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Source memory, subjective awareness, and the word frequency mirror effect

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SOURCE MEMORY, SUBJECTIVE AWARENESS, AND THE WORD FREQUENCY MIRROR EFFECT

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ABSTRACT

The current study investigated the subjective states of recollection and familiarity in source memory. Participants studied low and high frequency words, presented in one of two sources, and were then asked to make source decisions and subjective judgments of recollection and familiarity at test. Half of participants were asked to identify the source of an item before the subjective awareness judgment (SM-first group), while the other half of participants made a source decision to an item after judging it as recollected or familiar (RF-first group). The test order manipulation affected participants' patterns of responding. Participants in the RF-first group tended to give a *recollect* response to old items more often. Participants in the SM-first group demonstrated better source memory. Source memory was better for *recollect* judgments than *familiar* judgments; however, source memory was above chance for *familiar* judgments. The low frequency word advantage was found for recognition, source memory, and in judgments of subjective awareness. A review of the related literature and current theories concerning human memory attempts to account for the current results.

INTRODUCTION

Tulving (1983) introduced the classification of memory as being either episodic or semantic, referring to whether details of an event are consciously recollected or not at the time of retrieval, and further made the distinction between autonoetic and noetic consciousness to reflect different states of conscious awareness that account for one's personal past and relates to these two types of memory classes (Tulving, 1985). Autonoetic consciousness is thought to correspond to episodic memory, where details of a personal memory can be consciously retrieved, such as remembering the last movie one saw. Noetic consciousness is thought to correspond to semantic memory, or general knowledge about the world that is not associated with specific details of encountering an event's initial occurrence, such as having knowledge of one's own name. Delineating these two memory systems and their conscious correlates has given rise to a body of research investigating factors that may differentially affect one type of memory from another (e. g., Gardiner, 1988; Gardiner & Java, 1990; Donaldson, 1996; Yonelinas, 2002).

The *remember/know* procedure was developed by Tulving (1985) intended to separate remembering due to recollection of episodic details and remembering due to feelings of familiarity. This procedure queries participants' subjective state of awareness during a memory test. Typically, on a recognition memory test, participants are shown a list of items that have been previously studied along with new items that serve as distracters or foils. Participants must not only determine whether an item is old or new, but also must decide whether specific details of the item's occurrence that were encoded at the time of study are accessible or not for an item called old at retrieval. Participants are told to assign a *remember* designation to an item if specific details from the time of study are present. If an item called old lacks any specific episodic details of its initial occurrence, participants are told to make a *know* designation to refer to the general feeling of familiarity present for that item.

This subjective measure of awareness has yielded mixed results when used in past investigations of recognition memory. The frequency of *remember* and *know* responses to recognized items has been shown to vary across a range of manipulations applied at the time of encoding and retrieval. Deeper levels of processing (e.g., generating a word from an anagram) at encoding has been shown to produce more *remember* responses at test compared to *remember* responses given to items that were encoded under shallow conditions (e.g., generating an unrelated rhyming word) while often leaving *know* responses equal and unchanged (Gardiner, 1988; Rajaram, 1993; Bodner & Lindsay, 2003). Words have also been shown to receive more *remember* responses at retrieval compared to nonwords, however nonwords showed higher rates of *know* responses (Gardiner & Java, 1990). This pattern followed with items encoded as either a picture or word, with pictures receiving more *remember* responses while words received more *know* responses (Rajaram, 1993). Divided attention at study has also been shown to differentially affect patterns of *remember* and *know* responding, with divided attention conditions yielding fewer *remember* responses as difficulty on the divided attention task increases, while leaving *know* responses unchanged (Gardiner & Parkin, 1990).

The *remember/know* procedure has also had to account for the word frequency effect (Glanzer & Adams, 1985; 1990; Glanzer, Hilford, & Kim, 2004). The word frequency effect is the finding that words of low frequency are consistently more accurately recognized, in terms of greater hits and fewer false alarms to items at test, than high frequency words. An advantage for low frequency words has been found consistently in recognition memory and in recognition accompanied with a *remember* response (Gardiner & Java, 1990; Strack & Förster, 1995; Gardiner, Richardson-Klavenh, Ramponi, 1997; Guttentag & Carroll, 1997; Reder et al., 2000; Diana & Reder, 2006). Interestingly, correctly recognized words of low frequency have been shown to elicit equal rates of *know* responses compared to high frequency words and, in some cases, high frequency words have been shown to elicit even greater rates of *know* responses compared to low frequency words (e. g., Strack & Förster, 1995; Guttentag & Carroll, 1997; Diana & Reder, 2006). This consistent word frequency effect found in recognition memory may be able to account for some of the disparate findings in the way questions regarding one aspect of a remembered event or another are asked at the time of test. Specifically, how this effect may interact with the patterns of responding shown in *remember/know* judgments.

Thus, prior research suggests that certain manipulations can give rise to different patterns in *remember/know* responding, and that this subjective measure of awareness can vary in many ways. The *remember/know* procedure may not necessarily tap the processes present at retrieval assumed to contributed to conscious recollection of a remembered event or remembering based on general feeling of familiarity (cf. Rotello, Macmillan, Reeder, & Wong, 2005). Nevertheless, this procedure is useful in that responses fluctuate and interact with different manipulations that also affect overall recognition memory, and this subjective measure is useful in contributing to theories concerning the nature of human memory (see Yonelinas, 2002 for a review).

The source monitoring theory (Johnson, Hashtroudi, & Lindsay, 1993) has been used as a paradigm to measure details retrieved from an item or event's original occurrence. In a typical source monitoring paradigm, participants study items from two or more sources (e.g., seeing an item vs. hearing an item) and, at test, are asked to decide whether an item is old or new as well as distinguish from what source the item was originally presented (e.g., seen vs. heard). Memories for the source of an item may consist of spatiotemporal details (e.g., size or location), perceptual details (e.g., font or color), and different cognitive operations (e.g., imagine or rate), to name just a few. Some have argued that accurate source discrimination is accompanied by the conscious recollection of the details of an item's original occurrence, as might be the case for *remember* responses, and that accurate source recognition may not be able to occur if a test item lacks any associative details at retrieval, as might be the case for *know* responses (Donaldson, MacKenzie, & Underhill, 1996; Perfect, Mayes, Downes, & Van Eijk, 1996; Dewhurst & Hitch, 1999; Dudukovic & Knowlton, 2006). It is also important to note that a low frequency word advantage has also been found in source memory (Guttentag & Carroll, 1997; Glanzer et al., 2004; Diana & Reder, 2006).

Indeed, *remember* responses have been shown to reflect similar patterns of recognition when tested separately from source memory, either as a between-subjects manipulation or in separate experiments (Donaldson et al., 1996; Mather, Henkel, & Johnson, 1997; Diana & Reder, 2006), and this pattern has been shown consistently even when the *remember/know* and source decisions are made for each recognized item. Interestingly, a consistent pattern is not found in *know* responses when investigated along with source memory, and the prior research suggests that factors operating at retrieval may clarify the relationship between source memory and recognition associated with a *remember/know* responses.

A list of studies using the *remember/know* procedure and the source monitoring paradigm in combination at test is shown in Table 1. For the given studies, the findings are variable, and the methodologies regarding testing to measure source memory and subjective states of awareness are not consistent, but these studies provide insight into the patterns of responding given testing conditions present at retrieval. Some of the investigations show source memory at chance levels for *know* responses (Perfect et al., 1996; Dewhurst & Hitch, 1999; Dudukovic & Knowlton, 2006), suggesting no contextual details being retrieved for those items. Other studies have shown source memory being above chance levels for this subjective measure of familiarity (Conway & Dewhurst, 1995; Hicks, Marsh, & Ritschel, 2002; Meiser & Bröder, 2002; Starns & Hicks, 2005; Meiser & Sattler, 2007), suggesting that some contextual details may be present for those items at retrieval, but maybe not enough to decide that those items can be given a response reflecting the retrieval of episodic details. Although the studies listed in Table 1 vary in the types of sources used (e.g., perceptual or semantic), in the factors present at encoding (e.g., long or short encoding time), and in factors during retention (e.g., 1 hour or 1 week retention interval), the important point of these studies for present purposes is to focus on the factors at retrieval. More specifically, how are the *remember/know* and source questions asked?

Of the studies presented in Table 1, the investigations that show source memory at chance given a *know* response, the *remember/know* questions was always asked before the source question. For the studies that show source memory above chance for items

Table 1
Review of Studies of Source Memory and Remember-Know Judgments.

Study	Test Order	Source Memory for Ks
Conway & Dewhurst (1995) Exp. 2	O/N – R/K (test 1) SM – R/K (test 2)	above chance
Perfect et al. (1996) Exp. 1-5	R/K/N (test 1) SM (test 2)	at chance (except for Exp. 3)
Dewhurst & Hitch (1999) Exp. 2	R/K – SM (SM only if confident)	at chance
Hicks et al. (2002) Exp. 1 & 2	SM – R/K	above chance
Meiser & Bröder (2002) Exp. 2	O/N – R/K – SM	above chance
Starns & Hicks (2005) Exp. 1 & 2	R/K – SM	above chance
Dudukovic & Knowlton (2006) Exp. 1	O/N – R/K – SM1 – SM2	at chance
Meiser & Sattler (2007) Exp. 1-3	O/N – R/K – SM	above chance

given a *know* response, all but two asked the *remember/know* judgment after the source question. It could stand to reason that asking one type of question before the other may affect judgments concerning the types of details being retrieved. Several studies have manipulated the order of questions or type of questions asked at test, and have shown to affect patterns of responding in investigations of the *remember/know* procedure (Hicks & Marsh, 1999; Eldridge, Sarfatti, & Knowlton, 2002) and in source monitoring (Dodson & Johnson, 1993; Marsh & Hicks, 1998). However no direct manipulation of test order has been used when investigating *remember/know* responses and source memory in the same study. Details of subjective awareness that are claimed to be present at retrieval may reflect details of an item's source or other details not inherently associated with the item's perceptual features. This may be why source memory is not perfectly correlated with this subjective measure of recollection and why feelings of familiarity may contain enough details in memory, whether conscious or not, to correctly identify the source of a recognized item (i.e., *know* responses being above chance for accurate source memory). These details may be affected by asking what to consider first; memory for the source of an item, or if any episodic details are present or not for an item judged to be old.

Although a manipulation of test order has not been used in a combined source memory and *remember/know* design, past studies from both lines of research have shown how questions are asked at test can affect patterns of responses. Hicks and Marsh (1999), and Eldridge et al. (2002), investigated recollection and familiarity and gave participants either two questions at test, an *old/new* question followed by a *remember/know* judgment for items judged *old,* or one question at test, a *remember/know/new* judgment. Participants who were given the one question at test tended to produce higher hits and false alarms for items judged *remembered* and higher false alarms for items called *know* (no differences in *know* hits), suggesting participants who were given the one question at test responded more liberally than participants who were given two questions. Dodson and Johnson (1993) manipulated the testing situation in a source memory test by asking participants for either a binary source judgment or a four alternative forced-choice source judgment. Participants who received the four alternative judgment were less likely to make incorrect source judgments than participants who were given the binary judgment. Marsh and Hicks (1998) also manipulated the type of questions asked in a source memory test by asking participants if they remembered specific details of the item for the source decision (i.e., *Did you hear this item at study?* or *Did you see this item at study?*). Participants who were queried about the specific details of an item at test were better able to recognize the source of the item if it came from that particular source as oppose to the other source. These results suggest that having to judge features of an item at test (i.e., *old/new* or *which did you see?*) as oppose to the subjective details of an item or an open-ended source decision (i.e., *remember/know/new* or *seen/heard?*) may cause participants to focus more on those details of an item that would lead to more accurate remembering, as opposed to more spurious recognition shown in increases in false alarms for *remember* and *know* judgments and incorrect source memory.

The present experiment investigates source memory and the subjective state of awareness of an item's occurrence at study by manipulating the order in which the questions are asked at test and observing the patterns of responses given to low frequency and high frequency words. Participants will study low and high frequency words presented either on the left or right side of a computer monitor in a corresponding background color. For half of participants, a source memory question will be asked before a question concerning their subjective awareness of recollection or familiarity for each item at test. For the other half of participants, these questions will be reversed, with the subjective awareness question preceding the source question. In order to avoid any ambiguity in the interpretation of the recollection and familiarity distinction, the measure of subjective awareness asks participants to give a *recollect* response to items they feel give rise to the retrieval of contextual or episodic details (i.e., a *remember* response) and to give a *familiar* response to items they feel lack any episodic details from study (i.e., a *know* response). The questions of interest for the current investigation are: does manipulating the order of the type of question at test affect participants' recognition accuracy, source accuracy, and judgments of subjective awareness, and is any difference reflected in terms of items' normative word frequency? The results will be discussed as they relate to past findings in the literature and in terms of current theories of human memory.

METHOD

Participants

One hundred fifty-two Louisiana State University undergraduate students participated for an introductory course requirement or in exchange for extra credit towards a psychology course. Half of the participants were randomly assigned to the RF-first test order group and the other half were assigned to the SM-first test order group. Each participant was tested individually in sessions that lasted approximately 30 minutes.

Design and Materials

One hundred twenty words of high and low frequency were selected as stimuli from the Kučera and Francis (1967) compendium. Low frequency words had an average rate of occurrence of 6 per million. High frequency words had an average rate of occurrence of 63 per million. Word frequency was manipulated within-subjects. Participants were presented with 30 high and 30 low frequency words at study. Words were presented in all uppercase letters, either on the left side of the computer monitor in a red background or on the right side of the computer monitor in a green background. A set of arithmetic problems served as a four minute filler task between study and test. At test, all studied words were presented along with 60 lure words, 30 of high and 30 of low frequency. The order of test instructions was manipulated between-subjects and described in more detail in the procedure. All words were counterbalanced for the study and test portions of the experiment.

Procedure

At the beginning of the experimental session, participants were instructed to remember words for a later memory test. Participants then proceeded to the study phase of the experiment. Words were presented for 3 seconds each with an interstimulus interval of 150 ms. At completion of study, participants were given the filler task. Participants were told that their problem solving abilities were to be assessed, and were given a set of twelve multiplication problems to be solved for four minutes. After the filler task, participants were given instructions for the test.

Participants were given recollect-familiar instructions as well as instructions to identify an item's source at test. Recollect-familiar instructions were given as follows:

> For this part of the experiment, if you believe that a word was presented earlier, you will be asked to choose the reason that you believe a test word was presented. There are many possibilities for this decision. One option is that you believe the word was presented because it feels very familiar to you. This would be similar to the feeling that people have sometimes when they pass someone on the street and know that we've met the person before, but cannot think of when or where. There are other possibilities that all include cases in which you feel like you can mentally travel back in time to the specific moment you encountered the word. This feeling is called recollection. For example, you might recognize a test word because you remember forming an image of the word. Or perhaps you recall something you thought of when you encountered the word. Or perhaps you recall one or two words that were presented just before or after the test word. Or that you recall specifically which side of the screen the item was shown on. Or even that you recall something that happened in or near the room when the word was presented (such as a noise outside the door). But

> you should respond with one of these types of options ONLY if the test word brings back to mind a vivid recollection of one of these particular details. To summarize, you'll be making decisions about whether you remember that a test word was presented to you earlier or not presented at all. If you believe that the test word was presented earlier, you'll be asked to decide whether this word simply feels familiar to you or whether you recollect specific details. If it simply feels familiar, then press the 'FAM' key on the keyboard. If you can recollect any type of specific detail, then press the 'REC' key.

Participants were instructed to press one of two keys on the keyboard to make the recollect-familiar judgment. Instructions to identify an item’s source prompted participants to press one of two keys on the keyboard to judge whether an item appeared on the left side of the computer monitor in a red background or on the right side of the computer monitor in a green background. For all participants, the first set of options at test was accompanied with the option to call an item “new.” Participants were admonished from guessing, and told to make a “new” response if they felt they had to guess. All of the test instructions were shown on the computer monitor and verbally reiterated by the experimenter. All 120 words were presented one at a time in the center of the screen with the source options and recollect-familiar options appearing below the item. Half of the participants were prompted to make a recollect-familiar-new judgment first, then a source judgment for items labeled recollect or familiar (RF-first group). The other half of the participants were prompted to make a left/red-right/green-new source judgment first, then a recollect-familiar judgment for items given one of the two source claims (SM-first group). Participants were debriefed as to their involvement upon completion of the test phase.

RESULTS

Recognition Memory

Overall recognition memory performance is shown in Table 2. Recognition memory was measured using a corrected recognition measure (hits – false alarms). A 2 (test order: SM-first vs. RF-first) × 2 (word frequency: low vs. high) mixed factorial analysis of variance (ANOVA) was conducted with test order as the between-subjects factor and word frequency as the within-subjects factor. The analysis revealed a main effect of word frequency, F (1, 150) = 152.30, MSE = 1.67, $p < .01$, η^2_p = .50. Low frequency words (M = .57) were better recognized than high frequency words (M = .42), replicating the word frequency mirror effect. There was no main effect of test order, F (1, 150) = .349, MSE = .016, $p > .05$, η^2_p = .02. Participants in the SM-first group (M = .49) showed equal recognition performance as those in the RF-first group (M = .50). No interactions were found, F (1, 150) = .133, MSE = .001, $p > .05$, η^2_p = .001.

Recollect-Familiar Judgments

Recognition memory performance for the test order groups and for word frequency given either a *recollect* or *familiar* response is shown in Table 2. A 2 (test order: SM-first vs. RF-first) × 2 (word frequency: low vs. high) mixed factorial ANOVA was conducted on the mean hit rates, false alarm rates, and corrected recognition rates of *recollect* and *familiar* responses with test order as the between-subjects factor and word frequency as the within-subjects factor. The rate of *recollect* responses for corrected recognition was significantly higher for low frequency words (M = .38) than high frequency words (M = .27), F (1, 150) = 100.91, MSE = .825, $p < .01$, η^2_p = .402. The rate of *recollect* responses for corrected recognition for the RF-first group (*M* = .36) was significantly higher compared to the SM-first group (*M* = .29), *F* (1, 150) = 4.70, *MSE* =

Table 2
Hit Rates, False Alarm Rates, and Corrected Recognition Rates as a Function of Test Order, Word Frequency, and Response Type.

Test Order	Response Type	Word Frequency					
		Low			High		
		Hits	FAs	Corrected	Hits	FAs	Corrected
SM-first	Overall	.67 (.02)	.11 (.01)	.56 (.02)	.62 (.02)	.21 (.02)	.42 (.02)
	Recollect	.38 (.02)	.03 (.01)	.35 (.02)	.30 (.02)	.07 (.01)	.24 (.02)
	Familiar	.29 (.02)	.08 (.01)	.21 (.02)	.32 (.02)	.14 (.01)	.18 (.02)
RF-first	Overall	.70 (.02)	.12 (.01)	.58 (.02)	.65 (.02)	.23 (.02)	.42 (.02)
	Recollect	.44 (.03)	.04 (.01)	.40 (.03)	.37 (.02)	.06 (.01)	.31 (.02)
	Familiar	.25 (.02)	.08 (.01)	.17 (.02)	.28 (.02)	.17 (.01)	.11 (.02)

Note. Standard error of mean in parentheses.

.318, $p < .05$, $\eta^2_p = .03$. The same pattern followed for the hit rates of *recollect* responses. Low frequency words had a greater hit rate (*M* = .41) than high frequency words (*M* = .34), *F* (1, 150) = 56.46, *MSE* = .44, $p < .01$, $\eta^2_p = .273$, and the RF-first group gave *recollect* responses to old items more often (*M* = .40) than the SM-first group (*M* = .34), although this difference was marginal, *F* (1, 150) = 3.80, *MSE* = .305, $p = .053$, η^2_p = .025. *Recollect* responses to lures were significantly higher for high frequency words (*M* = .06) compared to low frequency words (*M* = .03), *F* (1, 150) = 35.40, *MSE* = .06, *p* <

.01, η^2_p = .191. There was also a marginal interaction of test order by word frequency with high frequency lures being given *recollect* responses slightly more often in the SM-first group (*M* = .07) than high frequency lures in the RF-first group (*M* = .06), and low frequency lures in the SM-first group (*M* = .03) and RF-first group (*M* = .04), *F* (1, 150) = 3.12, *MSE* = .005, *p* = .079, η^2_p = .02. There were no other differences found in *recollect* responses, all *F*'s (1, 150) < .548, *p's* > .05.

For items given a *familiar* response, there was a main effect of word frequency for corrected recognition rates. Low frequency words (*M* = .19) were given more *familiar* responses than high frequency words (*M* = .14), *F* (1, 150) = 17.51, *MSE* = .148, *p* < .01, η^2_p = .105. There was also a main effect of test order with participants in the SM-first group giving more *familiar* responses (*M* = .19) than those in the RF-first group (*M* = .14), *F* (1, 150) = 4.99, *MSE* = .192, *p* < .05, η^2_p = .032. For overall hit rates, the pattern slightly changed. A main effect was again found for word frequency, but was in the other direction for hit rates. High frequency old items were given more *familiar* responses (*M* = .30) than low frequency old items (*M* = .27), *F* (1, 150) = 7.30, *MSE* = .056, *p* < .01, η^2_p = .046. For *familiar* responses given to lures, a main effect of word frequency and a test order by word frequency interaction was found. *Familiar* responses given to high frequency new items was greater (*M* = .16) than those given to low frequency new items (*M* = .08), *F* (1, 150) = 95.72, *MSE* = .386, *p* < .01, η^2_p = .39, and this occurred more for participants in the RF-first group (*M* = .17) than in the SM-first group (*M* = .14), while low frequency new items were given *familiar* responses equally often for the RF-first group (*M* = .08) and SM-first group (*M* = .08), *F* (1, 150) = 4.57, *MSE* = .018, *p* < .05,

$\eta_p^2 = .03$. No other differences were found for *familiar* responses, all *F*'s (1, 150) < 1.78, *p's* > .05.

Source Memory

Source memory was measured using an average conditional source identification measure (ACSIM; Murnane & Bayen, 1996), calculated as the proportion of correct source identifications among all old items that were called old. Source memory is shown in Table 3. ACSIM scores were submitted to a 2 (test order: SM-first vs. RF-first) × 2 (word frequency: low vs. high) mixed factorial ANOVA with test order as the between-subjects factor and word frequency as the within-subjects factor. A main effect of word frequency was found, F (1, 150) = 61.04, $MSE = .62$, $p < .01$, $\eta_p^2 = .289$. Source memory for low frequency words ($M = .72$) was better than source memory for high frequency words ($M = .63$). Participants in the SM-first group showed similar source memory ($M = .69$) as those in the RF-first group ($M = .66$), F (1, 150) = 1.84, $MSE = .044$, $p > .05$, $\eta_p^2 = .012$, and no interaction was found, F (1, 150) = 1.51, $MSE = .015$, $p > .05$, $\eta_p^2 = .01$.

Source memory was also examined as accurate source identifications given either a *recollect* or *familiar* response. In other words, these measures were analogous to ACSIMs, but were contingent on whether participants gave a *recollect* or *familiar* response. These data are also shown in Table 3. The data were submitted to a 2 (test order: SM-first vs. RF-first) × 2 (word frequency: low vs. high) × 2 (response type: recollect vs. familiar) mixed factorial ANOVA with test order as the between-subjects factor and word frequency and response type as the within-subjects factors. Main effects

Table 3
Average Conditional Source Identification Measures (ACSIMs) as a Function of Test Order, Word Frequency, and Response Type (with measure conditionalized on type of response).

Test Order	Response Type	Word Frequency Low	High
SM-first	Overall	.74 (.01)	.63 (.01)
	Recollect	.81 (.02)	.74 (.02)
	Familiar	.65 (.02)	.58 (.02)
RF-first	Overall	.70 (.02)	.62 (.02)
	Recollect	.76 (.02)	.65 (.02)
	Familiar	.60 (.03)	.59 (.03)

Note. Standard error of mean in parentheses.

were found for test order, $F(1, 143) = 7.10$, $MSE = .379$, $p < .01$, $\eta_p^2 = .047$, word frequency, $F(1, 143) = 20.83$, $MSE = .671$, $p < .01$, $\eta_p^2 = .127$, and response type, $F(1, 143) = 53.00$, $MSE = 2.64$, $p < .01$, $\eta_p^2 = .27$. Participants in the SM-first group ($M = .70$) showed better source identification than the RF-first group ($M = .64$). Low frequency words ($M = .70$) were more correctly identified than high frequency words ($M = .64$). Source identifications associated with *recollect* responses ($M = .74$) was better than those associated with *familiar* responses ($M = .60$). Also of note is that the high frequency ACSIM given a *familiar* response was above chance ($M = .58$) and this was confirmed by comparing the mean value to the chance value of .50 through a one sample *t*-test, $t(148) = 4.48$, $p < .01$. Not surprisingly, low frequency words given a *familiar* response ($M =$

.63) were also significantly above chance, t (147) = 7.24, $p < .01$. There was a non-significant word frequency by response type interaction with more *recollect* responses given to low frequency words (M = .78) than *recollect* responses given to high frequency words (M = .69), than *familiar* responses given to low frequency (M = .63) and high frequency words (M = .58), F (1, 143) = 2.79, MSE = .094, p = .097, η_p^2 = .019. No other main effects or interactions were found, all F's (1, 143) < 1.54, p's > .05.

GENERAL DISCUSSION

The current results replicate previous collective findings from past investigations of subjective awareness, source memory, and the word frequency effect. Overall, recognition that was accompanied with a *recollect* response was more accurate than recognition accompanied with a *familiar* response (Gardiner, 1988; Gardiner & Java, 1990). In addition, recollection-based recognition was better for those in the RF-first group as compared to the SM-first group. This pattern is evident in the corrected recognition rates in Table 2. The reverse pattern was found in regards to source accuracy (Table 3) with the SM-first group showing better source memory following *recollect* responses as compared to the RF-first group (Perfect et al., 1996; Dewhurst & Hitch, 1999; Dudukovic & Knowlton, 2006; Conway & Dewhurst, 1995; Hicks et al., 2002; Meiser & Bröder, 2002; Starns & Hicks, 2005; Meiser & Sattler, 2007). The SM-first group showed higher rates of *familiar* responses in both the corrected recognition rates as well as in the source accuracy data; however, for source accuracy, this trend was only found for low frequency words, whereas high frequency words produced equal levels of source recognition for *familiar* responses. Source memory associated with *familiar* responses was shown to be above chance, suggesting that source memory is present at retrieval for items that were judged previously to have no associated episodic details (Conway & Dewhurst, 1995; Hicks et al., 2002; Meiser & Bröder, 2002; Starns & Hicks, 2005; Meiser & Sattler, 2007).

The findings also replicate the word frequency effect with low frequency words being recognized overall more accurately than high frequency words (Glanzer & Adams, 1985; 1990). Moreover, for hit rates and corrected recognition rates (see Table 2), low frequency words received more *recollect* responses than high frequency words. This pattern tended to occur more for participants in the RF-first group, but this was only evident in the hit rates for that group. High frequency words tended to produce more *familiar* responses, but this was only found in the hit rates and false alarm rates. The corrected recognition rates for *familiar* responses were higher for low frequency words than high frequency words. The hit rate and corrected recognition rates overall were greater for *familiar* responses in the SM-first group than in the RF-first group. High frequency words produced more false alarms overall than low frequency words, and there were more false alarms for *familiar* responses than for *recollect* responses (see Donaldson, 1996; Reder et al., 2000; Diana & Reder, 2006). The RF-first group showed higher rates of *familiar* false alarms than the SM-first group.

There was also a word frequency effect for source accuracy data (see Table 3). Overall, low frequency words produced better source accuracy than high frequency words, replicating the word frequency mirror effect (Glanzer et al., 2004; Diana & Reder, 2006). This was found in both the *recollect* responses and *familiar* responses. Again, the SM-first group showed better source accuracy in *recollect* and *familiar* responses for low and high frequency words than the RF-first group. The important points are the fact that *familiar* responses to high frequency words showed above chance source memory and that false alarms were found for *recollect* responses for both low and high frequency words, with high frequency words showing greater false alarm rates for *recollect* responses (Conway & Dewhurst, 1995; Hicks et al., 2002; Meiser & Bröder, 2002; Starns & Hicks, 2005; Meiser & Sattler, 2007).

The patterns found in the current data can be explained in terms of current theories of recognition memory. There are currently two predominant classes of models that have been used to accommodate past findings: single process theories and dual process theories. The single process theories posit that remembering is due to a single process of familiarity in memory. This process can be modeled in terms of signal detection theory (Macmaillan & Creelman, 2005), where two Gaussian distributions, one for new items and one for old items, are situated along an axis representing strength of memory. A decision criterion is then placed along the axis that accounts for the decision to call items old or new. Figure 1 depicts two such pairs of distributions, one pair for high frequency words and one pair for low frequency words.

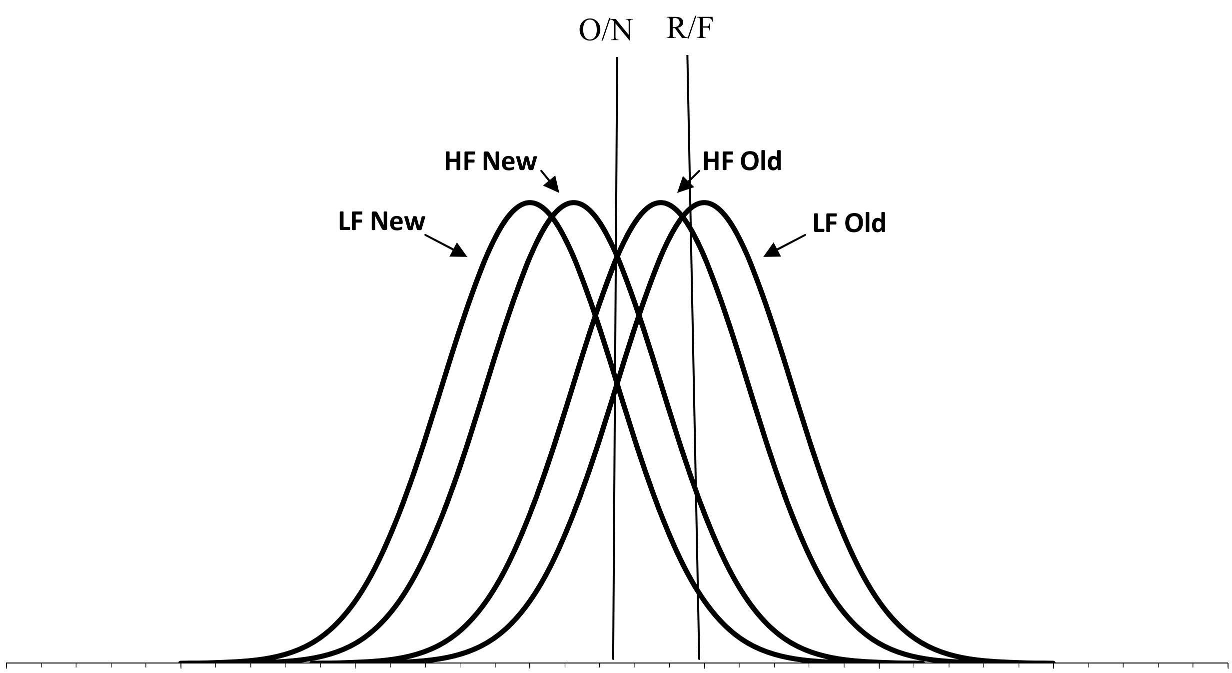

Figure 1. Signal detection model for recognition and *recollect/familiar* distinction. The distributions represent the memorial evidence for old and new words of low and high frequency. The vertical lines represent response criteria for *old/new* and *recollect/familiar* decisions.

Single process models of *recollect/familiar* responses involve two criteria that are placed along the decision axis (Donaldson, 1996; Hirshman & Master, 1997; Hirshman & Henzler, 1998). Items that fall to the right of the old-new decision criterion, but to the left of the recollect/familiar criterion, will be labeled *familiar*. If enough episodic detail of the item is present and the amount of evidence falls to the right of the recollect/familiar criterion, the result is the self-report of an item's consciously recollected experience (i.e., a *recollect* response). This would explain the higher hit rates and lower false alarm rates that are associated with *recollection* responses over *familiar* responses in the current data. This model would also explain why false alarms can occur for items given a *recollect* response, where no such episodic details should be retrieved from memory for a new item, and potentially why items given a *familiar* response can be associated with accurate source memory. The single process interpretation has been shown to account for results investigating *recollect/familiar* responses, source memory, and the word frequency effect (Donaldson, 1996; Donaldson et al., 1996; Hirshman & Master, 1997; Hirshman & Henzler, 1998; Wixted & Stretch, 2004; Dobbins & Kroll, 2005; Slotnick & Dodson, 2005).

Signal detection models of source memory account for source recognition by having two or more distributions, depending on the number of sources used, that represent the memory present for each source, after an item has been recognized as old (Slotnick & Dodson, 2005). These distributions are situated along a decision axis with criteria placed for each respective source decision. Given the amount of difference or similarity between sources, these distributions will move either closer together or farther away from each other, thus increasing or decreasing the discriminability between the sources. Given that the sources for the current study are relatively similar in memorability, these distributions should only change in terms of the strength associated with an item at test. This strength in the current data can be explained in terms of an item's normative word frequency (Glanzer, Adams, Iverson, & Kim, 1993; Wixted & Stretch, 2004).

Single process models can explain the word frequency effect in terms of two different distributions for old items that are situated along the decision axis; a distribution representing strong items (i.e., low frequency words) that is placed farther away from the distribution representing new items, and a distribution representing weak items (i.e., high frequency words) that is placed closer to the distribution of new items relative to the strong distribution (Glanzer et al., 1993; Wixted & Stretch, 2004). A conceptual model is presented in Figure 2. This can account for the advantage low frequency words have over high frequency words in recognition accuracy, which is replicated in the current findings. When applying the two criteria that are thought to account for *recollect* and *familiar* responses, as discussed above, this would also explain the advantage that low frequency words have over high frequency words in terms of greater hits and fewer false alarms for *recollect* and *familiar* responses, as well as in the low frequency word advantage found in the source accuracy data (Glanzer et al., 2004). The source memory evidence axis is orthogonal to the recognition memory axis. By examining Figure 2, one can see how source memory, on average, will be better for low frequency words, but also why source memory following *recollect* responses will be even higher as compared to source memory following *familiar* responses. Because recognition memory is generally correlated with source memory (Glanzer et al., 2004), low frequency words have an advantage in both respects.

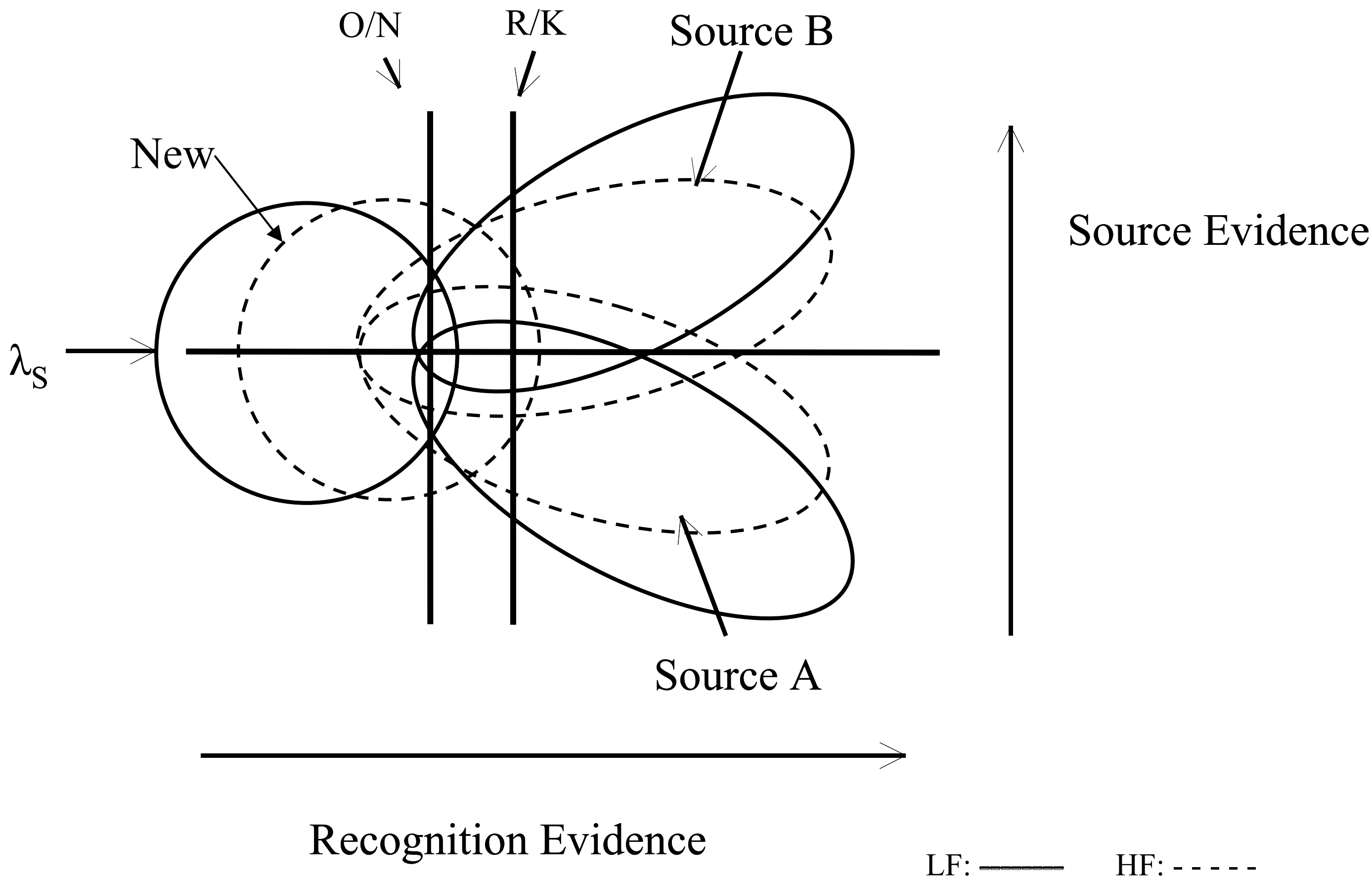

Figure 2. A model for recognition, source memory, and *recollect/familiar* distinctions. The ovals represent the memorial evidence for new words of low and high frequency and old words of low and high frequency from each source. The horizontal line represents source criterion. The vertical lines represent response criteria for *old/new* and *recollect/familiar* decisions.

Dual process theories hypothesize memory as two separate and independent systems that account for memories associated with contextual or episodic details (i.e., recollection) and for memories that lack these details and represents general memory strength (i.e., familiarity). For dual process models, familiarity is thought to be a continuous process that occurs automatically and is thought to reflect implicit memory, semantic memory, or generic familiarity, while recollection is thought to be a controlled process that occurs if an item or event gives rise to the recollection of episodic details, and is thought to reflect explicit memory or episodic memory (Mandler, 1980; Jacoby, 1991; Yonelinas, 2002). Familiarity should contain no associated episodic details, while recollection should reflect conscious awareness of an item or events' experience from encoding. Some models of dual process theory classify items in terms of their potential to be consciously recollected such as heightened activation for that item that would lead to recollection or some other experience that is entirely differentiated from familiarity (Reder et al., 2000). Some models account for remembering as being due to an assessment of familiarity of an item, or due to a controlled search process that would lead to recollection (Mandler, 1980). Some have also accounted for familiarity being due to processing fluency that occurs in an automatic fashion, while recollection is due to a consciously controlled search process where contextual and episodic details are retrieved from memory (Jacoby, 1991). It is also thought that familiarity is due to the quantitative memorial aspects of an item, whereas recollection results from the all-or-none likelihood for episodic or contextual details to be present at retrieval (Yonelinas, 1999; 2002). Some models have proposed a signal detection interpretation for the familiarity process, where the distributions for old and new items may overlap, while recollection functions independently (Yonelinas, 1999; 2002).

Dual process models account for the word frequency effect in terms of prior, or preexperimental, contexts associated with low and high frequency words and their respective activation maintained in memory (Joordens & Hockley, 2000; Reder et al., 2000; Diana & Reder, 2006). High frequency words are assumed to be associated with more prior contexts than low frequency words, thus accounting for higher rates of *familiar* responses, lower rates of *recollect* responses, and higher rates of false alarms. Low frequency words, being associated with fewer prior contexts, are better associated with the experimental context (or source), generating an overall accuracy advantage in recognition, in source memory, and the higher rates of *recollect* responses and lower rates of *familiar* responses that are given to those items.

Evidence from neuropsychology and cognitive neuroscience suggests that different brain regions can account for recognition that is accompanied by recollection and familiarity. Investigations from special populations that suffer amnesia due to some kind of brain injury show that both recollection and familiarity can be impaired, however recollection consistently appears to show greater deficits than familiarity (Knowlton & Squire, 1995; Yonelinas, Kroll, Dobbins, Lazzara, & Knight, 1998; Rajaram, Hamilton, & Bolton, 2002). This same pattern has been shown in patients with damage to the hippocampus due to childhood hypoxia, and the deficits in recollection and familiarity are affected by the extent of damage to that region (Yonelinas, Kroll, Quamme, Lazzara, Sauvé, Widaman, & Knight, 2002). Evidence from neuroimaging studies also show the hippocampus contributes to both recollection and familiarity; however, the hippocampus may be a more important contributor to recollection while areas of the medial temporal lobe surrounding the hippocampus appear to be a more important contributor to familiarity (Knowlton, 1998; Eldridge, Knowlton, Furmanski, Bookheimer, & Engel, 2000). Findings from studies using event-related potentials (ERPs) have shown that the frontal and parietal regions of the brain also contribute to recollection and familiarity (Rugg, Mark, Walla, Schloerscheidt, Birch, & Allan, 1998). The frontal areas have been shown to become quickly activated in the presence of recollection and familiarity, as well as in accurate source memory (Mitchell, Johnson, Raye, & Greene, 2004) and with recognition of low frequency words (Rugg, Cox, Doyle, & Wells, 1995). Activation has been shown to spread, however not as quickly, to the left lateral parietal region when recognition is thought to be accompanied exclusively with feelings of recollection (Curran, 2000). Interestingly, no studies have shown decrements in familiarity with recollection fully intact (Rugg & Yonelinas, 2003).

Regardless of the models utilized to test any hypothesis concerning recollection and familiarity, it is apparent in the data that this measure of subjective awareness may not necessarily reflect one memory system or the other, but is nevertheless useful in showing what is being retrieved from study when remembering is associated with normative word frequency and the requirement for source attributions. Just as *old/new* decisions are not process pure, it would appear that *recollect/familiar* decisions act much in the same way (Wixted & Stretch, 2004; Gonsalves, Kahn, Curran, Norman, & Wagner, 2005; Wixted, 2007). It may be the *recollect* responses reflect items recognized with high confidence while *familiar* responses reflect items recognized with relatively lower confidence in typical laboratory tasks. From the current data, as well as the findings from past investigations, it appears that recognition may occur due to contributions of both recollection and familiarity.

Though not subscribing to one theory or the other, the data suggest that when participants are asked for the RF distinction first, they tend be more inclined to give a *recollect* response to old items, while participants who were asked for the source decision first tended to exhibit more accurate recognition in terms of source identification for both items called *recollect* and for items called *familiar.* The data suggest that having the RF decision come first may cause participants to respond more liberally, as shown in the patterns of *recollect* responses and in the hits and false alarms in Table 2. Whereas having the source decision come first may cause participants to be more conservative in their responding, as evident in the increased source accuracy for that group in the data in Table 3. Although post hoc, this sort of criterion shift is more consistent with signal detection models of the *recollect/familiar* distinction that explicitly posit a decision criterion to separate recollection from familiarity (e.g., Donaldson, 1996; Hicks & Marsh, 1999). There is no a priori reason to expect differences between these test conditions owing to overall memory strength or to distribution placement as depicted in Figures 1 and 2. .

Obviously, the findings from the current study need to be validated with other manipulations that may affect what exactly is retrieved at the time of test, as well as other methods that may be better explained by a single or dual process model of memory. Certainly other manipulations of testing should be conducted to further delineate the cognitive processes at retrieval that may be affected by such manipulations. How might responding be affected if two separate tests at retrieval are administered and participants are asked for either *recollect* or *familiar* judgments first, and then given the same list of items judged old to be assigned to the correct source, and vice versa? How might responding change if participants are probed for a rationale for a given *recollect* decision to see what basis they are using to report items have associated episodic details?

Confidence ratings also be used with the current type of test manipulation to examine both source memory and what would be recollection or familiarity, and from these, receiver operating characteristic (ROC) curves can be generated and explained in terms of single and dual process models of memory. The current investigation is a first step toward understanding how questions asked at test can affect performance on a given recognition experiment.

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