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Presentation of cues during recall impairs recall of non-cued items (part-set cuing effect). Assessment of retrieval strategies (i.e. temporal associations) within the part-set cuing paradigm can lead to a better understanding of the mechanisms underlying the poorer recall of non-cued items. Research has shown that randomly ordered cues lead to greater memory impairment than cues presented in the original order of the list. These findings support the strategy disruption account, which proposes that cues disrupt participants' original retrieval strategy.

In the present study, I used the part-set cuing paradigm to investigate the nature of this disruption. While the results lent support to the strategy disruption account, they also provided a new perspective, which focuses specifically on the disruption in the use of temporal context during cued recall.

ASSESSING TEMPORAL ASSOCIATIONS IN RECALL:

A NEW TAKE ON THE STRATEGY DISRUPTION

ACCOUNT OF THE PART-SET

CUING EFFECT

By

Namrata Godbole

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Approved by

____
Committee Chair

To Shonu and Putu

APPROVAL PAGE

This thesis has been approved by the following committee for the Faculty of The Graduate School at The University of North Carolina at Greensboro.

Committee Chair ______________________________
Peter Delaney

Committee Members ______________________________
Lili Sahakyan

____
Robert Guttentag

____
Date of Acceptance by Committee

August 16, 2012____________
Date of Final Oral Examination

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CHAPTER I

INTRODUCTION

We rely on our memory in a lot of day-to-day situations. For example, we remember to pick up the laundry on the way back from work, the answer to a test question, or the items on a grocery list that we didn't take to the grocery store. Sometimes we have external help in the form of cues that help us remember. For example, buying eggs at the grocery store can remind us to pick up a loaf of bread. Thus, cues usually help people remember better. Cues and their effect on retrieval are widely studied topics in learning and memory. For example, when category names are presented as cues, people are better able to provide words that belong to that category than when the category names are withheld (e.g., Tulving & Pearlstone, 1966).

Despite the common finding that cues help retrieval, cues can sometimes hurt retrieval. The *part-set cuing effect* is the poor recall of the non-cued items relative to cued items, when a subset of the original items is presented as cues (e.g., Slamecka, 1968; Sloman, Bower, & Rorher, 1991; Basden & Basden, 1995; Bäuml & Aslan, 2006). The part-set cuing effect has been reported in both semantic and episodic memory tasks (Brown, 1968) with categorized and uncategorized lists (Slamecka, 1968), with incidental and intentional encoding (Peynircioğlu & Moro, 1995), and with both intra-list and extra-list cues (Watkins, 1975). It has also been demonstrated in different age groups (Marsh, Dolan, Balota, & Roediger, 2004; Zellner & Bäuml, 2005).

Accounts of the Part-Set Cuing Effect

Researchers have not been able to agree on a single, comprehensive explanation of the mechanisms underlying the part-set cuing effect. However, several theories have been proposed to account for this phenomenon (for reviews, see Nickerson, 1984; Roediger & Neely, 1982). The theories that have generated the most interest are the retrieval inhibition theory (Anderson, Bjork, & Bjork, 1994; Bäuml & Aslan, 2004), the competition-at-retrieval hypothesis (Rundus, 1973), and the strategy disruption account (Basden & Basden, 1995; Basden, Basden, & Galloway, 1977).

The *retrieval inhibition theory* (Anderson et al. 1994; Bäuml & Aslan, 2004) proposes that the representation of the non-cued item undergoes long-term changes. Specifically, when part-set cues are presented at the time of recall, they cause covert retrieval of the cues. Covert retrieval then reduces the activation level of the non-cued items. As a result, the non-cued items are less likely to be recalled. The retrieval inhibition theory is in direct contrast to the *competition-at-retrieval hypothesis* (Rundus, 1973), which proposes that when cues are presented before recall, they are strengthened. Strengthening of the cues increases their accessibility, which in turn leads to better recall of these highly accessible cues, reducing the probability that a non-cued item will be recalled. The *strategy disruption account*, on the other hand, proposes that poor retrieval of the non-cued words is a result of a disruption in the participant's original retrieval strategy (Basden & Basden, 1995; Basden, et al., 1977). This implies that when cues are provided by the experimenter, they most likely mismatch the strategy that was adopted by the participant. This disruption in retrieval strategy impairs recall of the non-cued items.

Although there are several different accounts of the part-set cuing effect, they are not mutually exclusive and may all contribute to the effect. In this paper, I propose a new account, temporality impairment. Since this account has evolved from the strategy disruption account, I will focus more on the latter relative to the other accounts described above. Undoubtedly, the strategy disruption account has received its fair share of attention; however, there is little discussion on what is meant by 'a disruption in participants' original retrieval strategy'. What does disruption in strategy entail and how can it be measured?

Fortunately, we now know more than we used to about how free recall occurs and the ways in which it can be measured. We have deepened our understanding of the strategies used during retrieval and their implications for recall. With this knowledge, we can study the use of strategies within the part-set cuing paradigm, which can potentially shed light on the disruption in strategy that is at the core of both strategy disruption and temporality impairment. Understanding the nature of this disruption can theoretically explain the mechanisms underlying the part-set cuing phenomenon.

Conditional Response Probabilities

According to the temporal context model (Howard & Kahana, 2002), when people are asked to study a list of words for a later memory test, they are likely to form associations between items that share similar temporal contexts. These shared temporal contexts are then activated during recall and aid in the retrieval of the originally presented words. I refer to these shared temporal contexts as *temporal associations.* Temporal associations in this sense are different from inter-item associations, proposed by associative theories of serial recall (e.g., Shiffrin & Cook, 1978; Lewandosky & Murdock, 1989). Inter-item associations as described in the associative theories of serial recall arise because of proximity of item presentations. Thus, items that are presented close to each other tend to become linked together purely because of contiguity. On the other hand, the temporal context model stresses the role of shared temporal contexts and defines associations as items being linked to a common context. In other words, in inter-item associations, items are linked horizontally (associations between items), whereas, in the temporal context model, items are linked vertically (via a common context). For the purposes of this study, I will be focusing on temporal associations as described in the temporal context model.

One way of investigating temporal associations is by plotting conditional response probabilities (Kahana, 1996). That is, given that an item has been recalled, from where in the original study list does the next recalled item fall? A *conditional response probability* (CRP) thus measures the probability of recalling the subsequent item given the possible transitions between correctly recalled non-cued items (see Figure 1). The CRP curve is plotted as a function of lag (x-y) and is the probability of recalling item y, immediately after item x. This probability is computed starting from the third output position and is conditional on the actual recall of item y. If item y was originally presented immediately after item x, the lag function will be denoted as +1. If item y was originally presented immediately preceding item x, the lag function will be denoted as -1. Thus, the absolute value of the lag denotes the degree of remoteness (at input) of the recalled items. The sign of the lag denotes whether recall is in the forward (positive sign) or the backward (negative sign) direction. CRP curves are used to explore output order effects in free recall by plotting the relative serial position at input of items recalled adjacently at output. CRP curves show that the recalled item is more likely to be from a nearby input position, subsequent to a recalled item, rather than preceding a recalled item (Kahana, 1996). The CRP curves demonstrate that items that are in nearby input positions are likely to be output together and the bias is usually in the forward direction. In addition to conditional response probabilities, the probability of first recall also provides a way of assessing retrieval strategy. The *probability of first recall* is obtained by dividing the number of times the first word that is recalled comes from a given serial position by the number of times the first word that is recalled could have come from that serial position (Unsworth & Engle, 2007). In other words, the probability of first recall denotes the probability of initiating recall from a particular item. Thus, analyses of conditional response probability and probability of first recall can be diagnostic of a disruption in retrieval strategy.

A sample CRP is shown in Figure 1. The line on the right, denoting forward recall, is almost always higher than the one on the left, denoting backward recall. According to the temporal context model proposed by Howard and Kahana (2002), specific contextual retrieval explains this asymmetry in the curves. When an item is presented for the first time, the context that is associated with the item before it is presented in the experiment is evoked. This is known as *pre-experimental context.* Presentation of every item evokes its own pre-experimental context. In addition, the pre-experimental context associated with a particular item also becomes associated with items that are presented subsequently, especially with immediately presented items. Thus, the pre-experimental context slowly changes over time, with consecutive items sharing similar pre-experimental contexts. On the other hand, pre-experimental context is not as strongly associated with items that precede the presented item. When an item is retrieved during a recall test, the pre-experimental context associated with that item is also retrieved. Drawing from the previous description, items subsequent to the recall item (at encoding), which are associated with a similar pre-experimental context are more likely to be output relative to items preceding the recalled item (at encoding). This leads to the observed asymmetry; subsequent items (forward recalls) have a higher probability of being recalled next, leading to a higher curve relative to preceding items (backward recalls). In addition, to the pre-experimental context, presentation of an item also evokes a new context, known as *current context*, which is the context present during the experiment. Contrary to pre-experimental context, current context leads to a higher probability for nearby recalls relative to remote recalls. Thus, reinstatement of pre-experimental and current context at the time of recall results in an asymmetric curve with a pronounced bias in the forward direction and a higher probability for nearby recalls relative to remote recalls (Howard & Kahana, 2002).

Knowing what we do about the use of retrieval strategies in free recall, we can now apply this knowledge to the part-set cuing paradigm. When participants complete a free recall test, they use temporal associations to aid the retrieval process, resulting in CRPs that resemble those described by Kahana (1996). To my knowledge, no study has examined CRPs with cued recall within the part-set cuing paradigm. I propose that when participants complete a cued recall test, the presence of cues during recall impedes the use of retrieval strategies, i.e. temporal associations. Limited use of temporal associations during retrieval then results in poorer recall of the non-cued items relative to when no cues are provided. Thus, an examination of CRPs within the part-set cuing paradigm will shed light on the use of temporal associations during cued recall. An example that lends further support to the argument of temporal associations and their disruption in part-set cuing comes from studies that have examined the effect of congruency of cues within the part-set cuing paradigm.

Congruency of Cues in the Part-Set Cuing Paradigm

Although the part-set cuing effect has been demonstrated in a variety of situations, presentation of part-set cues does not always impair recall (e.g., Rundus, 1978; Sloman et al., 1991). The part-set cuing effect has been studied within the context of congruency of cues. *Congruent cues* are cues that are presented in the order in which the words originally occurred on the list. Thus, congruent cues follow a fixed pattern (e.g., only even/odd words from the original list are presented as cues). *Incongruent cues* are cues that are presented in a random order (e.g., Serra & Nairne, 2000). Thus, incongruent cues do not follow a fixed pattern (e.g., cues are words that appear in random positions on the original list).

Sloman et al. (1991) conducted an experiment in which participants either completed a free recall test or a cued recall test. In the cued recall test, participants were either provided with congruent cues or with incongruent cues. Sloman et al. (1991) found that when congruent cues were provided, recall was comparable to scores on the free recall test. However, when incongruent cues were provided, recall was significantly lower than that observed in free recall. Basden and Basden (2002) also showed that when congruent cues are provided, serial recall of non-cued items is less impaired relative to when incongruent cues are provided. In a study by Serra and Nairne (2000, Experiment 3), participants were given blanks where they had to fill in the non-cued words, constructing the original order of the words, known as *serial reconstruction*. Serra and Nairne (2000) varied the congruency of the cues: some participants received congruent cues, which were placed in the same order in which they appeared on the original list. Participants had to complete the other blanks with the non-cued items. Other participants received incongruent cues that were placed in incorrect positions and the participants had to complete the blanks with the non-cued items. The incongruent cues never occupied the positions of the non-cued items. Finally, control participants received '+' signs in place of the cues and were asked to complete the blanks with the non-cued items. The results of this study showed that performance on the serial reconstruction task was best when the cues were congruent relative to the control condition (where '+' signs were presented in place of cues). The worst performance, however, was when the cues were placed in incorrect positions, i.e., the incongruent cues condition. While, these studies lend support to the strategy disruption account, they also beg the question, "What happens at retrieval that distinguishes the impact of congruent cues from that of incongruent cues?"

The Possible Role of Temporal Associations

Drawing from the temporal context model, I propose that temporal associations play an important role in determining whether cues enhance or impair retrieval. When congruent cues are presented at recall, they allow for the formation and relative intactness of temporal associations formed between the cued and non-cued items. Thus, congruent cues do not disrupt temporality and participants are able to use these associations to retrieve the non-cued items. When incongruent cues are presented, the random order of presentation of the cues disrupts the temporality between cued and non-cued items. Thus, participants cannot rely on temporal associations during retrieval of the non-cued items, leading to poorer recall of these items. I propose that a disruption in the use of temporal context during retrieval is fundamental to the part-set cuing effect. The disruption in the use of temporal context is known as *temporality impairment.*

To examine these predictions, I conducted three experiments. In Experiments 1A and 2A, I presented congruent cues while in Experiments 1B, 2B, and 3, I presented incongruent cues. In these experiments, I explored the effect of congruency of cues on the recall of items. However, my main aim was to assess temporal associations in recall for which, I used conditional response probabilities (CRPs) as they should be diagnostic of a disruption in the use of temporal associations.

CHAPTER II

OUTLINE OF PROCEDURES

Experiment 1

Method

Participants. A total of 142 undergraduate students from the University of North Carolina at Greensboro participated for course credit. Participants were tested in groups of three to four. There were 74 participants in Experiment 1A and 68 participants in Experiment 1B.

Materials. For the purposes of this experiment, 96 unique and unrelated words were selected from the MRC Psycholinguistic database. All 96 words were common nouns (e.g., pocket, radio, and musician) with a familiarity rating between 550 and 650, a concreteness rating between 550 and 650, and an imageability rating between 550 and 650. The number of letters in each word was restricted to between five and eight letters. The 96 unique words were randomly divided into four lists, with 24 words in each list. The order of the lists and words within each list were identical across all participants.

Procedure. The experiment was within-subjects with test type (cues vs. no cues) as the manipulated variable. An intentional encoding paradigm was used. Participants were told to read the words carefully as they would be tested on them later. The encoding phase was identical across all participants. Each word was presented individually on the computer screen for 5 s with an inter-item interval of 1 s. Following the last word on the list, participants completed a math task for 45 s as a recency control. The math task was a paper-pencil test in which participants solved two-digit by two-digit multiplication problems. After completing the math task, participants took a 2 min free recall test or cued recall test. The type of test alternated, such that for two of the lists, participants received free recall tests and for the alternate lists, they received cued recall tests. Whether participants received cued recall or free recall first was counterbalanced. The participants were unaware of the type of test that they would be completing.

In the *free recall test*, participants were asked to write down as many words as they could remember from the list they had just studied. In the *cued recall test*, participants were provided with half the words as cues. The cues appeared on the screen in a line and were present during the entire duration of the recall task. Participants were asked to use the cues to recall the other words that were on the list that they had just read.

In Experiment 1A, I presented congruent cues. On one of the cued recall tests, the cues were words which had occurred in the even positions on the list. On the other cued recall test, the cues were words which had occurred in the odd positions on the list. The even and odd cues were counterbalanced across participants, such that every even and odd word appeared equally often as a cue. The cues were presented in the same order as on the original list.

In Experiment 1B, I presented incongruent cues. For the two lists that required a cued recall test, the presented cues consisted of 12 randomly selected words from each list. The order of the cues on the screen was also random and did not match the order at encoding. No two participants received the same order of cues.

Results and Discussion

Part-set cuing. In order to equate the number of items scored for cued recall and free recall, only non-cued items were scored. The dependent variable in the analyses was the proportion of non-cued items recalled. In Experiment 1A, for cued recall tests with even numbered items as cues, the correct responses were items in the odd positions. For cued recall tests with odd numbered items as cues, the correct responses were items in the even positions. For free recall tests, either even numbered, non-cued items were scored as correct, or odd numbered, non-cued items were scored as correct. The scoring for the free recall tests was alternated between lists. In Experiment 1B, for cued recall tests, the correct responses were items that were not presented as cues. For free recall tests, the correct responses were the non-cued items in cued recall. The scoring for the free recall tests was alternated between lists.

For Experiment 1A, I conducted a within-subjects paired *t*-test to analyze the difference between the average proportion recalled on the cued recall and the free recall tests, t (73) = -1.71, p = .09, Cohen's d = .22. Since this difference was not significant at the .05 level, I concluded that there was no evidence of part-set cuing. However, the mean proportion recalled was numerically lower in cued recall tests (M = .37, SD = .19) relative to free recall tests (M = .41, SD = .18).

In Experiment 1B, the mean proportion recalled was lower in cued recall tests (M = .39, SD = .17) relative to free recall tests (M = .44, SD = .19). I conducted a within-subjects paired *t*-test to analyze the difference between the average proportion recalled on the cued recall and the free recall tests, t (67) = -2.11, p = .03, Cohen's d = .28. The results of the t-test implied a significant part-set cuing effect.

Conditional response probabilities. To assess temporal associations in recall, I carried out a conditional response probability analysis (Kahana, 1996). The non-cued items in both free recall and cued recall were ordered according to the original order of presentation. Participants' responses were then assigned serial numbers according to recall transitions based on the location of the non-cued item in the original list. The conditional response probability was calculated based on the probability of recalling items at a given lag. Since there were too few correct responses, probabilities for some of the lags could not be calculated for some participants. To facilitate analyses, these values were assumed to be zero.

For Experiment 1A, Figure 2 shows the conditional response probability curves for both free recall and cued recall with congruent cues. Both graphs suggest that there is a forward recall bias. Thus, subsequent items are more likely to be output than preceding items. Both graphs demonstrate that temporal associations were used to aid the retrieval process.

For Experiment 1B, Figure 4 shows the conditional response probability curves in both free recall and cued recall with incongruent cues. The graph for free recall shows evidence of a forward recall bias. The graph also demonstrates that temporal associations were used to aid the recall process. The graph for cued recall however, does not show a forward recall bias. In addition, the graph appears to be flatter implying that temporal associations may have been disrupted. The graph for cued recall with incongruent cues thus suggests that there may be a disruption in temporal associations.

Post-hoc analyses for conditional response probabilities. In order to compare recall at the various lags in both cued recall and free recall, the probability of recall was submitted to a 4 Lag (-1CRP vs. +1CRP vs. -2CRP vs. +2CRP) x 2 Test (cued vs. free) analysis of variance.

In Experiment 1A, there was a main effect of lag, F (3, 219) = 24.11, MSE = .51, p = .00, η^2 = .25. The main effect of test was not significant at the .05 level. The interaction between lag and test was not significant, F = 1.70, p = .17. Post-hoc analyses for Experiment 1A did not reveal any significant differences in probability of recall between cued recall and free recall. From these results, I concluded that when congruent cues were provided, there was no evidence of disruption in temporal associations.

In Experiment 1B, there was a main effect of lag, F (3, 201) = 10.69, MSE = .26, p = .000, η^2 = .14. The main effect of test was not significant at the .05 level. The interaction between lag and test was significant, F (3, 201) = 3.48, MSE = .06, p = .02, η^2 = .05. Post-hoc analyses revealed that when incongruent cues were provided during recall, probability of recall was significantly different at Lag 2 in backward recall, t (67) = 2.05, p = .04 (cued recall (-2CRP): M = .05, SD = .08; free recall (-2CRP): M = .11, SD = .19). In addition, difference in probability of recall between cued recall and free recall approached conventional levels of significance at Lag 1 in forward recall, t (67) = -1.91, p = .06 (cued recall (+1CRP): M = .15, SD = .18; free recall (+1CRP):

M = .19, *SD* = .16). From these results, I concluded that there was a disruption in temporal associations when incongruent cues were provided.

I also compared the index of asymmetry in cued recall and free recall. To compute an index of asymmetry, I used the following equation: (P-N) / (P+N), where P is +1CRP and N is the -1CRP (Spillers & Unsworth, 2011). I conducted paired *t*-tests comparing the index of asymmetry when cues were provided to when cues were not provided. A paired *t*-test yielded a significant difference between free recall and cued recall neither in Experiment 1A, *t* (73) = -1.09, *p* = .28, (cued recall: *M* = .21, *SD* = .71, free recall: *M* = .33, *SD* = .62), nor in Experiment 1B, *t* (67) = -1.13, *p* = .26, (cued recall: *M* = .07, *SD* = .69, free recall: *M* = .18, *SD* = .61). Overall, the results of the asymmetry analyses did not suggest a difference in asymmetry between cued recall and free recall neither with congruent cues nor with incongruent cues.

Probability of first recall. I also calculated the probability of first recall in both cued recall and free recall tests (Howard & Kahana, 1999).

For Experiment 1A, Figure 6 shows the probability of first recall in free recall and in cued recall with congruent cues. Both graphs demonstrate that participants were more likely to begin recall from the first item relative to any other item on the list.

For Experiment 1B, Figure 8 shows the probability of first recall in free recall and in cued recall. Both graphs demonstrate that participants were more likely to begin recall from the first item relative to any other item on the list. This is similar to what has been obtained in Experiment 1A.

Post-hoc analyses for probability of first recall. I conducted paired *t*-tests to compare the probability of first recall in both cued recall and free recall. The difference between cued recall and free recall was significant neither in Experiment 1A, t (73) = -1.13, p = .26 (cued recall: M = .32, SD = .33; free recall: M = .39, SD = .37), nor in Experiment 1B, t (67) = -.67, p = .50 (cued recall: M = .29, SD = .37; free recall: M = .33, SD = .37). From these results, I concluded that the presentation of cues did not impair the probability of initiating recall.

I also conducted paired *t*-tests to compare the end of list recall in both cued recall and free recall. Specifically, I carried out paired comparisons between the last item in cued recall and the last two items in free recall. I conducted the end of list comparisons to examine whether presentation of cues led to a disruption in retrieval strategy in terms of greater/lesser use of end of list items. The difference between cued recall and free recall was not significant in Experiment 1A, t (73) = 1.30, p = .19 (cued recall: M = .05, SD = .17; free recall: M = .02, SD = .07). The difference between cued recall and free recall approached conventional levels of significance in Experiment 1B, t (67) = 1.73, p = .08 (cued recall: M = .04, SD = .13; free recall: M = .01, SD = .04). From these results, I concluded that presentation of incongruent cues was likely to disrupt retrieval in terms of end of list recall, resulting in greater use of end of list items as opposed to free recall.

Limitations of Experiment 1

In summary, the results of Experiment 1 suggested that the presentation of incongruent cues led to poorer recall of non-cued items relative to the presentation of congruent cues. However, there were very few correct responses in Experiment 1. Consequently, the CRP curves may be less stable than ideal. Thus, the results of the post-hoc analyses may not be very reliable and need to be examined with caution.

Experiment 2

In order to increase the number of correct responses, I increased the total number of words studied by each participant. Specifically, I created 12 lists each containing 16 items. This resulted in a total of 192 items. Thus, compared to the first two experiments, there were a greater number of lists but fewer items on each list. Prior research showed that the part-set cuing effect can be obtained even with fewer items on the original list (e.g., Serra & Oswald, 2006, Experiment 3; Serra & Nairne, 2000). Increasing the total number of words to be studied led to more correct responses on each list.

Method

Participants. A total of 144 undergraduate students from the University of North Carolina at Greensboro participated for course credit. Participants were tested individually and were randomly assigned to one of the four conditions. There were 74 participants in Experiment 2A and 70 participants in Experiment 2B.

Materials. For the purposes of this experiment, 192 unique and unrelated words were selected from the MRC Psycholinguistic database. All 192 words were common nouns (e.g., level, daylight, and interest) with a familiarity rating between 550 and 650, a concreteness rating between 550 and 650, and an imageability rating between 550 and 650. The number of letters in each word was restricted to between five and eight letters.

The 192 unique words were randomly divided into 12 lists, with 16 words in each list. The order of the lists and words within each list were identical across all participants.

Procedure. The procedure was similar to the one used in Experiment 1 with one exception: participants studied 12 lists, receiving a test after each list. The type of test alternated, such that for six of the lists, participants received free recall tests and for the alternate lists, they received cued recall tests. Whether participants received a cued recall or a free recall test first was counterbalanced. The format of the free recall tests and cued recall tests was identical to that used in Experiment 1.

In Experiment 2A, I presented congruent cues on the cued recall tests. On three of the cued recall tests, the cues were words which had occurred in the even positions on the respective lists. On the other three cued recall tests, the cues were words which had occurred in the odd positions on the respective lists. The even and odd cues were counterbalanced across participants, such that every even and odd word appeared equally often as a cue. The cues were presented in the same order as on the original list.

In Experiment 2B, I presented incongruent cues on the cued recall tests. Thus, for the six lists that required a cued recall test, the presented cues consisted of eight randomly selected words from each list. The order of the cues on the screen was also random and did not match the order at encoding. No two participants received the same order of cues.

Results and Discussion

Part-set cuing. As in Experiment 1, only non-cued words were scored as correct. In Experiment 2A, the mean proportion recalled in cued recall (M = .44, SD = .17) and in free recall (M = .44, SD = .16) was identical. I conducted a within-subjects paired t-test to analyze this difference, *t* (73) = .52, *p* = .61. Since this difference was not significant at the .05 level, I concluded that there was no evidence of part-set cuing in Experiment 2A.

In Experiment 2B, the mean proportion recalled in cued recall (*M* = .44, *SD* = .15) and in free recall (*M* = .45, *SD* = .15) was identical. I conducted a within-subjects paired *t*-test to analyze this difference, *t* (69) = - .47, *p* = .64. Since this difference was not significant at the .05 level, I concluded that there was no evidence of the part-set cuing effect in Experiment 2B.

In summary, the results of Experiment 2 do not provide evidence of part-set cuing, neither with congruent cues nor with incongruent cues. Since there was no evidence of part-set cuing, analyses of conditional response probabilities were not conducted.

Experiment 3

A review of the literature suggested that within the part-set cuing paradigm, items are typically presented for periods shorter than 5 s (e.g., Slamecka, 1968; Bäuml & Aslan, 2004). In Experiment 3, I presented the items for 2 s each as opposed to the 5 s presentation time in Experiments 1 and 2. In order to ensure that short presentation times did not result in poor recall, I presented each item twice. Thus, the entire list of words was repeated in the same order in which it was originally presented.

Method

Participants. A total of 66 undergraduate students from the University of North Carolina at Greensboro participated in the experiment for course credit. They were tested in groups of two to three.

Materials. The lists were identical to the ones used in Experiment 2. The order of presentation of lists and the order of words within each list were the same across all participants.

Procedure. The procedure was similar to that used in Experiment 2B, with three changes: a) I eliminated the inter-stimulus interval, b) I added an 8 s inter-trial interval between presentations of two subsequent lists (e.g., Slamecka, 1968), and c) I reduced the time spent on the distractor task from 45 s to 30 s (e.g., Bäuml & Aslan, 2004). Thus, the entire list was presented at the rate of 2 s per item. There was no inter-stimulus interval. After the presentation of the last item on the list, the entire list was presented again in the same order at the rate of 2 s per item. After the second presentation of the list, participants completed the distractor task followed by the recall test. After completing the recall test, there was a break of 8 s before the start of the next list known as the *inter-trial interval*. Participants were shown a blank screen during this interval.

Results and Discussion

Part-set cuing. As in Experiments 1 and 2, only non-cued words were scored as correct. The mean proportion recalled was lower in cued recall (M = .46, SD = .18) relative to free recall (M = .49, SD = .16). I conducted a within-subjects paired t-test to analyze the difference between the average proportion recalled on the cued recall and the free recall tests, t (65) = -2.48, p = .01, Cohen's d = .20. The results of the t-test imply a significant part-set cuing effect.

Conditional response probabilities. Since there was a significant part-set cuing effect, I carried out a conditional response probability analysis to assess temporal associations in recall. The method used to calculate the conditional response probabilities was identical to that used in Experiment 1. Like in Experiment 1, probabilities that could not be calculated because of the small number of correct responses were assumed to be zero. Figure 10 shows the conditional response probability curves in free recall and cued recall. The graph for free recall shows evidence of a forward recall bias. The graph also demonstrates that temporal associations were used to aid the recall process. The graph for cued recall also shows a forward recall bias. However, this graph appears to be flatter relative to free recall implying that temporal associations may have been disrupted.

Post-hoc analyses for conditional response probabilities. Like in Experiment 1, I compared recall at the various lags in both cued recall and free recall. The probability of recall was submitted to a 4 Lag (-1CRP vs. +1CRP vs. -2CRP vs. +2CRP) x 2 Test (cued vs. free) analysis of variance. There was a main effect of lag, F (3, 192) = 92.72, MSE = 1.40, p = .000, η^2 = .59. The effect of test tended towards conventional levels of significance, F (1, 64) = 3.28, MSE = .03, p = .07, η^2 = .05. The interaction between lag and test was also significant, F (3, 192) = 8.75, MSE = .12, p = .000, η^2 = .12. Post-hoc analyses revealed that when incongruent cues were provided during recall, probability of recall was significantly different at Lag 1 in forward recall, t (65) = -4.41, p = .000 (cued recall (+1CRP): M = .26, SD = .17; free recall (+1CRP): M = .37, SD = .15). From these results I concluded that there was a disruption in temporal associations when incongruent cues were provided.

I compared the index of asymmetry when cues were provided to when cues were not provided. The index of asymmetry was calculated in the same way as in Experiment

1. A paired *t*-test between cued recall and free recall yielded a significant difference, t (64) = -2.29, p = .03, (cued recall: M = .18, SD = .56, free recall: M = .39, SD = .35). From these results, I concluded that when incongruent cues were provided, they led to lower asymmetry relative to when no cues were provided. This implies that incongruent cues disrupt the asymmetry that is typically observed in CRPs in free recall.

Probability of first recall. Like in Experiment 1, I calculated the probability of first recall for cued recall and free recall (Howard & Kahana, 1999). Figure 12 shows the probability of first recall in free recall and in cued recall. Both graphs demonstrate that participants were more likely to begin recall from the first item relative to any other item on the list. This is similar to what was obtained in Experiment 1.

Post-hoc analyses for probability of first recall. I conducted paired *t*-tests to compare the probability of first recall in both cued recall and free recall. The difference between cued recall and free recall approached conventional levels of significance, t (65) = -1.917, p = .06 (cued recall: M = .31, SD = .24; free recall: M = .37, SD = .26). From these results, I concluded that presentation of incongruent cues was likely to impair the ability to initiate recall as opposed to free recall.

I also conducted paired *t*-tests to compare the end of list recall in both cued recall and free recall. The difference between cued recall and free recall was significant at the .05 level of significance, t (65) = -2.44, p = .01 (cued recall: M = .10, SD = .12; free recall: M = .06, SD = .07). From these results, I concluded that the presentation of incongruent cues led to a disruption in retrieval strategy in terms of end of list recall, with greater use of end of list items as opposed to free recall.

In summary, the results of Experiment 3 suggested a part-set cuing effect, with cued recall significantly lower than free recall. Paired comparisons between cued recall and free recall at each lag implied a disruption in temporal associations. In addition, analyses also pointed to a possible disruption in the probability of first recall for cued recall relative to free recall. Analysis of asymmetry revealed that compared to free recall; cued recall showed lower asymmetry, implying that providing incongruent cues disrupted the asymmetry in CRPs. Paired comparisons of the end of list recall suggested that presentation of incongruent cues led to greater use of the end of list items relative to free recall. Overall, these findings suggested a disruption in the use of temporal associations and consequently in the original retrieval strategy of participants.

CHAPTER III

DISCUSSION

The part-set cuing effect is the poorer recall of the non-cued items relative to the cued items, when a subset of the original items is presented as cues (e.g., Slamecka, 1968; Sloman et al. 1991; Basden & Basden, 1995; Bäuml & Aslan, 2006). Although this finding has been well established in the literature, a comprehensive theoretical explanation is still elusive (for reviews, see Nickerson, 1984; Roediger & Neely, 1982). In this study, I proposed a new account, temporality impairment, which proposes that when cues are provided at the time of recall, they impede the use of temporal associations, leading to impaired recall of the non-cued items. In this study, I examined temporal associations in recall, which also have implications for the strategy disruption account of the part-set cuing effect (Basden & Basden, 1995; Basden, et al., 1977). Specifically, I sought to answer two questions: a) what is the nature of disruption within the part-set cuing paradigm? and b) what are the consequences of this disruption?

Drawing from the temporal context model, I defined retrieval strategy in terms of temporal associations formed between items that share similar temporal contexts. To assess these temporal associations, I used conditional response probabilities, i.e., the probability of recalling the subsequent item given the possible transitions between correctly recalled non-cued items (Kahana, 1996). Support for the temporality impairment account stemmed from studies examining the relation between the part-set cuing effect and congruency of cues (e.g., Sloman et al. 1991; Serra & Nairne, 2000). When incongruent cues are presented, they lead to greater impairment in the recall of non-cued items relative to when congruent cues are presented (e.g., Serra & Nairne, 2000; Basden & Basden, 2002). Merging the two ideas of temporal associations and congruency of cues, I proposed that when cues are presented, participants are not able to use temporal associations during recall, which results in poorer recall of the non-cued items relative to when cues are not presented. Specifically, I proposed that congruent cues retain temporal associations leading to lesser impairment in the recall of non-cued items relative to incongruent cues, which disrupt temporal associations leading to poorer recall of non-cued items.

In order to examine this proposition, I carried out three experiments using the part-set cuing paradigm. In Experiment 1A, I presented congruent cues, while in Experiment 1B; I presented incongruent cues and examined their effect on the recall of the non-cued items. The results of Experiment 1A did not show evidence of part-set cuing. On the other hand, Experiment 1B suggested that incongruent cues led to greater impairment in the recall of non-cued items. To assess temporal associations, I carried out a conditional response probability analysis for each experiment. In Experiment 1A, when congruent cues were presented, the CRPs did not show evidence of a disruption in temporal associations, which is supported by the post-hoc analyses. In Experiment 1B, when incongruent cues were presented, the CRPs for cued recall appeared to be flatter than that of free recall, which is supported by the post-hoc analyses, suggesting that there was a disruption in the use of temporal associations. In Experiments 2A and 2B, I again presented congruent and incongruent cues respectively. I increased the number of items presented, in order to obtain more stable estimates of conditional response probabilities. However, in Experiment 2, I did not find any evidence of part-set cuing, neither with congruent cues nor with incongruent cues. Due to the absence of impairment in recall, I did not calculate the conditional response probabilities. In Experiment 3, I reduced the presentation time of each item, doubled the number of presentations for each item, and only presented incongruent cues. The results suggested a significant part-set cuing effect with incongruent cues. A conditional response probability analysis revealed disruption in temporal associations when incongruent cues were presented relative to when no cues were presented. Overall, the results of the three experiments suggested a significant part-set cuing effect when incongruent cues were presented. Moreover, this impairment was likely caused by a disruption in the use of temporal associations.

In Experiment 1A, congruent cues did not lead to a significant impairment in the recall of the non-cued items, although the absolute difference between cued recall and free recall was found to be similar to that obtained in Experiment 1B. This implies that cues do disrupt recall to a certain extent; however, incongruent cues lead to greater impairment in recall. Post-hoc analyses for Experiment 1A did not reveal any significant differences in probability of recall between cued recall and free recall. However, post-hoc analyses for Experiments 1B and 3, suggested significant differences in probability of recall. Post-hoc analyses for Experiment 1B also showed that the difference between cued recall and free recall in terms of end of list recall approached conventional levels of significance, implying that people were more likely to use end of list items during recall when presented with incongruent cues. Moreover, for Experiment 3, the results also suggested significant disruptions in asymmetry between cued recall and free recall, with the difference in probability of first recall between cued recall and free recall approaching conventional levels of significance. In terms of end of list recall, post-hoc analyses for Experiment 3 suggested significant differences between cued recall and free recall, implying that presentation of incongruent cues les to greater use of end of list items relative to free recall. Overall, the post-hoc analyses suggested that incongruent cues resulted in disruptions in the use of temporal associations, specifically impairments in initiating recall and greater use of end of list items as opposed to free recall. These results provide support for the temporality impairment account.

Drawing from the temporal context model (Howard & Kahana, 2002); disruptions in context retrieval can explain the disruption in asymmetry obtained in Experiment 3. According to the temporal context model, forward recall bias is obtained mainly from the reinstatement of pre-experimental context at the time of retrieval of an item. This pre-experimental context is associated more with subsequent items rather than preceding items in relation to the recalled item. During a free recall test, when an item is recalled, its pre-experimental context is automatically reinstated, which then results in greater recall of subsequent items rather than preceding items. However, during a cued recall test, when incongruent cues are provided, two things are likely to happen: a) temporal associations are disrupted; b) the reinstatement of pre-experimental context is hindered. Thus, items subsequent to the recalled item lose some of their advantage over preceding items. I propose that it is this loss of advantage that leads to the observed lower asymmetry in cued recall. This does not imply that there is no forward recall bias. On the contrary, the graph clearly suggests the presence of a forward recall bias. However, what is interesting to note is the lower asymmetry that is observed in cued recall relative to free recall, implying that incongruent cues disrupt the reinstatement of temporal context.

At this point it is worthwhile to take a step back and re-examine the implications of this study for the strategy disruption account, which inspired the temporality impairment account. While Experiment 3 is not an exact replication of previous studies that have examined the strategy disruption account (e.g., Sloman et al. 1991; Basden & Basden, 1995), overall, the results lend support to this account of the part-set cuing effect. The retrieval inhibition theory (Anderson et al. 1994; Bäuml & Aslan, 2004) proposes that the covert retrieval of the cued items changes the activation level of the non-cued items leading to poorer recall of the latter. This theory does not make assumptions of the use of temporal associations in retrieval. Thus, plotting conditional response probabilities would likely result in flat CRP graphs. Similarly, the competition-at-retrieval account (Rundus, 1973) proposes that the presentation of cues leads to their strengthening and the simultaneous weakening of the non-cued items. Since this theory does not suggest the use of any temporal associations during retrieval either, the resulting conditional response probabilities would likely be flat. The findings pertaining to the conditional response probabilities in this study then do not lend themselves well to the theories of retrieval inhibition and competition-at-retrieval. The results of the current study point to the use of temporal associations to aid the retrieval process. The results suggest that the poor recall of non-cued items is likely driven by a disruption in these temporal associations, i.e., a disruption in participants' original retrieval strategy. Additionally, this is more evident when incongruent cues are provided at retrieval.

One intriguing point that deserves mention is the effect size obtained in this study (Cohen's d = .2). This is smaller relative to previous studies where Cohen's d was approximately .5 (e.g., Basden & Basden, 1995; Bäuml & Aslan, 2006; Serra & Oswald, 2006, Experiment 3). In a study assessing the relation between working memory capacity and part-set cuing, Cokely, Kelley, and Gilchrist (2006) showed that people with low working memory capacity are less likely to show the part-set cuing effect relative to those with high working memory capacity. Spillers and Unsworth (2011) demonstrated that people with low working memory capacity have flatter conditional response probability curves relative to those with high working memory capacity, implying that they were less likely to rely on temporal associations during the retrieval process. Together, the results obtained by Cokely et al. (2006) and Spillers and Unsworth (2011) suggest that people with low working memory capacity are likely to demonstrate a smaller part-set cuing effect and less likely to use temporal associations during retrieval, resulting in conditional response probability curves that are flatter. A recent study by Redick et al. (2012) showed that students from UNCG scored lower on complex span tasks relative to students from Georgia Institute of Technology and University of Georgia and at approximately the same level as non-students and Atlanta area students. Drawing from Redick et al. (2012), it is possible that the low working memory capacity of students at UNCG may be responsible for the smaller part-set cuing effect obtained in the current study.

Another aspect that demands attention is the presentation time of each item. In Experiments 1 and 2, each item was presented for 5 s. Following the same procedure as in Experiment 1, I presented double the number of items in Experiment 2. However, there was no evidence of part set cuing even with incongruent cues in Experiment 2. A review of the literature suggested that in the original experiment by Slamecka (1968), items were presented for shorter than 5 s. Moreover, other studies have also presented items for shorter amounts of time (e.g., Sloman et al. 1991; Bäuml & Aslan, 2004; Serra & Oswald, 2006). In Experiment 3, I thus presented each item for 2 s. In order to avoid poor recall because of short presentation times, I presented each item twice. The results of Experiment 3 showed evidence of part-set cuing with incongruent cues. The results implied that with longer presentation times, participants are able to avoid the negative effects of incongruent cues. However, to date no study has been conducted which examines the effect of presentation times within a part-set cuing paradigm. As a possible next step, it would be interesting to manipulate the presentation time of items and observe its effect on recall of cued and non-cued items. Although the design of my experiment does not allow a clear distinction between the effects of shorter presentation time and repeated presentations, further research could tease apart these two factors and examine the effect on the recall of non-cued items.

Conclusion

The results of this study claim that the poorer recall of non-cued items when cues are provided at the time of recall is based, at least in part, on a disruption in the use of temporal associations during recall. This disruption in temporal associations likely results from a disruption in the participant’s original retrieval strategy. Thus, while the results indirectly lend support to the strategy disruption account, they also provide evidence for the temporality impairment account of the part-set cuing effect.

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APPENDIX A

FIGURES

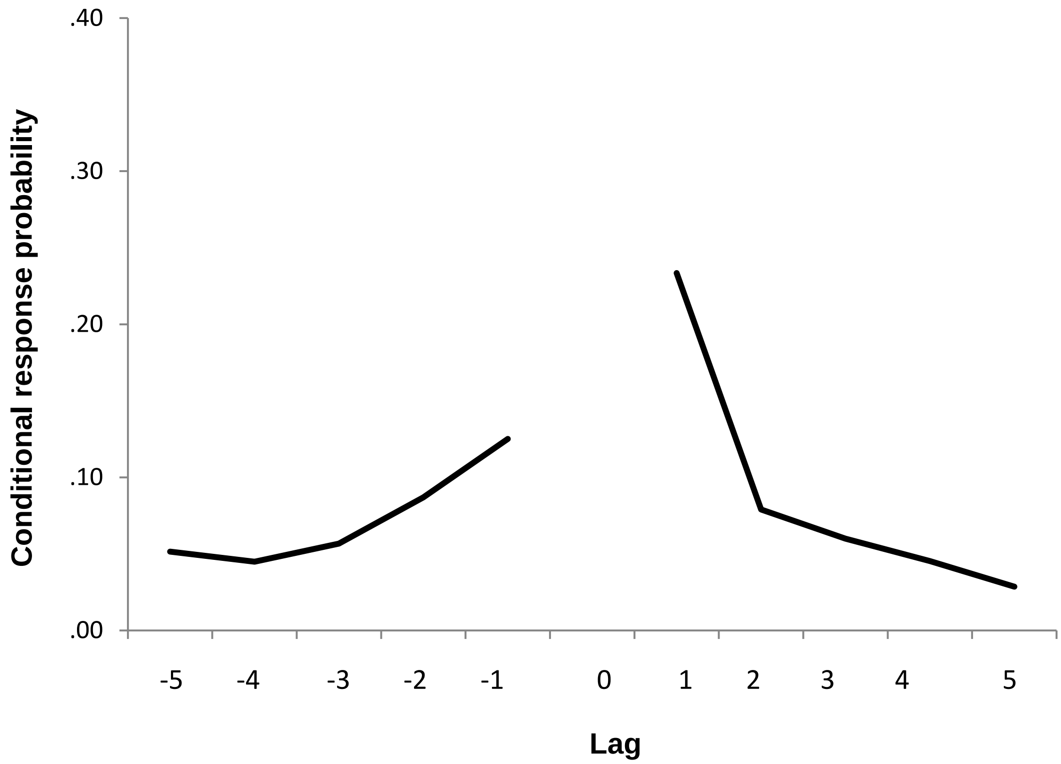

Figure 1: Conditional Response Probabilities in Free Recall

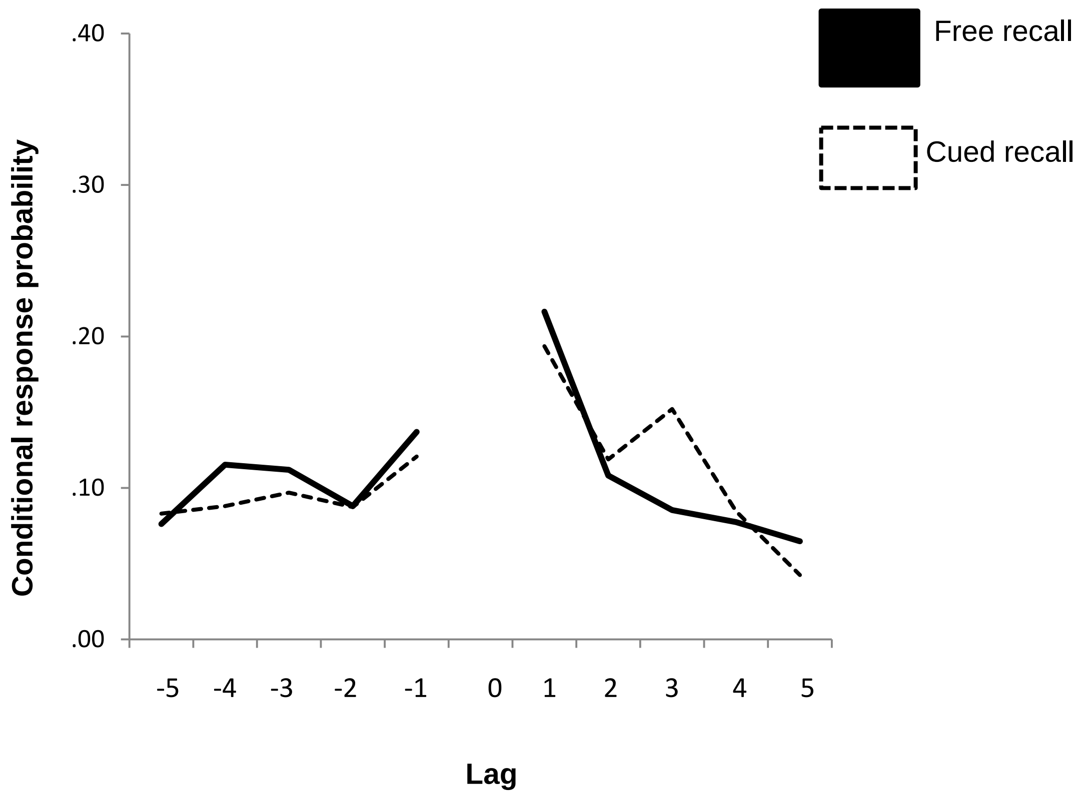

Figure 2: Conditional Response Probabilities in Experiment 1A (Non-Cued Items in Free Recall)

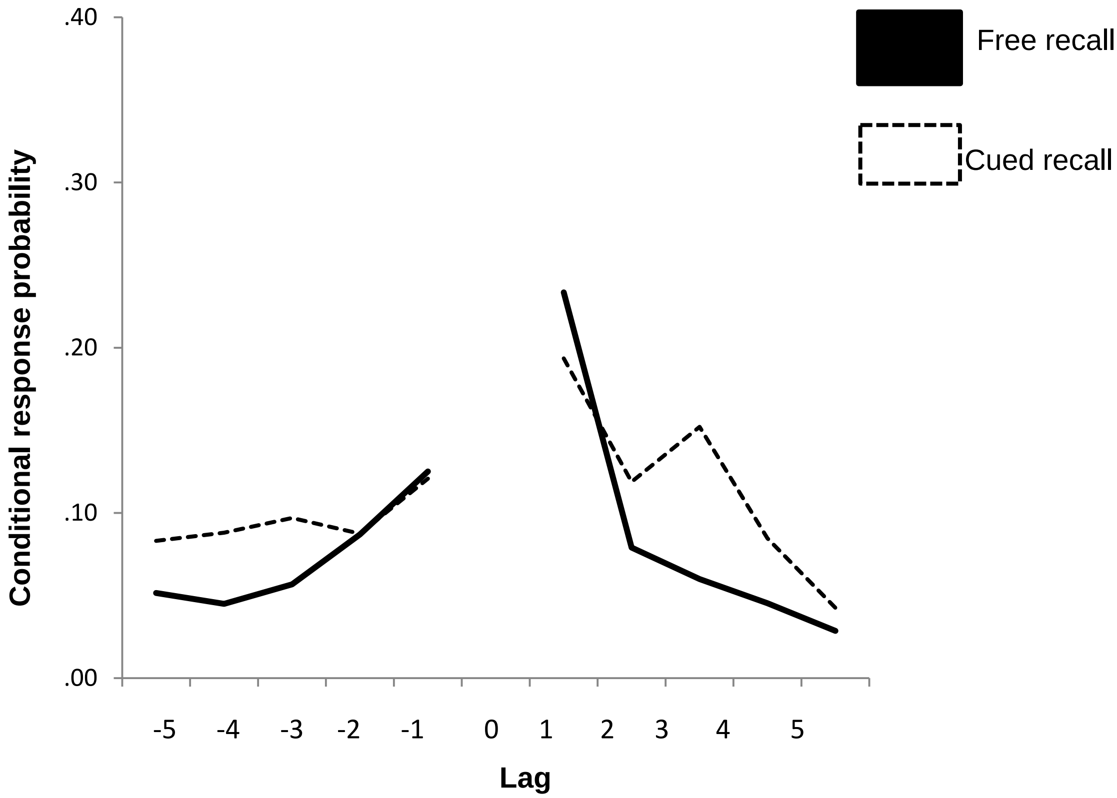

Figure 3: Conditional Response Probabilities in Experiment 1A (All Items in Free Recall)

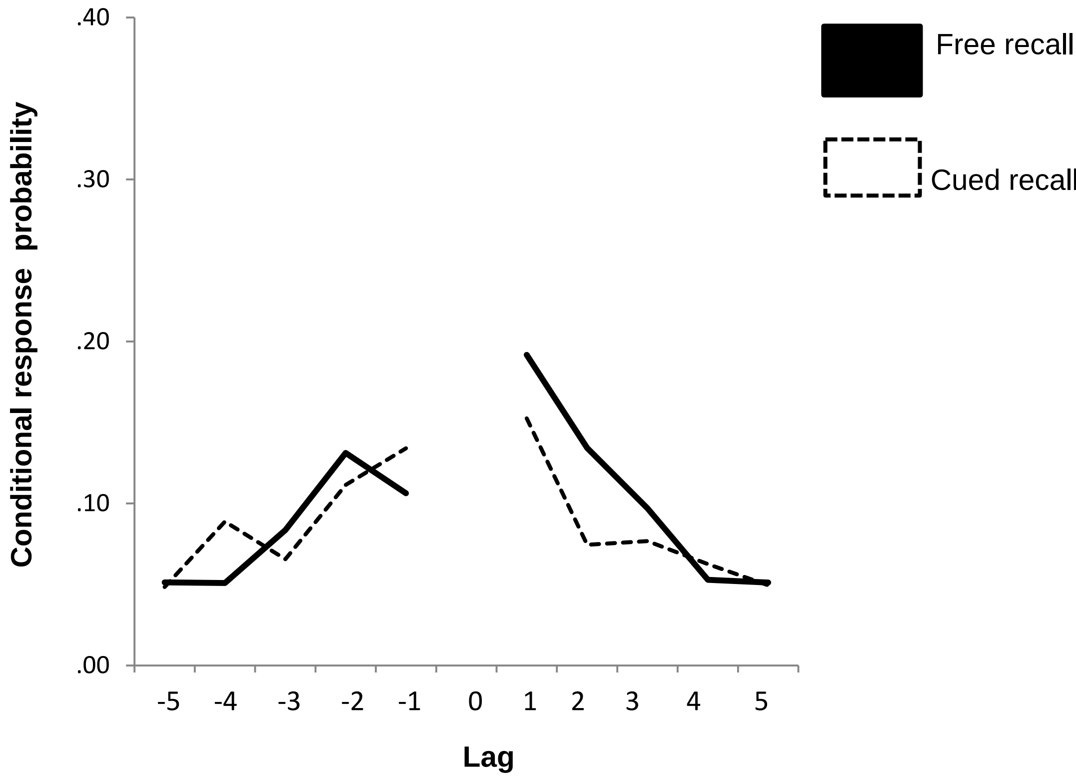

Figure 4: Conditional Response Probabilities in Experiment 1B (Non-Cued Items in Free Recall)

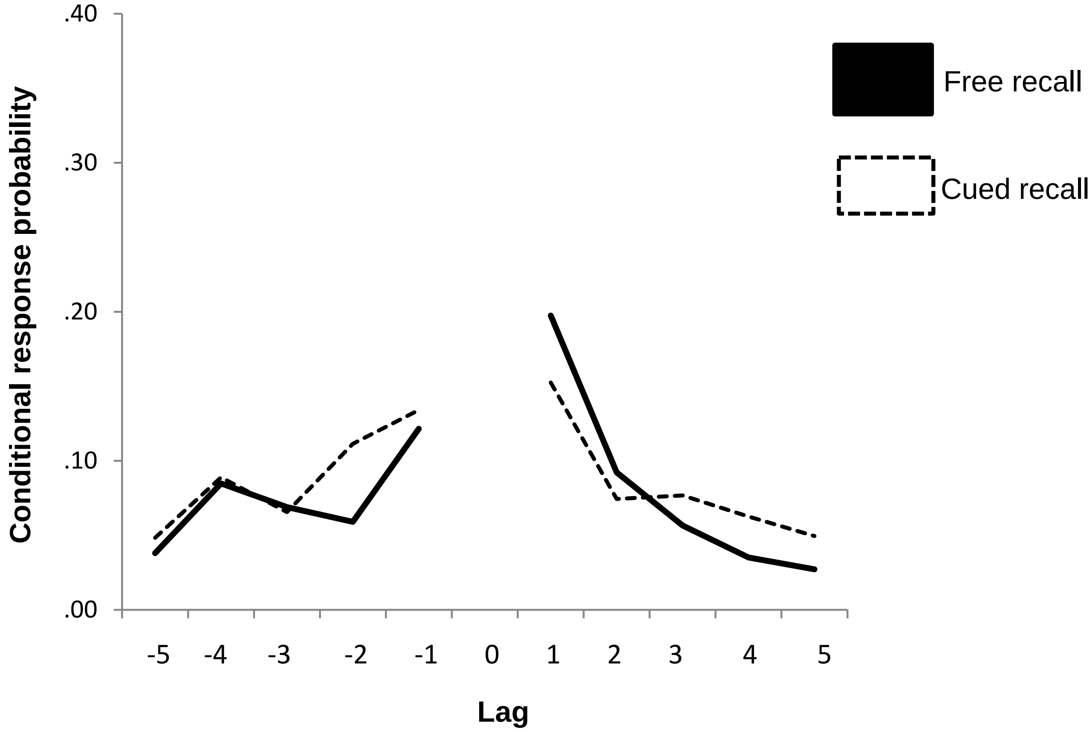

Figure 5: Conditional Response Probabilities in Experiment 1B (All Items in Free Recall)

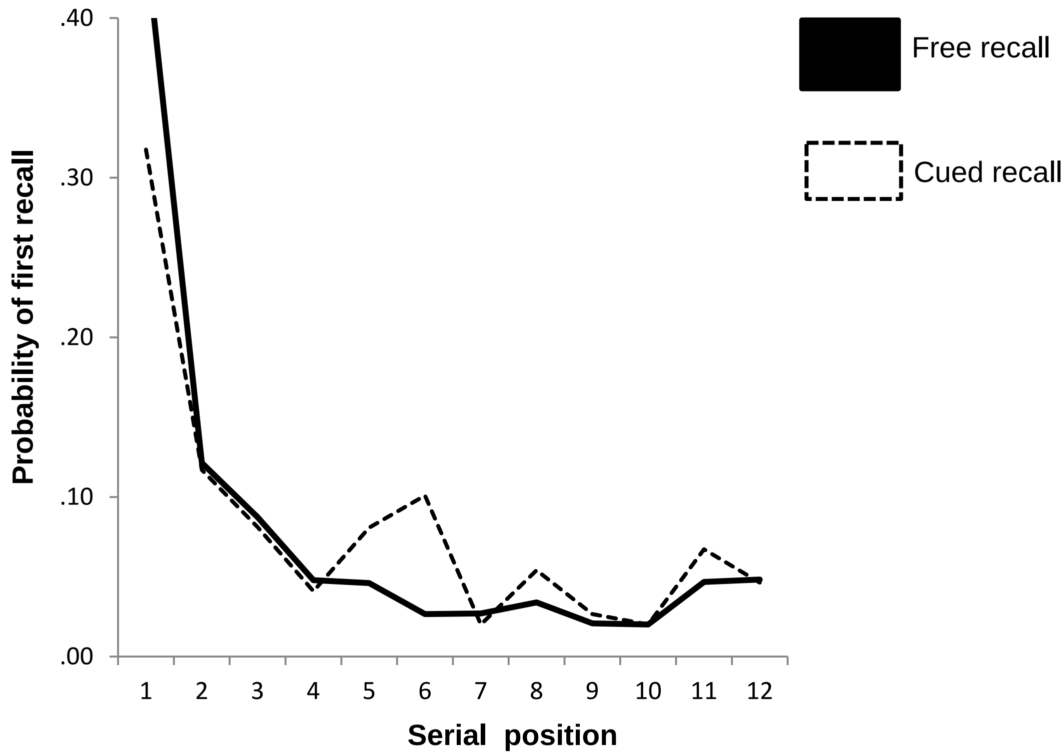

Figure 6: Probability of First Recall in Experiment 1A (Non-Cued Items in Free Recall)

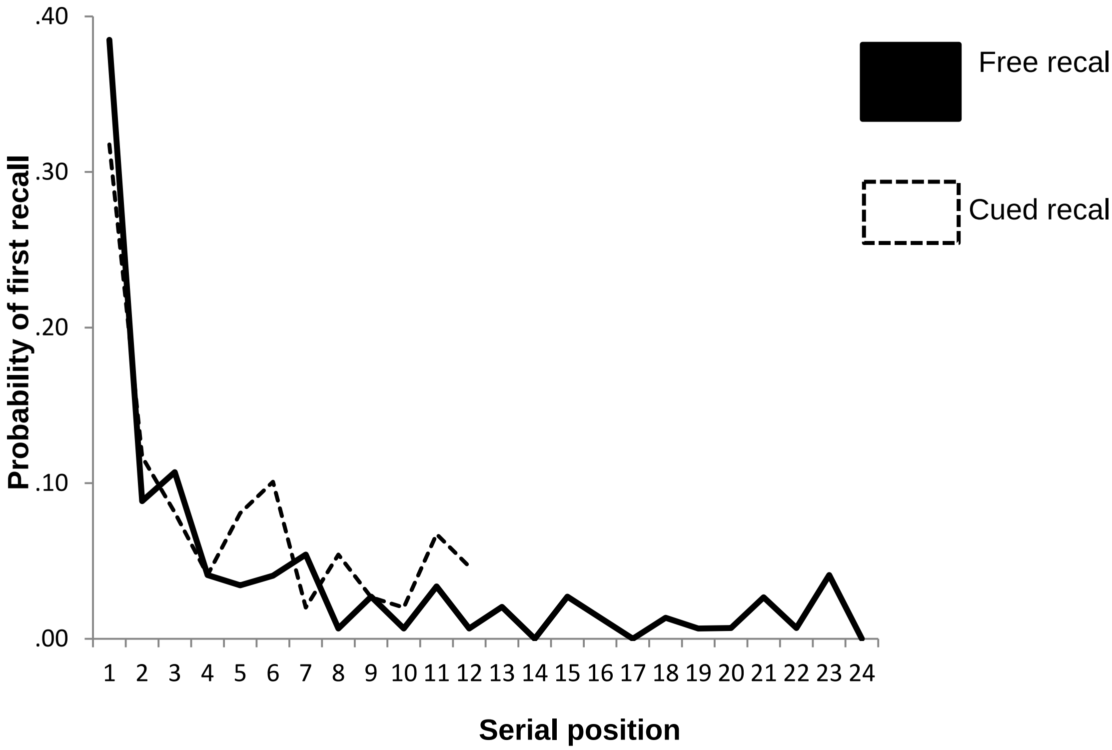

Figure 7: Probability of First Recall in Experiment 1A (All Items in Free Recall)

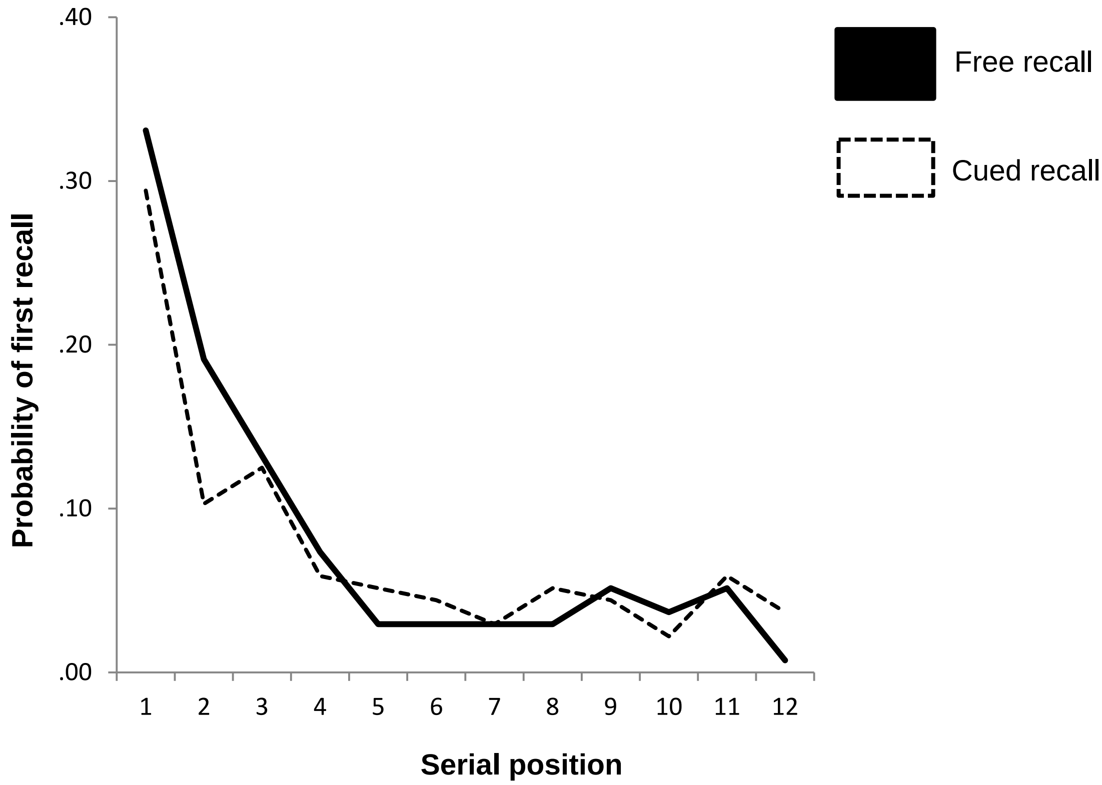

Figure 8: Probability of First Recall in Experiment 1B (Non-Cued Items in Free Recall)

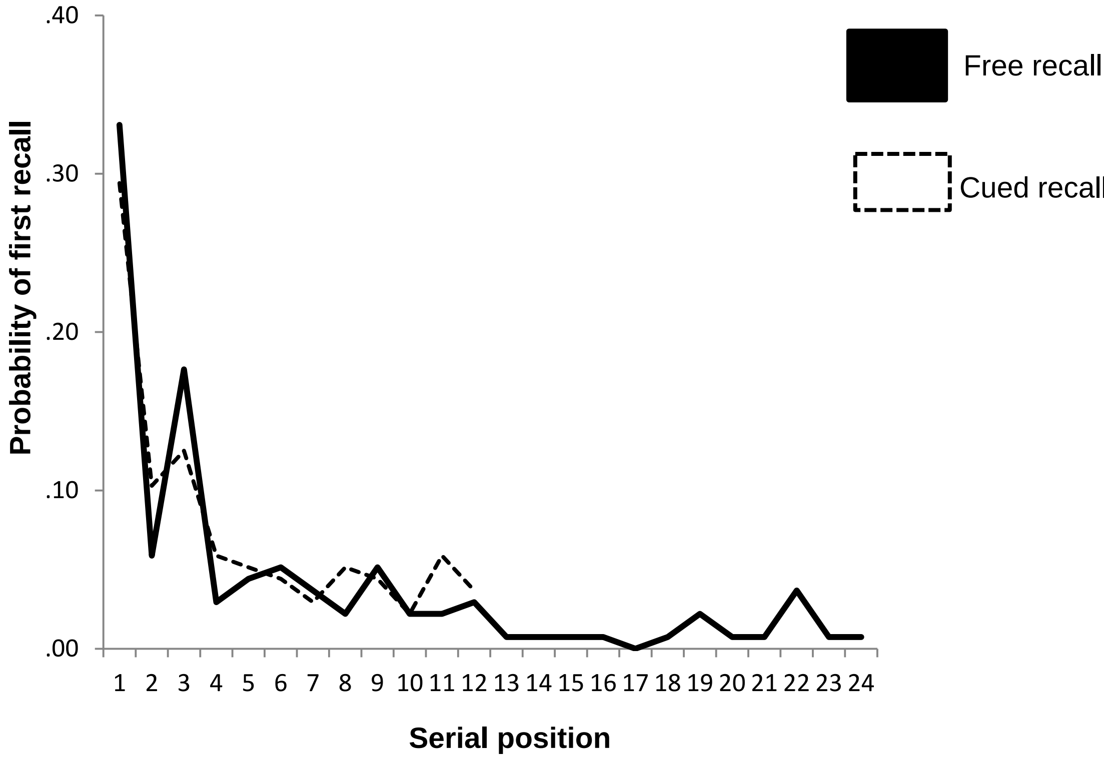

Figure 9: Probability of First Recall in Experiment 1B (All Items in Free Recall)

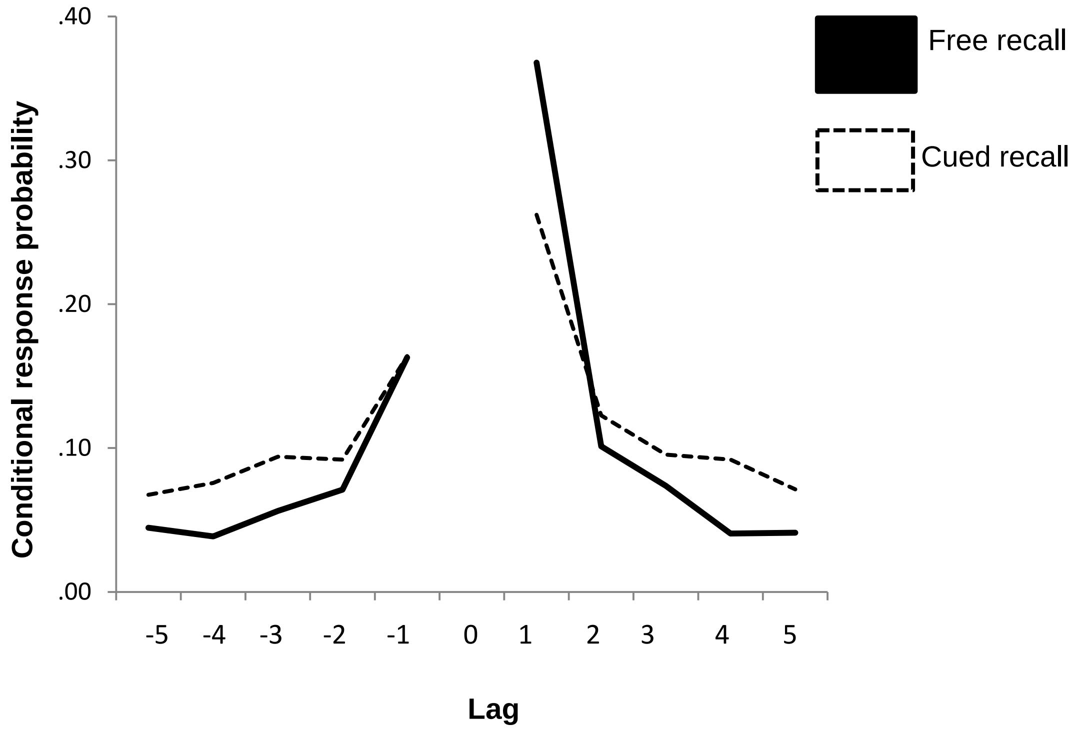

Figure 10: Conditional Response Probabilities in Experiment 3 (Non-Cued Items in Free Recall)

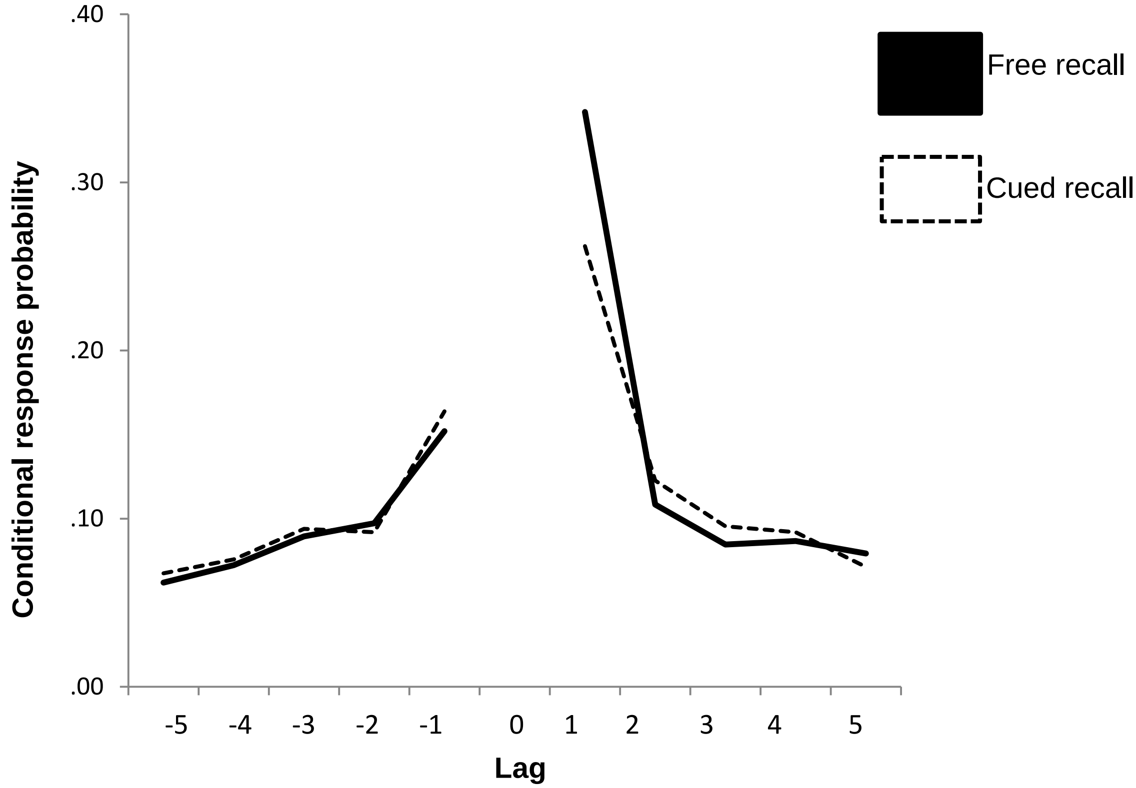

Figure 11: Conditional Response Probabilities in Experiment 3 (All Items in Free Recall)

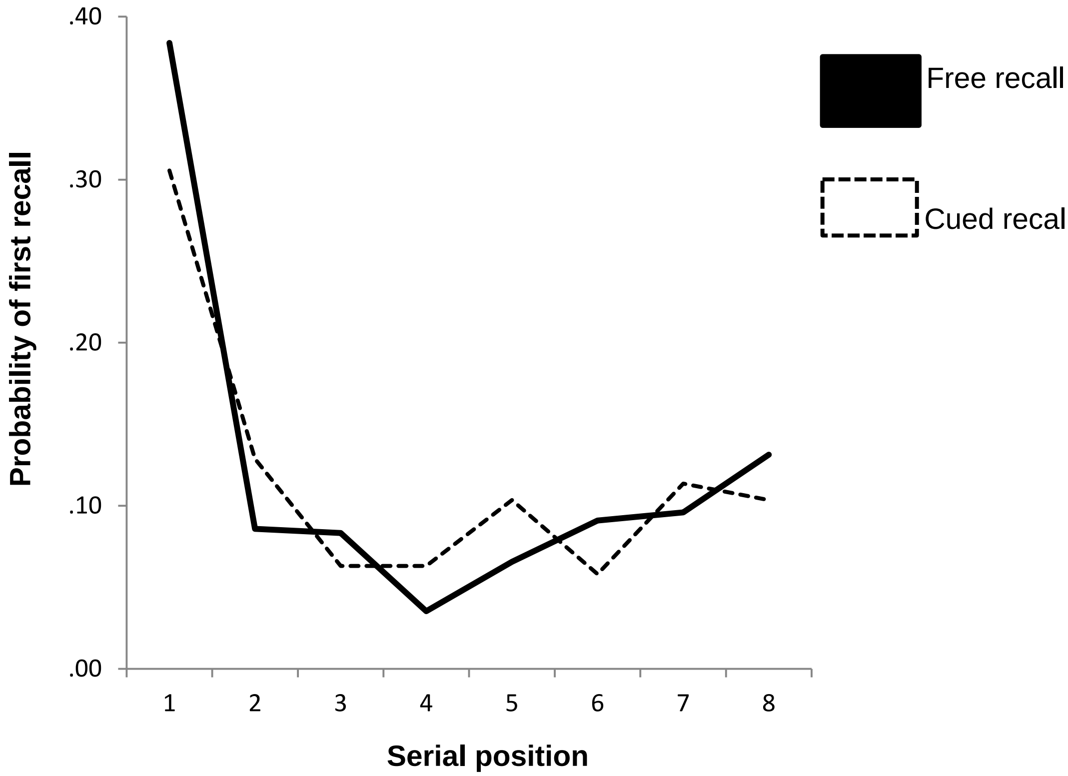

Figure 12: Probability of First Recall in Experiment 3 (Non-Cued Items in Free Recall)

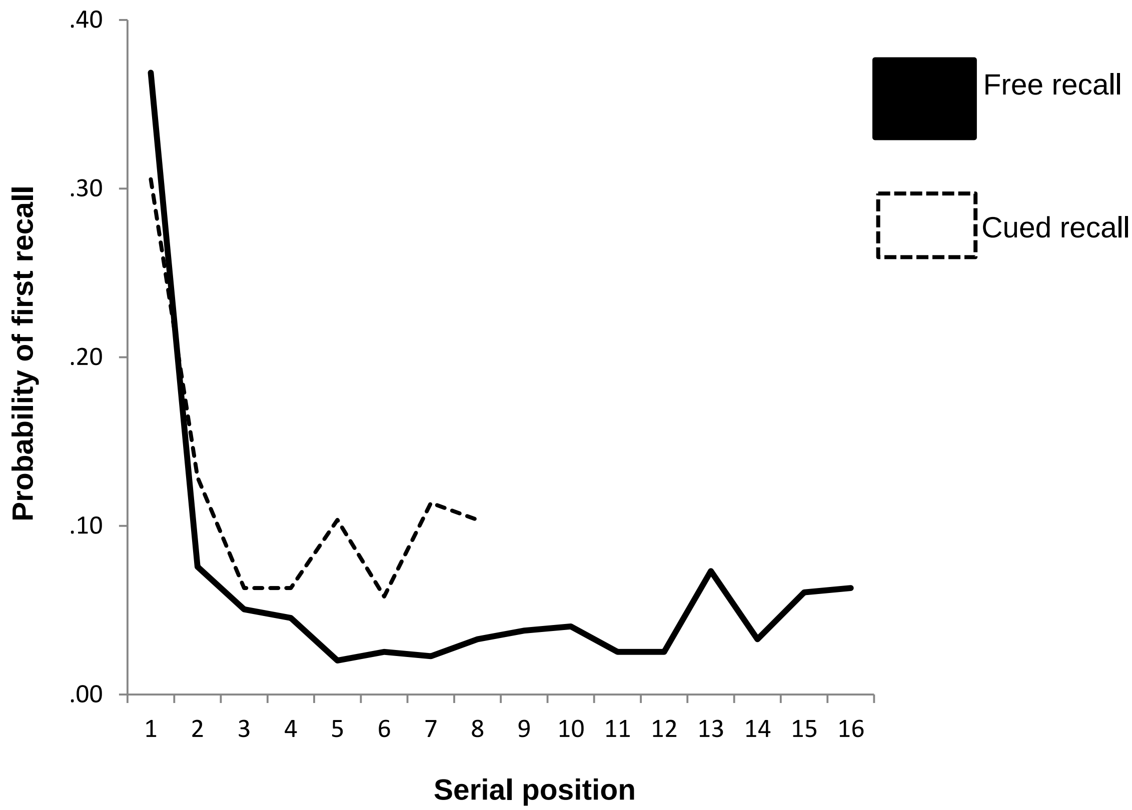

Figure 13: Probability of First Recall in Experiment 3 (All Items in Free Recall)