological false recall to be outputted relatively earlier in lists (i.e., after the short-term store that supports it has been depleted). In 37 cases in Experiment 3, participants produced samples of both semantic and phonological false recall for within-subjects statistical analysis. A ratio was calculated by dividing the average output position of predicted false recall items by total recall output. For the semantically associated lists the ratio was .60 whereas for the phonological lists it was .58. When the ratios were compared, contrary to immediate free recall in Experiment 2, in delayed recall conditions in Experiment 3, the relative output positions of false recall for these participants did not differ reliably, $t(35) = .33$, $SEM = .06$, $p = .74$, despite there being strong statistical power (.94) to detect differences (Campbell & Thompson, 2002). This is consistent with the scenario that because a short-term store was no longer available after a delay, phonological false recall emerging in the context of this store was depleted. This pattern of false output position concurs with the descriptive false recall output position data that differences exist between phonological and semantic false recall (see Ballou et al., 2008, for a discussion).

Conclusions

In Experiment 3 a delayed recall condition was implemented in order to test whether or not removing the processes that support the true recall recency effect would also remove the phonological false recency effect. If the short-term processes that support the recency effect were coded phonologically (see Baddeley, 1990 for a discussion), and phonological false recall is an indication of phonological activation in a short-term store, then delayed recall may have selectively reduced false recall for the phonologically associated list at the recency trimester. This did not occur. Rather, phonologically associated lists produced false recall that was not reliably associated with any particular serial position region. This finding is consistent with previous research examining coding in list recall memory for true recall using an immediate free recall paradigm (Bruce & Crowley, 1970; Craik & Levy, 1970) in which phonologically similar list materials did not selectively impair recall at the recency list region as it had under cued recall conditions (Kintsch & Buschke, 1969). Because no three-way interaction was found, no conclusions could be drawn concerning the relationship of delay to the phonological false primacy effect as compared to the phonological false recency effect. However, some evidence consistent with the implication of phonologically coded short-term resources in the production of phonological false recall was obtained in Experiment 3 in so far as delayed recall reduced phonological but not semantic false recall. Furthermore, although a null hypothesis result cannot be interpreted directly, the absence of differences in the relative output position of false recall for the two list-types is consistent with the notion that short-term phonological processes were depleted by the delay.

Congruent with the theory that delayed recall results in the removal of short-term phonological information, the delayed recall condition simultaneously reduced both the true recall at recency and phonological false recall. Furthermore, analyses of the combined data of Experiments 2 and 3 provided more convincing evidence that false recall arising from semantic association is most pronounced at primacy, whereas phonologically based false recall is highest at recency.

The next step in examining the distinction between semantically and phonologically based false recall SPE is to examine the impact of a manipulation thought to selectively impact recall for the earlier pre-recency study positions, positions sometimes thought to be indicative of long-term semantically coded memory (Glanzer, 1972; Talmi, Grady, Goshen-Gottstein & Moscovitch, 2005), and therefore more likely to produce semantically based false recall.

CHAPTER 4: FALSE RECALL AND LONG-TERM MEMORY

The previous chapter investigated the consequences of removing short-term memory resources on false recall SPE. This fourth chapter turns to manipulations that are thought to impact long-term memory. The theoretical framework guiding this thesis stems from the dual store notion that memory involves relatively independent long-term-semantic and short-term-phonological stores (Glanzer, 1972). From the perspective of known properties of the true recall serial position curve, the question can be asked: Does false memory in associated word-lists also show evidence of arising from such dual memory stores? In particular, how would manipulations of true recall SPE impact false recall as a function of serial position? Long-term memory is often associated with list items occurring prior to the final few list items, termed pre-recency (see Introduction). Specifically, at this stage of the investigation it was necessary to look for evidence of whether semantic false recall, in opposition to phonological false recall, is moderated by long-term semantic processes associated with the pre-recency list region.

The long-term aspect of the serial position curve has been viewed as sensitive to manipulations that affect rote learning (Glanzer, 1972). Manipulations that interfere with rehearsal, such as concurrent task demands, selectively reduce memory for list items falling at the pre-recency region. Differences in false recall SPE arising from semantically as compared to phonologically associated word-lists under concurrent task demands would provide data germane to the issue of the relationship between semantic (Deese, 1959) and phonological (Sommers & Lewis, 1999) false recall. Specifically, dual store logic would suggest that semantic false recall should show evidence of being more sensitive to rehearsal, particularly for the first two study trimesters (i.e., more representative of pre-recency) whereas phonological false recall should be relatively less rehearsal-dependent and hence may be less affected by concurrent task demands.

Several variables that impact rehearsal appear to selectively moderate recall for the pre-recency region of the serial position curve (Glanzer, 1972). Such variables include word frequency (Raymond, 1969), list length (Murdock, 1962), presentation rate (Raymond, 1969), and concurrent memory load during study (Richardson & Baddeley, 1975), all of which preserve the recency advantage (see Healy & McNamara, 1996 for a discussion). In modern discussions of the serial position curve, rehearsal continues to be regarded as a critical factor of interest in trying to understand SPE more fully (Brown & Lamberts, 2003; Tan & Ward, 2000). The classical dual store explanation of why such variables selectively affect pre-recency memory is that these variables reduce rehearsal in the short-term store and this impedes memory transfer into the long-term store (Atkinson & Shiffrin, 1968; Glanzer, 1972; Waugh & Norman, 1965).

The finding that the recency effect for true recall is resilient to concurrent memory load (Richardson & Baddeley, 1975) seriously draws into question the plausibility of the short-term store as it was originally conceived (see Baddeley, 1990 for a discussion). From the perspective of the modal dual store interpretations of list memory (see Introduction), a concurrent memory task should prevent list words from entering the limited capacity short-term store and therefore there should be no recency list items in the store to support the recency advantage. However, the recency effect survives (Richardson & Baddeley, 1975). It remains possible that the recency effect is the product of a short-term store, but that this store is independent of the capacity for rehearsal (Baddeley, 2004). The true recall recency effect may be a result of priming, which is not dependent on overt rehearsal (Baddeley & Hitch, 1977). The fact that the recency effect often appears rehearsal-independent does not discount the possibility that the concept of a relatively independent phonological store is tenable in explaining SPE (Baddeley, 1990; Talmi et al., 2005). If the phonological false recency effect is also rehearsal independent, it should survive divided attention during list study.

A strict short-term phonological/long-term semantic store interpretation of SPE suggests certain predictions concerning false recall SPE if it is assumed that false recall also arises from such stores. Specifically, false recall for the phonologically associated lists should produce a distinct pattern of SPE reflecting the association between phonological coding and recency on the one hand and semantic coding and pre-recency on the other. Dividing attention during the study phase could have a different impact on the two list-types and their respective false recall SPE. If false recall in the present paradigm is the result of the same processes that support true recall, then a concurrent memory load task should reduce false recall for the semantically associated lists at the pre-recency region in particular, and leave phonological false recall at recency region relatively stable in comparison. In order to evaluate these hypotheses, tasks that divide attention during list study were implemented in an experiment otherwise similar Experiments 2 and 3.

Experiment 4

Experiment 4 addressed the issue of how divided attention impacts false recall SPE described previously in this dissertation. Because this is the first research documenting SPE for associated false recall, no specific related empirical research exists. Research examining SPE for phonological false recall in associated word-lists (Sommers & Lewis, 1999) was also unavailable. Some research in the past few years has emerged examining divided attention and subsequent levels of semantic false recall, which has yielded mixed results (Dewhurst et al., 2007; Dodd & MacLeod, 2004; Peréz-Mata et al., 2002; Seamon et al., 1998; Seamon et al., 2003).

Seamon and colleagues (2003) argued that false recall arising from semantically associated word-lists is largely automatic and relatively unaffected by level of attention during study. This view is based on different lines of converging evidence demonstrating the resilience of false memory to various manipulations that impede attention during encoding. Semantic false recall is observed under conditions of rapid presentation duration (McDermott & Roediger, 1998; Seamon et al., 1998), under specific warnings not to remember semantically similar lure words (Gallo, Roberts & Seamon, 1997; McDermott & Roediger, 1998) and in the absence of intent to remember (Dodd & McLeod, 2004). Perhaps the most analogous previous investigation to the present Experiment is that of Seamon et al. (1998) in which participants were presented with semantically associated lists under the concurrent memory load condition of simultaneously remembering a seven-digit number. The authors found a reliable reduction in semantic false recognition; however they later suggested this might have been an anomalous result arguing from the view that associated semantic false memory appears on balance in the literature to be an automatic phenomenon (Seamon et al., 2003). The present dissertation advances from the working hypothesis that a similar process underlies semantic false recall and long-term true recall, and therefore the reduction in opportunity for semantic elaboration created by divided attention during list study should reduce semantic false recall along with true recall (also see Dewhurst et al., 2007 for a discussion). This is distinct from the view that semantic false recall is automatic (Seamon et al., 2003).

Other theories suggest that semantic false recall may increase under conditions of divided attention due to a simultaneous decrease in source monitoring capacity (Peréz-Mata et al., 2002) or to lowered response criterion under more difficult task conditions (Dewhurst et al., 2007; Peréz-Mata et al., 2002). Each of these views is supported by findings of higher levels of unpredicted false intrusions when attention is divided during study. Unpredicted intrusions are suggestive of response bias. However, and contrary to the above outlined view, Seamon et al.'s (1998) found reduced false semantic memory under divided attention. It is possible that such divergent results in the literature regarding divided attention and semantic false recall (see Seamon et al., 2003 for a discussion) may be a result of weak statistical power or control over response criterion. The researchers used a concurrent memory task of remembering a six-digit letter-number string during list study in order to divide attention. Response bias was carefully controlled using individual testing and with cautious instructions concerning guessing. It is logical to argue that declines in false recall result because divided attention impacted the degree to which semantic associations can be formed during list study (Roediger et al., 1998; Thapar & McDermott, 2001). Contrary to the interpretation of Seamon et al. (2003), which emphasizes the automaticity of DRM false recall, the perspective taken in this present thesis is more consistent with research showing that deeper semantic processing often increases DRM false memory (Kronlund & Whittlesea, 2005; Read, 1996; Roediger et al., 1998; Thapur & McDermott, 2001) just as it does for true long-term memory (Craik & Lockhart, 1972). This is possibly because the same semantic associative processes that underlie long-term true memory also underlie false memory based on semantic association (also see McDermott, 1996 for a discussion). Clearly, as the previous Experiments show, different serial position regions can produce different levels of false recall, which is not predicted by an automatic activation account of false recall.

The DRM false recall effect (Deese, 1959; Roediger & McDermott, 1995) involves lists of semantically associated words (e.g., *bed, rest, awake, etc.*) which produce predicted false intrusions (e.g., *sleep*). As discussed in the introduction, subjectively convincing predicted false recall (e.g., *sleep*) also arises from studying lists which are phonologically associated (e.g., *sweep, steep, sleet*; Sommers & Lewis, 1999). No research specifically examining phonological false recall (Sommers & Lewis, 1999) and divided attention was found in the current false memory literature. If the phonological and semantic forms of associated false recall under study are produced by the same mechanisms, then there is no reason to assume any differences should exist in their respective sensitivities to manipulations. The previous three Experiments reported in this thesis speak against this view by showing that the two forms of false recall express distinct SPE.

Despite there being no previous research on divided attention and phonological false recall (Sommers & Lewis, 1999), previous research has been conducted using phonologically associated materials that may have some potential bearing on interpreting the present research. The phonological similarity effect (Baddeley, 1966), whereby serial order recall is impaired for phonologically similar compared to phonologically dissimilar items, is abolished using a concurrent learning task of repeatedly counting to six (Coltheart, 1993), which suggests that the concurrent task occupied resources that support the effect. Therefore, on the basis of previous research, it was certainly possible that the concurrent task used in the present experiment would alter memory for phonologically and semantically associated materials differently; however, it was not known how any such alterations interact with serial position.

A concurrent handwriting task was devised in consideration of recent false memory research (Seamon et al., 2003). In Seamon et al.'s (2003) investigation of semantic false recall and divided attention, each of the concurrent learning tasks used to divide attention involved some type of handwritten response. The present Experiment was intended to explore the hypothesis that semantic false recall should decline just as true recall does, hypothetically due to reduced opportunity for elaboration during list study (also see Dewhurst et al., 2007 for a similar view).

In summary, Experiment 4 was designed to test hypotheses concerning distinct SPE for semantic (Deese, 1959; Roediger & McDermott, 1995) and phonological (Sommers & Lewis, 1999) false recall. For true recall, manipulations that impede rehearsal during study selectively impact the pre-recency region of the serial position curve (Glanzer, 1972). If the phonological false recall recency effect found in the previous Experiments reported in this thesis is a product of the same processes that support the true recall recency effect, it should show evidence of being less sensitive to divided attention than semantic false recall (see Baddeley & Hitch, 1977; Glanzer, 1972 for discussions). If this is the case, then the true recall recency effect and the false phonological recency effect should remain relatively less modified by a concurrent memory task. However, the previous Experiments have shown that elevated phonological false recall is not confined to the recency aspect of the serial position curve as a strict phonological/semantic stores account would suggest, but rather evidence was found for a false phonological primacy effect. Semantic false recall was expected to decline under divided attention, particularly for the first two study trimesters which are most representative of the pre-recency aspect of the serial position curve. Other outcomes were certainly possible, including that both forms of false recall would be similarly impacted by divided attention across serial positions, which would stand as evidence against the view that the two forms of false recall are distinct in terms of the impact of serial position on false recall.

Method

The method and materials for Experiment 4 were matched to the previous Experiments for the purpose of making meaningful cross-experimental comparisons. The only difference between the method for Experiment 4 and the previous Experiments was the implementation of a concurrent task during the study phase which is described below.

Participants

Experiment 4 involved 60 university undergraduate student recruits from a university participant pool with an average age 19.16 years (*SD* = 2.0). The sample included 45 females. Participation was for course credit and was conducted under established ethical guidelines. It was explicitly stated to participants that credit would be received whether or not they chose to volunteer; participants had the option of leaving after listening to a description of the research being conducted. One participant reported previous knowledge of the experimental paradigm and none reported English as a second language. Participants were also given the option of an article review assignment in lieu of experimental participation. No one took either of the alternative options.

Materials

Experiment 4 involved 36 pairs of associated word-lists adapted from Watson et al. (2003; see Appendix B). Additional materials required to divide attention were six mixed letter/number sequences (Appendix C). Each sequence alternated between a letter and a number and every second sequence began with either a letter or a number. Selections were made on the basis that the symbols used did not contain any obvious way of chunking the elements of the strings in memory.

Design and procedure

The design and procedure remained the same in all respects to the previous Experiments except that in Experiment 4 a concurrent task was introduced during the study phase. Prior to reading study lists, participants were presented with a card with a number/letter string resembling a postal code or license plate number printed on it. They were asked to view the string, begin writing it down on a provided paper sheet in a column from top to bottom one entry at a time. Participants were asked to write at a steady and comfortable rate using the rate of list reading to help keep a consistent writing pace from list to list. Participants were instructed to immediately abandon the handwriting task and begin writing down the list words upon the cue to recall the list words.

Results and Discussion

True recall analyses

The true recall serial position curves are shaped similarly to curves produced by lists of unassociated words including a primacy effect and an even more pronounced recency effect and are similar to curves found in the previous Experiments (see Figure 2-1 for an example). This shows that under divided attention conditions lists comprised of trimesters of associated words produce typical serial position curves. In order to assess the impact of divided attention during list study using a concurrent handwriting task, comparisons were made between the full attention study conditions of Experiment 2 and the divided attention conditions of Experiment 4. A mixed factor ANOVA was conducted with the two within-subjects factors of study position (study-position; primacy, middle, recency) and list-type (phonological, semantic) and the between subjects factor of attention (full attention, concurrent writing). These analyses indicated significant main effects of list-type, serial position and attention. The between subjects factor of attention interacted with both list-type (Figure 4-1) and serial position (Figure 4-2).

The main effect of list-type, evident in Figure 4-1, was due to the phonologically associated lists producing less true recall (M = .21; SD = .06) than the semantically associated lists (M = .37; SD = .10), $F(1, 118) = 726.03$, $p < .001$, MSE = 4.67. This main effect was qualified by a significant interaction with the between-subjects factor of attention, $F(1, 118) = 9.93$, MSE = .06, $p = .002$ (see Figure 4-1). All pair wise comparisons of values depicted in Figure 4-1 are significant. The interaction indicates that the reduction in true recall under concurrent handwriting for the semantically associated lists from M = .41; SD = .10 to M = .23; SD = .06

was larger than the reduction from *M* = .27; *SD* = .07 to *M* = .15; *SD* = .05 for the phonologically associated lists. This interaction is consistent with the view that memory for semantically associated materials is more reliant on elaborative rehearsal whereas memory for phonologically associated materials is more reliant on rehearsal-independent phonological processes. It is also possible that the interaction was produced by floor effects for phonologically associated lists under concurrent handwriting conditions.

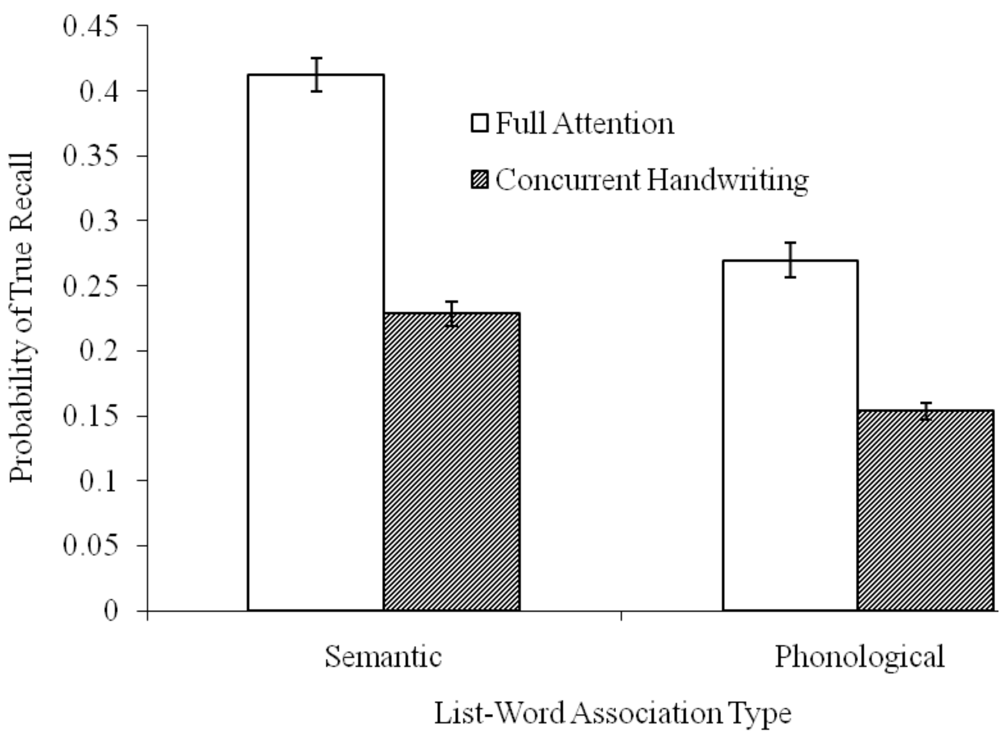

Figure 4-1. True recall as a function of attention condition and list-type. Error bars represent standard error of the mean.

List-type also interacted with serial position, $F(2, 118) = 6.70$, $p < .01$, $MSE = .04$, $p < .001$ (see Figure 4-2). Particularly high levels of true recall were observed for the semantically associated lists at recency trimester (*M* = .47; *SD* = .01). This level was higher than for the semantically associated lists at primacy (*M* = .37; *SD* = .01), *t*(119) = 8.43, *SEM* = .01, *p* < .001, and for all other experimental conditions, all *p*'s < .001. Conversely, the lowest levels of recall were observed for the phonologically associated lists at middle trimester under (*M* = .15; *SD* = .08), which were lower than for the phonologically associated lists at primacy (*M* = .20; *SD* = .10) and for all other conditions, all *p*'s < .001.

The interaction also indicates the possibility that concurrent handwriting may have impacted true recall differently across serial position trimesters for the two list-types. In order to evaluate differences in the patterns of SPE for the list-types, a difference score was calculated by subtracting true recall probabilities for semantically associated lists from phonologically associated lists for each serial position trimester. The decline in true recall at primacy serial position trimester (*M* = .18; *SD* = .11) was greater than the decline at middle (*M* = .13; *SD* = .10), *t*(119) = 3.37, *SEM* < .01, *p* < .001, and the decline at recency trimester (*M* = .17; *SD* = .10) was also greater than at middle, *t*(119) = 2.95, *SEM* < .01, *p* = .004. For whatever reason, more pronounced primacy and recency effects were observed for the semantically associated materials.

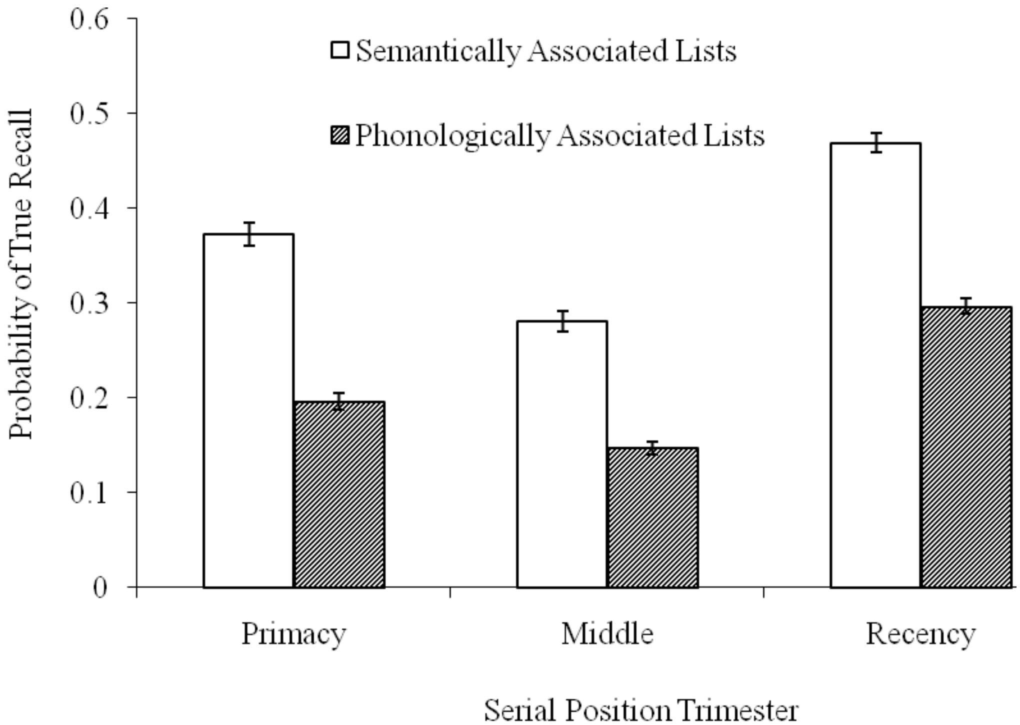

Figure 4-2. True recall as a function of list-type and serial position trimester. Error bars represent standard error of the mean.

Also of importance with regard to Figure 4-2 is that the typical pattern of SPE were observed for true recall in terms of serial position trimesters for both list-types. For the semantically associated lists primacy trimester produced more true recall (*M* = .37; *SD* = .13) than middle trimester (*M* = .28; *SD* = .12), *t*(119) = 8.77, *SEM* = .01, *p* < .001. Recency (*M* = .47; *SD* = .11) produced more than middle, *t*(119) = 18.55, *SEM* = .01, *p* < .001. Recency also produced more than primacy, *t*(119) = 8.34, *SEM* = .01, *p* < .001. Similarly for the phonologically associated lists, higher true recall was observed for primacy trimester (*M* = .20; *SD* = .09) compared to middle (*M* = .15; *SD* = .08), *t*(119) = 5.37, *SEM* = .01, *p* < .001. Recency (*M* = .30; *SD* = .09) was higher compared to middle, $t(119) = 15.58$, $SEM = .01$, $p < .001$. Recency was higher than primacy, $t(119) = 9.35$, $SEM = .01$, $p < .001$, also. Typical SPE are further substantiated by the observed main effect of serial position, $F(2, 118) = 230.97$, $MSE = 1.72$, $p < .001$, indicating that across Experiments 2 and 4 and across list-type, SPE were observed such that primacy trimester produced more true recall ($M = .28$; $SD = .10$) than middle ($M = .21$; $SD = .08$), $t(119) = 9.42$, $SEM = .01$, $p < .001$, and recency produced more ($M = .38$; $SD = .08$) than middle, $t(119) = 22.75$, $SEM = .01$, $p < .001$, trimester and finally the typical result of higher true recall for recency than for primacy, $t(59) = 1.85$, $SEM = .04$, $p = .07$. So although the primacy and recency effects for the semantic lists are more pronounced, both list-types produced typical SPE in terms of the trimesters of associated words.

Figure 4-3 below represents an interaction between attention and serial position, $F(2, 118) = 3.97$, $MSE = 3.97$, $p = .02$. Highest true recall was observed at recency position under full attention ($M = .40$; $SD = .09$). This was higher than at recency under concurrent handwriting conditions ($M = .37$; $SD = .08$), $t(119) = 2.02$, $SEM = .02$, $p = .045$, and higher than all other conditions, all p's $< .001$. Conversely, the lowest level of false recall was observed at middle trimester under concurrent handwriting ($M = .19$; $SD = .07$). This was reliably lower than for middle position under full attention ($M = .24$; $SD = .08$), $t(119) = 3.88$, $SEM = .01$, $p < .001$, and for all other conditions, all p's $< .001$.

It is of interest to the present discussion of SPE to consider whether the attention/serial position interaction was due to concurrent handwriting differentially impacting true recall SPE for semantic and phonological list-types. It appears from Figure 4-3 that true recall for the first two trimesters, which are more representative of the pre-recency list region, was reduced to a greater extent than at recency trimester, a pattern that has been observed using unrelated word-lists under divided attention learning (e.g., Richardson & Baddeley, 1975). In order to determine whether differences in true recall were greater for the earlier two trimesters than for the recency trimester, difference scores between full and divided attention were calculated and compared. The only significant comparison was the decline in true recall for primacy trimester (*M* = .08; *SD* = .12) compared to recency trimester (*M* = .03; *SD* = .10), $t(59) = 22.75$, *SEM* = .02, $p = .006$. This is consistent with previous research suggesting that earlier list items are more sensitive to manipulations that impact rehearsal during study (Glanzer, 1972; Richardson & Baddeley, 1975).

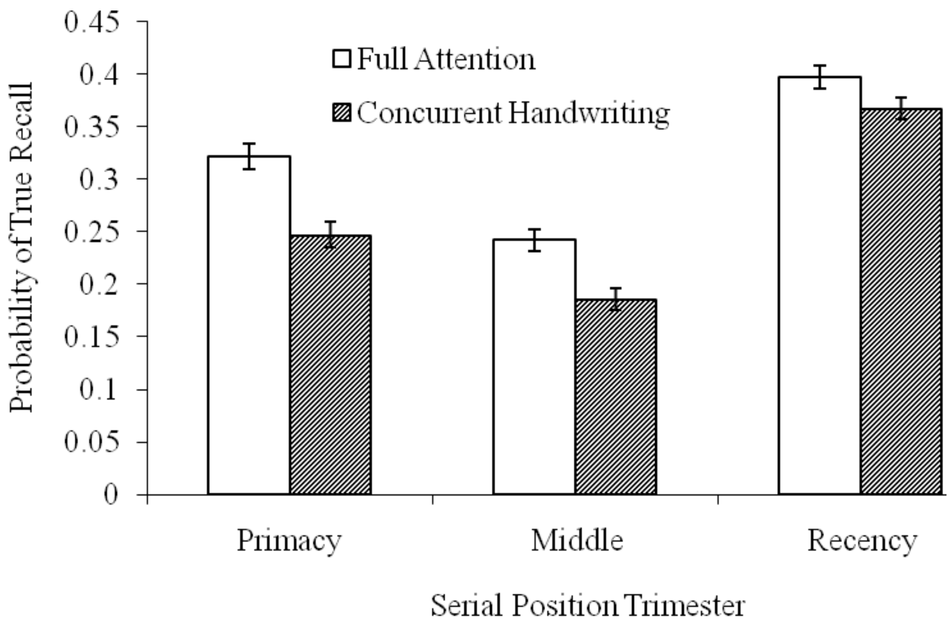

Figure 4-3. True recall as a function of attention condition and serial position trimester. Error bars represent standard error of the mean.

Figure 4-3 also illustrates that concurrent handwriting was successful at reducing true recall for each serial position trimester regardless of the fact that these reductions were not uniform. True recall at primacy trimester fell from full attention (*M* = .32; *SD* = .10) to concurrent handwriting (*M* = .25; *SD* = .09) conditions, *t*(118) = 4.33, *SEM* = .02, *p* < .001, at middle serial position true recall fell from full attention (*M* = .24; *SD* = .08) to concurrent handwriting (*M* = .19; *SD* = .07), *t*(119) = 3.88, *SEM* = .01, *p* < .001, and at recency from full attention (*M* = .40; *SD* = .09) to concurrent task conditions (*M* = .37; *SD* = .08), *t*(119) = 2.02, *SEM* = .02, *p* = .045.

Finally, the observed main effect of serial position trimester, *F*(2, 118) = 230.97, *MSE* = 1.72, *p* < .001, is evident in Figure 4-3, which represents typical true recall SPE across list-types. Collapsed across list-types, the primacy advantage (*M* = .25; *SD* = .09) over middle serial position trimester (*M* = .19; *SD* = .07) was significant, *t*(59) = 7.38, *SEM* = .01, *p* < .001. The recency advantage (*M* = .37; *SD* = .08) over middle position trimester was significant, *t*(59) = 18.19, *SEM* = .01, *p* < .001. Recency trimester was higher than primacy, *t*(59) = 10.25, *SEM* = .01, *p* < .001.

False recall analyses

In order to assess the impact of divided attention on false recall, a 2 × 2 × 3 mixed factor ANOVA was conducted including the between subjects factor of attention (full attention; concurrent handwriting) and the two within-subjects factors of position (primacy/middle/recency) and list-type (phonological/semantic).

The three-way interaction among list-type, position and attention was significant, *F*(2, 118) = 6.61, *MSE* = 0.15, *p* = .002, (see Figure 4-4). The most outstanding features of Figure 4-4 are the apparently higher levels of false recall for the semantically associated lists at primacy trimester and for the phonologically associated lists at recency trimester. For semantically associated lists, reliably more false recall was observed at primacy position under divided attention (*M* = .25; *SD* = .23), than under full attention in Experiment 2 (*M* = .17; *SD* = .23), *t*(118) = 2.11, *SEM* = .04, *p* = .054. The increased phonological false recall at recency position under divided attention (*M* = .25; *SD* = .21) compared to full attention (*M* = .18; *SD* = .17) was also significant, $t(118) = 1.99$, $SEM = .03$, $p = .049$. These results are suggestive of differences in coding as a function of serial position with greater sensitivity to semantic coding observed for primacy trimester and for phonological coding at recency trimester. Increased false recall under divided attention is consistent with some previous research (Dewhurst et al., 2007; Peréz-Mata et al., 2002). Both list-types interacted with serial position to produce higher levels of associated false recall in the divided attention condition, but at opposite ends of the serial position curve.

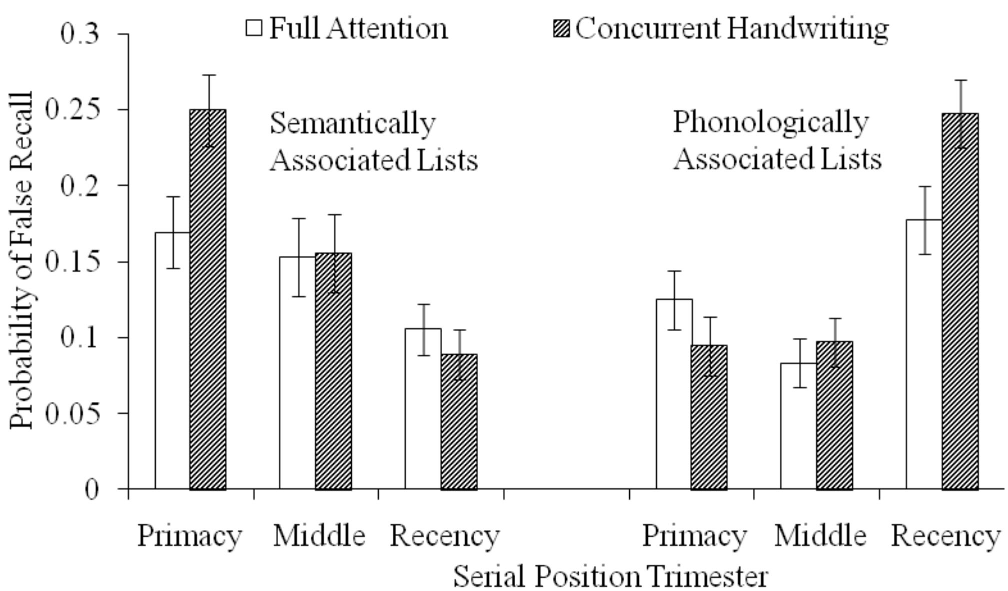

Figure 4-4. False recall as a function of attention condition, list-type and serial position trimester. Error bars represent standard error of the mean.

The ANOVA also produced a list-type × position interaction, $F(2, 118) = 35.44$, $MSE = 0.80$, $p < .001$ for false recall, further substantiating the finding of distinct SPE for semantic and phonological false recall. Across attention conditions, semantically associated lists produced false recall that declined from primacy ($M = .21$; $SD = .21$) to middle ($M = .15$; $SD = .18$), $t(119)$

= 2.66, *SEM* < .02, *p* = .009, and from middle to recency (*M* = .10; *SD* = .13) positions, *t*(119) = 3.69, *SEM* < .02, *p* = .001. Conversely, the phonologically associated list-type produced a distinct pattern of false SPE. False recall was higher for recency serial position trimester (*M* = .21; *SD* = .19) than for middle (*M* = .09; *SD* = .13), *t*(119) = 5.97, *SEM* = .02, *p* < .001, and higher for recency than for primacy (*M* = .11; *SD* = .14) , *t*(119) = 4.79, *SEM* < .02, *p* < .001. It is also notable in the right panel of Figure 4-4 that the phonological false primacy effect observed in Experiments 2 and 3 was not observed under Experiment 4 divided attention conditions. This suggests that dividing attention may remove the primacy but not the recency aspect of phonological false recall SPE. Differential sensitivity to divided attention for the two aspects of phonological false recall SPE suggests the possibility that they are mediated by different processes.

The main effect of position, *F*(2, 118) = 4.84, *MSE* = 0.10, *p* = .009, was due to greater overall false recall for primacy (*M* = .15; *SD* = .13) than for middle (*M* = .12; *SD* = .11) study position, *t*(119) = 2.75, *SEM* = .01, *p* = .007. This indicates that associated false recall arising from either semantically or phonologically associated list-types combined is more prevalent for primacy compared to middle serial position trimester.

Unpredicted false recall is a dependent measure of importance in interpreting the results because it may be indicative of guessing and therefore may be an indication of response bias. Response bias has been suggested as a mechanism for associated false recall more generally (Dewhurst et al., 2007; Peréz-Mata et al., 2002; Sommers & Lewis, 1999). That is, bias toward accepting potential responses may underlie unpredicted and predicted false recall. It is possible that response bias plays a different role in false recall depending on the type of word association. No change in predicted false recall as a result of divided attention was observed in Experiment 4, however it was still informative to know if dividing attention increased unpredicted false intrusions as it has been suggested it may (Dewhurst et al., 2007; Peréz-Mata et al., 2002). The unpredicted false recall probability for semantically associated lists was non-significantly different between divided (*M* = .51; *SD* = .07) and full attention (*M* = .50; *SD* = .09) conditions, $t(59) = .12$, $SEM = .11$, $p = .90$. The average probability of observing unpredicted false recall for phonologically associated lists under full (*M* = 1.38; *SD* = .15) and divided (*M* = 1.23; *SD* = .17) attention was also non-significantly different, $t(59) = .59$, $SEM = .25$, $p = .56$. Therefore, there is no evidence to suggest that dividing attention increased response bias.

False recall output analyses

As discussed in the general introduction, by definition, output order in free recall cannot be controlled. Some analysis of false recall output position is often undertaken in order to describe free recall output data (e.g., Brainerd et al., 2002; Roediger & McDermott, 1995; Watson et al., 2003) in the event that output characteristics provide clues as to the mechanisms underlying free recall memory. Furthermore, if phonological false recall were a product of a short-term phonological store, then for immediate free recall, phonological false recall may also be outputted relatively earlier than semantic false recall, ostensibly the product of a long-term store that becomes dominant later in recall after the depletion of the short-term store.

As can be seen in Figure 4-5, the output patterns for semantic and phonological false recall are similar to those seen in the previous experiments and replicate output patterns observed in other research also (McDermott, 1996; Watson et al., 2003). There appears to be a slight tendency for false recall to be outputted systematically later, especially for the semantically associated lists. Output functions appear below the straight line that represents random output position of predicted false recall indicating that false recall is outputted less frequently at first. The same order of output functions (i.e., semantic false recall is outputted more systematically late than phonological false recall) is present in each Experiment here and in previous research also (McDermott & Watson, 2001). Despite there being no inferential statistical test associated with this description of output position, together, the findings suggest different relative output positions for the two types of false recall.

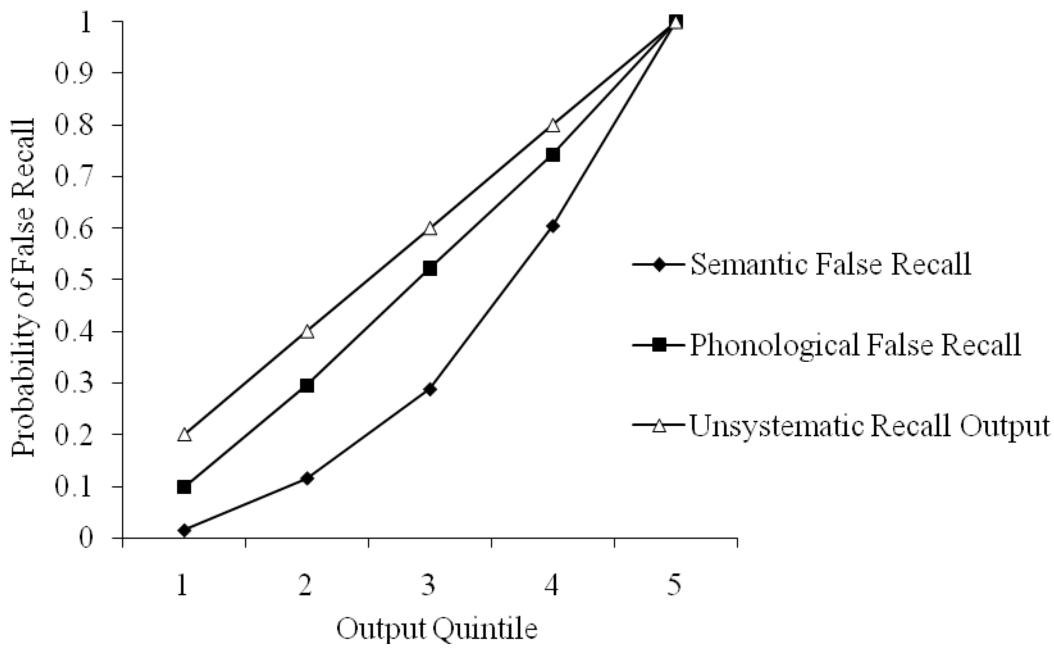

Figure 4-5. False recall as a function of output quintile.

In order to examine the hypothesis that phonological false recall, like true recall arising at recency serial positions (Deese & Kaufman, 1957), may be outputted at earlier recall positions, further analysis of the relative output positions of semantic and phonological false recall was undertaken as in Experiments 2 and 3 above. Critical false items for the semantically associated lists were outputted at an average position of 7.21 of a total average of 9.09 items outputted, or approximately 71% of the way through total output. For the phonologically associated lists, the average output position was 4.20 of an average total output of 6.39 words, or 59% of the way through output. Of the 60 participants, 47 provided samples of both semantic and phonological false recall for analysis. The output positions of these samples were averaged for each participant. A paired sample t-test of the ratios of critical output to total output for semantically (M = .71, SD = .03) compared to phonologically (M = .59, SD = .03) associated false recall was significant, $t(46) = -3.00$, SEM = .04, p = .004, consistent with the hypothesis that phonological false recall was strategically offloaded from a short-term store earlier than long-term semantic false recall. For Experiments 2 and 4, which involved immediate free recall, phonological false recall was outputted relatively earlier than semantic false recall. However, under delayed recall conditions in Experiment 3, in which the short-term store would presumably be depleted and hence be of no strategic benefit, differences in output position for the two list-types were non-significant. These statistical comparisons must be tempered by the fact that they are based on a selected sample of data.

Conclusions

Evidence for distinct patterns of semantic and phonological false recall SPE was obtained in Experiment 4, and this evidence bore some consistency with a dual store mechanism of false recall. An interaction of list-type with position was replicated in Experiment 4 such that semantic and phonological false recall presented with entirely different patterns of SPE (see Figure 4-4), and this was regardless of the difference in demand on attention during study. The fact that dividing attention did not produce a reduction in semantic false recall, whereas veridical recall did decline, is consistent with view that DRM false recall is largely automatically generated regardless of changes in attention demands at encoding, and is therefore distinct from true recall (e.g., Brainerd, Payne et al., 2003; Seamon et al., 2003). In the present paradigm, where lists are blocked into trimesters of associated words, *increased* semantic false recall was detected under divided attention at primacy serial position trimester. Contrary to previous research no evidence was found to suggest that this increase was due to response bias (Dewhurst et al., 2007). Phonological false recall showed some signs of being a stable product of an automatically activated phonological store insofar as there was no main effect of attention on this variable. However, an interaction occurred such that at recency trimester, phonological false recall was increased under divided attention learning conditions. This is consistent with the notion that a short-term phonological store exists which is subject to phonological interference.

Dividing attention during study did not reduce semantic false memory as has previously been observed (Seamon et al., 1998). It is possible that the secondary task type used in Experiment 4 did not specifically interrupt the cognitive resources that support semantic false recall to a large enough extent to produce reductions. Alternately, there may be differences specific to tasks used to divide attention (Seamon et al., 2003). In order to disambiguate alternative explanations of divided attention and false recall, a final experiment was devised that specifically divided verbal resources during list study. A purely verbal and non-graphemic secondary task may increase attention demands that are specific to forming long-term semantic associations and also to short-term store resources. True and false recall may occur at similar levels to Experiment 4 or may either decrease or increase. Any outcome is informative to the thorny question of whether and how divided attention impacts false recall. Stability of false recall would suggest automatic processing; decreases or increases may suggest a role for either interference or activation respectively. It was also possible that response bias, as measured by unpredicted false recall, may increase under higher attention demand. Similar patterns of false recall SPE for Experiments 4 and 5 would provide good evidence that dividing attention generally has a similar impact on false recall, whereas diverging patterns would indicate a need for further research into secondary task type and false recall.

Experiment 5

Research on the impact of divided attention on associated false recall has met with mixed results (see Experiment 4 Introduction above). The concurrent handwriting task used above in Experiment 4 used to divide attention was successful in lowering true recall compared to the full attention conditions of Experiment 2. However, semantic false intrusions, rather than declining as if activation of predicted false intrusions had been impeded (see Dewhurst et al., 2007; Seamon et al., 1998), increased. Heading into Experiment 4 it was thought that the discrepancies in research indicating either stable or increased semantic false recall under divided attention (e.g., Peréz-Mata et al., 2002) may be due to response bias as measured by unpredicted false intrusions. Experiment 4 provided no evidence that attention demand changed unpredicted false intrusion rates, and still there was no main effect of divided attention on semantic false recall. Research that employs concurrent task designs often manipulates the concurrent task in order to draw inferences about the relative independence of underlying cognitive processes, such as for phonological and spatial processes (e.g., Baddeley, 2000). Perhaps the handwriting task used in Experiment 4 engaged a greater level of spatial processing due to the letter/number strings being visible as they were repeatedly being written down. This may have created less interference with verbal processing than a verbal secondary memory task would have. The handwriting task may have interfered with the memory task rather than reducing activation of false recall.

If true recall and false recall are typical products of the same memory system, both should show signs of being similarly impacted by the same experimental manipulations. This hypothesis was not supported by Experiment 4 data, which indicated a decline in true recall but a qualified increase in false recall. Rather than activation of semantic false recall showing evidence of being reduced by divided attention, it was increased at primacy position. Phonological false recall increased under divided attention at recency, rather than being stable as an automatic activation account would predict, or decreasing, as an activation account would predict. Regardless of the reasons as to why false recall increased under divided attention, the issue of divided attention and false recall has been little studied, and what data exist provide a mixed picture as discussed above in the introduction to Experiment 4.

A possible reason for the discrepant findings on divided attention and associated false recall is due to the secondary tasks used. Experiment 5 was designed to provide data relevant to the issue of divided attention and false recall generally and more specifically to divided attention and secondary task type (Dewhurst et al., 2007). Dewhurst and colleagues (2007) also found increased false recall under divided attention learning conditions. These authors reasoned that the reduction in opportunity for semantic elaboration created by divided attention, and therefore decreased activation of the predicted false items, would reduce semantic false recall. Dewhurst et al. suggested that their finding of higher false semantic memory under divided attention may have been due to more liberal response bias under more difficult learning conditions. This view is based on the fact that unpredicted false recall, which is indicative of random error, rose along with predicted false intrusions under divided attention in their research. Unlike Dewhurst et al.'s method, the present methodology provided clear instructions about guessing.

A straightforward replication of Experiment 4 using an explicitly verbal task stood to solidify the finding that increases in both semantic and phonological false recall under divided attention occur, but at opposite ends of the serial position curve. Furthermore, the issue of how false memory is impacted by dividing attention would be given some relevant data for consideration. Articulatory suppression was expected to be a more difficult task than concurrent handwriting and therefore should reduce true recall compared to Experiment 4. The interesting thing to determine was whether this more difficult verbal task would increase or decrease false recall. If a more verbally demanding task reduced true and false recall, it would suggest the possibility that reduced encoding was a common factor for both dependent measures. However, if articulatory suppression reduced true recall and increased false recall, then opposite mechanisms would be suggested. Therefore in order to further address the issue of divided attention and associated false recall, another divided attention experiment was devised which ensured the specific occupation of verbal resources in particular in the event that verbal demanding tasks differ from handwriting secondary tasks in how they impact false recall.

Method

The method for Experiment 5 was matched to the previous Experiments for the purpose of making meaningful cross Experiment comparisons. The only difference between the method for Experiment 5 and the previous three Experiments was the type of concurrent task used to divide attention. Rather than the handwriting task used in Experiment 4, an articulatory suppression task was implemented similar to that used by Richardson and Baddeley (1975). Comparisons of Experiments 4 and 5 provided an opportunity to examine differences in how the type of secondary task impacts the production of both semantic and phonological false recall.

Participants

Experiment 5 involved 60 university undergraduate student recruits from the University of Saskatchewan participant pool. There were 41 females and 19 males, the average age was 20.09 (*SD* = 1.8). Two participants reported English as their second language and none reported knowledge of the experimental paradigm. None of the participants opted out of the Experiment.

Stimuli and design

The only changes to Experiment 5 compared to the Experiment 4 concerned the method by which attention was divided during study. Rather than participants repeatedly writing down the letter/number strings, they were required to retain letter/number strings in memory through repeatedly whispering the string based on methodological considerations described by Jones et al. (2004).

Procedure

Experiment 5 participants whispered the same mixed letter-number strings presented in Experiment 4 (see Appendix C) during list presentation. Prior to the list being read, participants were briefly shown a card with the mixed letter-number string printed on it, which they were asked to read out loud. They were instructed to continue reciting the string in a whisper while listening to the word-list being read by the experimenter. It was explained that the Experiment intended to capture conditions of learning under distraction. Participants were asked to whisper at a comfortable steady pace throughout the reading of the list using the timing of the experimenter's list reading to help keep a steady pace of rehearsal. Upon hearing the experimenter's instruction to begin recall, participants were asked to immediately stop whispering and to recall as many words as possible. It was suggested that they may be asked to recall the letter/number string. If participants became too silent during the list reading they were reminded to continue whispering throughout list presentation. Where compliance appeared to be a possible issue, participants were asked if they could still remember the string after list recall. This was to encourage people to continue rehearsing the string throughout the study phase.

Results and Discussion

True recall analyses

The true recall serial position curves observed are characteristic of what would be expected for unrelated word-lists and are similar those described in Experiment 2 (e.g., see Figure 2-1). As in the previous Experiments above, true recall data were analyzed in terms of trimesters of associated words prior to examining the false recall data. Data for both true and false recall were entered into two ANOVAs, one comparing full attention conditions of Experiment 2 with the articulatory suppression conditions of Experiment 5, and one comparing Experiment 4 concurrent handwriting condition with Experiment 5 articulatory suppression condition. Analyses were based on a 2 × 2 × 3 mixed factor ANOVA similar to those described in the previous three Experiments.

The first analyses compared true recall for Experiments 2 and 5. As in Experiment 4 the analyses produced a significant interaction between list-type and the between-subjects factor of attention condition, $F(1, 118) = 3.58$, $MSE = .02$, $p = .002$. A typical main effect of list-type was observed such that true recall was lower for the phonological lists ($M = .19$; $SD = .07$) compared to the semantically associated lists ($M = .34$; $SD = .11$), $F(2, 118) = 607.75$, $MSE = 3.95$, $p < .001$. For the semantic lists, true recall under articulatory suppression was significantly lower ($M = .27$; $SD = .07$) than under full attention ($M = .41$; $SD = .10$), $t(118) = 8.49$, $SED = .02$, $p = .01$. Also for the phonological lists true recall was reduced ($M = .16$; $SD = .05$) compared to full attention ($M = .23$; $SD = .06$), $t(118) = 7.12$, $SED = .01$, $p = .032$. However, the interaction indicates that the decline in true recall was greater for the semantic lists. This is consistent with the idea of a rehearsal dependent semantic store and a rehearsal independent phonological store (see Baddely, 1977; Glanzer, 1972 for discussions).

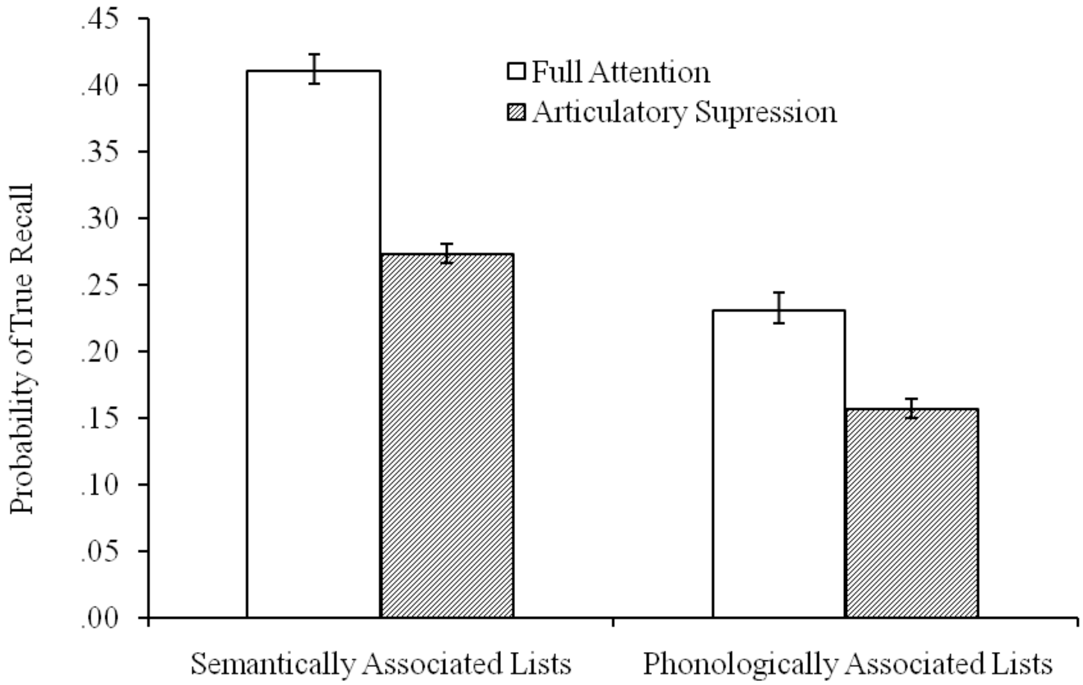

Figure 5-1. True recall as a function of divided attention condition and list-type. Error bars represent standard error of the mean.

A main effect of reduced true recall from full (*M* = .32; *SD* = .08) to divided attention (*M* = .21; *SD* = .06), *F*(1, 118) = 75.12, *MSE* = 2.03, *p* < .001, was qualified by a significant interaction with serial position, *F*(2, 118) = 3.58, *MSE* = .02, *p* = .029 (see Figure 5-2). As is evident in Figure 5-2, the highest true recall was observed at recency position under full attention (*M* = .40; *SD* = .09), higher than at primacy under full attention (*M* = .32; *SD* = .10), *t*(59) = 5.85, *SEM* = .11, *p* < .001), and all other conditions, all *p*'s < .001. Conversely, particularly low recall was observed at middle position under divided attention (*M* = .16; *SD* = .07), lower than all other conditions, all *p*'s < .001

The serial position/attention interaction also indicates the possibility that the influence of the experimental manipulation was not uniform across serial positions compared to Experiment 2 full attention condition. In order to assess this further, difference scores were calculated by subtracting full from divided attention scores. The decline in true recall at primacy serial position trimester (M = .18; SD = .11) was greater than the decline at middle (M = .13; SD = .10), $t(119)$ = 3.37, SED < .01, p < .001, and the decline at recency trimester (M = .17; SD = .10) was also greater than at middle, $t(119)$ = 2.95, SED < .01, p = .004. For whatever reason, middle study trimester appears less prone to true recall reduction under divided attention than primacy or recency.

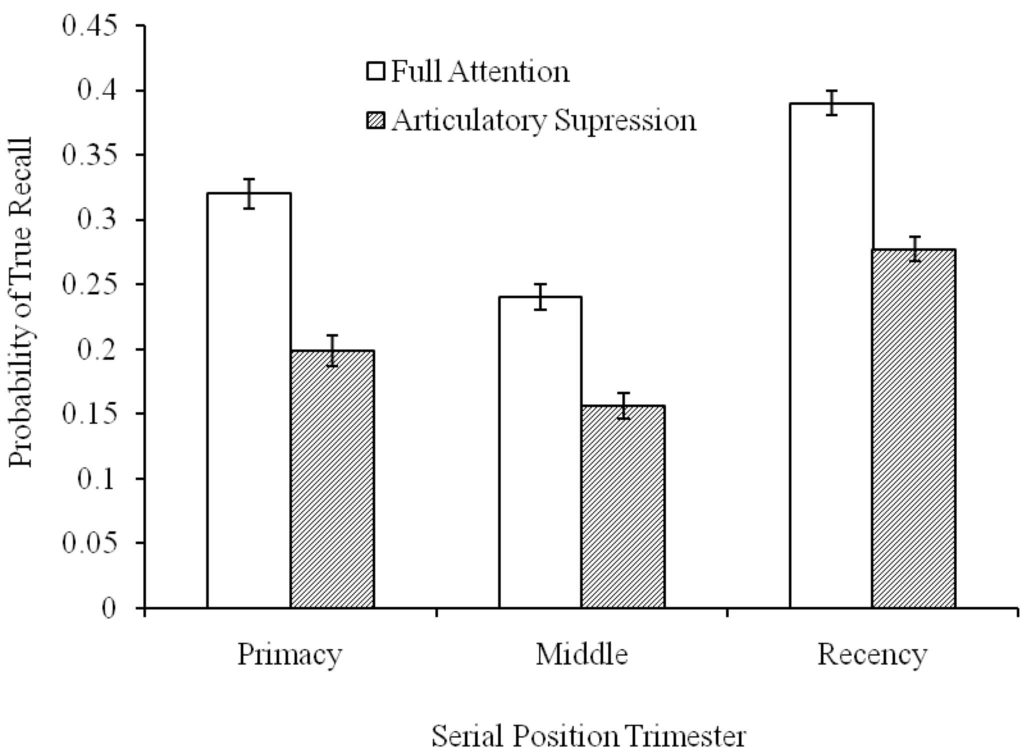

Figure 5-2. True recall as a function of attention condition and serial position trimester. Error bars represent standard error of the mean.

Figure 5-2 further depicts a significant main effect whereby true recall declined under divided attention. Compared to the full attention conditions of Experiment 2, true recall under articulatory suppression at primacy trimester (*M* = .20; *SD* = .08) was significantly reduced compared to full attention (*M* = .32; *SD* = .10), $t(118) = 7.12$, *SED* = .02, $p < .001$. At middle trimester the articulatory suppression condition produced less true recall (*M* = .24; *SD* = .08) than under full attention (*M* = .15; *SD* = .07), $t(118) = 5.95$, *SED* = .01, $p < .001$. Similarly at recency, true recall under divided attention was significantly lower (*M* = .40; *SEM* = .09) than under full attention (*M* = .28; *SEM* = .07), $t(118) = 8.30$, *SED* = .01, $p < .001$. Articulatory suppression succeeded in reducing true recall for each serial position for both list-types. As in Experiment 4, semantic lists at middle trimester (*M* = .24; *SD* = .07) produced a non-significantly different probability of true recall than the phonological lists at recency (*M* = .26; *SD* = .04), which explains part of the interaction between serial position and attention.

Finally concerning Figure 5-2, a main effect of serial position was a result of the typical pattern of true recall SPE across list-types under divided attention. For the articulatory suppression condition, primacy trimester produced more true recall (*M* = .20; *SD* = .10) than middle (*M* = .16; *SD* = .08), $t(59) = 7.38$, *SEM* = .01, $p < .001$. Recency trimester (*M* = .28; *SD* = .09) produced more true recall than middle, $t(59) = 14.23$, *SEM* = .01, $p < .001$, and recency more than primacy, $t(59) = 5.85$, *SEM* = .02, $p < .001$.

It was also of interest to know whether using articulatory suppression to divide attention impacted true recall differently than the concurrent handwriting task used in Experiment 4. In order to address this question, a mixed factor 2 × 2 × 3 ANOVA of Experiment 4 and 5 data was conducted. A significant three-way interaction was produced, $F(1, 59) = 3.47$, *MSE* = .01, $p = .033$ (see Figure 5-3). There was reliably more true recall under concurrent handwriting conditions at recency position for the semantically associated lists (*M* = .45; *SD* = .45) than true recall under articulatory suppression at recency for the semantically associated list (*M* = .33; *SD* = .09), *t*(118) = 6.80, *SEM* = .02, *p* = .004, and all other conditions, all *p*'s < .001. Conversely, the lowest experiment-wise true recall levels were observed at middle position for the phonologically associated lists under articulatory suppression (*M* = .10; *SD* = .06), where recall was lower than under articulatory suppression at primacy and all other values depicted in Figure 5-3, all *p*'s < .001.

It also appears in the patterns of SPE that there are greater losses in true recall as a result of articulatory suppression at recency trimester. Difference scores were calculated between concurrent handwriting and articulatory suppression data at each serial position trimester. For the phonologically associated lists, none of the comparisons were significant. However, for the semantic lists, there was significantly greater reduction in true recall at recency, than at both middle and primacy. This is a surprising pattern of results given that the earlier two trimesters are more representative of pre-recency, a region typically more sensitive to attention demand at encoding than recency region (Glanzer, 1972).

Comparing the left and right panels of Figure 5-3 a main effect of list-type is clearly evident. True recall for the semantically associated lists is generally higher (*M* = .31; *SD* = .08) than for the phonologically associated lists (*M* = .18; *SD* = .06), *F*(1, 118) = 721.10, *MSE* = 3.01, *p* < .001. Further evident in Figure 5- 3, comparing the white and shaded bars, is the main effect produced by the method of dividing attention. Articulatory suppression produced less true recall (*M* = .21; *SD* = .06) than concurrent handwriting (*M* = .27; *SD* = .07), *F*(1, 118) = 21.33, *MSE* = 0.48, *p* < .001.

Typical SPE for both list-types were produced. For the phonologically associated lists in Experiment 5, true recall was elevated at primacy (*M* = .17; *SD* = .09) in comparison to middle (*M* = .13; *SD* = .08), *t*(59) = 3.15, *SEM* = .01, *p* = .003, and at recency (*M* = .28; *SD* = .08) compared to middle, *t*(59) = 10.80, *SEM* = .01, *p* < .001, and with the recency serial position trimester producing more true recall than primacy, *t*(59) = 7.17, *SEM* = .01, *p* < .001. A similar pattern was observed for the semantically associated materials in Experiment 5. Primacy produced more true recall (*M* = .27; *SD* = .11) than middle (*M* = .21; *SD* = .09), *t*(59) = 4.05, *SEM* = .01, *p* < .001, recency (*M* = .34; *SD* = .09) more than middle, *t*(59) = 9.24, *SEM* = .01, *p* < .001, and recency more than primacy, *t*(59) = 4.77, *SEM* = .01, *p* < .001.

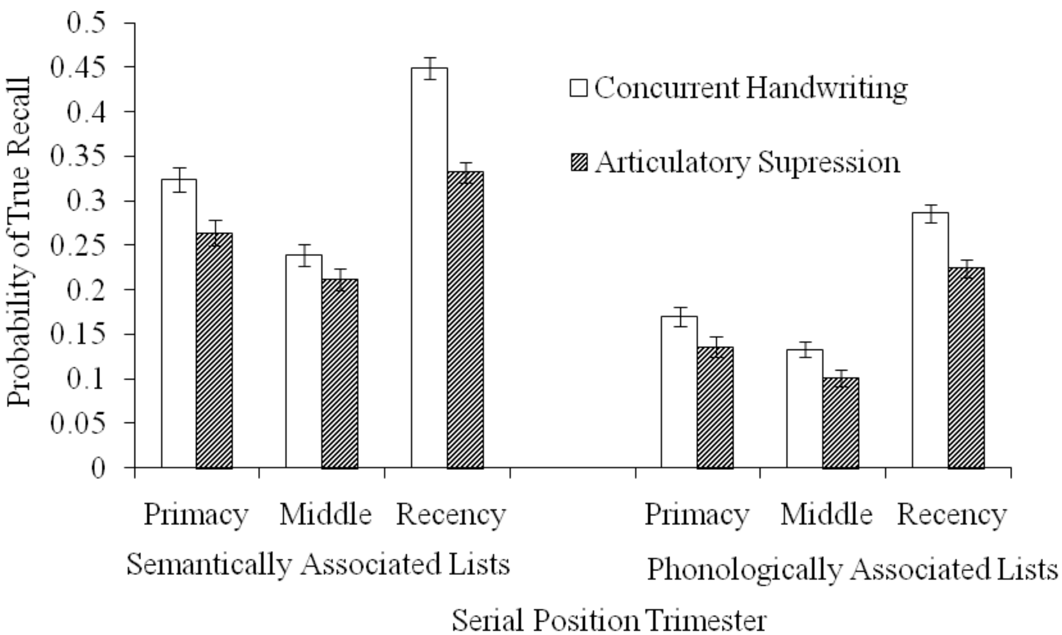

Figure 5-3. True recall as function of serial position trimester, divided attention condition, and list-type. Error bars represent standard error of the mean.

Both secondary tasks used to divide attention produced relatively similar patterns of true recall SPE and furthermore articulatory suppression reduced true recall in comparison to concurrent handwriting. If increased false recall is caused by increased demand on attention at encoding, and this increased demand is measured by reduced true recall, then increased false recall would be expected in Experiment 5 compared to Experiment 4.

False recall analyses

The false recall analyses involve two 2 × 2 × 3 mixed factor ANOVAs parallel to those conduced above for true recall. The first ANOVA compares Experiment 2 data collected under full attention study conditions with Experiment 5 articulatory suppression conditions. The second ANOVA compares Experiment 4 concurrent handwriting with Experiment 5 where articulatory suppression was used to divide attention.

The analyses of Experiments 2 and 5 data produced a main effect of position, $F(2, 118) = 4.96$, $MSE = 0.11$, $p = .008$, that was qualified by an interaction with list-type, $F(2, 118) = 17.52$, $MSE = 0.35$, $p < .001$ (see Figure 5-4). This interaction represents the same distinct patterns of semantic and phonological false recall SPE seen throughout the previous Experiments. Semantic false recall declined from primacy ($M = .17$; $SD = .18$) to recency ($M = .11$; $SD = .13$), $t(59) = 2.68$, $SEM = .02$, $p = .009$. For the phonologically associated lists the pattern of false recall was similar to that of true recall with higher levels observed at primacy ($M = .13$; $SD = .15$) than middle position ($M = .08$; $SD = .12$), $t(59) = 2.14$, $SEM = .02$, $p = .037$, and at recency ($M = .18$; $SD = .17$) than middle, $t(59) = 3.29$, $SEM = .03$, $p = .002$. Articulatory suppression during list study did not produce a main effect on false recall, and neither did it produce a similar three-way interaction of the factors that the concurrent handwriting task did in Experiment 4. This adds to previous null findings on the impact of divided attention on semantic false recall (Seamon et al., 2003) and furthermore extends this null result to phonological false recall.

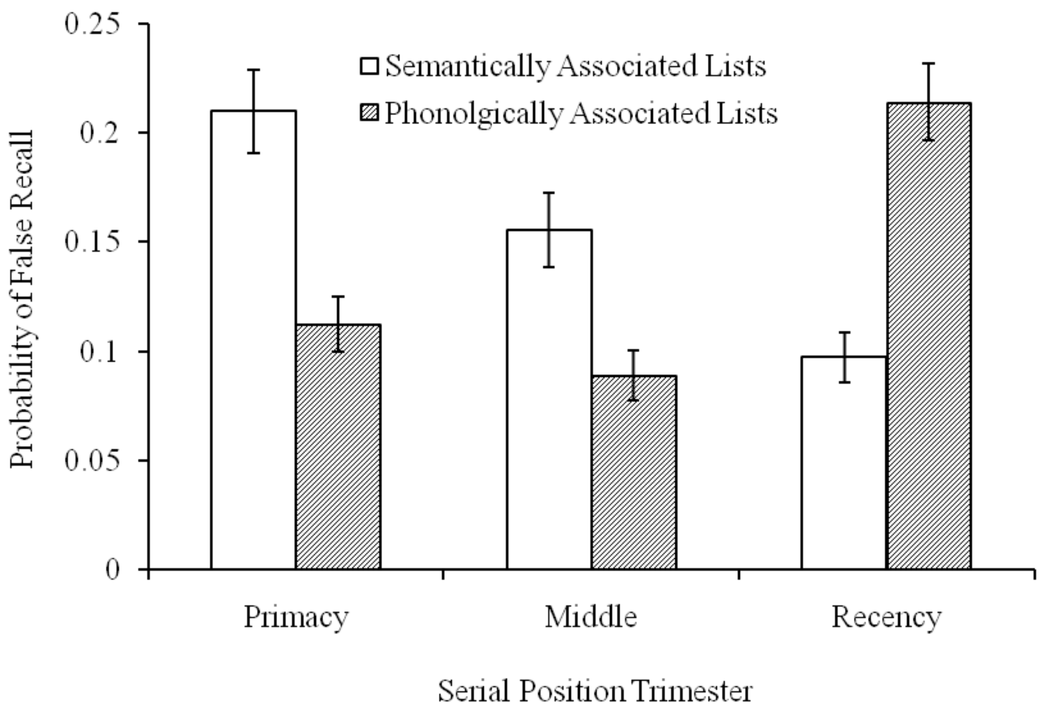

Figure 5-4. False recall as a function of serial position trimester and list-type. No interaction between full attention and concurrent handwriting conditions was observed. Error bars represent standard error of the mean.

A second ANOVA of false recall probabilities comparing concurrent handwriting to articulatory suppression reproduced a similar main effect of position qualified by its interaction with list-type observed in the previous analysis (see Figure 5-5). The analysis also produced a main effect of attention condition such that articulatory suppression reduced overall false recall in comparison to concurrent handwriting.

The main effect of position again indicates that across list-type and attention conditions, greater false recall was observed for primacy (M = .15; SD = .14) and recency (M = .16; SD = .12) trimesters than for middle (M = .11; SD = .10), $t(119) = 3.87$, SEM = .01, $p < .001$, and *t*(119) = 4.58, *SEM* = .01, $p < .001$, respectively. Evident in Figure 5-5 are the distinct patterns of phonological and semantic false recall SPE indicated by the interaction of serial position with list-type (see Figure 5-5). These data are independent of Experiment 2 data and produced similar patterns of false recall SPE. For semantically associated lists, false recall was higher for primacy trimester (*M* = .22; *SD* = .22) than middle (*M* = .13; *SD* = .15), *t*(119) = 4.24, *SEM* = .02, $p < .001$, and higher for middle than for recency (*M* = .08; *SD* = .12), *t*(119) = 3.18, *SEM* = .02, $p = .002$. For the phonologically associated lists false recall for primacy and middle trimesters did not differ reliably, however recency produced significantly more false recall (*M* = .23; *SD* = .19) than either primacy (*M* = .09; *SD* = .12), *t*(119) = 7.04, *SEM* = .02, or middle trimester (*M* = .08; *SD* = .12), *t*(119) = 8.19, *SEM* = .02. This is precisely the pattern of results that would be expected if phonological false recall was produced by a short-term phonological store mechanism. Furthermore concerning Figure 5-5, the fact that no evidence of a phonological false recall primacy effect was found suggests that this effect may be independent from the phonological false recall recency effect.

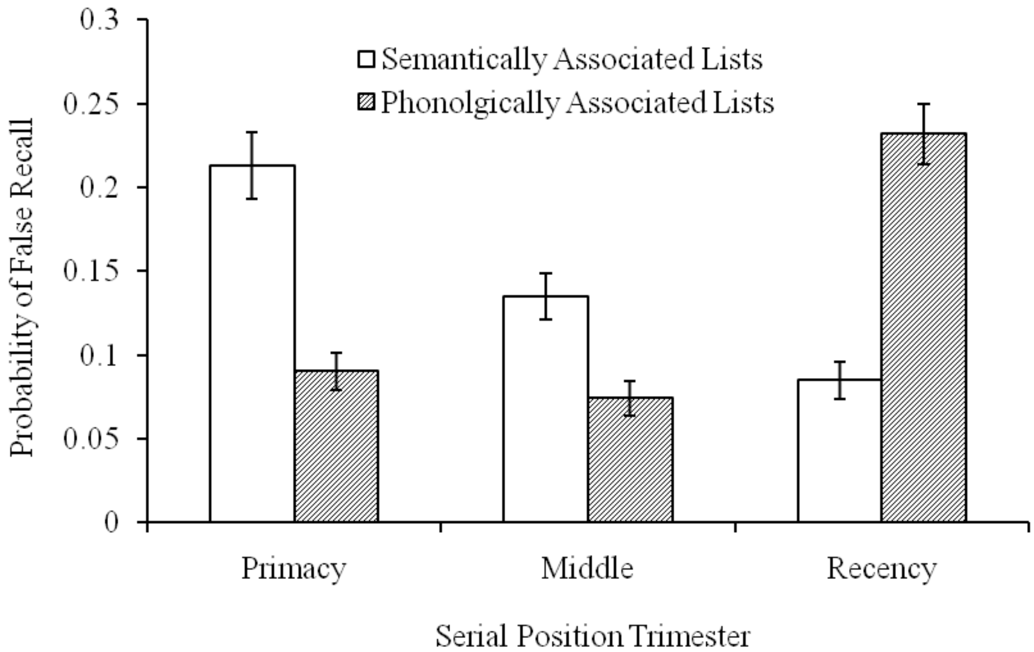

Figure 5-5. False recall as a function of list-type and serial position trimester. No interaction between full attention and articulatory suppression conditions was observed. Error bars represent standard error of the mean.

The between-subjects factor of secondary task produced a main effect whereby articulatory suppression produced less false recall (*M* = .12; *SD* = .08) than concurrent handwriting (*M* = .16; *SD* = .10), *F*(1, 118) = 4.27, *MSE* = .21, *p* = .041. The fact that no interaction with list-type or position was detected provides no evidence that articulatory suppression influenced false recall systematically for any of the factorial conditions. The results indicate that for Experiment 2 the total predicted false recall for both list-types (*M* = .14; *SD* = .07) was not significantly different than for either concurrent handwriting (*M* = .16; *SD* = .10) or articulatory suppression conditions (*M* = .12; *SD* = .08).

False recall output analyses

The output positions relative to total output of the two forms of false recall produced the same pattern observed in the previous Experiments and in previous research (McDermott & Watson, 2001). There is no statistical test associated with this type of analysis; however there is remarkable consistency in the pattern of results obtained throughout this thesis and in comparable previous research (McDermott, 1996; Watson et al., 2003). Semantic false recall appears to be outputted later than phonological false recall, which is in turn later than an unsystematic pattern would indicate Rather than false recall being evenly dispersed throughout response output; earlier output quintiles contained less false recall than chance.

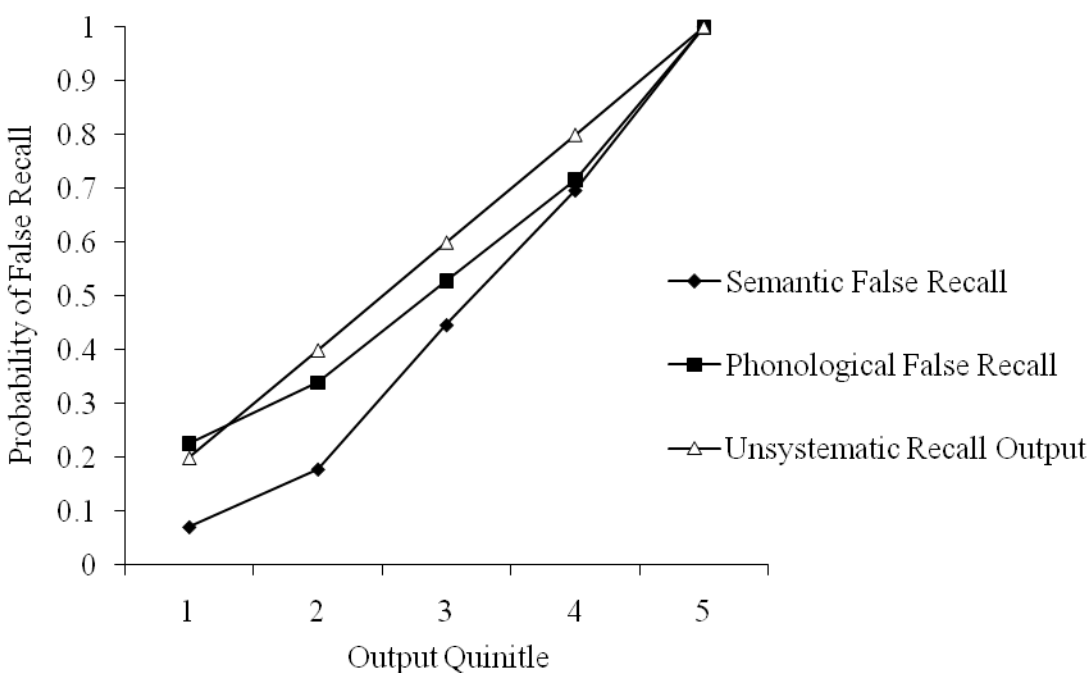

Figure 5-6. False recall as a function of output quintile.

Critical false items for the semantically associated lists were outputted at an average position of 5.83 of a total average of 7.68 items, or approximately 64% of the way through output. For the phonologically associated lists, the average output position was 3.43 of an average total output of 5.45 words, or 59% of the way through output. Of the 60 participants, 41 provided samples of both semantic and phonological false recall for within-subjects comparative analysis. The false recall output positions were averaged for each participant for both list-types. A paired sample *t*-test of the ratios of critical output to total output for semantic (*M* = .66, *SD* = .19) compared to phonological (*M* = .61, *SD* = .22) false recall was not significant. Therefore, Experiment 5 did not produce evidence that the two forms of false recall are outputted at different stages. This is contrary to Experiments 2 and 4 where immediate free recall conditions produced earlier output for phonological compared to semantic false recall. The power (Campbell & Thompson, 2002) to detect differences in output position in Experiment 5 was low at .16.

Finally, unpredicted false recall levels as a function of two divided attention conditions were addressed in order to look for evidence that response bias may have driven differences in false recall levels between Experiments 4 and 5 (see Dewhurst et al., 2007 for a discussion). The average probability of observing unpredicted false recall for either list-type in Experiment 4 (*M* = .86; *SD* = .96) and Experiment 5 (*M* = 1.03; *SD* = .69) was non-significantly different. The statistical power (Campbell & Thompson, 2002) to detect differences was low at .18.

Conclusions

As in the Experiments leading to Experiment 5, semantic and phonological false recall presented with distinct patterns of SPE. The patterns of false recall SPE were consistent with a short-term phonological/long-term semantic store mechanism of false recall SPE. Higher levels of semantic false recall were produced by the earlier two serial position trimesters, which in the present experimental paradigm are most representative of the long-term pre-recency list region.

Conversely, phonological false recall peaked at recency. Finally for Experiment 4, some evidence was obtained suggesting that phonological false recall was outputted earlier than semantic false recall as if it were outputted from a short-term store, however this did not replicate in Experiment 5.

The above investigation of false recall SPE and divided attention yielded results that are largely consistent with previous research in so far as false recall is stable or increases under divided attention (see Dewhurst et al., 2007; Seamon et al., 2003 for discussions). As discussed in the introduction to Chapter 4, research on divided attention and associated false recall has tended to find either no difference (Seamon et al., 2003) or increased false recall (Dewhurst et al., 2007; Peréz-Mata et al., 2002). The working hypothesis heading into Chapter 4 was that divided attention may selectively reduce rehearsal-dependent semantic false recall. It was hypothesized that semantic false recall may arise from the same processes that produce long-term true recall and hence would share a parallel sensitivity to divided attention. This did not occur. Rather, dividing attention using either concurrent handwriting nor by articulatory suppression produced no main effect on false recall. Dividing attention using concurrent handwriting produced an interaction with serial position in which higher probabilities of false recall were observed. Increased false recall is more consistent with increased interference than with reduced activation. Dividing attention would presumably reduce activation of related words decreasing activation of associated false recall. Conversely, the finding of increased false recall under the same conditions that produced decreased true recall is more consistent with the view that relatively different operations generally underlie true and false recall (e.g., Brainerd, Yang, Reyna, Howe & Mills, 2008). This may be due to less true recall being available for editing false items (Brainerd et al., 2002; Roediger et al., 2001) however in Experiment 5 true recall was reduced compared to Experiment 4 and false recall declined. Therefore the relationship between true and false memory is not simple. The findings are on the whole quite consistent with findings in the true memory literature that suggest pre-recency list memory is representative of a semantically coded long-term memory whereas recency arises from a short-term phonologically coded store (Glanzer, 1972).

An interesting outcome of Experiments 4 and 5 is that no evidence for a primacy effect was found for phonological false recall as it was in the previous Experiments. This result suggests differences between the primacy and recency aspects of phonological false SPE in so far as divided attention appears to attenuate phonological false recall at primacy and exacerbate it at recency. This is consistent with the view that primacy list region is sensitive to rehearsal and recency region is not.

The false recall output analyses spoke to the finding in true recall memory that recency items are offloaded early suggesting that they are being selectively offloaded from a quickly decaying short-term phonological store (Deese & Kaufman, 1957). It was hypothesized that if phonological false recall were mediated by a short-term store, then it should be offloaded relatively earlier than semantic false recall. Evidence consistent with this was obtained in Experiment 4; however in Experiment 5 the difference in relative output position between the two forms of associated false recall was non-significant.

The combined results of Experiments 4 and 5 provide clear evidence relevant to the issue of the relationship between associated false recall and divided attention during list study. Increased false recall was observed at the primacy serial position trimester for semantic false recall and at the recency trimester for phonological false recall. This three-way interaction is remarkably consistent with the dual store theory of a dual long-term semantic/short-term phonological mechanism underlying the two forms of associated false recall.

CHAPTER 5: GENERAL DISCUSSION

This dissertation began with a discussion of false memory in a broad comprehensive context and then turned to the specific questions of whether associated false recall (Deese, 1959; Sommers & Lewis, 1999) produces SPE, and if false SPE are influenced by whether word association is semantic or phonological. Clear evidence was obtained in each of five Experiments that SPE for associated false recall exist and that the patterns of SPE are distinct depending on the type of word association. Distinct patterns of SPE for semantic and phonological false recall suggest possible differences in underlying mechanisms. This latter possibility is further supported by findings that the two forms of false recall are differentially sensitive to delayed recall and to divided attention. With the exception of Read (1996), no research had been conducted on false recall and serial position. Research on true recall SPE (Glanzer, 1972) indicates that semantically based word-list effects are often associated with pre-recency serial position region and phonologically based effects with recency serial position region. A dual long-term semantic/short-term phonological store explanation of short-term true recall SPE (Atkinson & Shiffrin, 1968; Waugh & Norman, 1965) was used to generate predictions about false recall SPE. Greater semantic false recall (Deese, 1959) was observed in relation to pre-recency list region whereas greater phonological false recall (Sommers & Lewis, 1999) was observed in relation to recency. These findings have implications to current theories and future research which are discussed below.

Activation monitoring theory and false recall SPE

Activation/monitoring theory posits that associated false recall results from automatic spreading activation in a densely interconnected network of associated lexical representations (e.g., Gallo, 2006; Robinson & Roediger, 1997; Seamon, Luo, & Gallo, 1998). Non-studied lexical representations may be incidentally activated and subsequently monitored and reported as having been studied. The theory posits that false representations may be activated any time during study or test and that the degree of activation may or may not reach the level of conscious awareness (Roediger et al., 2001). The incidentally activated false representation may enter intentional rehearsal any time prior to recall and be monitored as a studied item, or it may be retrieved immediately at recall as being a studied item. Lexical representations may be either surface features and/or more general relational properties of the lexical items (Roediger et al., 2001).

With respect to activation/monitoring theory (Roediger et al., 2001) and semantic false recall SPE, the fact that semantic false recall declined with advancing serial position trimester could be explained by activation and/or monitoring processes. The greater elaborative rehearsal afforded by earlier study positions (e.g., Tan & Ward, 2000) may have increased the possibility of activating critical false representations. As study proceeded, and presumably working memory became increasingly occupied, opportunity for elaboration declined. This may have decreased activation of false items for increasingly later serial positions. Alternately, because earlier studied list words may have been interfered with by an accumulation of to-be-remembered list items, this could have impeded accurate monitoring of whether or not list items associated to earlier serial positions were actually studied or not. For immediate free recall, appeal to both activation and monitoring processes could provide plausible accounts of semantic false recall SPE.

Delayed free recall did not produce any detectable changes in semantic false recall, which is consistent with previous research (e.g., McDermott, 1996; Payne et al., 1996; Toglia et al., 1999). This was the case even though true recall at recency was greatly reduced compared to immediate free recall, suggesting that monitoring of recency activations was impaired. If semantic false recall SPE were caused by increased difficulty in monitoring as study proceeded, then it would be expected that a distractor filled delay would create greater interference with source monitoring and drive up false recall at recency. The fact that the pattern of semantic false recall SPE was similar after the delay suggests a relatively stable pattern of activation/monitoring processes relating to false recall across the distractor filled delay. Throughout all five thesis Experiments, phonological false recall presented with a prominent recency effect. The same pattern of phonological false recall SPE was observed for immediate and delayed free recall, however phonological false recall declined after the delay. This decline suggests that activation and monitoring processes are not parallel for semantic and phonological false recall.

Dividing attention during study could be seen as either reducing the potential for activation of semantically associated false items and/or as impeding source monitoring processes. The simultaneous increase in semantic and phonological false recall observed under divided attention in Experiment 4 could not plausibly be attributed to increased activation because cognitive resources were being drawn on for a semantically unrelated task. This increased task demand is reflected in reduced true recall under divided attention. The simultaneous reduction in true recall and increase in false recall under divided attention could both be explained by increased interference in source monitoring under divided attention. Reduced source monitoring capacity under divided attention may have resulted in difficulty monitoring true activations and in difficulty discriminating true from false activations.

Under the concurrent handwriting conditions in Experiment 4, phonological false recall was increased at recency and semantic false recall was increased at primacy. Dividing attention should, if anything, decrease the potential for incidental activation of critical false items.

Therefore, from the perspective of activation/monitoring theory, interference with source monitoring is a more plausible mechanism for increased false recall under divided attention.

Fuzzy-trace theory and false recall SPE

Fuzzy-trace theorists (e.g., Brainerd et al., 2008; Brainerd et al., 2005; Brainerd et al., 2002) refer to the illusory recall of semantically associated words (Deese, 1959) as *phantom recall* because the critical items are often recollected as though they were actual list items (Brainerd, Payne et al., 2003). Fuzzy-trace theory posits that memory involves the formation of two dissociated memory traces that are instantiated in parallel, resilient *gist* traces and less stable *verbatim* traces. Verbatim traces are representations of surface forms and gist traces are representations of patterns, meanings and relations (e.g., Brainerd & Reyna, 2002; Brainerd & Reyna, 2005). The theory posits that available verbatim traces are directly accessed at retrieval, whereas retrieval from gist traces involves memory reconstruction from features that are related to many specific representations. Fuzzy-trace theory also posits an operation called *recollection rejection* (Brainerd, Reyna et al., 2003) in which false items that come to mind during recall may be rejected on the basis of comparison to available verbatim samples. False responses arise from reconstructive gist processes in the absence of enough verbatim memory to offset false acceptance (Brainerd et al., 2001). Fuzzy-trace theory can account for the relatively later output of semantic false recall by positing that later outputted items are the result of slower gist reconstruction processes (e.g., Barnhardt, Choi, Gerkens & Smith, 2006).

Fuzzy-trace theory (e.g., Brainerd & Reyna, 2008) may be used to describe false recall SPE by appeal to gist and/or verbatim memory processes. As list study advanced, the opportunity for gist extraction may have declined resulting in a decline in semantic false recall from primacy to recency trimesters. Alternately, the pattern of semantic false recall SPE for immediate free recall may have been due to quickly dissipating verbatim traces being used to edit out false recall for later serial positions. The fact that the same pattern of false recall remained after the distractor-filled delay detracts from the latter explanation as a plausible account of semantic false recall SPE. If quickly decaying verbatim traces caused semantic false recall SPE, then the delay should have increased false recall for later categories by removing verbatim traces used to edit out false items for recency in immediate free recall. Indeed, the principle index of verbatim traces is true recall (Brainerd, Payne et al., 2003) and true recall sharply declined for recency after the delay. Therefore, declining gist trace formation with advancing study position is the more plausible account of semantic false recall SPE from the perspective of fuzzy-trace theory.

From the perspective of fuzzy-trace theory dividing attention during study may be conceptualized as either having impeded the formation of gist traces and/or verbatim traces. Increases in the formation of either type of memory trace does not seem possible under conditions where cognitive resources were being used for a different task. The fact that semantic and phonological false recall showed qualified increases under divided attention could indicate either a greater reliance on gist processing or an impediment in false recall editing as a result of reduced verbatim trace formation, or possibly both these processes. The latter is the more likely interpretation because true recall was reduced under divided attention which suggests reduced verbatim processing (Brainerd et al., 2003). Furthermore, the opportunity for elaborative rehearsal during study should be reduced under divided attention, which would ostensibly reduce gist trace formation. The fact that phonological false recall declined reliably after a delay and semantic false recall did not suggests the possibility of different processes of gist and verbatim trace formation for semantic and phonological false recall.

Conclusions on central false memory theories and false recall SPE

The two current central theories of false recall considered in the introduction of this thesis, activation/monitoring theory (Roediger et al., 2001) and fuzzy-trace theory (Brainerd et al.,

2002) continue to be used in conceptualizing false recall (e.g. Brainerd et al., 2008; Gallo, 2006). For the present experimental findings, false recall SPE can be explained with either of the current central theoretical perspectives. For semantic false recall, earlier study position may be described as having created relatively stronger semantic activation (Roediger et al., 2001) or stronger gist memory trace formation (Brainerd, Payne et al., 2003) and therefore promoted higher false recall. For phonological false recall SPE, either theory may argue that there is no reason to assume differences in processing of phonological false recall SPE and true recall SPE. Divided attention may be described as having reduced verbatim or gist trace formation or as having reduced semantic activation or source monitoring accuracy. Furthermore, the relatively late output of false recall, as observed in these thesis Experiments, has been cited as evidence for source monitoring impediment (Roediger et al., 2001) and for a shift from verbatim trace to gist processing as recall proceeds (Brainerd, Reyna et al., 2003). Neither central false memory perspective has been used to make experimental predictions concerning false recall SPE. Dual store theory of true SPE (Glasner, 1972) was incorporated into this thesis because it generated specific testable predictions concerning false recall SPE (Read, 1996).

In the context of the present research, the central question for the activation/monitoring and fuzzy-trace perspectives becomes how to accommodate distinct SPE for the semantic and phonological forms of associated false recall. If repeated presentation of associated words ultimately instantiates critical false responses, why are SPE so different for the two types of word association? Without assuming somewhat distinct semantic and phonological processes, the theories are silent with regard to why the patterns of SPE are so different for the two forms of associated false recall. The positing of separate semantic and phonological networks is indeed what is currently taking place within the activation/monitoring literature as differences between the semantic and phonological forms of associated false recall emerge (see Sommers & Ballou, 2008 for a discussion). Gist processing in Fuzzy-trace theory has typically described in terms of indices of semantic memory (e.g., Brainerd et al., 2008), some theorists (Holliday & Weeks, 2006) have suggested fuzzy-trace theory also implies a *phonological gist* that can help to explain phonological false memory effects.

The accounts of false recall SPE are somewhat similar for the activation/monitoring theory and fuzzy-trace theory perspectives (also see Roediger et al., 2001). Research framed within the context of fuzzy-trace theory could typically have the terms *gist* and *verbatim* replaced with activation monitoring terms (e.g., *semantic* and *accurate source monitoring*). Lindsay and Johnson (2000) have remarked that the two general theoretical perspectives are perhaps better characterized as theoretical frameworks rather than as theories that entail specific, mutually exclusive, falsifiable hypotheses. Gallo (2006) suggests that debate about false memory theory tends to focus on negative aspects and oversimplified characterizations of opposing views. This appears to be a continuing feature of the debate. For example, in recent fuzzy-trace research (Brainerd & Reyna, 2008) activation/monitoring theory is characterized as being an associative rather than semantic-associative theory, as being a single process rather than a dual process theory, and as positing that false recall is exclusively a priming effect, none of which are the case according to Roediger and colleagues (2001). Brainerd and Reyna (2008) make the argument that because verbatim traces and gist traces are associated with different retrieval operations that fuzzy-trace theory is a dual process theory. However, activation and monitoring are also explicitly described as distinct processes and furthermore retrieval may be based on either surface or relational aspects (Roediger et al., 2001).

Dual store theory and false recall SPE

At the outset of this thesis the central contemporary theories of false memory (Brainerd et al., 2002; Roediger et al., 2001) were considered in relation to the ensuing Experiments and were found to be too underspecified to form clear or distinct predictions (e.g., see Gallo, 2006; Hancock et al., 2003; Roediger et al., 2001 for similar comments). Rather than proceeding on the basis of current theory, this dissertation was advanced theoretically on the bases of influential findings in the true recall word-list literature that posit the existence of a dual long-term-semantic/short-term-phonological memory stores. These proposed mechanism have been used to explain manipulations of short-term true recall SPE (Atkinson & Shiffrin, 1968; Waugh & Norman, 1965). This theoretical perspective that continues to influence modern discussions of SPE despite known limitations of the theory in the broader context (see Baddeley, 2004; Healy & McNamara, 1996; Hoffman, Jefferies et al., 2009; 2004; Kimball et al. 2007, Sederberg, Howard & Kahana, 2009; Talmi et al., 2005 for discussions). Most importantly, this theoretical perspective on true recall SPE, applied to associated false recall, made falsifiable predictions concerning the respective distribution of semantic and phonological false recall through the serial position curve (see Read, 1996 for a discussion). Neuropsychological and neuroimaging researchers continue to entertain the possibility of a dual store view of true recall SPE indicating that differences in retrieval are qualitative not quantitative (see Talmi et al., 2005 for a discussion). Specifically, the research indicates that retrieval from the primacy aspect of the serial position curve is associated with brain activity in known long-term memory structures whereas retrieval from the recency aspect is not.

Among possible outcomes for the current research was that semantic false recall (Deese, 1959) could dominate for pre-recency serial position region because this region has been associated with long-term semantic memory (e.g., see Glanzer, 1972; 2009; Talmi et al., 2005 for discussions). Indeed the prediction that semantic false recall may be associated with early serial positions had been previously made by Read (1996) who correctly predicted that subjective judgments of the serial position at which false recall occurred would be early in study lists. Conversely for phonological false recall (Sommers & Lewis, 1999), a recency effect was hypothesized because the recency effect often appears to be sensitive to short-term processes, processes that have sometimes appeared to be coded phonologically (e.g., see Hoffman, Jefferies et al., 2009; Kintsch & Buschke, 1969; Talmi et al., 2005 for discussions).

Predictions were based on what has been described as the “popular generalization” (Glanzer, 1972, p. 176) that long-term memory is coded semantically and short-term memory phonologically. Although a simple semantic-phonological stores theory has generally proven inadequate in explaining SPE more generally (Baddeley, 2004; Baddeley & Hitch, 1993), it was the most useful theoretical starting point in drawing comparisons between the relative patterns of true and false recall SPE in the present research. The generalization of short-term semantic/long-term phonological stores remains interesting in terms of short-term list learning experiments such as in the current case but does not directly explain long-term recency effects or short-term semantic aspects of recall (Baddeley, 1990; Hoffman, Jefferies et al., 2009). Dual store theory as implemented in the *search of associative memory* model has been used to describe both serial position effects and semantic false memory (Kimball, Smith & Kahana, 2007). Sederberg et al. (2008) have recently remarked that if not for long term recency effects, the dual store model would be adopted without question. Others (see Neath & Surprenant, 2003; Sederberg et al., 2008 for discussions) are impressed by the fact that long-term recency effects and short-term recency effects are often impacted by the same factors and believe that both long and short-term recency effects are mediated by similar processes. Baddeley (1990) has suggested that because the short-term recency effect is larger than the long-term recency effect that the two effects may be distinct and that the dual store view may be an appropriate model for short-term recency effects. Baddeley (2004) further argues that the short-term recency effect may be a form of automatic priming effect that impacts different stores. In the present research, the phonological false recency effect did not dissipate after a distractor filled delay suggesting that it may not be supported by the same processes as the true recall recency effect.

The prediction of distinct SPE for semantic and phonological false recall was supported by the Experiment 1 results. Semantic false recall showed evidence of a primacy effect and phonological false recall showed evidence of a recency effect. However, if the true recall recency effect and the phonological false recall recency effect are both simply the products of a rapidly fading short-term store, then the recency trimester should have produced more phonological false recall than both middle *and* primacy serial positions. The primacy items should be well outside the purview of the temporarily activated short-term phonological store. After more careful experimentation in Experiment 2, the primacy trimester produced significantly higher levels of false recall than the middle trimester, indicating a phonological false recall primacy effect. For phonological false recall, the pattern of SPE was clearly more consistent with the U-shaped pattern of true recall SPE. This suggests the possibility that phonological false recall SPE may be supported by the same processes that support true recall SPE. The fact that phonological false recall varied along with true recall is more consistent with a mechanism involving the simultaneous activation/trace formation of true and false recall rather than a process of editing out false candidate responses on the basis of correct word items.

Different possibilities exist as to why the phonological false recall primacy effect was observed in Experiments 2 and 3. The effect may be the result of long-term phonologically coded processes. It is possible that the recency aspect may be the result of offloading incidentally activated traces directly from a short-term store, whereas the primacy aspect may arise as the result of rehearsal of the better remembered primacy items in working memory during the recall phase. Experimenting with concurrent task demand during recall may help to understand this. Regardless, if the same distinct short-term processes that support the true recall recency effect also support the phonological false recall recency effect, then the phonological false recall recency effect should have diminished along with the true recall recency effect after a delay. The phonological false recency effect remained intact after a delay indicating longer retention properties than would be suggested if phonological false recall arose from within the context of the same short-term phonological store that supports the true recall recency effect.

For semantic false recall under delayed recall conditions, there was no reason to think that the semantic false recall primacy effect, presumably a semantic and therefore long-term phenomenon (e.g., see Brown & Craik, 2000; Glanzer, 1972 for discussions), would decline after a delay. No evidence of a decline was found. However, phonological false recall was reduced by the delay, consistent with the notion that the effect has special dependence on a short-term phonological store. However, this reduction was not contained within the recency trimester as would be expected if the processes underlying this reduction were contained in a temporary short-term phonological store.

Experiments 4 and 5 produced data relevant to several key issues. Firstly, the analyses indicate distinct patterns of semantic and phonological false recall using data independent of Experiment 2 (see Figure 5-5). Manipulations that divide attention at encoding typically reduce true recall for list items falling at the pre-recency region of the true recall serial position curve, a region often associated with long-term semantic memory (e.g., see Brown & Craik, 2000;

Glanzer, 1972; Hoffman et al., 2009; Talmi et al., 2005 for discussions). The finding of null results comparing false recall under full and divided attention is consistent with previous research using single theme lists (Dewhurst et al., 2007; Dodd & MacLeod, 2004; Peréz-Mata et al., 2002; Seamon et al., 2003). In Experiment 4, a concurrent handwriting task was used to divide attention during study and this selectively reduced true recall for the pre-recency serial position region. An increase in false recall under concurrent handwriting conditions was observed at primacy position for semantic false recall, and higher phonological false recall was observed at recency. This is consistent with the pattern of false recall SPE that a dual semantic/phonological store mechanism would suggest with semantic intrusions being elevated at pre-recency positions and phonological intrusions at recency. The fact that these were increases rather than decreases is not consistent with an activation/gist-formation account of increased false recall because resources that would be used to activate false items were being depleted by the unrelated secondary task. Furthermore, decreased representational activation is suggested by decreased true recall. If increased false recall was the result of divided attention lowering response bias, then an increase in unpredicted false recall would be expected (see Dewhurst et al., 2007 for a discussion). This was not observed.

In Experiment 5 an articulatory suppression task of concurrent whispering during study was used to divide attention, a task that specifically draws on self-generated verbal rehearsal. This final Experiment was intended to clarify how divided attention impacts false recall SPE. The articulatory suppression task reduced true recall more than concurrent handwriting did, suggesting reduced true lexical activation. Therefore, if reduced lexical activation was a factor in exacerbating false recall, then Experiment 5 should have produced more false recall than Experiment 4 did. This was not the case. The concurrent handwriting task used in Experiment 4 resulted in less true recall but more false recall than the articulatory suppression conditions of Experiment 5. It is interesting that the more demanding secondary task used in Experiment 5 to divide attention decreased rather than increased false recall relative to Experiment 4. Judging from true recall performance, concurrent handwriting was more attention demanding than simple free recall, and this concurrent task drove false recall up. Yet concurrent whispering that was more demanding in terms of true recall drove false recall down relative to concurrent handwriting. There may be a qualitative difference between the secondary tasks that influences false recall differently, this issue requires further examination controlling for task difficulty.

Research on associated false recall sometimes compares the relative levels of true and false recall using the same manipulations in order to draw inferences about differences between the two variables (see Gallo, 2006 for a discussion). For semantic false recall, it has been found that after a 24-hour delay true recall declines while false recall is not significantly changed (Payne, Elie et al., 1996). Some manipulations that impact true memory, such as attention demand during study, often do not significantly impact false recall (see Seamon et al., 2003 for a discussion), while other manipulations increase true and false recall (e.g., Thapur & McDermott, 2001). This divergence may be taken to suggest that either similar processes or different processes underlie true as compared to false memory. The *more is less* phenomena (Toglia et al., 1999), whereby false and true memory simultaneously occur at high rates, is perhaps due to deeper semantic (Roediger et al., 1998; Thapar & McDermott, 2001) or gist (Brainerd, Payne et al., 2003) encoding. Other research has suggested an opposite pattern, with lower veridical recall being accompanied by higher semantic false recall, perhaps because manipulations that reduce veridical recall impede source monitoring capacity for false items as well as true items (e.g., Peréz-Mata et al., 2002). Several research efforts have concluded that because true and false memory are impacted differently by similar manipulations, that different processes must underlie the two dependent measures (see Brainerd et al., 2008 for a discussion). However, as the true recall serial position curve and manipulations of it illustrate, the single words used to measure true recall do not necessarily reflect the same underlying memory processes. Depending on the serial position of initial study, true recall has different retention properties and this current research shows that this is also the case for both semantic and phonological false recall.

Future research

The Experiments reported in this thesis were designed to provide empirical data relevant to the question of the relative patterns of SPE for true and false recall in the context of manipulations of the true free recall serial position curve. Effort must be made to extend the investigation of false recall SPE to a broader set of experimental situations and more ecologically valid sets of materials as is being done in the true memory literature on SPE (e.g., Maylor, 2002; Terry, 2005). If false SPE are as regular a feature of memory as true SPE are, then a large amount of research may be generated by conducting false memory research that parallels findings in the true memory literature as has been done in the present thesis. Such a program of research would speak to the empirical relationship between true and false memory more completely than using the traditional single theme method of investigation into associated false recall. Rather than memory being interpreted in terms of the total amount of true memory reported, as has been traditionally the case (Koriat, 2000; Roediger et al., 1998).

Another important future direction concerns the nature of the interaction between semantic and phonological false recall (Ballou & Sommers, 2008; Chan et al., 2005; Watson et al., 2003). Lists of hybrid semantically and phonologically associated materials are known to produce over-additive levels of false recall (Watson et al., 2003). The interaction of semantic and phonological factors may well vary as a function of serial position of study, and this may help in understanding how these factors combine to produce SPE generally. Experimentation using hybrid semantic/phonological lists segmented into blocks of associated words may help to further understanding of the interaction of semantic and phonological processes in the production of verbal SPE.

A current *recency* theory of true recall SPE (Ward & Tan, 2004) which has generated much attention has possible implications for future research based on this present thesis work. Ward and Tan's (2004) research, in which participants verbalized aloud during list study, has shown that primacy items are rehearsed comparatively late into the study phase. Plotting final rehearsal position as a function of recall probability produced a recency effect only. Therefore recency provides a parsimonious explanation of the true free recall serial position curve whereby closer proximity of the final study rehearsal to recall output (i.e., recency) serves to explain both the recency and primacy effects. This is precisely the pattern of phonological false recall observed in Experiments 4 and 5 where rehearsal opportunity was removed by concurrent study demands. The results of these thesis Experiments suggest a diametrically opposite circumstance for semantic false recall with decreased recency producing more false responses. This suggests that a more complete model of list recall that includes both true and false responses may require the incorporation of a process at recency to account for phonological false recall on the one hand, and an opponent recency process for semantic false recall on the other. Kimball and colleagues (2007) have implemented semantic false memory parameters in a version of the *search of associative memory* model (Raaijmakers & Shiffrin, 1981) that successfully simulates several semantic false recall effects by increasing connection strengths to critical distractors as a proportion of semantic relatedness to adjacent study words. It is possible that this model could be used to help describe and understand false recall SPE.

It is conceivable that understanding the conditions under which memories are formed in simple lab based experiments may lead to an understanding of false memory in the larger context (see Introduction). No such progress in naturalistic settings is possible without a basic understanding of the mechanisms involved in producing false recall. Theories of false recall and of SPE have rich histories that will undoubtedly benefit each other.

Conclusions

The preceding research investigated SPE for false recall in associated word-lists (Deese, 1959; Sommers & Lewis, 1999). Verbal list memory has often been used in experimental psychology to make inferences about the basic nature of memory. The study of SPE dates to a time when falsely remembered responses were thought to be unimportant (see the Introduction for a discussion). False responses are now accepted as a typical aspect of the scientific analysis of memory (Koriat et al., 2000). This research indicates that SPE exist for false recall and these effects impact the overall assessment of recall accuracy. In particular, semantic false recall at primacy and phonological false recall at recency may especially compromise overall accuracy. Dual store theory continues to provide a theoretical framework within which to generate hypotheses about SPE and about false recall (e.g., Hoffman et al., 2009; Kimball et al., 2007). The fact that dual store memory theory has been useful in generating meaningful predictions and in interpreting these data suggests that contemporary theories of false memory may benefit from some level of integration with traditional dual store theories of true recall SPE.

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APPENDIX A
STUDY LIST MATERIALS FOR EXPERIMENT 1

Unpresented critical target words in capitals with semantic followed by phonological study lists (Watson, Balota & Roediger, 2003).

BAD		BALL		BEER		BLACK	
good	had	bounce	doll	drunk	leer	white	mack
rotten	lad	throw	bile	keg	peer	gray	block
harmful	bat	basket	bail	pub	tear	tar	blank
worse	bag	bowling	balk	suds	rear	bruise	lack
villain	bud	golf	wall	liquor	seer	brown	sack
severe	band	play	fall	booze	gear	oil	smack
trouble	dad	tennis	bald	alcohol	bill	tuxedo	track
awful	bide	soccer	pall	Bud	deer	dark	pack
terrible	bid	round	tall	bar	boar	prejudice	snack
evil	pad	catch	bill	bottle	beard	minority	rack
corrupt	ad	pitch	bell	wine	hear	coffee	flack
horrible	bed	moth	all	mug	fear	color	slack
nasty	ban	bat	boil	barrel	year	Africa	bleak
attitude	tad	kick	bull	drink	bear	coal	back
mood	sad	racket	gall	can	veer	soul	hack
punish	fad	hit	hall	cooler	ear	race	plaque

BREAD		CAR		CHAIR		COLD	
rye	bled	auto	char	sit	pair	chill	code
loaf	bride	drive	call	couch	share	hot	called
crust	braid	engine	care	rocking	char	warm	fold
wheat	read	wreck	are	swivel	air	sneeze	sold
butter	broad	garage	card	cushion	scare	shiver	culled
crumb	bed	motor	carp	seat	check	Arctic	chord
garlic	thread	van	cot	recliner	lair	ice cream	scold
muffin	tread	truck	core	wicker	hair	chilly	bold
dough	brad	crash	par	Lazyboy	their	freezer	hold
toast	pled	accident	scar	table	tear	frigid	coiled
flour	wed	trunk	cart	stool	cherry	heat	colt
Wonder	breed	tire	far	furniture	cheer	ice	old
bun	breadth	mechanic	bar	sofa	stair	frost	polled
baked	fled	vehicle	carve	rocker	fair	freeze	gold
biscuit	head	tow	cough	desk	care	winter	told
roll	dread	gas	tar	bench	chore	snow	coal

DOG		FACE		FAT		FLAG	
hound	log	mouth	fake	thin	fate	American	slag
puppy	dodge	expression	vase	obese	that	banner	flab
bite	dug	nose	fuss	large	sat	pledge	brag
mutt	hog	eyes	faith	weight	foot	wave	wag
pet	bog	frown	lace	calorie	fact	allegiance	flak
beware	doff	wrinkle	fail	slim	cat	country	sag
bone	daub	makeup	fain	pudgy	feat	stars	nag
tail	cog	cheek	ace	diet	fit	USA	snag
cat	dock	head	case	slender	bat	pole	bag
animal	dawn	mask	fate	wide	pat	stripes	crag
paw	fog	moustache	fame	cheek	fan	freedom	flat
poodle	dig	beard	race	skinny	fast	nation	lag
flea	doll	chin	base	lean	hat	pennant	gag
bark	frog	lips	faze	plump	fought	salute	flog
Lassie	jog	shave	fade	chubby	flat	symbol	drag
vet	dot	smile	pace	huge	at	checkered	rag

GOD		GLASS		GUN		HAND	
lord	pod	bottle	class	pistol	gown	glove	land
holy	gone	lens	grass	shot	bun	finger	sand
heaven	goad	shatter	blass	holster	nun	shake	hound
bible	odd	prism	lass	rifle	gush	palm	panned
bless	tod	mirror	glaze	bullet	one	thumb	stand
angel	good	hour	sass	hunt	ton	wave	hanged
sin	sod	crystal	bass	military	gut	grip	fanned
faith	wad	jar	glance	powder	sun	foot	canned
church	guide	pane	mass	shoot	run	fist	band
Jesus	nod	fragile	brass	trigger	goon	mitten	grand
religion	gob	mug	crass	murder	gain	wash	honed
pray	gad	looking	gloss	aim	gum	hold	hind
devil	gall	shard	glad	bang	pun	knuckle	tanned
deity	rod	cup	plass	cannon	fun	wrist	and
Christ	cod	break	pass	revolver	done	arm	had
worship	got	window	gas	weapon	gone	clap	brand

HARD		HATE		KILL		LAW	
rigid	bard	dislike	rate	slay	skill	rights	raw
difficult	hark	love	wait	suicide	cull	attorney	paw
easy	harm	hostility	hail	violence	kid	enforce	chaw
work	lard	anger	hot	hunt	hill	criminal	lawn
cement	charred	detest	fate	shoot	fill	lawyer	lock
concrete	scarred	resent	haste	stab	chill	court	claw
stiff	hoard	fear	height	attack	sill	government	flaw
tough	hired	jealousy	date	homicide	kilt	regulation	log
rock	sparred	envy	gate	destroy	call	legal	lay
simple	heart	despise	hay	shot	coil	officer	saw
complex	harp	abhor	bait	smother	till	rules	gnaw
firm	starred	war	late	poison	pill	justice	low
solid	tarred	enemy	hat	assassin	kick	legislation	lot
soft	yard	loathe	hit	murder	kit	amendment	awe
rough	card	disgust	heat	deadly	keel	police	slaw
coarse	herd	like	ate	choke	ill	order	loss

MAIL		MAN		PEN		RAIN	
stamp	meal	woman	can	ink	pan	umbrella	train
deliver	nail	guy	moon	paper	then	drench	main
receive	mate	sir	main	marker	hen	weather	ran
bills	mile	boss	fan	eraser	ken	hail	wren
letters	hail	super	tan	pencil	pawn	cloud	pain
send	make	lady	pan	writing	pain	dew	rave
fax	mall	person	mean	notebook	fen	pour	raise
express	sail	fellow	map	Bic	peg	storm	brain
post	veil	mister	van	point	when	thunder	bane
zip	mill	bachelor	ran	mark	ben	wind	raid
address	mole	uncle	mat	write	pine	puddle	rate
envelope	maid	con	mad	scribble	pun	acid	range
package	may	macho	ban	pal	yen	mist	wane
UPS	ail	handsome	mine	quill	ten	lightning	lane
telegram	gale	gentleman	moan	fountain	pet	sunshine	vain
junk	mull	male	an	pad	pent	flood	gain

RIGHT		SICK		SLEEP		SLOW	
correct	tight	healthy	sock	bed	sweep	quick	mow
perfect	rye	ill	sink	rest	steep	fast	crow
equal	rife	flu	lick	yawn	sleet	snail	slope
accurate	night	nausea	sake	pillow	slop	hesitant	slaw
fair	bright	cancer	soak	snooze	heap	brisk	owe
justify	rile	cough	kick	awake	weep	swift	snow
left	ripe	virus	six	nap	seep	molasses	blow
turn	bite	disease	suck	dream	sleek	lazy	throw
angle	rat	medicine	silk	tired	slope	cautious	row
answer	rot	doctor	sack	pajamas	bleep	lethargic	flow
mistake	white	fever	stick	snore	slip	speed	slew
wrong	rice	hospital	thick	doze	slap	hurry	hoe
truth	ride	germ	seek	drowsy	leap	sluggish	show
ethics	light	clinic	slick	coma	cheap	turtle	sew
direction	writhe	vomit	tick	wake	sleeve	rapid	glow
proper	rate	well	sip	slumber	sloop	delay	low

SMELL		SMOKE		SNAKE		SWEET	
odor	bell	fire	poke	viper	brake	honey	beat
cologne	swell	nicotine	joke	lizard	quake	bitter	heat
sniff	spell	cigar	cloak	slither	snack	nice	skeet
stench	tell	pot	smirk	serpent	sake	ice cream	street
scent	hell	pipe	stroke	deadly	ache	sugar	swat
nose	smile	chimney	oak	hiss	snuck	tart	wheat
deodorant	yell	fumes	smote	reptile	shake	taste	feet
aroma	jell	cigarette	spoke	cobra	flake	fudge	meet
skunk	small	ashtray	choke	fangs	lake	candy	sleet
fragrance	fell	Marlboro	bloke	poison	make	syrup	seat
dirty	knell	marijuana	woke	venom	sneak	kind	sweep
sense	sell	smog	smack	slimy	stake	chocolate	fleet
perfume	shell	habit	stoke	bite	rake	dessert	sheet
stink	well	tobacco	yoke	python	snail	sour	sweat
foul	dell	puff	smock	worm	take	frosting	treat
whiff	smelt	inhale	soak	rattle	wake	salty	tweet

TEST		TOP		TRASH		WET	
quiz	zest	bottom	mop	garbage	gash	slippery	vet
final	pest	peak	stop	waste	slash	damp	watt
study	tossed	hill	tap	dumpster	track	paint	wheat
evaluate	west	over	tup	junk	brash	splash	pet
experiment	chest	roof	chop	refuse	flash	dry	west
essay	tent	summit	bop	Hefty	ash	humid	bet
stress	toast	pinnacle	tock	litter	stash	water	wed
screen	crest	zenith	cop	sewage	trap	dripping	well
score	fest	apex	hop	scraps	lash	soak	net
exam	best	spin	tape	dump	rash	moist	let
fail	text	above	taupe	rubbish	mash	saturate	welt
lab	taste	ceiling	pop	landfill	thrash	sponge	wit
tube	vest	tip	type	can	bash	towel	wait
pass	hest	lid	tot	pile	dash	slick	get
grade	rest	mountain	sop	bag	crash	soggy	yet
analysis	guest	best	whop	recycle	clash	douse	wear

APPENDIX B
STUDY LIST MATERIALS FOR EXPERIMENTS 2-5.

The lists below were adapted from Watson et al. (2003). Critical unpresented items are in capitals followed by columns of 8 semantic then 8 phonological associates. Words that shared both semantic and phonological association to the target false items were removed. Double entries, non-words or rare words that might be mistaken for non-words were also removed from the original Watson et al., materials. New items were taken from the remaining 8 items from Watson et al.'s 16-item lists by substitution until lists than met the above criteria were met. For the semantically associated lists the following items were removed and replaced from the Watson et al. materials as duplicates from different lists: *nose, hunt, deadly, shoot, wave, cheek, shot, bite, wave, bottle, ice cream* and *junk*. For the phonologically associated lists the following duplicate items were removed: *wheat, west, track, sake, ran, pan, pain, log, hail, fate, char, call, bat and band.* For the phonologically associated lists, the following lists words were replaced due to semantic association to the target unpresented words, or to other words within that 8 word sub-list: *wall, tear, glaze, stand, cull, moon* and *well*. Also removed from the phonological lists were non-words or words so rare they may be interpreted as non-words; *blass, doff, fen* and *tup*. The word *feat* was replaced because of confusion with the homonym *feet*.

BAD		BALL		BEER		BLACK	
good	had	bounce	doll	drunk	leer	white	mack
rotten	fad	throw	bile	keg	peer	gray	back
harmful	pad	basket	bail	bottle	boar	tar	plaque
worse	ad	bowling	tall	mug	rear	bruise	lack
villain	bud	golf	wall	liquor	seer	brown	sack
severe	bid	play	gall	booze	gear	oil	smack
trouble	sad	tennis	bald	alcohol	bill	tuxedo	rack
awful	bide	soccer	pall	can	beard	dark	pack

BREAD		CAR		CHAIR		COLD	
rye	bled	auto	scar	sit	pair	frigid	code
loaf	bride	drive	par	couch	share	hot	called
crust	braid	engine	care	rocking	char	warm	fold
wheat	read	wreck	are	swivel	air	sneeze	sold
butter	broad	tire	card	cushion	scare	shiver	culled
crumb	brad	motor	carp	seat	check	Arctic	chord
garlic	thread	van	cot	recliner	lair	ice cream	coiled
muffin	tread	truck	core	wicker	hair	chilly	bold

DOG		FACE		FAT		FLAG	
cat	fog	mouth	fake	thin	hat	American	slag
puppy	dock	expression	vase	obese	that	banner	flab
bite	jog	head	fuss	large	sat	pledge	brag
mutt	hog	eyes	fate	weight	fought	pole	wag
pet	bog	frown	case	calorie	fact	allegiance	flak
beware	dawn	wrinkle	fail	slim	bat	country	sag
bone	daub	makeup	fain	pudgy	fast	stars	nag
tail	cog	cheek	ace	diet	pat	USA	snag

GOD		GLASS		GUN		HAND	
lord	pod	looking	class	pistol	gown	glove	land
holy	gone	lens	grass	shot	bun	finger	sand
heaven	goad	shatter	glad	holster	nun	shake	hound
bible	odd	prism	lass	rifle	gush	palm	panned
bless	tod	mirror	mass	bullet	gain	thumb	band
angel	nod	hour	sass	trigger	ton	wave	hanged
sin	sod	crystal	bass	military	gut	grip	fanned
faith	wad	jar	gas	powder	sun	foot	canned

HARD		HATE		KILL		LAW	
rigid	sparred	dislike	rate	slay	skill	rights	raw
difficult	hark	love	wait	suicide	till	attorney	paw
easy	harm	hostility	hey	violence	kid	enforce	chaw
work	lard	anger	bate	hunt	hill	criminal	lawn
cement	charred	detest	gate	shoot	fill	legal	lock
concrete	scarred	resent	haste	stab	chill	court	claw
stiff	hoard	fear	height	attack	sill	government	flaw
tough	hired	jealousy	date	homicide	kilt	regulation	log

MAIL		MAN		PEN		RAIN	
stamp	meal	guy	pan	ink	pine	umbrella	train
deliver	nail	sir	an	paper	then	drench	main
receive	mate	boss	moan	marker	hen	weather	ran
bills	mile	super	fan	eraser	ken	thunder	wren
letters	hail	lady	tan	point	pawn	cloud	pain
send	make	person	mine	writing	ben	dew	rave
fax	mall	fellow	ban	notebook	when	pour	raise
express	sail	mister	map	Bic	peg	storm	brain

RIGHT		SICK		SLEEP		SLOW	
correct	tight	healthy	sock	bed	sweep	quick	mow
perfect	rot	ill	sink	rest	steep	cautious	crow
equal	rife	flu	lick	yawn	sleet	snail	slope
accurate	night	nausea	silk	pillow	slop	hesitant	slaw
fair	bright	cancer	soak	snooze	heap	brisk	owe
justify	rile	cough	kick	awake	weep	swift	row
left	ripe	virus	six	nap	seep	molasses	slew
turn	rat	disease	suck	dream	sleek	lazy	hoe

SMELL		SMOKE		SNAKE		SWEET	
odor	small	fire	poke	viper	brake	honey	sheet
cologne	swell	nicotine	smock	fangs	quake	bitter	heat
sniff	spell	cigar	cloak	slither	snack	nice	skeet
stench	tell	pot	smirk	serpent	sake	candy	street
scent	hell	pipe	stroke	deadly	ache	sugar	swat
nose	smile	chimney	oak	hiss	snuck	tart	fleet
deodorant	yell	fumes	smote	reptile	stake	taste	feet
aroma	jell	cigarette	spoke	cobra	flake	fudge	meet

TEST		TOP		TRASH		WET	
quiz	zest	bottom	mop	garbage	mash	slippery	welt
final	pest	peak	stop	waste	slash	damp	watt
study	tossed	apex	tap	dumpster	track	paint	wit
evaluate	fest	over	pop	junk	brash	splash	yet
experiment	chest	roof	chop	refuse	flash	dry	west
essay	tent	summit	bop	Hefty	ash	humid	bet
score	toast	pinnacle	tock	litter	stash	water	wed
screen	crest	zenith	tape	sewage	trap	dripping	let

APPENDIX C
EXPERIMENTS 4 AND 5 LETTER/NUMBER SEQUENCES

7H2E4K	9P5H3X	8F6B5K
6S2W5T	7D4H2K	3M5X8Q
A9C3R7	F8K3T2	X5Q4A7
J3L4W2	U3L5R6	T2K4Q3