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WASHINGTON UNIVERSITY IN ST. LOUIS
Department of Psychological & Brain Sciences

How Does Increasing the Power of Retrieval Cues Change the Experience of Remembering?
by
Oyku Uner

A thesis presented to
The Graduate School
of Washington University in
partial fulfillment of the
requirements for the degree
of Masters of Arts

December 2017
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Abstract

How Does Increasing the Power of Retrieval Cues Change the Experience of Remembering?

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Increasing the power of retrieval cues typically enhances recall and recognition. Is this driven by remembering, knowing, or both? The current study used the remember/know paradigm in different recall tasks that manipulated the power of retrieval cues. In the first two experiments, participants studied words in a semantic or phonetic context, and were tested in one of these contexts, resulting in two match and two mismatch conditions. Participants recalled more in the match conditions, and this was driven by remembering. In the third experiment, participants studied multiple word lists and were tested immediately after each list with varying number of letter cues. Participants recalled more as the strength of the lexical cues increased, and this was driven by knowing. These findings suggest that successful retrieval can be achieved through either remembering or knowing, supporting the functional independence of these two subjective states of awareness.

Chapter 1: Introduction

Reinstating aspects of encoding at retrieval serves as a powerful retrieval cue, and typically enhances recall and recognition. Numerous studies have demonstrated this effect (Tulving & Thomson, 1973; for a review see Roediger, Tekin, & Uner, 2017); however, little is known how encoding/retrieval interactions affect states of awareness during retrieval. For instance, when recall increases with the provision of more powerful retrieval cues, are *remembering* and *knowing* equally responsible? The current study investigated this question by using the remember/know paradigm (Tulving, 1985) in different word recall experiments that manipulated the power of retrieval cues.

1.1 Encoding/Retrieval Interactions

The finding that providing more powerful retrieval cues increases recall and recognition has been shown in many contexts. Early research in this domain focused on manipulations of verbal context, and led to the encoding specificity principle (Tulving & Thomson, 1973) and the transfer-appropriate processing framework (Morris, Bransford, & Franks, 1977), which are now used to explain similar findings in other contexts as well. According to the encoding specificity principle, what is stored when an event is encoded is not just the objective characteristics of an event, but the subjective way in which the event is experienced. The critical point is that there is nothing inherent in an event that determines how well it will be retrieved; instead the manner in which the event is encoded in is important. This specific encoding determines what is stored and what cues can be effective for its retrieval. According to the encoding specificity principle, a retrieval cue will be effective when it taps into aspects of how the event was encoded. Tulving and Thomson (1973) demonstrated this by having participants study and retrieve target words

(e.g., *queen*) in different contexts. When participants studied weak cue-target pairs (*lady-queen*) and later generated words from strong cues (*king*), they often failed to recognize the target words when they generated them. Instead, participants were more successful when they recalled given the weak cue they originally studied a target word with. This “failure to recognize recallable words” (p. 364) showed that a strong associate to a word is not inherently a better retrieval cue; the context in which a target word is initially encoded greatly determines later retrieval.

Similar to the encoding specificity principle, the transfer-appropriate processing framework emphasizes the match between encoding and retrieval conditions (Morris et al., 1977). Morris et al. (1977) sought to reevaluate findings from levels of processing studies that argued a deeper and more semantic encoding resulted in more successful retrieval (Craik & Lockhart, 1972; Craik & Tulving, 1975). They argued that no encoding condition is inherently better than another and therefore retrieval does not depend solely on the quality of encoding. Instead, the learning goals and the nature of a test determine which encoding condition is better. To the extent that the encoding condition is appropriate to a subsequent test and the encoding condition can transfer to the retrieval condition, retrieval will be more successful (Morris et al., 1977). In their experiments, participants learned target words with semantic or phonetic acquisition tasks. For the semantic acquisition trials, participants determined whether the target word fit into a given sentence, and for the phonetic acquisition trials, they determined whether the target word rhymed with another word. Using a similar design, Craik and Tulving (1975) originally showed that on a standard yes/no recognition test, words encoded with semantic questions were recognized better than those encoded with phonetic questions. Morris et al. (1977) argued that retrieval in the standard recognition test would be more successful for words learned with semantic acquisition, because the standard recognition test emphasizes meaning and

hence is a more appropriate test for the initial semantic acquisition than it is for phonetic acquisition. They hypothesized that if an appropriate test for phonetic acquisition was created, then retrieval would be more successful for target words learned with phonetic acquisition. This is in fact what they found: Half of the participants took a standard recognition test after the acquisition phase and the other half took a rhyme recognition test. The instructions on the rhyme recognition test asked participants to indicate a test word as previously seen if it rhymed with one of the target words previously seen. Recognition in the standard test was higher for semantic acquisition words, but more importantly recognition in the rhyme test was higher for phonetic acquisition words than for semantic acquisition words, at least when the answers to the respective orienting questions during learning were *yes*. These results confirmed that some encoding conditions are not inherently better than others; they are better only when retrieval conditions match the way the event is encoded (Morris et al., 1977).

Fisher and Craik (1977) were interested in a similar question, and they conducted three experiments varying the match between encoding and retrieval. In their second experiment, participants studied words with associate or rhyme cues, and were tested with associate or rhyme cues, resulting in four conditions: associate cue at study-associate cue at test, associate cue at study-rhyme cue at test, rhyme cue at study-associate cue at test, and rhyme cue at study-rhyme cue at test. The first and the last were conditions in which encoding and retrieval matched, and the middle two were those in which encoding and retrieval did not match. Fisher and Craik (1977) showed an interaction between encoding and retrieval; recall in the matching conditions was higher than recall in the non-matching conditions. Using a different paradigm, Jacoby (1975) also showed a similar pattern. Participants studied a list that contained either semantically or physically related pairs along with unrelated pairs. On a subsequent recognition test, they were

asked to mark the test items that were similar to the words they studied and to indicate whether they were similar semantically or physically. Participants who studied the semantic list were better at identifying semantically similar test items, whereas participants who studied the physical list were better at identifying physically similar test items. A study published around the same time by McDaniel, Friedman and Bourne (1978) provided further evidence that the effectiveness of a particular encoding condition depends on what information is tested by the retrieval condition. McDaniel et al. showed that participants were better at recall and auditory recognition tests (i.e., tests that require name-code information) for the words they processed conceptually, but they were better at a visual recognition test (i.e., a test that requires perceptual information) for the words they processed perceptually. According to McDaniel et al. (1978), different information about words are extracted with different kinds of processing, and similarly, different retrieval tasks demand different information from participants. To the extent that the information extracted during encoding is congruent with the information needed during retrieval, participants will be more accurate. Overall, the interactions between encoding and retrieval conditions reported in this section suggest that powerful retrieval cues are the ones that tap into the conditions in which encoding occurred.

The studies discussed previously focus on the match between encoding and retrieval conditions, and how reinstating aspects of encoding during retrieval serves as a powerful retrieval cue. The power of retrieval cues, however, can also be increased gradually. In one such experiment, Tulving and Watkins (1973) manipulated the number and nature of retrieval cues provided to participants at test. Participants studied multiple five-letter word lists and were immediately tested on each list. On most of the tests, they were provided with the first two, three, four or all five letters of the words on the preceding study list as retrieval cues. They were

required to type in one of the words in the preceding list that the cue reminded them of. For one of the studied lists, participants were given a surprise free recall test, where they did not receive any cues. As expected, recall increased when the power of retrieval cues during test increased from self-provided cues (i.e., free recall) to a very powerful cue (i.e., the word itself). Matching encoding and retrieval conditions typically increases the power of retrieval cues and enhances memory, but this can occur also with gradually increasing the power of retrieval cues on one feature, in this case a lexical dimension. In the experiments reported below, the power of retrieval cues will be increased via a match between encoding and retrieval conditions, and via the provision of more letter cues.

1.2 Retrieval Experience

The aim of the current study is to investigate how providing powerful retrieval cues affects retrieval experience. Of interest is whether the increased recall with the provision of more powerful retrieval cues is related to increased remembering, knowing, or both, as measured by the remember/know paradigm (Tulving, 1985).

Tulving (1985) measured phenomenological experience during recall and recognition by having participants state whether they remembered or knew a word to be on the list they studied. Remembering indicated that participants “‘remembered’ [the item’s] occurrence in the list” and knowing indicated participants “‘simply ‘knew’ on some other basis that the item was a member of the study list” (Tulving, 1985, p. 8). Tulving argued that remembering and knowing tapped into different types of consciousness (autonoetic and noetic, respectively) that characterized different memory systems (episodic and semantic, respectively). According to Tulving, correct recall or recognition should be a joint product of episodic trace information and semantic cue information. If participants recall or recognize an event based more dominantly on episodic trace

information, they should give more remember responses. On the other hand, if participants recall or recognize an event based more on semantic cue information, they should give more know responses. Tulving (1985) had participants study category names paired with an instance of the category. The participants then took three successive tests. The first test was free recall, where participants were asked to recall all category instances. Next, participants were given the names of the categories and were asked to recall the category instances. Finally, participants were given the category name with the first letter of the category instance and were asked to recall the category instances. In all three tests, participants gave a remember or know response after each word they recalled. Tulving argued that, from the first to the last test, episodic trace information should decrease due to forgetting across time, while the semantic cue information should increase. The proportion of remember and know responses supported Tulving's argument; remember responses decreased from the first test to the last test, while know responses increased.

Instead of considering remembering and knowing to be tapping into two memory systems, others held a unitary view of memory (one system) and considered these judgments to be tapping into dual-components of recognition (Graf & Mandler, 1984; Jacoby, 1983; Mandler, 1980; Yonelinas, 2002). From this point of view, remembering is associated with a conscious recollective experience of an event, whereas knowing is associated with a feeling of familiarity in the absence of any recollective experience (Jacoby, 1991; Mandler, 1980; Yonelinas, 2002). For instance, one can recognize a face and remember talking to that person at a party the night before, and remember what they were wearing or where the party was. This would be a conscious recollective experience, and would lend itself to a remember response in a memory experiment. On the other hand, one can also confidently recognize a face based on strong feelings of familiarity, without having a conscious recollection of seeing the person before. This

is akin to Mandler's butcher-on-the-bus phenomenon (1980), where one sees their butcher on the bus, recognizes his face, knows they know him from somewhere but cannot identify the context. In a memory experiment, such an experience would lend itself to a know response. Broadly, these two experiences make a distinction between the intentional and incidental use of memory (Jacoby, 1984), and are sometimes referred to as conceptually-driven and data-driven processes (Jacoby, 1983), elaboration and integration (Graf & Mandler, 1984), or more commonly as recollection and familiarity (Mandler, 1980). Both contribute to recognition, and various experimental manipulations should change the extent to which one is used more dominantly during retrieval.

One of the first systematic investigations of remembering and knowing was conducted by Gardiner (1988), who showed that there is a functional distinction between each response. In two experiments, he manipulated encoding conditions and examined how these manipulations affected remembering and knowing on a recognition test. In the first experiment, he manipulated levels of processing by asking participants to write down a rhyming word (i.e., shallow processing) or a semantically related word (i.e., deep processing) to words on a study list. In the second experiment, he asked participants to generate some of the words from a cue and to read some of the words presented intact. Replicating prior findings, recognition was greater for words that were deeply processed (Experiment 1) and for words that were generated (Experiment 2) during study. Critically, both manipulations only affected remembering. Participants gave more remember responses during recognition to words they processed more deeply compared to the others (Experiment 1), and to words they generated compared to the words they read (Experiment 2). In both experiments, the encoding manipulations did not affect the proportion of know responses.

Further research following Gardiner (1988) showed that remember and know responses can be dissociated and are functionally independent. Some manipulations affect only remember but not know responses, some affect only know but not remember responses, and others have similar or even opposite effects on the two responses (see Roediger, Rajaram & Geraci, 2007, for a review). One early explanation of these findings was that conceptual manipulations (e.g., levels of processing) affect remembering and perceptual manipulations (e.g., masked repetition priming) affect knowing (Rajaram, 1993). However, later findings showed perceptual manipulations could affect remembering and conceptual manipulations could affect knowing (Rajaram, 1996; Rajaram & Geraci, 2000). For instance, Rajaram (1996) showed that matching the study and test format during recognition, a perceptual manipulation, increased remember responses. In another experiment, when participants were primed with semantically related words before each item on a recognition test, a conceptual manipulation, they gave more know responses (Rajaram & Geraci, 2000). To explain these inconsistencies with the earlier explanation, Rajaram (1996, 1998) put forth a new framework that emphasized distinctiveness and fluency instead of conceptual and perceptual processing. According to this framework, processing distinctive or salient aspects of events increases remembering, whereas fluency or ease of processing of events increases knowing, regardless of the conceptual or perceptual aspects of the process. This framework successfully accounted for most findings regarding the functional independence of the two retrieval experiences and will be used to discuss the results of the three experiments reported below.

1.3 Methodological Issues in Remember/Know Research

Before considering the current project, it is worth mentioning several issues regarding the use of the remember/know procedure. One issue is whether data from know responses are noisy,

because they might include guessing. To resolve this issue, Gardiner, Java and Richardson-Klavehn (1996) added a guess option to the procedure. This allowed participants to indicate if they were merely guessing the occurrence of an event during study, when they recalled or recognized it at test. As a result, guessing was eliminated from know responses without affecting remember responses (Gardiner et al., 1996; Gardiner, Ramponi, & Richardson-Klavehn, 1998), and this procedure became widely adopted. The guess option is included in the experiments in this thesis as well, in order to obtain better estimates of remembering and knowing.

When using the remember/know procedure, it is crucial to make sure participants understand the distinction between each response type. In a review of the methodological issues in the remember/know paradigm, Migo, Mayes and Montaldi (2012) discussed the importance of checking whether participants understood and actually followed the instructions regarding the distinction between response types. They noted that majority of the studies using the remember/know procedure did not mention whether or how they checked if participants understood and followed the instructions. One suggestion they made is to ascertain how many participants were replaced based on their understanding of instructions, and why they were replaced. Typically, in remember/know studies, written and/or verbal instructions are provided to participants. In some of these studies, participants are asked to repeat the instructions back to the experimenter. In the experiments in this thesis, the experimenter gave verbal instructions to a group of participants prior to the beginning of the experiment and asked one of the participants in the group to explain the distinction between remembering, knowing and guessing in their own words. In addition, participants were asked to explain how they distinguished between each response type in a post-experimental questionnaire. These responses were used to identify whether participants understood the instructions correctly and to replace the participants who did

not accurately explain the distinction between remembering, knowing and guessing (see Eldridge, Sarfatti, & Knowlton, 2002, for a similar procedure). The main focus will be the data from those participants who were able to describe the distinction between response types correctly, and data from all of the participants will be reported in the appendices. As will be discussed later, whether or not the participants were able to correctly describe the distinction did not change the results.

Another issue with remember and know responses is their statistical analysis. When only using remember and know options, these responses are dependent on each other (Rajaram, 1993). That is, for a fixed level of recall or recognition, as remember responses increase, know responses must decrease (and vice versa). In the early days of remember/know research, Gardiner (1988) compared these responses by including response type as a factor in an analysis of variance (ANOVA), but he noted that this practice may be questionable since these are not independent variables manipulated by the experimenter. Rajaram (1993) proposed a different way of comparing remember and know responses. She calculated two proportions, one of remember responses divided by the total number of recognition responses and the other of know responses divided by the total number of recognition responses in each condition. She then compared the remember proportions between two conditions using a paired comparison *t* test, and did a separate *t* test for the know proportions. However, when there are more than two conditions in an experiment, comparison of response type proportions across multiple conditions requires an analysis of variance (ANOVA) instead of multiple *t* tests. In the experiments reported below, remember, know, and guess responses will be compared across conditions using separate ANOVAs for each response type following prior research (e.g., Dewhurst & Brandt, 2007; Hamilton & Rajaram, 2003).

The proportion of each response type, however, can be calculated two different ways: One way is to divide the number of each response type to the total number of items in a particular condition. This way, the proportion of remember, know, and guess responses add up to the proportion correctly recalled or recognized in that condition. These absolute or raw proportions are not very informative when comparing each response type across conditions that vary greatly in the level of recall or recognition, because they are dependent on accuracy in their respective conditions. For instance, if recognition in Condition A is 0.3 and recognition in Condition B is 0.7, the absolute proportion of a response type will almost always be lower in Condition A than Condition B. In order to make a better comparison without being limited by the level of recall or recognition, relative or conditional proportions can be used (Chan & McDermott, 2006; Dewhurst & Conway, 1994; Rajaram, 1993). These proportions can be obtained by dividing the number of each response type to the proportion correctly recalled or recognized in a particular condition. This way, the proportion of remember, know, and guess responses in a condition add up to one. These relative proportions, therefore, are more informative when comparing response types across conditions that differ greatly in their respective accuracy level. In this thesis, both proportions will be reported, but the main focus will be on the relative proportions because recall varies widely across conditions.

When inferring how much recollection and familiarity contribute to recall or recognition using remember and know responses, both ways of calculating response proportions assume that remembering and knowing are mutually exclusive: Recollection is measured only through remember responses, and familiarity only through know responses. Jacoby, Yonelinas and Jennings (1997) argued against this assumption and stated that remember responses can be provided based on both recollection and familiarity, instead of only recollection. This meant that

using only know responses underestimates familiarity, because some familiarity contributes to remembering. Because this issue cannot be addressed using the typical ways of analyses discussed above, Jacoby et al. introduced the Independence Remember/Know (IRK) procedure that did not assume exclusivity between remember and know responses, but rather considered familiarity to be contributing to both response types. In this procedure, recollection is measured by the proportion of remember responses; however, familiarity is measured differently. Instead of taking the proportion of know responses as a proxy of familiarity, familiarity is estimated by the proportion of know responses for trials in which participants do not use the remember option. This measure then reflects a group of familiarity-based responses where there was no recollection, or $\text{Know}/(1-\text{Remember})$ in an equation form (Yonelinas & Jacoby, 1995). Transforming know responses using this equation results in an estimate of familiarity independent of recollection. One key point is that this estimate is derived from the absolute (or raw) proportion of remember and know responses. Therefore, the absolute proportion of remember responses (instead of the relative proportion) is the appropriate measure to consider when comparing estimates of familiarity to recollection.

1.4 The Current Study

As previously noted, remembering and knowing are functionally independent. Which one, then, is related to the increase in recall when the power of retrieval cues increases? Although few studies addressed this question using recognition, evidence from recall experiments is minimal (see Hamilton & Rajaram, 2003; Tulving, 1985). The aim of this thesis is to more fully explore the relation of increasing the power of retrieval cues to retrieval experience using word recall experiments.

Tulving (1976) stated that recall and recognition involve similar processes, with the

major difference between the two tasks being the cue information available during retrieval. Tulving and Watkins (1973) showed that assuming recall and recognition are continuous yields a more parsimonious account of retrieval, instead of assuming they are fundamentally different tasks. As discussed above, participants in their experiment studied multiple lists of five-letter words and were tested on the words with varying numbers of letters of the words as cues. Participants either recalled with no letters (i.e., free recall), the first two letters, three letters, four letters, or with all five letters of a word (recognition-like recall task). Recall gradually increased as more letter cues were provided, suggesting that recall and recognition are not fundamentally different, but they are continuous.

Further evidence showing that recall and recognition employ similar processes comes from studies using the remember/know procedure in recall tasks. Although the number of studies using this procedure in recognition is much higher, remember/know studies using recall has consistently shown that knowing also contributes to accurate recall (Hamilton & Rajaram, 2003; Lindsay & Kelley, 1996; McCabe, Roediger, & Karpicke, 2010; McDermott, 2006; Mickes, Seale-Carlisle, & Wixted, 2013). For instance, McCabe et al. (2010) used inclusion and exclusion tasks (see Jacoby, 1991 and Jacoby et al., 1997) and the remember/know paradigm to assess automatic processes in free recall. The two methods showed converging evidence that free recall does not only rely on conscious recollection or controlled processing, but that familiarity or automatic processing is also involved. This finding is inconsistent with the claim by Quamme, Yonelinas, Widaman, Kroll and Sauvé (2004) that recall only involves recollection, and recognition involves both recollection and familiarity.

Given that recollection and familiarity both are processes involved in successful retrieval, are they equally responsible when recall increases with the provision of more powerful retrieval

cues? Although a few studies asked similar questions using recognition tasks, the extent to which remembering and knowing contribute to this increase in accuracy in recall tasks is unclear (but see Hamilton & Rajaram, 2003; Tulving, 1985). Because recall and recognition employ similar processes, there is no theoretical reason why this question cannot be asked in the context of recall. In this thesis, I will examine whether the increase in recall via increasing the power of retrieval cues is driven by remembering, knowing, or both.

According to the encoding specificity principle and the transfer-appropriate processing framework, retrieval is enhanced when retrieval cues tap into the original encoding episode or when retrieval conditions match those of encoding. Because some aspect of encoding is reinstated at retrieval, recollection might increase. If so, participants should give more remember responses when retrieval cues and/or conditions tap into those of encoding, while know responses should not necessarily be affected. Previous research on remember and know responses mentioned the possibility of this relationship in passing. For instance, Rajaram (1993) argued that “‘remember’ responses, by definition, require recollecting the study phase and reinstating its context” (p. 100). Similarly, Dewhurst and Conway (1994) stated that “when these activated memories contain details of sensory and perceptual information, semantic information, and records of cognitive operations performed at study, then recognition memory is dominated by recollective experience” (p. 1098).

In fact, several studies have shown this pattern in word recognition experiments. Macken (2002) manipulated the context in which participants studied items and then took a recognition test, collecting remember and know responses for each recognized item. Context was defined as a combination of color of the screen, color of the presented item and location of these on the screen. Participants studied items in one of two contexts and were tested on those in either the

old context or a novel context (Experiment 1 and 2), or were tested in the two old contexts (Experiment 3). As expected, matching the context in which items were studied and tested increased recognition for both words (Experiment 1 and 3) and nonwords (Experiment 2). Critically, the match in study and test contexts selectively increased remember responses, but did not affect know responses. Macken (2002) concluded that context effects in recognition memory occur only when recognition is accompanied by conscious recollection (i.e., remember responses), but not when an item is recognized based on familiarity (i.e., know responses).

In a different study, Dewhurst and Brandt (2007) contrasted generation of five-letter words from four-letter fragments and reading intact five-letter words at learning and at test, and asked participants about their retrieval experience at test. Both experiments in their study produced similar results. Generating words during study increased recognition of words generated and read during test; more importantly, recognition memory was enhanced when the same words were also generated at test. In both experiments, they asked participants to indicate their retrieval experience during recognition by giving a remember, know or guess response after each recognition judgment. Participants gave more remember responses when words generated during study were also generated at test, but not when words read during study were also read at test. Dewhurst and Brandt (2007) concluded that matching effortful encoding and retrieval conditions (i.e., generation) enhanced recognition memory and was accompanied by a conscious recollection of encoding (i.e., more remember responses), whereas matching more automatic encoding and retrieval conditions (i.e., reading) did not show a similar pattern. Taken together, these studies suggest that matching certain study and test conditions, therefore providing more powerful retrieval cues at test, enhances recognition and that this is associated with an increase in only remember responses.

Yet several other studies have shown different or opposite effects. For instance, Tulving (1985) showed that, when participants studied category instances they recalled more when they were provided with the category name or the category name with the first letter of the instance, compared to free recall of category instances. Critically, this increased recall was accompanied by decreased proportions of remember responses. However, as Hamilton and Rajaram (2003) noted, Tulving's participants took three successive tests (free recall, category cued recall, and then category plus first letter cued recall) and therefore the decrease in remember responses could be due to passage of time, item selection or output interference. Hamilton and Rajaram (2003) argued that with this design, remember and know responses in each of the three tasks cannot be properly compared. In their first experiment, after studying category-exemplar pairs, participants were assigned to a free recall, category cued recall, category plus first letter recall or a recognition condition that were manipulated between participants. As expected, performance increased when more powerful retrieval cues were provided; however, the relative proportion of remember responses did not change. This suggests that increases in recall or recognition with the provision of more powerful retrieval cues may not always be accompanied by increased recollection.

In another study, Gregg and Gardiner (1994) showed that matching study and test presentation modalities (visual and auditory) selectively increased know responses, leaving remember responses unaffected. In Experiment 2, they presented words visually and rapidly to half of the participants, who were not informed of a subsequent recognition test. These participants were asked to count the number of words with blurred letters on the list (none of the words were blurred). The remaining half of the participants were informed of a subsequent recognition test and they studied the words at a slower presentation rate. Words were presented

visually at study, and all participants took a recognition test in which half of the words were presented visually and the remaining half were presented auditorily. Participants indicated whether they remembered or knew the words they recognized at test. Gregg and Gardiner (1994) found that the group that was asked to count the number of blurred letters on the list showed higher recognition performance when the presentation modalities matched. Critically, this better recognition performance was accompanied by increased know responses, suggesting that reinstating some aspects of encoding at retrieval might selectively increase know responses under certain circumstances.

The goal of this thesis is to focus on word recall experiments and investigate how provision of more powerful retrieval cues relates to remembering and knowing. Previous studies typically investigated retrieval experience when encoding and retrieval conditions match in recognition memory, but of course remembering and knowing were originally intended to apply to recall, too (e.g., Tulving, 1985). In the first two experiments, retrieval cues were matched or mismatched with the study conditions using cued recall. These two experiments used semantic and rhyme cues at study and test, similar to Fisher and Craik's (1977) study. In the third experiment, the power of retrieval cues was gradually increased by providing different numbers of letters of words as cues, similar to Tulving and Watkins' (1973) study, rather than matching and mismatching study and test conditions, which allowed a comparison between free recall, cued recall and recognition-like conditions. In contrast to the first two experiments, the third experiment used lexical cues. In all three experiments, participants were asked to provide remember, know and guess responses to each word they recalled. Recall, remembering and knowing were then compared across conditions to see if providing more powerful retrieval cues increased recall and if so, whether remembering, knowing or both drove this increase.

1.5 Experiments 1 and 2

In the first two experiments, participants studied words with associate or rhyme orienting questions, and were tested with associate or rhyme cues, resulting in four within-subjects conditions: associate at study-associate cue at test (AA), associate at study-rhyme cue at test (AR), rhyme at study-associate cue at test (RA), rhyme at study-rhyme cue at test (RR). These experiments were based on the study by Fisher and Craik (1977, Exp. 2) discussed earlier, with the addition of asking participants to provide remember, know, or guess responses after each word recalled. Replication of Fisher and Craik's recall findings was expected, with recall increasing when the cues at test match the cues at study (i.e., AA, RR) compared to when the cues do not match (i.e., RA, AR). It was predicted that this increase in recall when the cues match would be accompanied with increased remembering, but not knowing. When participants study target words by judging whether they are associated with or rhyme with another word, they may elaborate on the relationship between the target word and the cue word in the orienting question, potentially resulting in distinctive processing of targets. Then, if participants are provided with the same cue words at test (i.e., in match conditions) they may recall the target word based on the distinctive processing during encoding, leading to increased remembering according to the distinctiveness/fluency framework (Rajaram, 1996). Alternatively, providing a similar sounding cue to the target word (i.e., rhyme cue) may increase fluency of processing, increasing know responses, especially in the RR condition.

Chapter 2: Experiment 1

2.1 Method

2.1.1 Participants

One hundred eleven Washington University undergraduates from the Psychology Department's subject pool participated in the experiment. The set sample size was 64 to double the sample size in Fisher and Craik's (1977, Exp. 2) study in order to increase power. Data from the additional 47 participants were collected in order to get a final sample of 64 participants who correctly explained the distinction between remembering and knowing. This exclusion criterion will be discussed later, but it did not much change the results. Participants were tested in groups of up to six and received either 1 course credit or \$10 for their participation. The study was approved by Washington University's Institutional Review Board.

2.1.2 Materials

Eighty target words, their associates and rhymes, and words unrelated to them were selected using Nelson, McEvoy and Schreiber's norms (1998), the English Lexicon Project database (Balota et al., 2007) and an online rhyme dictionary (<http://rhymezone.com>). All words were four to ten letters long and had a minimum logarithmic frequency of 7 (identified via the English Lexicon Project database, see Balota et al., 2007). The target words were selected with the constraints that they had at least one associate with a minimum of 0.4 backward associative strength, and they had at least one rhyme. The materials can be found in Appendix A.

The study phase was a random presentation of forty associate orienting questions (e.g., *Is the following word associated to argue?*) and 40 rhyme orienting questions (e.g., *Does the following word rhyme with kite?*), followed by a presentation of the target word (e.g., *fight*).

For the distractor task between the study phase and the test phase, simple arithmetic problems were presented for three seconds each, until seven minutes were completed. The arithmetic problems were either a sum, subtraction, multiplication or division of two numbers between zero and ten.

The test consisted of a random presentation of thirty associate cue words (e.g., *argue*, for the target word *fight*) and 30 rhyme cue words (e.g., *kite*, for the target word *fight*). The cues corresponded to only one of the target words from the study phase.

The instructions regarding remembering, knowing and guessing were based on Gardiner et al. (1998). Exact instructions can be found in Appendix B.

2.1.3 Design

Three independent variables were manipulated within subjects. Participants studied half of the 80 target words with associate orienting questions and studied the other half with rhyme orienting questions. The answer to 60 of these questions was yes (congruent trials), and the answer to the remaining 20 questions was no (incongruent trials). Participants were tested only on the 60 target words from the congruent trials. The incongruent trials were used to keep participants on task during the study phase. Thus, during the study phase, participants received an associated word with half of the target words (e.g., *sand – beach*) and a rhyming word with the remaining half of the target words (e.g., *honey - money*). At test, participants were provided with a rhyme or an associate for each target word from the study phase. Thus, there were four within-subjects conditions: associate at study-associate cue at test (AA), associate at study-rhyme cue at test (AR), rhyme at study-associate cue at test (RA), rhyme at study-rhyme cue at test (RR). AA and RR were match conditions, whereas AR and RA were mismatch conditions. All variables were counterbalanced such that each target word was presented with each orienting

question, was in a congruent or incongruent trial, and was tested with each test cue type an equal number of times across participants. After detailed instructions, all participants were asked to provide a remember, know, or guess response following each recall response. The dependent variables were proportion recalled in the four conditions, and the proportions of remember, know and guess responses in the four conditions.

2.1.4 Procedure

All participants were tested on the computers in the laboratory in groups of up to six. At the beginning, the experimenter briefly outlined the experiment and read instructions regarding how to provide remember, know, and guess responses. Participants were instructed to give a remember response “if recall is accompanied by some recollective experience”, a know response “if recall is accompanied by strong feelings of familiarity in the absence of any recollective experience”, and a guess response when they “think it possible that the word was presented but [they] are not sure that it was” (see Appendix B for the detailed instructions). The experimenter then asked one of the participants to repeat the distinction between remembering, knowing and guessing, to make sure all participants understood the instructions before they began the experiment.¹ The rest of the experiment was computerized, and relevant instructions and an example were presented on the computer screen before the study phase and the test phase.

In the study phase, participants studied eighty target words, half with rhyme and the other half with associate orienting questions. The orienting questions were mixed and randomized for each participant. Participants were instructed to give yes or no responses to questions that were presented on the screen by clicking one of two buttons on the screen. Each question was

¹The first thirty-four participants were not given verbal instructions prior to the experiment. Responses on the post-experimental questionnaire showed that 26 of these participants did not understand the instructions regarding how to provide a remember, know, and guess response correctly. Verbal instructions were provided for the remaining participants and the experimenter made sure participants understood the instructions correctly before they began the experiment.

presented for three seconds and was followed by the presentation of a target word for two seconds. Each question asked whether the following target word rhymed with or was associated to the word provided in the question. Participants clicked yes or no buttons on the screen after they were presented with the question and the target word. Clicking yes or no was self-paced.

At the end of the study phase, participants solved simple arithmetic problems for seven minutes. Each arithmetic problem was presented for three seconds until seven minutes were completed.

The test phase followed the arithmetic problems. Before the test, participants were provided with written instructions reminding them how to provide remember, know and guess responses for each word they recalled. Participants were then presented with thirty associate cue words and 30 rhyme cue words and they were instructed to type in a target word from the study phase that the cue word reminded them of. Each cue word corresponded only to one of the target words in the congruent trials from the study phase. Recalling the target words was self-paced. After participants submitted each recall response, a screen with four buttons appeared. Participants were instructed to click NO RECALL if they left the response box empty, and they were instructed to pick between the REMEMBER, KNOW, and GUESS buttons if they submitted a response. Providing this response was self-paced.

After the test phase, participants completed a computerized, self-paced questionnaire regarding their experience during the experiment (see Appendix C). Among other questions, they were asked how they distinguished between remember, know and guess responses. The responses to this question were scored and were used to identify the participants who did not explain the distinction between these responses correctly.

At the end of the questionnaire, participants were debriefed and thanked for their participation. The experiment lasted 32.6 minutes on average.

2.1.5 Scoring

Recall scoring was computerized. Answers from the post-experimental questionnaire were scored to identify the participants who understood the distinction between remember, know and guess responses correctly. If a participant did not put in a response or did not explain the distinction correctly, they were given a score of 0. If participants explained how they distinguished between these judgments correctly, they were given a score of 1. Two raters scored all responses. Pearson's r showed reasonable agreement between the raters ($r = 0.81, p < 0.01$). The participants who were given a score of 0 were replaced until the set number of participants ($N = 64$) was obtained.

2.2 Results

47 participants with a score of 0 on the post-experimental question regarding the distinction between remember, know and guess responses were replaced until a sample of 64 participants with a score of 1 was obtained. This exclusion of participants did not change the results and is discussed later. Two participants from this sample of 64 were excluded from the analyses because they were not able correctly recall any of the target words. Therefore, results reported below are based on 62 participants who were able to correctly explain the distinction between remember, know and guess responses in the post-experimental questionnaire. All omnibus tests of statistical significance used an alpha level of .05. Because many of the critical comparisons required post hoc tests to determine the nature of interactions, an alpha level of .001 was used for these comparisons. Effect sizes are reported using partial eta-squared (η_p^2).

2.2.1 Recall

The proportion of words correctly recalled was calculated for each of the four within-subjects conditions: associate at study-associate cue at test (AA), associate at study-rhyme cue at test (AR), rhyme at study-associate cue at test (RA), rhyme at study-rhyme cue at test (RR).

Figure 1 shows the proportion recalled in each condition. When participants answered associate orienting questions during study, they recalled more at test ($M = 0.46$, 95% CI [0.44, 0.47]) compared to when they answered rhyme orienting questions ($M = 0.33$, 95% CI [0.30, 0.37]), $F(1, 61) = 77.87$, $\eta_p^2 = 0.56$. This is another instance of the levels-of-processing effect (Craik & Lockhart, 1972; Craik & Tulving, 1975). Likewise, participants recalled more with associate words ($M = 0.61$, 95% CI [0.57, 0.64]) than they did with rhyme words at test ($M = 0.18$, 95% CI [0.15, 0.21]), $F(1, 61) = 283.52$, $\eta_p^2 = 0.82$. The interaction between orienting question and test cue was also significant, $F(1, 61) = 262$, $\eta_p^2 = 0.81$. Participants recalled more in the AA condition ($M = 0.88$, 95% CI [0.85, 0.91]) compared to both the RA ($M = 0.33$, 95% CI [0.27, 0.40]) and the AR ($M = 0.04$, 95% CI [0.02, 0.05]) conditions ($t(61) = 17.26$ and $t(61) = 53.35$, respectively). Participants also recalled more in the RR condition ($M = 0.33$, 95% CI [0.27, 0.39]) compared to the AR condition ($t(61) = 10.68$), but not compared to the RA condition.² Although the predicted interaction was obtained between encoding and retrieval conditions, the extremely low recall in the AR condition and the lack of a superiority of the RR condition over the RA condition is not in line with the predictions. I will address this point further in the discussion.

² Recall results of the full sample did not differ from the results reported here. See Appendix D for the table including individual means.

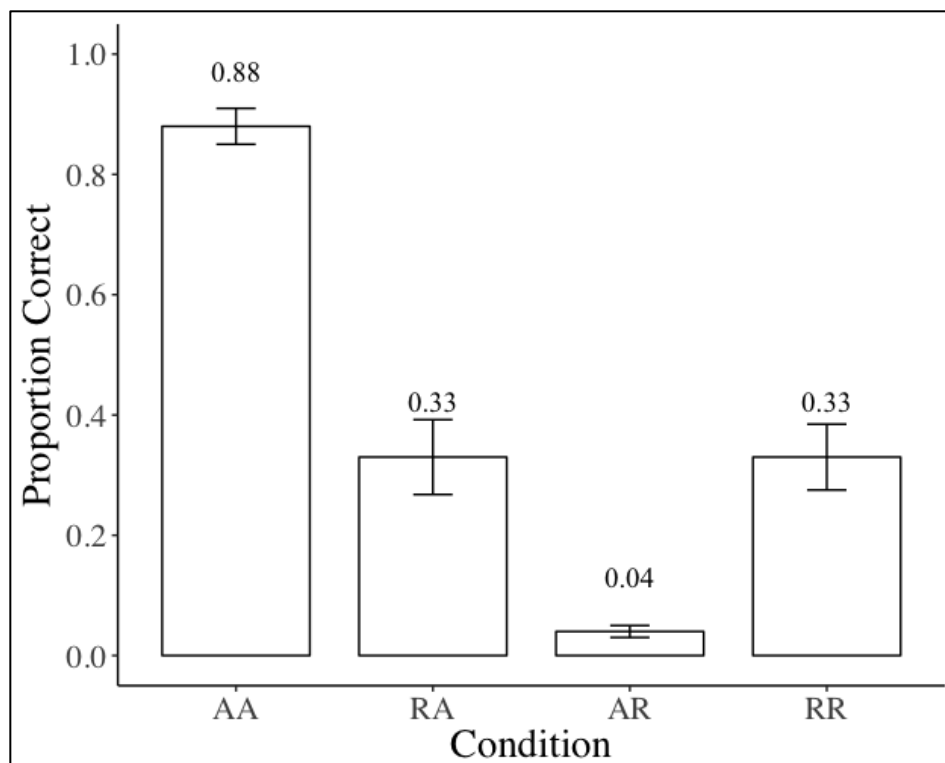


Figure 1. Recall across the different conditions in Experiment 1. AA: Associate study-Associate test; RA: Rhyme study-Associate test; AR: Associate study-Rhyme test; RR: Rhyme study-Rhyme test. Error bars represent 95% confidence intervals.

2.2.2 Remember, know, and guess responses

Absolute and relative proportions of remember, know and guess responses were calculated for each of the four within-subjects conditions only using accurate recall responses. As mentioned earlier, absolute proportions are the number of a response type divided by the total possible responses in a condition, whereas relative proportions are the number of a response type divided by the correct responses in a condition. When a participant does not correctly recall any of the target words in a condition, the proportions cannot be calculated due to having zero in the denominator. Therefore, in those cases, the proportions of remember, know and guess responses were recoded as zero (see Chan & McDermott, 2006, for a similar procedure). There were 35

such cases in the AR condition (due to the extremely low recall in this condition), six in the RA condition and four in the RR condition.

I will report analyses on the relative proportions and then note if the analyses on the absolute proportions differ. Figure 2 shows relative proportions of remember and know responses across conditions. The relative proportion of remember responses showed a similar pattern to the accurate recall responses. Participants gave more remember responses at test when they answered associate orienting questions during study ($M = 0.41$, 95% CI [0.37, 0.45]), compared to when they answered rhyme orienting questions ($M = 0.34$, 95% CI [0.28, 0.39]), $F(1, 61) = 9.76$, $\eta_p^2 = 0.14$. Likewise, participants also gave more remember responses at test when they recalled with associate words ($M = 0.44$, 95% CI [0.40, 0.48]) than when they recalled with rhyme words ($M = 0.31$, 95% CI [0.25, 0.37]), $F(1, 61) = 21.46$, $\eta_p^2 = 0.26$. Critically the interaction between orienting question and test cue was also significant, $F(1, 61) = 367.63$, $\eta_p^2 = 0.86$. Participants gave more remember responses in the AA condition ($M = 0.76$, 95% CI [0.70, 0.81]) compared to the RA ($M = 0.12$, 95% CI [0.07, 0.18]) and AR ($M = 0.07$, 95% CI [0.01, 0.12]) conditions ($t(61) = 20.38$ and $t(61) = 19.90$, respectively). Participants also gave more remember responses in the RR condition ($M = 0.55$, 95% CI [0.47, 0.64]) compared to the AR and RA conditions ($t(61) = 11.47$ and $t(61) = 9.41$, respectively). These comparisons support the prediction that the increased recall when encoding and retrieval conditions match would be accompanied by increased remembering.

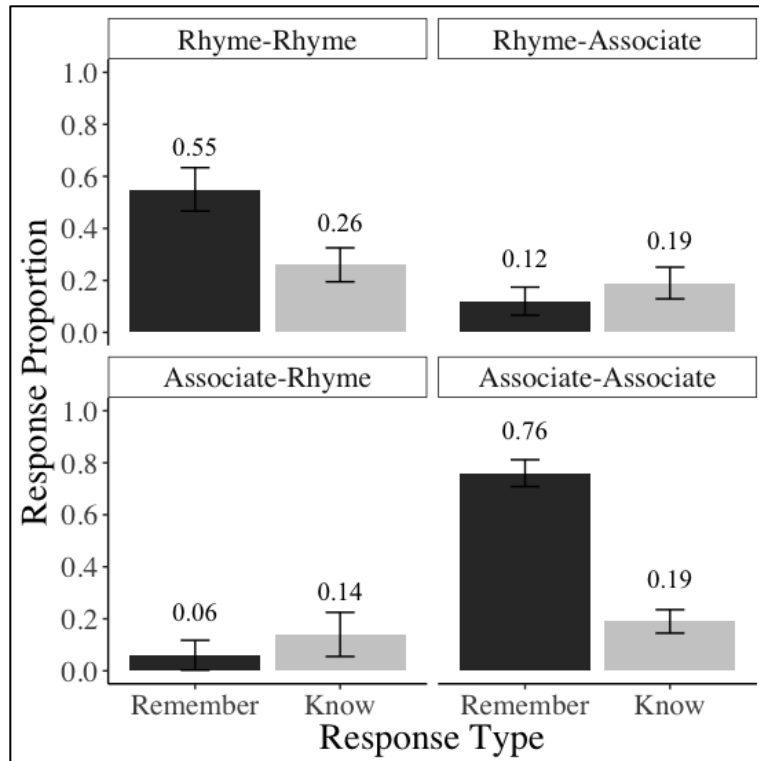


Figure 2. Relative proportions of remember and know responses across the different conditions in Experiment 1. Error bars represent 95% confidence intervals.

Unlike remember responses, know responses were not affected by the orienting question and test cue manipulations. Answering rhyme orienting questions during study led to more know responses at test ($M = 0.22$, 95% CI [0.18, 0.27]) compared to answering associate orienting questions during study ($M = 0.17$, 95% CI [0.11, 0.22]), $F(1, 61) = 4.90$, $\eta_p^2 = 0.07$. Neither the test cues nor the interaction between orienting questions and test cues significantly affected the proportion of know responses. The prediction that knowing would be highest in the RR condition, due to fluency in processing similar sounding words to target words at test, was not supported. Overall, the lack of differences in the know proportions across conditions supports the prediction that the increased recall when encoding and retrieval conditions match would not much affect knowing. However, we might not have a good estimate of knowing in the AR

condition because performance in that condition was at floor, thus no definitive conclusions can be made yet.

Although only 17% of the accurate recall responses were guessed, guessing differed across the four conditions. Participants guessed more when they had answered rhyme orienting questions during study ($M = 0.32$, 95% CI [0.26, 0.38]) compared to when they answered associate orienting questions ($M = 0.11$, 95% CI [0.06, 0.16]), $F(1, 61) = 32.05$, $\eta_p^2 = 0.34$. Guessing was also higher when recalling with an associate word ($M = 0.30$, 95% CI [0.25, 0.35]) as opposed to recalling with a rhyme word ($M = 0.13$, 95% CI [0.09, 0.18]), $F(1, 61) = 25.17$, $\eta_p^2 = 0.29$. The interaction between orienting questions and test cue was also significant, $F(1, 61) = 58.88$, $\eta_p^2 = 0.49$. Participants guessed more in the RA condition ($M = 0.54$, 95% CI [0.45, 0.64]) compared to the AA ($M = 0.05$, 95% CI [0.06, 0.13]) and RR ($M = 0.10$, 95% CI [0.06, 0.13]) conditions ($t(61) = 9.96$ and $t(61) = 9.06$, respectively). Participants in the AR condition ($M = 0.17$, 95% CI [0.08, 0.26]) did not guess significantly more compared to the AA and RR conditions (both $ps > .001$).³

The results on the analyses of the absolute proportions of remember and guess responses did not differ from that of the analyses reported above. The only difference between the analyses of absolute and relative proportions was in the know responses. Unlike the results reported above, absolute proportions of know responses did not differ based on which orienting question participants answered during study. However, the test cue participants were provided did affect knowing, $F(1, 61) = 45.96$, $\eta_p^2 = 0.43$. Participants reported more know responses when

³ Results based on the relative proportion of remember responses of the full sample did not differ from the results reported here. Know responses in the full sample were significantly affected by the interaction between orienting question and test cue: Knowing in the RR condition was significantly greater than knowing in the AR condition. The main effects and interaction in guessing were similar in both samples; however, guessing in the AR condition was significantly higher than guessing in the AA condition in the full sample. See Appendix D for the table including individual means.

recalling with associate words ($M = 0.12$, 95% CI [0.10, 0.14]) compared to recalling with rhyme words ($M = 0.05$, 95% CI [0.04, 0.06]). In addition, the interaction between orienting question and test cue was significant when looking at absolute proportions, $F(1, 61) = 25.35$, $\eta_p^2 = 0.29$. The absolute know proportions were greater in the AA condition ($M = 0.17$, 95% CI [0.13, 0.21]) compared to the RA ($M = 0.07$, 95% CI [0.05, 0.09]) and AR ($M = 0.01$, 95% CI [0.004, 0.02]) conditions ($t(61) = 3.88$ and $t(61) = 7.54$, respectively). The absolute proportion of know responses was also greater in the RR condition ($M = 0.09$, 95% CI [0.06, 0.11]) compared to the AR condition ($t(61) = 5.54$), but not the RA condition.⁴ This interaction is likely driven by the large recall (and therefore absolute proportion of knowing) difference between the AA and the AR conditions. Because absolute proportions are bound by the level of recall in a condition, it is not informative to use them in cases where recall differs dramatically across conditions. As this is the case in the current experiment, conclusions will be made based on the analyses of relative proportions.

As mentioned in the Introduction, the Independence Remember/Know (IRK) Procedure is often used to obtain a better estimate of familiarity. According to Jacoby et al. (1997), remember responses can be taken as a pure measure of recollection; however, taking only know responses as a measure of familiarity underestimates it. Because some familiarity also contributes to remembering under the independence assumption, Jacoby et al. introduced a new calculation that corrected for this: $K/(1-R)$. By dividing the absolute proportion of know responses into the opportunities participants did not make a remember response, a better estimate of familiarity can be obtained. Absolute proportions of know responses were used to calculate an

⁴ Results based on the absolute proportion of remember and guess responses of the full sample did not differ from the results reported here. The only difference was in the absolute proportion of know responses. Know responses were significantly affected by the orienting questions during study. See Appendix D for the table including individual means.

estimate of familiarity. Figure 3 shows the absolute proportion of remember responses together with estimates of familiarity across conditions, to compare recollection and familiarity across conditions. Analyses of these estimates showed that familiarity at test was higher when participants answered associate orienting questions during study ($M = 0.25$, 95% CI [0.20, 0.29]), compared to when they answered rhyme orienting questions ($M = 0.10$, 95% CI [0.08, 0.12]), $F(1, 61) = 45.06$, $\eta_p^2 = 0.43$. Likewise, familiarity was higher when recalling with associate words ($M = 0.28$, 95% CI [0.24, 0.32]) compared to recalling with rhyme words ($M = 0.06$, 95% CI [0.05, 0.08]), $F(1, 61) = 110.65$, $\eta_p^2 = 0.65$. The interaction between orienting question and test cue significantly affected familiarity, $F(1, 61) = 81.07$, $\eta_p^2 = 0.57$. Familiarity in the AA condition ($M = 0.48$, 95% CI [0.40, 0.56]) was greater than in the RA ($M = 0.08$, 95% CI [0.06, 0.11]) and AR ($M = 0.01$, 95% CI [0.004, 0.02]) conditions ($t(61) = 8.53$ and $t(61) = 11.19$, respectively). Familiarity in the RR condition ($M = 0.11$, 95% CI [0.08, 0.15]) was greater compared to the AR condition ($t(61) = 5.63$), but not compared to the RA condition. Overall, these results mirror that of accurate recall and remembering, though of course with lower estimates.⁵ Considering the estimates of recollection (remember responses), and familiarity (know responses transformed with the IRK procedure), the increased recall when encoding and retrieval conditions match seems to be accompanied by both recollection and familiarity.

⁵ Familiarity estimates of the full sample did not differ from the results reported here. See Appendix D for the table including individual means.

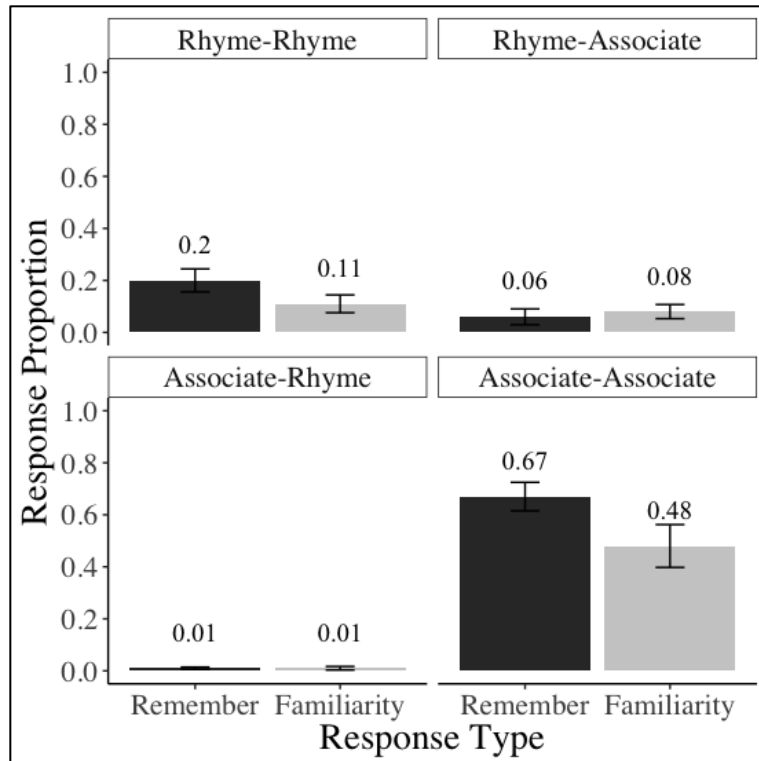


Figure 3. Absolute proportions of remember responses together with estimates of familiarity across the different conditions in Experiment 1. Error bars represent 95% confidence intervals.

2.3 Discussion

This experiment investigated whether the increased recall when encoding and retrieval conditions match is accompanied with increased remembering, knowing, or both. Recall was highest for the associate at study-associate cue at test (AA) condition, followed by the rhyme at study-rhyme cue at test (RR) and the rhyme at study-associate cue at test (RA) conditions, which did not differ. Recall was lowest in the associate at study-rhyme cue at test (AR) condition. Although there was an interaction between encoding and retrieval conditions, the recall results did not exactly replicate Fisher and Craik's (1977), because recall in the RA condition was not lower than recall in the RR condition. We had expected recall in the matching conditions (AA

and RR) would be greater than recall in both non-matching conditions (RA and AR). In addition, recall in the AR condition was much lower than expected given Fisher and Craik's results.

One possible reason for the differences in recall between the current study and Fisher and Craik's is the nature of the test cues. Participants in Experiment 1 were presented with a word that either rhymed with or was associated to one of the words they studied (e.g., *wing* or *crown*, for the word *king*); however, the test did not explicitly state whether each cue word was a rhyme or an associate cue. This may have confused participants and they may have treated cues as semantically related, resulting in a failure to replicate Fisher and Craik's results. Experiment 2 was conducted to resolve this issue. Therefore, discussion of the results regarding remember, know and guess responses will be deferred and those results will be discussed together with those of Experiment 2.

Chapter 3: Experiment 2

Experiment 2 had the same design, materials, and procedure of Experiment 1, except for the test cues. To replicate Fisher and Craik's (1977) procedure, test cues were disambiguated by stating whether they were associate or rhyme cues (e.g., *associated with crown*, or *rhymes with wing*, for the word *king*). Participants studied words with associate or rhyme orienting questions, and were tested on these words with associate or rhyme cues, resulting in the same four within-participants conditions as in Experiment 1: associate at study-associate cue at test (AA), associate at study-rhyme cue at test (AR), rhyme at study-associate cue at test (RA), rhyme at study-rhyme cue at test (RR). Participants also provided a remember, know, and guess response after each word they recalled. An interaction between encoding and retrieval conditions was expected, whereby recall in the AA and the RR conditions was predicted to be greater than recall in both the AR and the RA conditions. As in Experiment 1, it was predicted that the greater recall in the match conditions (i.e., AA and RR) would be accompanied with increased remember, but not know, responses. Again, obtaining the highest know responses in the RR condition due to potential fluency of processing when recalling with a similar sounding cue was predicted.

3.1 Method

3.1.1 Participants

Ninety-two Washington University undergraduates from the Psychology Department's subject pool participated in the experiment. As in Experiment 1, the set sample size was 64, which doubled the number of participants in Fisher and Craik's study (1977, Exp. 2) to increase power. Data from the additional 28 participants were collected to obtain a final sample of 64 participants who could correctly explain the distinction between remembering and knowing. As in the first experiment, this exclusion criterion did not much change the results and will be

discussed later. Participants were tested in groups of up to six and received either 1 course credit or \$10 for their participation. The study was approved by Washington University's Institutional Review Board.

3.1.2 Materials and Design

The materials and design of Experiment 2 was the same as Experiment 1, except for the test cues. Instead of a random presentation of cue words at test (e.g., *argue* or *kite*, for the target word *fight*), the test in Experiment 2 was a random presentation of cues whose nature was made clearer by stating whether they were associate cues or rhyme cues (e.g., *associated with argue* or *rhymes with kite*, for the target word *fight*). Specifically, cue words from Experiment 1 were presented either with the phrase *associated with* in front of those that are semantically related to target words, or with the phrase *rhymes with* in front of those that are phonetically related to target words (see Appendix A for a list of the target words with their respective associates and rhymes).

3.1.3 Procedure

The procedure of Experiment 2 was the same as Experiment 1. All participants in this experiment were given an outline of the experiment and were read the instructions regarding how to provide remember, know, and guess responses. One of the participants in each session was asked to repeat the distinction between remembering, knowing and guessing, to check whether participants understood the instructions before they began the experiment. The experiment lasted 34.6 minutes on average.

3.1.4 Scoring

Scoring was similar to Experiment 1. Recall scoring was computerized. Only one rater scored the post-experimental questionnaire, because the two raters had shown good agreement in

the first experiment. The participants who were given a score of 0 for their understanding of the distinction between remember, know and guess judgments were replaced until the set number of participants ($N = 64$) was obtained.

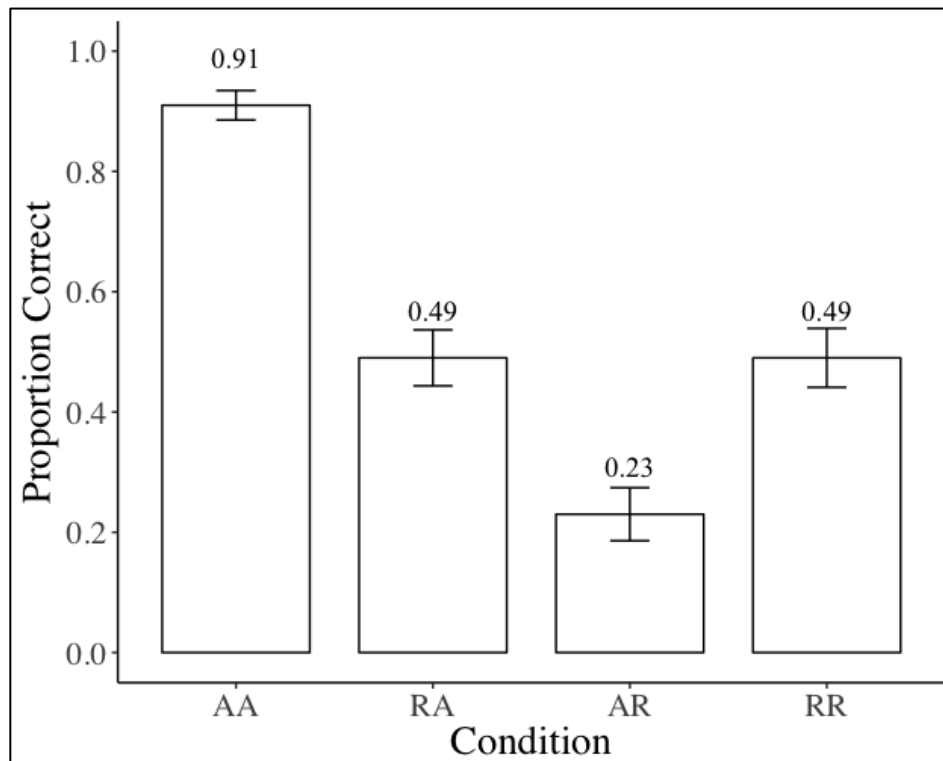
3.2 Results

28 participants with a score of 0 on the post-experimental question regarding the distinction between remember, know and guess responses were replaced until a sample of 64 participants with a score of 1 was obtained. As in Experiment 1, this exclusion of participants did not change the results and is discussed later. The results reported below are based on 64 participants who were able to correctly explain the distinction between remember, know and guess responses in the post-experimental questionnaire. All omnibus tests of statistical significance used an alpha level of .05. Because many of the critical comparisons required post hoc tests to determine the nature of interactions, an alpha level of .001 was used for these comparisons. Effect sizes are reported using partial eta-squared (η_p^2).

3.2.1 Recall

The proportion of words correctly recalled was calculated for each of the four within-subjects conditions: associate at study-associate cue at test (AA), associate at study-rhyme cue at test (AR), rhyme at study-associate cue at test (RA), rhyme at study-rhyme cue at test (RR). Figure 4 shows proportion recalled in each condition. Similar to the first experiment, answering associate orienting questions during study led to greater recall ($M = 0.57$, 95% CI [0.54, 0.60]) compared to answering rhyme orienting questions ($M = 0.49$, 95% CI [0.45, 0.52]), $F(1, 63) = 39.50$, $\eta_p^2 = 0.39$. In addition, recalling with associate cues increased recall ($M = 0.70$, 95% CI [0.67, 0.73]) compared to recalling with rhyme cues ($M = 0.36$, 95% CI [0.32, 0.40]), $F(1, 63) = 448.41$, $\eta_p^2 = 0.88$. The interaction between orienting question and test cue was also significant,

$F(1, 63) = 193.06, \eta_p^2 = 0.75$. Similar to the first experiment, participants recalled more in the AA condition ($M = 0.91, 95\% \text{ CI } [0.88, 0.93]$) compared to both the RA ($M = 0.49, 95\% \text{ CI } [0.44, 0.54]$) and the AR ($M = 0.23, 95\% \text{ CI } [0.19, 0.28]$) conditions ($t(63) = 16.10$ and $t(63) = 26.52$, respectively). Participants recalled more in the RR condition ($M = 0.49, 95\% \text{ CI } [0.44, 0.54]$) compared to the AR condition ($t(63) = 8.73$), but not compared to the RA condition.⁶ Overall recall was higher in this experiment, and performance in the AR condition was not at floor. However, unlike what was predicted, recall in the RR condition was still not higher than recall in the RA condition. I will consider this outcome in the discussion.



⁶ Recall results of the full sample did not differ from the results reported here. See Appendix E for the table including individual means.

Figure 4. Recall across the different conditions in Experiment 2. AA: Associate study-Associate test; RA: Rhyme study-Associate test; AR: Associate study-Rhyme test; RR: Rhyme study-Rhyme test. Error bars represent 95% confidence intervals.

3.2.2 Remember, know, and guess responses

As in the previous experiment, absolute and relative proportions of remember, know and guess responses were calculated for each of the four within-subjects conditions only using accurate recall responses. Again, for the cases in which these proportions could not be calculated due to having zero in the denominator, the proportions were recoded as zero. There were only seven such cases, all in the AR condition.

Figure 5 shows the relative proportion of remember and know responses across conditions. The relative proportion of remember responses was similar to that in the first experiment. Answering associate orienting questions during study led to more remembering at test ($M = 0.48$, 95% CI [0.43, 0.53]), compared to answering rhyme orienting questions ($M = 0.36$, 95% CI [0.30, 0.41]), $F(1, 63) = 30.14$, $\eta_p^2 = 0.32$. Recalling with associate cues also led to more remembering at test ($M = 0.47$, 95% CI [0.42, 0.51]) compared to recalling with rhyme cues ($M = 0.37$, 95% CI [0.31, 0.43]), $F(1, 63) = 21.66$, $\eta_p^2 = 0.26$. Again, the interaction between orienting question and test cue was also significant, $F(1, 63) = 185.35$, $\eta_p^2 = 0.75$. Participants gave more remember responses in the AA condition ($M = 0.76$, 95% CI [0.71, 0.81]) compared to the RA ($M = 0.17$, 95% CI [0.11, 0.23]) and AR ($M = 0.20$, 95% CI [0.12, 0.27]) conditions ($t(63) = 18.12$ and $t(63) = 13.70$, respectively). Participants also gave more remember responses in the RR condition ($M = 0.54$, 95% CI [0.47, 0.62]) compared to the AR and RA conditions ($t(63) = 7.11$ and $t(63) = 9.53$, respectively). These results replicate those of the first

experiment and further support the prediction that the increased recall when encoding and retrieval conditions match would be accompanied by increased remembering.

Similar to the first experiment, know responses were not much affected by the encoding and retrieval manipulations. Although the effect of orienting questions on knowing was significant in the first experiment, the pattern only approached significance in this experiment, $F(1, 63) = 3.32, p = .07, \eta_p^2 = 0.05$. Answering rhyme orienting questions during study led to slightly greater knowing at test ($M = 0.26, 95\% \text{ CI } [0.22, 0.30]$) compared to answering associate orienting questions ($M = 0.21, 95\% \text{ CI } [0.17, 0.26]$). Neither the test cues nor the interaction between orienting questions and test cues significantly affected the proportion of know responses. These results further support the prediction that the increased recall when encoding and retrieval conditions match does not much affect knowing.

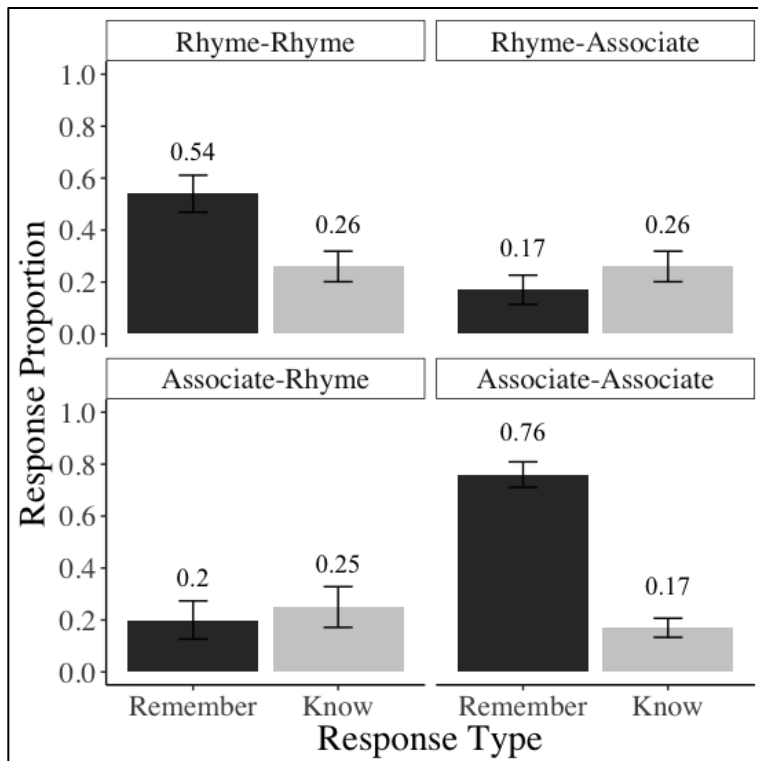


Figure 5. Relative proportions of remember and know responses across the different conditions in Experiment 2. Error bars represent 95% confidence intervals.

Guessing was similar to that in the first experiment. Participants guessed more when they answered rhyme orienting questions during study ($M = 0.36$, 95% CI [0.31, 0.41]) compared to when they answered associate orienting questions ($M = 0.24$, 95% CI [0.18, 0.29]), $F(1, 63) = 17.43$, $\eta_p^2 = 0.22$. Unlike the first experiment, the kind of test cue did not significantly affect guessing. The interaction between orienting questions and test cues was significant, $F(1, 63) = 127.60$, $\eta_p^2 = 0.67$. As in the first experiment, participants guessed more in the RA condition ($M = 0.52$, 95% CI [0.45, 0.59]) compared to the AA ($M = 0.06$, 95% CI [0.04, 0.09]) and RR ($M = 0.20$, 95% CI [0.14, 0.25]) conditions ($t(63) = 13.64$ and $t(63) = 8.76$, respectively). Participants in the AR condition ($M = 0.41$, 95% CI [0.31, 0.51]) also gave more guess responses compared to the RR and AR conditions ($t(63) = 4.44$ and $t(63) = 7.33$, respectively).⁷

The results on the analyses of the absolute proportions of remember responses did not differ from the results reported above. The analyses of the absolute proportions of know responses was different from that of relative proportions. Unlike the results reported above, absolute proportions of know responses did not differ based on which orienting question participants answered during study. However, test cue significantly affected knowing, $F(1, 63) = 22.61$, $\eta_p^2 = 0.26$. Participants gave more know responses when they recalled with associate cues ($M = 0.15$, 95% CI [0.12, 0.17]) compared to when they recalled with rhyme cues ($M = 0.09$, 95% CI [0.07, 0.11]). The interaction between orienting question and test cue was still non-significant. Absolute proportion of guess responses were similar to relative proportions, except

⁷ Results based on the relative proportion of remember and guess responses of the full sample did not differ from the results reported here. The only difference was in the relative proportion of know responses. Know responses were not affected by the orienting questions during study. See Appendix E for the table including individual means.

test cue significantly affected guessing: Participants guessed more when they recalled with associate cues ($M = 0.14$, 95% CI [0.12, 0.16]) compared to when they guessed with rhyme cues ($M = 0.08$, 95% CI [0.07, 0.10]), $F(1, 63) = 22.48$, $\eta_p^2 = 0.26$.⁸

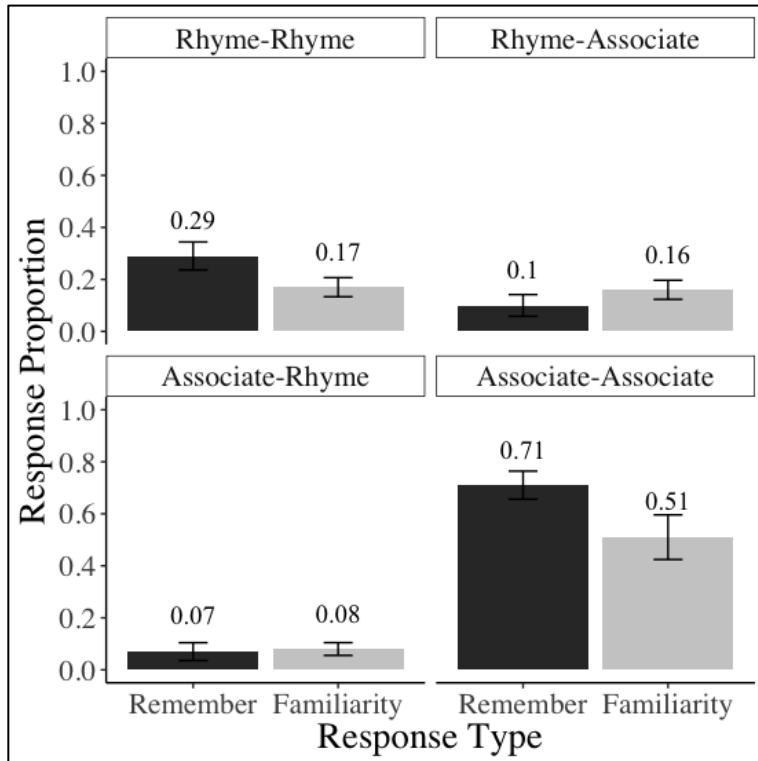


Figure 6. Absolute proportions of remember responses together with estimates of familiarity across the different conditions in Experiment 2. Error bars represent 95% confidence intervals.

As in the previous experiment, an estimate of familiarity was calculated for each condition using the IRK Procedure, where the absolute proportion of know responses was divided by one minus the absolute proportion of remember responses. The results were similar to that of the previous experiment. Figure 6 shows the absolute proportion of remember responses together with estimates of familiarity across conditions. Answering associate orienting questions

⁸ Results based on the absolute proportion of remember and guess responses of the full sample did not differ from the results reported here. The only difference was in the absolute proportion of know responses. The interaction between orienting question and test cue was significant. See Appendix E for the tables including individual means.

during study increased the estimates of familiarity at test ($M = 0.29$, 95% CI [0.24, 0.34]), compared to when answering rhyme orienting questions ($M = 0.17$, 95% CI [0.14, 0.19]), $F(1, 63) = 25.59$, $\eta_p^2 = 0.29$. Familiarity was also higher when recalling with associate cues ($M = 0.33$, 95% CI [0.28, 0.39]) compared to recalling with rhyme cues ($M = 0.12$, 95% CI [0.10, 0.14]), $F(1, 63) = 70.76$, $\eta_p^2 = 0.53$. The interaction between orienting question and test cue was significant as well, $F(1, 63) = 82.34$, $\eta_p^2 = 0.57$. As in the first experiment, familiarity in the AA condition ($M = 0.51$, 95% CI [0.42, 0.59]) was greater than in the RA ($M = 0.16$, 95% CI [0.12, 0.20]) and AR ($M = 0.08$, 95% CI [0.05, 0.10]) conditions ($t(63) = 7.90$ and $t(63) = 10.51$, respectively). Familiarity in the RR condition ($M = 0.17$, 95% CI [0.13, 0.21]) was greater compared to the AR condition ($t(63) = 4.13$), but not compared to the RA condition. Based on these results, some familiarity seems to accompany the increased recall when encoding and retrieval conditions match.⁹

3.3 Discussion

As in Experiment 1, we were interested in whether the increased recall when encoding and retrieval conditions match is accompanied by increased remembering, knowing, or both. The pattern of recall results was similar to the results of Experiment 1, although overall recall in this experiment was higher. In addition, recall in the AR condition was not as low as the previous experiment, suggesting that changing the test cues clearly helped the participants. In both experiments, answering associate orienting questions during study increased recall compared to answering rhyme orienting questions, replicating prior research on the levels-of-processing effect (Craik & Lockhart, 1972; Craik & Tulving, 1975). Similarly, in both experiments, participants recalled more target words with associate cues than with rhyme cues, suggesting that associate

⁹ Familiarity estimates of the full sample did not differ from the results reported here. See Appendix E for the table including individual means.

cues are more powerful regardless of learning conditions. There was also an interaction between orienting questions and test cues in both experiments. However, we failed to completely replicate Fisher and Craik's (1977, Exp. 2) recall results in both experiments. Although recall in the AA condition was higher than both the AR and RA conditions, recall in the RR condition was only higher than the AR condition and was equivalent to the RA condition.

A major difference between the first two experiments and Fisher and Craik's is the material used, which may explain the difference in recall results. In Fisher and Craik's second experiment, the difference between recalling with associate cues and recalling with rhyme cues (calculated by subtracting the marginal means) was equivalent to the difference between studying with associate cues and studying with rhyme cues. In the experiments reported above, however, the effect size of the superiority of associate cues over rhyme cues at test was larger than the effect size of the superiority of associate orienting questions during study over rhyme orienting questions. This suggests that the associate cues in the first two experiments were very powerful, and may have led participants to guess the correct answer. This is further supported by the finding in both of the experiments that the largest proportion of accurate guess responses was given in the RA condition. If less powerful associate cues were used at test, recall in the RA condition may have been lower, resulting in a replication of Fisher and Craik's (1977, Exp. 2) pattern of recall across conditions.

In both experiments, remember, know and guess results were similar to each other despite the differences in the level of recall. Accurate remember responses generally mimicked overall accurate responding. Participants remembered a word more often when they had studied it with an associate orienting question than a rhyme orienting question, replicating previous research showing that deeper levels of processing lead to more remember responses (Gardiner,

1988). Participants also provided more remember responses when they recalled with an associate cue compared to a rhyme cue. These results were consistent across the different ways of measurement and across the two experiments. As predicted, participants gave significantly more remember responses when encoding and retrieval conditions matched (AA and RR conditions) compared to when they did not (AR and RA conditions). In a sense, Fisher and Craik (1977, Experiment 2) was replicated, at least with accurate recall responses due to remembering. These results suggest that encoding/retrieval interactions are accompanied by increased remembering. This conclusion is further supported by examining the proportion of know responses. In both experiments, relative know proportions were similar across conditions. In the first experiment, answering rhyme orienting questions led to more knowing at test, and this effect was only marginally significant in the second experiment. Absolute know proportions in both experiments showed that participants gave more know responses when they recalled with an associate cue. Since these proportions are bound by the level of recall in a condition, this difference in the absolute proportion of know responses is likely due to the large recall difference between recalling with associate and rhyme cues. Absolute proportion of know responses were affected by the interaction between orienting questions and test cues in the first experiment; however, this effect disappeared in the second experiment. As previously discussed, relative proportions are considered more informative than absolute proportions when comparing response type across conditions that differ greatly in recall. Hence, the results suggest that knowing does not accompany encoding/retrieval interactions in recall.

In order to infer whether recollection and/or familiarity accompanied the encoding/retrieval interactions in recall, one must consider remember responses and the estimates of familiarity (know responses transformed using the IRK Procedure). In both

experiments, estimates of familiarity showed a similar pattern to accurate recall in which there was a large difference between the AA and AR conditions but no difference between the RA and RR conditions. Although more recollection (as measured by the remember responses) typically contributed to recall, some familiarity seems to contribute to the encoding/retrieval interactions in recall as well.

A confound in Fisher and Craik's (1977, Exp. 2) design is that participants in the match conditions (AA and RR) were always given cue words they had seen in the study phase (i.e., intralist cues), whereas the participants in the mismatch conditions (RA and AR) were always given novel words (i.e., extralist cues). Therefore, recalling with intralist cues may have increased fluency of processing and may explain any increase in knowing and estimates of familiarity in the first two experiments. Although Fisher and Craik later addressed this confound (Exp. 3, 1977) and still showed an interaction between encoding and retrieval even when all test cues were novel, whether this would change the extent to which remembering and knowing are responsible awaits future research.

The guess option in the remember/know paradigm is thought to serve as a way to purify know responses, so that participants' guesses are not lumped into the know category (Gardiner et al., 1996, 1998), and they are not of great interest to the issues at hand. However, both experiments obtained differences in guess responses. Participants typically provided more guess responses when they studied words with rhyme orienting questions and when they were tested with associate cues. The proportions of guess responses also suggest that participants tended to guess more when encoding and retrieval conditions did not match.

To sum up, the first two experiments matched encoding and retrieval conditions to

increase the power of retrieval cues and to observe how this matching affected remembering and knowing. Recall was generally greater when the test cues matched study conditions, but the lack of superior recall in the RR condition compared to the RA condition resulted in a failure to replicate Fisher and Craik's results (1977). However, using remember responses as a measure of episodic recollection, the interaction between encoding and retrieval was more pronounced and, in a sense, replicated the results of Fisher and Craik (1977). In addition, when examining what retrieval experience was responsible for this increase, results revealed that the increased recall when encoding and retrieval conditions match was in general accompanied by recollection (measured by remember responses) and some familiarity (measured by know responses transformed with the IRK procedure).

Chapter 4: Experiment 3

We consider a different manipulation in the next experiment. The third experiment was based on Tulving and Watkins' (1973) study discussed earlier, in which participants studied five-letter words and recalled them with varying number of letter cues ranging from zero letters (i.e., free recall) to five letters (i.e., recognition). As expected, Tulving and Watkins showed that as the power of retrieval cues gradually increased, recall also gradually increased. The third experiment asked if this improvement in recall would be accompanied with increased remembering, knowing, or both. Participants studied multiple five-letter word lists and were tested after each list with different number of letters provided as cues. For all but one of the lists, participants were given a mixture of the first two letters, first three letters, first four letters or all five letters of the words as a cue. They were asked to type in a word they studied in the prior list that the cue reminded them of. For one of the lists, participants were given no cues (i.e., free recall), and they were asked to type as many words as they can recall from the list they just studied. The response requirement across conditions was the same such that even when participants were given all five letters of a word as a cue, their task was to type in the complete word. On all the tests, participants provided a remember, know, or guess response after each word they recalled.

We expected to replicate Tulving and Watkins' recall findings, where recall increased when more letters were provided as cues. Using a similar design, Tulving (1985) had shown decreased remembering from free recall to cued recall. However, Hamilton and Rajaram (2003) later showed that remembering stayed the same across free recall, cued recall and recognition tests when the tests were not successive, as was the case in Tulving's (1985) study. Based on these findings, provision of more powerful retrieval cues that increase recall should not increase

the rate of remembering, unlike the two experiments reported above. According to the distinctiveness/fluency framework, remembering increases when distinctive or salient aspects of events are processed during encoding (Rajaram, 1996). Since encoding conditions were not manipulated in the third experiment and participants were only instructed to study words for a subsequent test, remembering should not differ across conditions. In addition, the third experiment used lexical cues (varying numbers of letter cues for each word) instead of associate and rhyme cues used in the previous experiments, which might lead to different results. In fact, the distinctiveness/fluency framework would predict increased knowing in the third experiment due to increased fluency at test. After studying intact words, participants in the third experiment may process test items more easily when they are presented intact (i.e., the 5 Letters condition) as opposed to when the cues have fewer letters. In addition, recognition tests often show higher levels of know responses compared to recall tests, therefore knowing in the recognition-like 5 Letters condition was expected to be the highest across the different cue conditions.

4.1 Method

4.1.1 Participants

Forty-seven Washington University undergraduates from the Psychology subject pool participated in the experiment. The set sample size was 30 to increase the sample size in Tulving and Watkins' (1973) study (their sample size was 20) to increase power. As in the previous experiments, data from the additional participants were collected in order to get a final sample of 30 participants who correctly explained the distinction between remembering and knowing. The exclusion criterion did not change the results, and will be discussed later. Participants were tested in groups of up to six and received either 1 course credit or \$10 for their participation. The study was approved by Washington University's Institutional Review Board.

4.1.2 Materials

Each study list contained twenty words. The lists were five-letter words with the constraints that the words should have a minimum logarithmic frequency of 6 (identified via the English Lexicon Project database, see Balota et al., 2007), no two words in a list should have the same first two letters, and changing the last letter of each word should form another word (e.g., *crust* and *crush*). This constraint was intended to discourage participants from guessing a word as more letters were provided as cues. Thus, altogether this procedure yielded two sets of five lists that were counterbalanced across participants. There were 200 words in total, with a mean logarithmic frequency of 8.92. The lists can be found in Appendix F.

Participants were given thirty arithmetic problems between each study and test list as a distractor task. The arithmetic problems were either addition, subtraction, multiplication or division of two numbers between zero and ten.

Except for the free recall, all tests were a randomized presentation of cues corresponding to the words that were on the list participants had just studied. These cues were the first two, first three, first four or all five letters of a word, equally distributed for the words in a corresponding study list. The first letter alone was not used as a cue as there was more than one word on the study lists that started with the same letter.

The instructions regarding remembering, knowing and guessing were same as the previous experiments. Exact instructions can be found in Appendix G.

4.1.3 Design

Participants studied five word lists and were tested on each list after a brief delay. The presentation order of the lists was fixed, but the presentation of words within each list was randomized. Cue type was manipulated within-subjects on four lists such that all participants

received the first two letters, first three letters, first four letters, or all five letters of the words as retrieval cues an equal number of times across all tests. Following a fifth list, participants engaged in free recall. Four levels of the cue type variable (2 Letters, 3 Letters, 4 Letters, and 5 Letters) were mixed within four test lists, and the remaining level of the variable (Free Recall) was used for the remaining test list. The placement of the free recall list was counterbalanced; across the five lists, free recall occurred in each position an equal number of times across participants. Cue type was also counterbalanced, whereby all words were tested with each level of the variable an equal number of times across participants. All participants were asked to provide a remember, know, or guess response following each recall response. The dependent variables were proportion recalled in each cue type condition, and the proportions of remember, know and guess responses in each cue type condition.

4.1.4 Procedure

All participants were tested on the computers in a laboratory setting in groups of up to six. At the beginning, the experimenter briefly outlined the experiment and read instructions regarding how to provide remember, know, and guess responses. The experimenter then asked one of the participants to repeat the distinction between remembering, knowing and guessing, to reinforce the participants' understanding of the instructions before they began the experiment. The rest of the experiment was computerized and relevant instructions were presented before each study and test list. Participants were provided with a practice study list of five words and a corresponding practice test before the experiment began. The words on the practice test were different from the material used in the experiment. The practice test was used to make sure participants understood how to make a recall response (i.e., writing a complete word instead of the completion based on a cue) and a remember, know or guess response.

The words in each study list were presented one at a time for two seconds. After twenty words were presented, participants solved arithmetic problems for two minutes. Each arithmetic problem was presented and answered for three seconds until two minutes were completed. A test list followed the arithmetic problems. Before each test list appeared, participants were again provided with instructions regarding remembering, knowing and guessing. For four of the five test lists, the test was cued recall, where participants were presented with a mixture of the first two, three, four or all five letters of the words they just studied, resulting in five words per each cue type. Participants were instructed to type in a complete word that the cue reminds them of from the list they just studied. They were instructed to type in a word even when they were given all five letters of a word as a cue. For one of the five test lists, participants were given a surprise free recall test, where no letters were provided. Participants were instructed to type in all the words they could recall from the list they just studied in any order they preferred. The response requirement was the same in all five cue conditions, where participants were asked to type a complete word. Participants were instructed to type the whole word even if they saw all five letters as a cue and they were instructed against typing only the completion (e.g., *ush* when the cue is *cr*). Recall was self-paced for all test lists.

In all test lists, after the participants submitted a recall response, a screen with four buttons appeared. Participants were instructed to click NO RECALL if they left the response box empty, and they were instructed to pick between the REMEMBER, KNOW, and GUESS buttons if they submitted a response. Participants gave a remember, know, or guess response immediately after each recall response, including free recall. Making a remember, know, guess, or no recall response was self-paced.

After participants studied and were tested on all five lists, they completed a computerized, self-paced questionnaire regarding their experience during the experiment (see Appendix C). Among other questions, they were asked how they distinguished between remember, know and guess responses. The responses to this question were scored and participants who did not explain the distinction between these responses correctly were not included in further analyses.

At the end of the questionnaire, participants were debriefed and thanked for their participation. The experiment lasted 41.5 minutes on average.

4.1.5 Scoring

Scoring was similar to the first two experiments. Responses where participants typed the correct completion of a cue instead of the complete word were considered accurate. There were very few such cases. As in Experiment 2, only one rater scored the post-experimental questionnaire, because the two raters had shown good agreement in the first experiment. The participants who were given a score of 0 for their understanding of the distinction between remember, know and guess judgments were replaced until the set number of participants ($N = 30$) was obtained.

4.2 Results

Twelve participants with a score of 0 on the post-experimental question regarding the distinction between remember, know and guess responses were replaced until a sample of 30 participants with a score of 1 was obtained. As in the previous experiments, this exclusion did not change the results and is discussed later. The results reported below are based on a final sample of 35 participants who were able to correctly explain the distinction between remember, know and guess responses in the post-experimental questionnaire. Due to the high sign-up rate,

data from five additional participants were included in the final sample, making the final sample 35 instead of 30. All tests of statistical significance used an alpha level of .05 unless otherwise stated. If the sphericity assumption was violated, a Greenhouse-Geisser correction was used. Effect sizes are reported using partial eta-squared (η_p^2).

4.2.1 Recall based on list order and set

Participants were presented the lists in a fixed order, where half the participants studied the same five lists in the same order from Set A and the remaining half of the participants studied the same five lists in the same order from Set B. Neither the order of the lists, nor the set from which word lists were drawn significantly affected recall. Thus, data were collapsed across these variables.

4.2.2 Remember, know, and guess responses

Proportion of words correctly recalled was calculated for each cue type. Figure 7 shows that proportion recalled increased as the number of letter cues provided increased from 0.31 (95% CI [0.24, 0.39]) for free recall, to 0.32 (95% CI [0.26, 0.38]) for two-letter cues, to 0.56 (95% CI [0.50, 0.62]) for three-letter cues, to 0.79 (95% CI [0.74, 0.84]) for four-letter cues, and to 0.95 (95% CI [0.90, 1]) for five-letter cues. A one-way repeated measures ANOVA showed that cue type had a significant main effect on recall, $F(3.22, 109.41) = 169.94$, $\eta_p^2 = 0.83$. Pairwise comparisons using the Bonferroni correction confirmed that recall significantly increased as more letters were provided as cues. Free recall and recall when the first two letters were provided were not significantly different, but all remaining differences were significant.

These results replicate Tulving and Watkins (1973), although the current experiment yielded higher overall recall.¹⁰

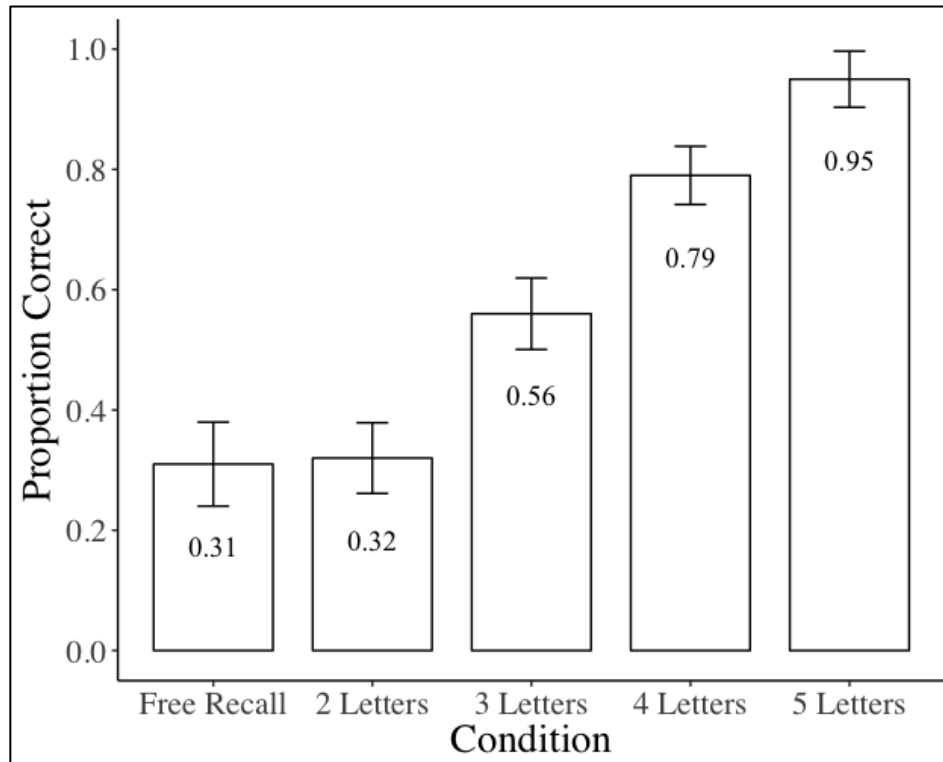


Figure 7. Recall across the different conditions in Experiment 3. Error bars represent 95% confidence intervals.

4.2.3 Remember, know, and guess responses

Absolute and relative proportions of remember, know and guess responses were calculated for each cue type condition using only accurate recall responses. As in previous experiments, when absolute and relative proportions could not be calculated due to having zero in the denominator, they were recoded as zero. There were six such cases in the free recall condition and one in the 2-letter cue condition.

¹⁰ Recall results of the full sample did not differ from the results reported here. See Appendix H for the table including individual means.

I will first consider relative proportions and then discuss if the analyses on the absolute proportions differed from relative proportions. Figure 8 shows relative proportion of remember and know responses across the cue conditions. The relative proportion of remember responses did not change based on cue type, $F(2.49, 84.68) = 1.13$. Remember responses were similar for the first four cue type conditions (Free Recall, 2 Letters, 3 Letters, and 4 Letters), ranging from 0.68 to 0.71. The proportion of remember responses was lowest in the 5 Letters condition ($M = 0.62$, 95% CI [0.53, 0.71]), and it was only significantly lower than remember responses in the 4 Letters condition. The finding that remember responses roughly stay the same as more powerful retrieval cues are provided (except for the drop in remembering from the 4 Letters condition to the 5 Letters condition) replicates Hamilton and Rajaram's (2003) findings.

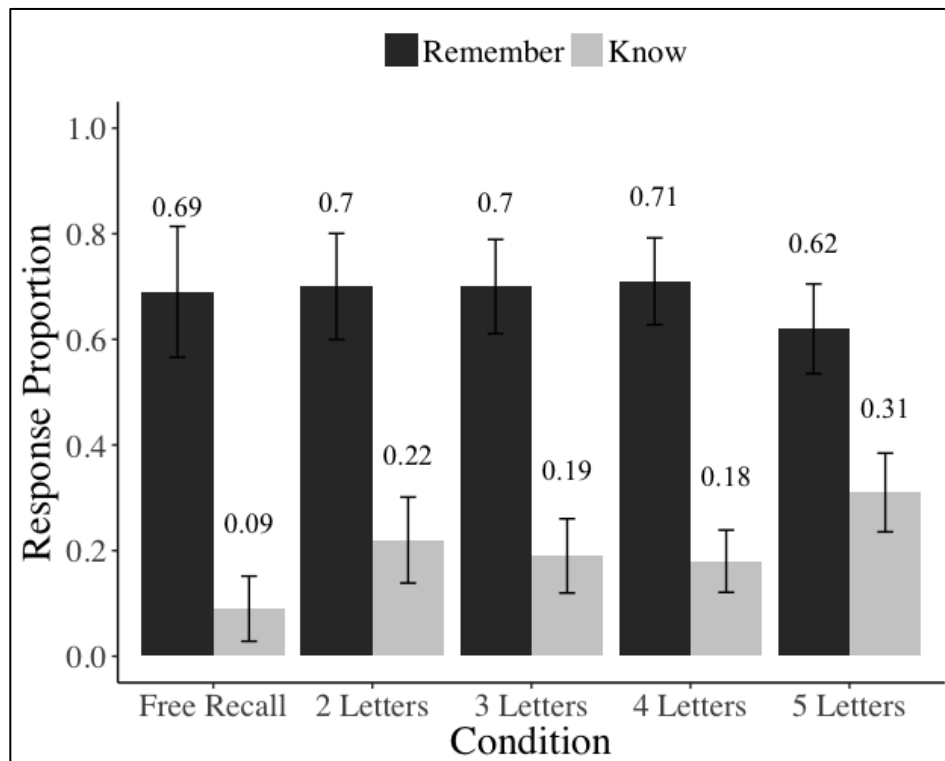


Figure 8. Relative proportions of remember and know responses across the different conditions in Experiment 3. Error bars represent 95% confidence intervals.

Although the main effect of cue type on the relative proportion of remember responses was not significant, the relative proportion of know responses differed based on cue type, $F(4, 136) = 9.62, \eta_p^2 = 0.22$. The proportion of know responses in the 5 Letters condition ($M = 0.31, 95\% \text{ CI } [0.23, 0.39]$) was higher than in the Free Recall ($M = 0.09, 95\% \text{ CI } [0.03, 0.16]$), 3 Letters ($M = 0.19, 95\% \text{ CI } [0.12, 0.27]$), and 4 Letters ($M = 0.18, 95\% \text{ CI } [0.12, 0.25]$) conditions, but was not different from that in the 2 Letters condition ($M = 0.22, 95\% \text{ CI } [0.13, 0.30]$). No other differences were significant. Thus, the gradual increase in recall when more letter cues were provided was accompanied by increased knowing. However, the increase in knowing did not exactly mimic the increase in recall levels, as knowing in the 2 Letters, 3 Letter and 4 Letters conditions did not differ.

The relative proportion of guess responses also differed based on cue type, $F(4, 136) = 3.18, \eta_p^2 = 0.09$. Pairwise comparisons using the Bonferroni corrections showed that none of the differences between cue type conditions were significant. Participants guessed most in the 4 Letters ($M = 0.11, 95\% \text{ CI } [0.06, 0.15]$) and 3 Letters ($M = 0.10, 95\% \text{ CI } [0.05, 0.15]$) conditions, which were followed by the 5 Letters ($M = 0.06, 95\% \text{ CI } [0.03, 0.09]$), 2 Letters ($M = 0.05, 95\% \text{ CI } [0.01, 0.09]$) and Free Recall ($M = 0.05, 95\% \text{ CI } [0.01, 0.09]$) conditions.¹¹

The results on the analyses of the absolute proportions of know and guess responses did not differ from that of the analyses reported above. The only difference was in the analyses of the absolute proportions of remember responses. These proportions were significantly affected by cue type, $F(3.03, 103.14) = 56.01, \eta_p^2 = 0.62$, unlike the results reported above. These proportions mimicked accurate recall responses, where absolute proportion of remember

¹¹ Results based on the relative proportion of remember and know responses of the full sample did not differ from the results reported here. Guess responses did not significantly differ based on cue type, unlike the results reported here. See Appendix H for the table including individual means.

responses increased as more letters were provided cues. The difference between the Free Recall ($M = 0.27$, 95% CI [0.20, 0.34]) and the 2 Letters ($M = 0.24$, 95% CI [0.18, 0.30]) conditions did not differ. The highest absolute proportion of remember responses were given in the 5 Letters condition ($M = 0.60$, 95% CI [0.51, 0.69]) and the 4 Letters condition ($M = 0.58$, 95% CI [0.49, 0.67]), followed by the 3 Letters condition ($M = 0.41$, 95% CI [0.33, 0.49]), which were followed by the Free Recall and the 2 Letters conditions.¹²

Estimates of familiarity were obtained transforming the absolute proportion of know responses using the IRK Procedure. Figure 9 shows the absolute proportion of remember responses with the estimates of familiarity across the cue conditions. Estimates of familiarity increased as more letter cues were provided, $F(2.63, 89.50) = 67.26$, $\eta_p^2 = 0.66$. Familiarity was highest in the 5 Letters condition ($M = 0.69$, 95% CI [0.57, 0.80]), followed by the 4 Letters Condition ($M = 0.32$, 95% CI [0.21, 0.42]), followed by the 3 Letters condition ($M = 0.16$, 95% CI [0.10, 0.22]), which was followed by the 2 Letters ($M = 0.08$, 95% CI [0.04, 0.11]) and Free Recall ($M = 0.04$, 95% CI [0.01, 0.07]) conditions. Overall, these results mimic accurate recall.¹³ Considering the estimates of recollection (remember responses), and familiarity (know responses transformed with the IRK procedure), the increased recall when more letter cues are provided seems to be accompanied by increased familiarity, although recollection generally contributed more across conditions.

¹² Results based on the absolute proportion of remember, know and guess responses of the full sample did not differ from the results reported here. See Appendix H for the table including individual means.

¹³ Familiarity estimates of the full sample did not differ from the results reported here. See Appendix H for the table including individual means.

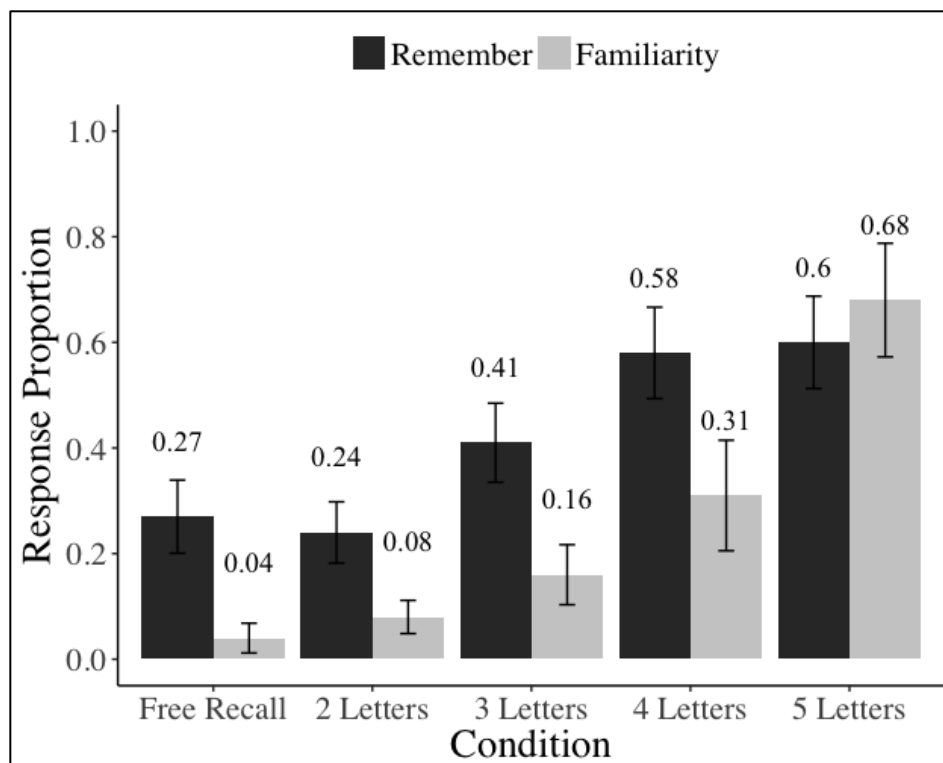


Figure 9. Absolute proportion of remember responses together with estimates of familiarity across the different conditions in Experiment 3. Error bars represent 95% confidence intervals.

4.3 Discussion

The goal in this experiment was to investigate whether the increased recall as a function of increased lexical retrieval cues is accompanied by increased remembering, knowing, or both. We replicated Tulving and Watkins' (1973) results, although overall recall in this experiment was higher. This is likely due to differences in the number of words per list (20 in the current experiment, 28 in theirs). Critically, participants recalled more when they received more letter cues, supporting the claim that gradually increasing the power of retrieval cues (i.e., increasing the number of letter cues provided at test from zero to five) increases recall.

The main interest was whether the increase in recall would be accompanied by remembering, knowing, or both. Both the absolute and relative proportions of know responses, as well as the estimates of familiarity, showed that the increase was accompanied by knowing or familiarity. The relative proportion of remember responses were similar across conditions; however, the absolute proportion of remember responses increased as more letter cues were provided. Since recall in each condition was significantly different from others (except for the Free Recall and 2 Letters conditions), and since the absolute proportions are much affected by recall levels, it seems more reasonable to consider relative proportions and conclude that remember responses were not affected by the provision of more powerful lexical retrieval cues. This is not surprising given the findings of Hamilton and Rajaram (2003, Experiment 1). Their participants studied category names and instances, and recalled the category instances via free recall, category recall, category and letter recall, or recognition, providing remember and know responses after each recalled word. Recall gradually increased as participants received more powerful retrieval cues; however, the proportion of accurate remember responses stayed the same across conditions. Based on these results and the results of the current experiment, it appears that increasing retrieval support by giving more letter cues does not affect remembering. Instead, the increased recall when more powerful lexical cues are provided is accompanied with increased knowing.

The results are also not surprising given how differently remembering and knowing are thought to contribute to recall and recognition. Typically, recall is considered to be driven more by recollection than familiarity, whereas recognition is considered a combination of recollection and familiarity (Quamme et al., 2004). We compared relative remember and know proportions between the condition akin to recognition (i.e., 5 Letters condition) and conditions akin to recall

(i.e., Free Recall, 2 Letters, 3 Letters, and 4 Letters conditions) using paired sample *t*-tests. The results showed that participants gave significantly more remember responses in the recall conditions compared to the recognition condition ($t(34) = 2.98, p < 0.01$), and gave significantly more know responses in the recognition condition compared to the recall condition ($t(34) = 5.32, p < 0.01$). However, although there was more recollection and less familiarity in recall conditions compared to the recognition condition, recall still was not solely driven by recollection. This replicates earlier studies showing that some familiarity contributes to recall and that free recall is not a pure measure of recollection (Hamilton & Rajaram, 2003; McCabe et al., 2010; McDermott, 2006; Mickes et al., 2013).

Chapter 5: General Discussion

The principal aim of this thesis was to investigate whether the increased recall with increasingly powerful retrieval cues is accompanied by increased remembering, knowing, or both. The remember/know procedure (Tulving, 1985) was used in two recall paradigms to address this question. The first two experiments manipulated semantic and rhyme contexts using cued recall, and the third experiment manipulated lexical cues employing conditions akin to free recall, cued recall and recognition. Both when the power of retrieval cues was increased by matching encoding and retrieval conditions (Experiments 1 and 2) and by gradually providing more powerful cues (Experiment 3), participants recalled more. Although there was more remembering in all three experiments compared to knowing, the increase in recall when the power of retrieval cues increased was accompanied primarily by increased recollection and also with some increased familiarity in the first two experiments with rhyme and semantic cues, and it was accompanied only by increased familiarity in the third experiment with lexical cues.

I will now consider different theoretical frameworks to understand the results of the current study. One primary distinction between theories regarding remember and know judgments is whether these judgments require a single process or dual processes. I will first discuss single process theories and why they likely do not explain the results of this study, and then I will discuss different dual process theories to account for the results.

5.1 Single Process Theories

Single process theories assume that remember and know judgments do not tap into the separate processes of recollection and familiarity, but that they reflect responding based on different adopted criteria on a single continuum of memory signal or strength (Donaldson, 1996; Dunn, 2004). This theory assumes the signal detection model in which remember and know

judgments reflect different levels of confidence. The stronger the memory trace is, the more confident participants will be, and they will provide a remember response. On the other hand, if the memory trace is weaker, participants will be less confident and therefore give a know response (Donaldson, 1996). Although this model can account for many findings in the existing literature (Dunn, 2004), some studies have shown that remember and know judgments do not directly map onto high versus low confidence responses (e.g., Gardiner & Java, 1990; Rajaram, Hamilton, & Bolton, 2002).

The current study cannot test the single process theory of remembering and knowing due to recall being used instead of recognition. False alarms and confidence judgments are critical to the signal detection model; however, the current study did not use recognition tests or collect confidence judgments. Although a definitive conclusion cannot be reached, the instructions regarding remembering, knowing and guessing used in the study should suggest that remembering and knowing are not high and low confidence judgments, respectively. Know responses were defined as cases in which participants recall a word confidently without having any recollective experience. In fact, the participants who explained the distinction between remembering and knowing based on different levels of confidence were replaced. 22 of the 87 participants that were replaced were such cases, suggesting that these responses may be tied to confidence. However, since the main analyses across the three experiments exclude these participants, the single process theory cannot explain the findings.

5.2 Dual Process Theories

Dual process theories state that remember and know judgments tap into two separate systems or processes. When Tulving (1985) introduced the remember/know paradigm, he claimed that remembering tapped into episodic memory, whereas knowing tapped into semantic

memory. The argument that knowing is related to semantic memory was controversial, as researchers noted many times that recall or recognition of events encountered once recently does not necessitate the use of semantic memory (Gardiner & Richardson-Klavehn, 2000). Research after Tulving (1985) revised the knowing component of the memory systems theory, and stated that knowing tapped into procedural memory instead of semantic memory (Gardiner & Parkin, 1990). At the time, most findings showed that perceptual manipulations selectively affected knowing, and knowing was influenced by manipulations known to affect implicit memory (Jacoby & Dallas, 1981) However, later studies by Rajaram (1996) showed that some perceptual manipulations selectively affected remembering, undermining the procedural memory account of know judgments.

In the experiments in this thesis, participants studied words once and were tested on them once. In all three experiments, participants could have come up with an answer from semantic memory that fit the given cue, but simply guessing should have led them to give a guess response instead of a know response. In addition, the systems theories cannot account for the dissociation obtained in the current study. It is difficult to rationalize why matching semantic and rhyme cues would selectively increase remembering stemming from episodic memory, but why providing more lexical cues would lead to more knowing stemming from semantic or procedural memory. Overall, although the systems theories have greatly contributed to remember/know research, they cannot explain the results of this study.

Other dual process theories suggest that remembering and knowing are related to the processes of recollection and familiarity, respectively (Jacoby, 1991; Yonelinas, 2002). The terms recollection and familiarity come from earlier research investigating a dual-process model of recognition memory (Jacoby, 1991; Mandler, 1980) and have been used to discuss remember

and know judgments. Within this framework, recollection and familiarity are considered to contribute to remembering, whereas knowing occurs when there is familiarity in the absence of recollection (Jacoby, 1991). Therefore, although remember responses can be taken as a proxy of recollection, know responses underestimate the familiarity that contribute to successful retrieval. The IRK procedure discussed previously solves this issue by assuming independence between the responses (Jacoby et al., 1997). Therefore, these dual process theories suggest that remembering and knowing can be used to observe recollection and estimates of familiarity.

There are several dual process signal detection models regarding recollection and familiarity. For instance, Yonelinas (1994) suggested that recollection is a threshold, whereas familiarity is a signal detection process. Based on this interpretation, familiarity assesses the quantitative trace or signal strength, but recollection assesses the qualitative information about what is recalled or recognized (Yonelinas, 1994, 2002). However, a different dual process signal detection model by Wixted (2009) assumes that recollection and familiarity are two continuous processes that become aggregated for an event to be recognized. This model suggests that remembering and knowing are not process-pure (Jacoby, 1991), and that recollection and familiarity both contribute to the two responses. These models rely on having recognition memory experiments where confidence judgments are obtained, therefore the results of the current study cannot address which model fits the data better. However, in general, the dissociation between remembering and knowing obtained across the three experiments are supportive of dual process explanations of remembering and knowing.

Dual process theories that consider remembering and knowing in the context of recall are not entirely lacking. Mickes et al. (2013) were interested in the issue of what know responses mean in the context of free recall, and argued that “Know judgments reflect the cue-dependent

retrieval of item-only information (though from episodic memory, not semantic memory)...Remember judgments reflect the retrieval of item plus associative information from an episodic search set, whereas Know judgments reflect the retrieval of item plus little or no associative information from that same episodic search set” (p. 334). Although source memory was not assessed in the current study, responses on the post-experimental questionnaire support the possibility that remembering in recall involves item and associative information and that knowing involves only item information. For instance, one participant in Experiment 1 said “If I remembered encoding the word with a story/experience/association, then that connection is almost always what triggered me to recall the word and click ‘remember’, otherwise there were some words that I know I saw but didn't remember how I encoded them”. Similarly, one participant in Experiment 2 said “I said ‘remember’ if I could associate some song, thought process, or memory with the word (during the 'study' phase, I was sure to make connections with every word). I clicked ‘know’ if I happened to think of a word I remembered seeing, but could not recall what my association had been”. Finally, one participant in Experiment 3 said “For remember, I had a feeling, image or story connected to the word. Know was for when I knew the word, but there was no real connection to it”. Not all participants gave such responses, but for those who did, it is clear that remembering meant that participants remembered the word and some other information surrounding the experience of studying that word, whereas knowing meant that participants knew the word but did not recall anything else about studying it. As Mickes et al. (2013) argue, know responses in recall might mean knowing that an event occurred during the study phase without being able to recall any associative information.

The distinctiveness/fluency framework also considers remembering and knowing to be tapping into dual processes. Specifically, distinctive or salient processing of events during study

are associated with increased remembering, and fluency or ease of processing of events at test is associated with increased knowing (Rajaram, 1996, 1998). Even though recall increased in all experiments reported above as more powerful retrieval cues were provided, there was a dissociation between remembering and knowing. Increasing the power of retrieval cues via matching semantic and rhyme cues selectively increased remembering, whereas increasing the power of retrieval cues via providing more lexical cues selectively increased knowing. The distinctiveness/fluency framework is a viable account to explain the data. It is likely that distinctive processing was induced in the first two experiments when participants were asked to relate a target word to the cue word within the corresponding orienting question. Receiving the same cue from study at test may have reminded participants of their distinctive processing of targets, resulting in increased remembering. In the third experiment, only knowing accompanied the increase in recall. The fluency or ease of processing a test item likely increased as more letter cues were provided and processing was likely most fluent when all five letters of a word was presented at test, resulting in increased knowing. In addition, in the third experiment, participants studied words without any orienting questions or instructed strategy. The only instruction was to learn the words for a later test, and unless participants employed a specific strategy to use distinctive processing, the distinctiveness/fluency framework should not predict an increase in remembering across the different cue conditions. Although, the experiments in this thesis were not designed to test the distinctiveness/fluency framework, the framework is useful in understanding why a dissociation between remembering and knowing was observed.

5.3 Remembering and Knowing in Recall Tasks

The theories of remember and know judgements, with few exceptions, typically are developed using recognition memory experiments. However, the current study was based on

various recall tasks. Although the first study to use the remember/know procedure used free recall, cued recall and recognition (Tulving, 1985), the procedure has been used mostly in recognition memory experiments since then. Yet, there is a small number of studies that investigated remembering and knowing in free recall or cued recall tasks (e.g., Hamilton & Rajaram, 2003; Lindsay & Kelley, 1996; McCabe et al., 2010; McDermott, 2006; Mickes et al., 2013). These studies have shown that remembering accounts for most of accurate recall; however, some knowing contributes to accurate recall as well. Even though free recall is sometimes considered a pure measure of recollection, the use of the remember/know procedure revealed that some familiarity is involved in recall tasks (Mickes et al., 2013). This is further supported in the data reported in this thesis. Although remembering was the most commonly reported retrieval experience and contributed to 60% of accurate recall responses on average across the three experiments, knowing contributed to 22% of all accurate recall responses. These results, along with those of others who used the remember/know procedure in recall tasks, suggest that both remembering and knowing lead to correct recall.

5.4 Instructions Regarding Remembering and Knowing

In all three experiments, a post-experimental questionnaire was used to identify the participants who did not understand the remember, know, and guess instructions correctly. To our surprise, although participants were given both written and verbal instructions and one participant in each group was asked to explain the instructions to the experimenter, 35% of all the participants in the current study did not correctly explain the distinction on the post-experimental questionnaire. Geraci, McCabe and Guillory (2009) noted that, based on their post-test questionnaire, about 20% of their participants did not understand their instructions. We used a conservative criterion and excluded these participants from the main analyses. Any differences

in the results when all participants are included in the analyses are reported in the footnotes, but the results were similar to the main results in general. This lack of a difference suggests that participants may be using each response as instructed during the experiment, but that the distinction between remembering, knowing and guessing may not be easily verbalizable for participants.

Prior researchers have noted the difficulty of using the remember/know procedure. Regarding remember/know studies, Migo et al. (2012) stated that “the methods should matter as much as the theory” (p. 1451). Similarly, Geraci et al. (2009) noted the great variability in the remember/know instructions provided across labs. According to Geraci et al., some researchers instruct participants to provide a remember response when they can remember contextual details and to provide a know response when they cannot. Some instructions relate know responses to a sense of familiarity, and some instructions associate them with high confidence in the absence of contextual details. In two experiments, Geraci et al. (2009) showed that simply using different instructions (i.e., whether remembering and knowing are related to high confidence or whether only remembering is related to high confidence) can change the degree of remembering and knowing. Because the use of remembering and knowing in everyday life do not exactly map onto their meaning within the remember/know procedure, participants are typically given extensive instructions on how to provide these responses. For instance, participants are given written and verbal instructions, and are also asked to explain what the distinction is before they begin making these judgements. In some cases, researchers pick a few of each participants’ responses and ask them to explain why they remembered or knew that particular response (e.g., Gardiner, Richardson-Klavehn, & Ramponi, 1997). In order to avoid confusions, McCabe and Geraci (2009) used the terms Type A memory and Type B memory to refer to remembering and

knowing, and showed that participants made fewer remember false alarms and therefore had higher overall accuracy when remembering and knowing were introduced as neutral terms. Although these kinds of control are necessary, it appears that asking participants to explain how they distinguished between these responses as in the current study does not necessarily indicate whether they provided these responses as instructed. Across the three experiments, we arrived at similar conclusions when including or excluding those participants who could not explain the distinction between remembering, knowing and guessing correctly.

5.5 Conclusion

This thesis investigated how retrieval experience changes when participants receive more powerful retrieval cues to enhance recall. In the first two experiments, recall was enhanced by matching encoding and retrieval conditions using semantic and phonetic cues. This is in line with the encoding specificity principle and the transfer-appropriate processing framework. Critically, the increase in Experiments 1 and 2 was primarily driven by remembering. In the third experiment, recall was enhanced by increasing the strength of lexical cues, replicating Tulving and Watkins (1973). However, this increase was primarily driven by knowing. These findings suggest that successful retrieval can be achieved through either remembering or knowing, further supporting the functional independence of these two subjective states of awareness.

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Appendix A

Materials for Experiments 1 and 2

<u>TARGET</u>	<u>ASSOCIATE</u>	<u>RHYME</u>	<u>UNRELATED</u>
ALONE	ISOLATED	STONE	POOL
ANSWER	QUESTION	DANCER	THIEF
ARMOR	KNIGHT	FARMER	TIME
BACK	FRONT	RACK	ROSE
BALL	BOUNCE	WALL	LIGHT
BEACH	SAND	PEACH	CHURCH
BELT	BUCKLE	MELT	MOVIE
BIRD	PARROT	WORD	JUDGE
BLOOD	DONOR	FLOOD	PHONE
BOAT	SAIL	VOTE	DEER
BOOK	PAGE	COOK	PURSE
BRUSH	COMB	FLUSH	SPEED
CHAIR	TABLE	BEAR	SALAD
CHILD	ADULT	WILD	EXIT
CHOICE	OPTION	VOICE	LION
CITY	TOWN	PITY	POTATO
CLOSE	SHUT	DOSE	JUICE
COUCH	SOFA	CROUCH	RING
DEATH	FUNERAL	BREATH	SOAP
DEVIL	DEMON	LEVEL	SLEEVE
DIRTY	CLEAN	THIRTY	ZIPPER
DREAM	FANTASY	CREAM	COIN
DRUNK	SOBER	TRUNK	QUEEN
EARTH	PLANET	WORTH	WIFE
EGGS	BACON	LEGS	DRAWER
FAST	QUICK	PAST	CHEESE
FIGHT	ARGUE	KITE	NOVEL
FIND	SEEK	KIND	PALE
FLOWER	BLOOM	HOUR	TOOL
FOREVER	INFINITY	CLEVER	GLOVE
FORGET	FORGIVE	SWEAT	NOUN
FORK	SPOON	CORK	ARTICLE
FRIEND	BUDDY	ATTEND	TUBE
GHOST	PHANTOM	POST	SOCK
GIVE	TAKE	LIVE	MOUSE

GOLD	SILVER	MOLD	STREET
GRAPE	VINE	SHAPE	SHUTTLE
GRASS	WEED	BRASS	DEBATE
GUESS	ESTIMATE	LESS	NAVY
HAMMER	NAIL	GRAMMAR	SPICE
HARD	SOFT	YARD	COFFEE
HATE	DISLIKE	WEIGHT	SPINE
HORSE	PONY	SOURCE	CHALK
IDEA	CONCEPT	DIARRHEA	BEARD
JAIL	PRISON	TAIL	JACKET
KING	CROWN	WING	SAUCE
LAUGH	JOKE	GRAPH	BONE
LETTER	ENVELOPE	BETTER	NURSE
MATH	EQUATION	BATH	DRUG
MIDDLE	CENTER	RIDDLE	DOOR
MILK	DAIRY	SILK	EXPLODE
MONEY	BANK	HONEY	OCEAN
MOUNTAIN	HILL	FOUNTAIN	MUSTARD
PAIN	HURT	LANE	SPEND
PLACE	LOCATION	GRACE	BUTLER
POLICE	OFFICER	RELEASE	NEAT
PRESENT	GIFT	PEASANT	ORANGE
PUSH	SHOVE	BUSH	DIAMOND
RABBIT	HARE	HABIT	PERFUME
RICH	POOR	WITCH	BAND
SAME	SIMILAR	FAME	PENCIL
SHIRT	BLOUSE	ALERT	CLIMB
SHORT	TALL	COURT	SEARCH
SICK	ILLNESS	BRICK	DOZEN
SLEEP	TIRED	CHEAP	DOLPHIN
SLOW	SNAIL	BLOW	SOIL
SMART	WISE	CART	FRAME
SMELL	ODOR	BELL	ALTER
SMOKE	CIGARETTE	CLOAK	CAKE
SNAKE	SERPENT	LAKE	BUTTER
SONG	MELODY	WRONG	DOCTOR
SWEET	SUGAR	RECEIPT	ROCK
TALK	SPEAK	WALK	WINNER
TEACHER	INSTRUCTOR	FEATURE	LUNCH
TEST	EXAM	WEST	LORD

TREE	FOREST	KNEE	RECALL
TRIP	JOURNEY	GRIP	CLOCK
UNDER	OVER	WONDER	FIRST
WAITER	SERVER	SKATER	LOVE
WORK	LABOR	JERK	FISH

Appendix B

Instructions for Experiments 1 and 2

In the study phase, you will answer YES/NO questions about target words. Each question is followed by a target word presented in the middle of the screen in capital letters. Pay close attention to each question and make sure your answer is correct. You will take a test on the target words presented in capital letters, so try to learn each word in addition to making the YES/NO response.

In the test phase, you will see a cue on the screen. Your task is to type in a target word from the study phase that the cue reminds you. You should then click SUBMIT. After you submit your response, you will see a screen with four buttons. These buttons will be REMEMBER, KNOW, GUESS, and NO RECALL, respectively. You should select one of these buttons that describes your recall response the best. Here is how we want you to distinguish between these judgments.

Memory is associated with two different kinds of awareness. Often, recall brings back to mind something you recollect about what it is that you recall. For example, you recognize a face, and remember talking to this person at a party the previous night. At other times recall brings nothing back to mind about what it is you recall. For example, you are confident that you recognize someone, and you know you recognize them, because of strong feelings of familiarity, but you have no recollection of seeing this person before. You do not remember anything about them.

The same kinds of awareness are associated with recalling the words you will see during the study phase. Sometimes when you recall a word, this will bring back to mind something you remember thinking about when the word appeared in the study phase. You will recollect something you consciously experienced at that time. But sometimes recalling a word won't bring back to mind anything you remember about seeing it in the study phase. Instead, the word will seem familiar, you'll feel confident it was one you saw in the experiment, even though you won't recollect anything you experienced when you saw it in the study phase. For each word that you recall, please then click the REMEMBER button if recall is accompanied by some recollective experience, or the KNOW button if recall is accompanied by strong feelings of familiarity in the absence of any recollective experience.

If the word you recall triggers something you experienced when you saw it in the study phase, for example, something about its appearance on the screen, or the order in which the word came in, please indicate this kind of recall by clicking the REMEMBER button. The word you recall may also remind you of something you thought about when you saw it in the study phase, for example, an association you made to the word, the question the word was paired with, an image you formed when you saw the word, or something of personal significance that you associated with the word. If you can recollect any of these aspects when you recall the word, please click the REMEMBER button.

Instead, at other times, you will recall a word, but the word will not bring back to mind anything you remember about seeing it in the study phase, the word will just seem extremely familiar. When you feel confident that you saw the word in the study phase, even though you do not recollect anything you experienced when you saw it, please indicate this kind of recall by clicking the KNOW button.

There will also be times when you won't remember the word, nor will it seem familiar,

but you might want to guess that it was one of the words you saw in the study phase. Feel free to do this, but if your recall response is really just a guess, please then click the GUESS button. With a guess response, you think it possible that the word was presented but you are not sure that it was. For example, some people say that the word looks like a word that could have possibly been there. When you think your response is really just a guess, please click the GUESS button.

Finally, if you are unable to recall the target word, please click the NO RECALL button in the following screen. In other words, you should click NO RECALL if you were not able to type in a response in the immediately preceding trial.

Appendix C

Post-Experimental Questionnaire

1. At test, what led you to give a remember, know or a guess response? How did you distinguish between the three responses?
2. Did you find the instructions regarding remember, know and guess responses confusing? If so, in what way?
3. Did you find the test difficult? If so, in what way?
4. Did you experience any problems during the experiment? Please explain if your answer is yes.
5. Were you doing anything else while the experiment was going on? (Your compensation does not depend on your answer.)
6. Have you participated in this experiment before?

Appendix D

Additional Results from Experiment 1

Recall, Remember, Know and Guess Proportions and Estimates of Familiarity in Experiment 1 for the full sample (N = 108).

		Associate Test		Rhyme Test		
		Study	Associate (AA)	Rhyme (RA)	Associate (AR)	Rhyme (RR)
Recall			.88 (.12)	.37 (.24)	.06 (.08)	.32 (.21)
Relative Proportions	Remember		.73 (.25)	.13 (.21)	.05 (.19)	.54 (.34)
	Know		.22 (.23)	.17 (.22)	.12 (.30)	.26 (.26)
	Guess		.05 (.07)	.52 (.37)	.24 (.41)	.11 (.19)
Absolute Proportions	Remember		.65 (.25)	.07 (.12)	.01 (.02)	.19 (.17)
	Know		.19 (.20)	.07 (.10)	.01 (.04)	.09 (.11)
	Guess		.04 (.06)	.18 (.16)	.03 (.05)	.04 (.06)
Familiarity			.48 (.34)	.09 (.13)	.01 (.04)	.12 (.14)

Note. Standard deviations are reported in parentheses. AA: Associate study-Associate test; RA: Rhyme study-Associate test; AR: Associate study-Rhyme test; RR: Rhyme study-Rhyme test. Familiarity refers to the know proportions transformed with the IRK procedure.

Appendix E

Additional Results from Experiment 2

Recall, Remember, Know and Guess Proportions and Estimates of Familiarity in Experiment 2 for the full sample (N = 92).

Study		Associate Test		Rhyme Test	
		Associate (AA)	Rhyme (RA)	Associate (AR)	Rhyme (RR)
Recall		.90 (.12)	.47 (.20)	.21 (.17)	.47 (.20)
Relative Proportions	Remember	.73 (.23)	.14 (.21)	.18 (.29)	.52 (.29)
	Know	.19 (.18)	.23 (.24)	.22 (.30)	.24 (.23)
	Guess	.08 (.12)	.58 (.30)	.42 (.39)	.23 (.24)
Absolute Proportions	Remember	.67 (.25)	.08 (.15)	.06 (.12)	.28 (.22)
	Know	.16 (.15)	.12 (.13)	.06 (.08)	.11 (.10)
	Guess	.07 (.09)	.24 (.15)	.09 (.09)	.09 (.08)
Familiarity		.46 (.35)	.14 (.15)	.07 (.09)	.16 (.14)

Note. Standard deviations are reported in parentheses. AA: Associate study-Associate test; RA: Rhyme study-Associate test; AR: Associate study-Rhyme test; RR: Rhyme study-Rhyme test. Familiarity refers to the know proportions transformed with the IRK procedure.

Appendix F

Study Lists for Experiment 3

Set A

ALLOY	ALONE	ANGEL	APPLY	AUDIT
AWARE	BASIL	BELLE	BLANK	BLIND
BLOOM	BOWEL	BOXER	BREAK	BROOM
BRAID	BRAVE	BRING	CANOE	CHEST
CHAIR	CHARM	CHEAP	CHEER	COLOR
CLEAR	CLASH	CREEP	CROWD	CRUST
CRANE	DEBUG	DREAD	FLASK	FLING
FLOOR	FORTE	GRAPE	GRASS	GREEN
GRAIL	GRAND	GUILT	GUESS	LEVER
HEARD	IDIOM	LATER	LEASH	PEACH
LINEN	MEDIA	MOUND	PASTA	QUOTE
PHONE	PLAIN	PLANE	PRICK	ROUGH
PRONE	QUART	QUEEN	QUILL	SCORN
SCALE	REACH	RELAX	SCENT	SHOOK
SHORT	SCARE	SHEET	SHELL	SPARE
SEVER	SHARK	SLICE	SLEEP	STEAM
SPEAR	SLANG	SPORT	SQUAD	SWEET
START	SPOOL	STORY	STRAW	THREW
SWEAT	STEEL	SWORE	THING	TOWER
TRUCE	TRACE	TRAIL	TREAT	TRIAL

Set B

ALLOW	ALONG	ANGER	APPLE	AUDIO
AWARD	BASIC	BELLY	BLAND	BLINK
BLOOD	BOWED	BOXED	BREAD	BROOK
BRAIN	BRAVO	BRINE	CANON	CHESS
CHAIN	CHART	CHEAT	CHEEK	COLON
CLEAN	CLASS	CREEK	CROWN	CRUSH
CRANK	DEBUT	DREAM	FLASH	FLINT
FLOOD	FORTY	GRAPH	GRASP	GREED
GRAIN	GRANT	GUILD	GUEST	LEVEL
HEART	IDIOT	LATEX	LEASE	PEACE
LINER	MEDIC	MOUNT	PASTE	QUOTA
PHONY	PLAID	PLANT	PRICE	ROUGE
PRONG	QUARK	QUEER	QUILT	SCORE
SCALP	REACT	RELAY	SCENE	SHOOT

SHORE	SCARF	SHEEP	SHELF	SPARK
SEVEN	SHARP	SLICK	SLEEK	STEAK
SPEAK	SLANT	SPORE	SQUAT	SWEEP
STARK	SPOON	STORE	STRAP	THREE
SWEAR	STEER	SWORD	THINK	TOWEL
TRUCK	TRACK	TRAIN	TREAD	TRIAD

Appendix G

Instructions for Experiment 3

In this experiment, you will study words and you will be tested on them. There will be five different word lists, each containing twenty words. You will be tested on each list immediately after studying it. In the study phase, the words will be presented to you one at a time in the middle of the screen for two seconds. In the test phase, you will receive a total of twenty clues, each corresponding to a word on the immediately preceding list. Your task is to type in the word that the clue reminds you of from the study list. In the test phase, after you submit a response, you will also be asked to click one of three buttons (REMEMBER, KNOW, or GUESS), regarding your experience recalling each word you will type in. Click NO RECALL if you leave the response box empty. Click REMEMBER, KNOW, or GUESS if you typed in a word. Here is how we want you to distinguish between these judgments.

Memory is associated with two different kinds of awareness. Often, recall brings back to mind something you recollect about what it is that you recall. For example, you recognize a face, and remember talking to this person at a party the previous night. At other times recall brings nothing back to mind about what it is you recall. For example, you are confident that you recognize someone, and you know you recognize them, because of strong feelings of familiarity, but you have no recollection of seeing this person before. You do not remember anything about them.

The same kinds of awareness are associated with recalling the words you will see during the study phase. Sometimes when you recall a word, this will bring back to mind something you remember thinking about when the word appeared in the study phase. You will recollect something you consciously experienced at that time. But sometimes recalling a word won't bring back to mind anything you remember about seeing it in the study phase. Instead, the word will seem familiar, you'll feel confident it was one you saw in the experiment, even though you won't recollect anything you experienced when you saw it in the study phase. For each word that you recall, please then click the REMEMBER button if recall is accompanied by some recollective experience, or the KNOW button if recall is accompanied by strong feelings of familiarity in the absence of any recollective experience.

If the word you recall triggers something you experienced when you saw it in the study phase, for example, something about its appearance on the screen, or the order in which the word came in, please indicate this kind of recall by clicking the REMEMBER button. The word you recall may also remind you of something you thought about when you saw it in the study phase, for example, an association you made to the word, an image you formed when you saw the word, or something of personal significance that you associated with the word. If you can recollect any of these aspects when you recall the word, please click the REMEMBER button.

Instead, at other times, you will recall a word, but the word will not bring back to mind anything you remember about seeing it in the study phase, the word will just seem extremely familiar. When you feel confident that you saw the word in the study phase, even though you do not recollect anything you experienced when you saw it, please indicate this kind of recall by clicking the KNOW button.

There will also be times when you won't remember the word, nor will it seem familiar, but you might want to guess that it was one of the words you saw in the study phase. Feel free to do this, but if your recall response is really just a guess, please then click the GUESS button.

With a guess response, you think it possible that the word was presented but you are not sure that it was. When you think your response is really just a guess, please click the GUESS button.

Finally, if you are unable to recall a word, please click the NO RECALL button in the following screen. In other words, you should click NO RECALL if you were not able to type in a response in the immediately preceding trial.

Appendix H

Additional Results from Experiment 3

Recall, Remember, Know and Guess Proportions and Estimates of Familiarity in Experiment 3 for the full sample (N = 47)

		Free Recall	2 Letters	3 Letters	4 Letters	5 Letters
		_____	CR__	CRU__	CRUS_	CRUST
Recall		.29 (.22)	.32 (.18)	.54 (.19)	.78 (.15)	.94 (.16)
Relative Proportions	Remember	.65 (.41)	.71 (.28)	.70 (.27)	.69 (.25)	.62 (.27)
	Know	.09 (.21)	.21 (.23)	.18 (.21)	.18 (.17)	.29 (.23)
	Guess	.08 (.22)	.06 (.13)	.12 (.17)	.12 (.14)	.18 (.12)
Absolute Proportions	Remember	.23 (.21)	.25 (.18)	.40 (.23)	.56 (.26)	.59 (.28)
	Know	.03 (.09)	.06 (.07)	.09 (.11)	.13 (.12)	.27 (.22)
	Guess	.02 (.10)	.01 (.03)	.05 (.07)	.08 (.09)	.06 (.10)
Familiarity		.04 (.10)	.08 (.09)	.14 (.16)	.30 (.30)	.64 (.35)

Note. Standard deviations are reported in parentheses. Familiarity refers to the know proportions transformed with the IRK procedure.