Do Recall and Recognition Lead to Different Retrieval Experiences?

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The relation between recall and recognition has been debated in various contexts, and researchers have asked whether these tasks lie on a single continuum depending on the type of retrieval cues or whether they represent distinctly different processes. In the current experiment, we considered the continuity hypothesis, which states that recall and recognition are different only in cue information available, and we asked whether retrieval experience during various tests can further inform the nature of this relationship. Participants studied lists of 5-letter words and were tested with either no overt cues (free recall) or with the first 2 letters, first 3 letters, first 4 letters, or all 5 letters (recognition) of a word as retrieval cues. We used the remember/know/guess paradigm and asked participants to report their retrieval experience to infer the underlying experiences of recollection and familiarity. Accuracy increased continuously as the number of letter cues increased. This continuity was reflected in experiences of recollection, but familiarity increased nonlinearly across cue conditions. Our results show some support for the continuity hypothesis; however, recall and recognition do differ in that recall relies more heavily on recollection, whereas recognition relies on both recollection and familiarity.

KEYWORDS: recall, recognition, recollection, familiarity, remember/know

Recall and recognition are different tasks, but do they involve different cognitive processes, or are they points along a continuum? Differences between recall and recognition have been debated in various contexts (Anderson & Bower, 1972; Jacoby, 1991; Kintsch, 1970; Mandler, 1980; Tulving, 1976; Tulving & Watkins, 1973). Some theorists claimed that recall involves two stages (generate–recognize theories; e.g., Anderson & Bower, 1972) and recognition involves only one, whereas others argued that the only fundamental difference between the two tasks is the cue information available during retrieval (e.g., Tulving, 1976). The purpose of our article is to consider one method of addressing this issue and to develop it further.

In a straightforward experiment published in this journal, Tulving and Watkins (1973) examined whether recall and recognition are part of the same continuous process. The continuity hypothesis states that retrieval is a product of what is stored in memory and what information is available during retrieval; as one of these factors changes, the amount retrieved should also change. According to Tulving and Watkins, recall and recognition differ only in the cue information available and do not recruit different memory processes. Continuously increasing the

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number of retrieval cues (from free recall, to cued recall, to recognition) should therefore result in continuous increases in accuracy.

In their study, participants studied lists of five-letter words and were immediately tested on each list. They were provided with either no overt cues (i.e., free recall) or the first two, three, four, or all five letters of the words on the preceding study lists as retrieval cues, and if possible they wrote down one of the words from the list of which the cue reminded them. Not surprisingly, probability of recall increased from approximately .24 in free recall to .29, .55, .70, and .85 with two-, three-, four-, and five-letter cues, respectively (data points were estimated from their Figure 1). Of course, receiving the five-letter cues converts the task to recognition even though participants signaled recognition by writing down the word if it was in the list.

Tulving and Watkins discovered a continuous relation between recall and recognition and suggested that no fundamental difference exists between the two tasks; recognition tests simply provide more powerful retrieval cues than do various forms of recall tests (but see Tulving & Thomson, 1973). In light of these results they posed the question, Where does recall end and recognition begin? If free recall and recognition are thought to be qualitatively different, then how does one classify cued recall with two-, three-, and four-letter cues? They argued that such distinctions would be arbitrary and concluded that a more parsimonious account should assume that recall and recognition are continuous.

A tremendous amount of research has been devoted to the relation between recall and recognition since the Tulving and Watkins (1973) experiment, but the issue about whether recall and recognition are continuous has fallen to the wayside. In a chapter published in 1976, Tulving stated, "When . . . we wonder about the processes involved in remembering that are not directly observable, the relation between recall and recognition becomes less obvious and a more searching analysis is necessary" (p. 37). Thus, we find this issue worth reviving, and we propose that measures other than accuracy, such as retrieval experience, can further inform the nature of this relationship. That is, instead of only examining the success of retrieval on various memory tasks, we investigated whether participants' experiences during successful retrieval provide more information about how recall and recognition relate to each other. Specifically, we examined whether recollection and familiarity processes, as measured by Tulving's remember/know paradigm (1985), are consistent with a continuity position (see Yonelinas, 2002, for a review of dual process theories). We describe these retrieval experiences next.

In Tulving's remember/know paradigm (1985), participants report their retrieval experience during experimental tasks by categorizing, for each item recalled or recognized, whether they "remember" (if retrieval is accompanied by some recollective experience) or "know" (if retrieval is accompanied by strong feelings of familiarity and certainty in the absence of recollective experience) that the item had been studied (Gardiner, Ramponi, & Richardson-Klavehn, 1998; Rajaram, 1993; Tulving, 1985). Although Tulving (1985) originally argued that remembering and knowing tapped into retrieval from episodic and semantic memory, respectively, others have suggested that "remember" and "know" judgments are based on subjective experiences of recollection and familiarity (Jacoby, 1991; Mandler, 1980; Rajaram, 1993, 1996; Yonelinas, 2002).

Dual process models of recognition memory suggest that recollection and familiarity are two dissociable processes that give rise to a memory decision, and the remember/know paradigm is one of the methods frequently used to measure these processes (Wixted & Mickes, 2010; Yonelinas, 2002). The distinction between the two processes is commonly explained through the example of running into your butcher (whom you have previously seen at a particular location) on the bus (a novel location) and failing to remember who the person is and where you know them from, despite the sense of having met them before—familiarity in the absence of recollection (Mandler, 1980). That is, recollection occurs when participants consciously remember details about prior events or items they encountered, whereas familiarity occurs when participants feel as though they have previously encountered an item or event but are unable to access the contextual details of this previous encounter (see Yonelinas, 2002, for a review).

Some researchers have already considered whether recall and recognition differ based on the processes of recollection and familiarity. For instance, Quamme, Yonelinas, Widaman, Kroll, and Sauvé (2004) argued that recall involves only recollection, whereas recognition involves both recollection and familiarity. However, several studies using the remember/know paradigm in different recall tasks have shown that there is some knowing in recall too (Hamilton & Rajaram, 2003; Mickes, Seale-Carlisle, & Wixted, 2013; Tulving, 1985; also see McCabe, Roediger, & Karpicke, 2011; McDermott, 2006; Uner & Roediger, 2018, for interpretations of knowing as indicating familiarity in recall), suggesting that recall also involves both processes. Given that experiences of recollection and familiarity can drive both recall and recognition, we asked whether both of these processes change continuously from one memory test to the other, as does correct retrieval.

In a series of experiments, Hamilton and Rajaram (2003) asked a similar question and examined whether participants' experiences of recollection differed across explicit memory tasks. In their first experiment, participants studied pairs of category names and instances (e.g., *musical instrument–viola*) and retrieved those category instances after a brief delay via free recall, category cued recall, category plus letter cued recall, or recognition. On each test, participants indicated whether they "remembered" or "knew" the category instance they recalled. Hamilton and Rajaram demonstrated that although correct responding increased with increasing retrieval support (e.g., a recognition test provides more retrieval support than does category cued recall), the proportion of those correctly recalled words that participants "remembered" (rather than "knew") remained consistent across tests.

Hamilton and Rajaram's findings (2003) suggest that recall and recognition may not differ in terms of subjective experiences of recollection (the rate of "remember" responses serves as a measure of recollection); however, these findings cannot demonstrate whether these tasks differ regarding experiences of familiarity. In these experiments, participants only gave "remember" or "know" responses for words they recalled, meaning that levels of knowing were statistically dependent on levels of remembering. Therefore, the authors could make claims only about how remembering changes across different explicit memory tasks, but not about changes in knowing.

In the current study, we examined how experiences of both recollection and familiarity change across tests ranging from free recall to recognition. Our experiment was based on the Tulving and Watkins (1973) study, in which participants studied five-letter words and recalled them with varying numbers of letter cues ranging from zero letters (free recall) to five letters (recognition). We used the remember/know paradigm as a proxy of retrieval experience during these tests, with the addition of the guess option. The guess option was included so that participants' guesses based on the letter cues would not be lumped into the know category (Gardiner et al., 1998). This procedure also allowed us to examine both remembering and knowing across various tests rather than just rates of remembering, as in Hamilton and Rajaram's (2003) study.

An important consideration is that a categorization of recalled or recognized items as remembered or known assumes the processes underlying these judgments are mutually exclusive: A retrieved item is either recollected or is familiar. Jacoby, Yonelinas, and Jennings (1997) proposed that "remember" and "know" judgments do not need to purely reflect subjective experiences of recollection or familiarity; instead, they argued that recollected items can also be familiar. According to Jacoby et al., knowing is based on familiarity, but "know" judgments by themselves underestimate the measure of familiarity, because "remember" responses are also driven partly by familiarity.

To accommodate this consideration and to measure the contribution of familiarity more accurately, Jacoby et al. proposed the Independence Remember/Know (IRK) procedure (Familiarity = Know/[1 – Remember]) using data in remember/know experiments (see Yonelinas, 2002 and Yonelinas & Jacoby, 2012, for further explication). Accounting for the familiarity involved in remembering through the IRK procedure, the remember/know paradigm can therefore be used to infer how experiences of recollection and familiarity independently contribute to retrieval. In the current study, we used "remember" responses as measures of recollective experience and "know" responses (transformed via the IRK procedure) as a measure of experiences of familiarity (Jacoby et al., 1997). By manipulating the strength of retrieval cues in a gradual manner, we were able to test the continuity hypothesis from a retrieval experience perspective. In other words, we asked whether experiences of both recollection and familiarity increase gradually with letter cue strength to drive responding.

Based on Hamilton and Rajaram's findings, the provision of more powerful retrieval cues should not increase the relative rates of remembering across different tests. Instead, we expected an increase in knowing with increasing numbers of letters on the test, based on Rajaram's (1996) distinctiveness/fluency framework. This framework suggests that ease or fluency of processing increases rates of knowing. After studying intact words, participants may process test items more easily when they are presented with increasing numbers of letters. That is, as participants receive more letter cues, fluency may gradually increase, which in turn should lead to greater knowing. Overall, we predicted that as participants received more letters of a word as retrieval cues, their recall would increase (replicating Tulving & Watkins, 1973). We also predicted that this would be associated with increased relative rates of knowing (i.e., proportions of successfully retrieved items given a "know" judgment) but more constant relative rates of remembering (i.e., proportions of successfully retrieved items given a "remember" judgment), a proxy of recollection. In addition, we predicted raw levels of knowing (i.e., proportion of all items given a "know" judgment) transformed with the IRK procedure, a proxy of familiarity, to also show an increase with increasing numbers of letter cues at test (see Yonelinas, 2002, for arguments on the sensitivity of familiarity to fluency manipulations). Critically, if the change in familiarity is gradual, this would suggest that the relation between recall and recognition is continuous.

EXPERIMENT

METHOD

In this experiment, participants studied multiple five-letter word lists and were tested after each list with a 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. For one of the lists, participants were given no cues, and they were asked to type as many words as they could recall from the list they just studied (free recall). On all the tests, participants indicated whether they remembered, knew, or guessed each word they retrieved.

Participants

We based our sample size on Tulving and Watkins's (1973) study, which had 20 participants. However, their study did not report any measures of variability to calculate an effect size. Therefore, we set our sample size to 35 participants to achieve sufficient power to detect a medium-sized effect (Cohen's f = 0.25) in a within-subject design. To obtain this sample, we tested Washington University undergraduate students until we had 35 participants who could correctly explain the distinction between remembering and knowing (see Eldridge, Sarfatti, & Knowlton, 2002 and Uner & Roediger, 2018 for similar procedures). Altogether, we tested 47 participants and excluded data from 12 of these participants who failed to explain the remember/know distinction. Excluding subjects according to this criterion did not change the results and is discussed later. With our final sample size, we achieved 0.96 power to detect a medium-sized effect (Cohen's f = 0.25) and 0.58 power to detect a small to medium-sized effect (Cohen's f = 0.15). All participants received either 1 course credit or $10 for their participation. The study was approved by Washington University's institutional review board.

Materials

The study lists were made up of five-letter words with the following constraints: The words had a minimum logarithmic frequency of 6 (identified via the English Lexicon Project database; see Balota et al., 2007), no two words in a list had the same first two letters, and changing the last letter of each word formed another word (e.g., *crust* and *crush*). This last constraint, the same as used by Tulving and Watkins (1973), was intended to discourage participants from guessing a word as more letters were provided as cues. In total, there were 200 words with a mean logarithmic frequency of 8.92, split into two sets of five 20-word lists, counterbalanced across participants (see https://osf.io/qmztk, for materials).

Except for 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, because there was more than one word on the study lists that started with the same letter.

The instructions regarding remembering, knowing, and guessing were based on Gardiner et al. (1998). Participants were instructed to select "remember" "if recall is accompanied by some recollective experience," "know" "if recall is accompanied by strong feelings of familiarity in the absence of any recollective experience," and "guess" if they "think it possible that the word was presented but [they] are not sure that it was" (for the full instructions, see https://osf.io/qmztk).

Design

Participants studied five lists of 20 words 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 (free recall, two letters, three letters, four letters, and five letters) 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 four tests. After a fifth list, participants engaged in free recall. The placement of the free recall list was counterbalanced; across the five lists, free recall occurred in each list 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 after each recall response.

Procedure

All participants were tested on computers in a laboratory setting in groups of up to six. At the beginning, the experimenter outlined the experiment and read instructions about 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 participants' understanding of the instructions before they began the experiment. The rest of the experiment was computerized.

First, participants completed a practice phase where they studied a list of five words (different words from those used in the experiment) and took a test. The practice phase was used to ensure participants understood how to make a recall response (i.e., writing a complete word instead of the completion based on a cue) and how to provide a "remember," "know," or "guess" response.

The words in each study list were presented one at a time for 2 s. After each study list, participants solved simple arithmetic problems as a distractor task for 2 min. They were then reminded of the instructions about remembering, knowing, and guessing before the test list. For four of the five lists, the test was cued recall, with participants presented a mixture of the first two, three, four, or all five letters of the words they just studied (i.e., five words per each cue type). They were instructed to type in a complete word, if possible, from the most recent list if the cue reminded them of a relevant word. 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 instructed to type a complete 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*). The test was self-paced for all lists.

In all test lists, immediately after the participants submitted a recall response, a screen with four buttons appeared. Participants were instructed to click "No Recall" if they had left the response box empty; if they had written a response, they were instructed to pick between the "Remember," "Know," and "Guess" buttons. Providing responses was self-paced.

After participants studied and were tested on all five lists, they completed a self-paced questionnaire about their experience in the experiment. Among other questions, they were asked how they distinguished between "remember," "know," and "guess" responses ("At test, what led you to give a remember, know, or a guess response? How did you distinguish among the three responses?"). The responses to this question were scored, and participants who did not explain the distinction correctly were not included in further analyses. The experiment lasted 41.5 min on average.

Scoring

Responses where participants typed the correct completion of a cue instead of the complete word (2% of all correct responses) were considered accurate. Answers from the postexperimental 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 the distinction correctly, they were given a score of 1. The participants who were given a score of 0 were replaced until 35 participants were obtained.

RESULTS

Twelve participants with a score of 0 on the postexperimental question about the distinction between "remember," "know," and "guess" responses were replaced until a sample of 35 participants with a score of 1 was obtained. This exclusion did not change the results and is discussed later. The results reported here 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 postexperimental questionnaire. Omnibus tests of statistical significance used an alpha level of .05 unless otherwise stated. For all pairwise comparisons, an alpha level of .001 was used. If the sphericity assumption was violated, a Greenhouse–Geisser correction was used.

Recall

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. The first row of Table 1 shows that the proportion recalled increased as the number of letter cues provided increased. A one-way repeated-measures ANOVA showed that cue type significantly affected recall, $F(3.22, 109.41) = 169.94$, $p < .001$, $\eta_p^2 = .83$. Free recall and recall when the first two letters were provided were not significantly different, $p = 1.00$, $d = 0.07$, but all remaining differences were significant, ts > 4.74, ps < .001, ds > 0.81, replicating Tulving and Watkins (1973). Our experiment yielded higher overall recall, perhaps because each list had 20 words, whereas the original study had 28 words per list, and we used our newly developed lists.

Absolute "Remember" and "Know" Responses

The top row of Table 1 represents overall levels of recall, and the next three rows decompose recall into "remember," "know," and "guess" responses. We provide guess rates for completion but do not report statistical analyses for them, because they are dependent on "remember" and "know" responses and are not of theoretical interest. Nonetheless, guess rates were low and did not show notable changes across conditions.

"Remember" responses, like overall recall, increased with the number of letter cues, $F(3.03, 103.14) = 56.01$, $p < .001$, $\eta_p^2 = .62$. The difference in "remember" responses between the free recall and the two-letter conditions was not significant, nor was that between the four- and five-letter conditions, ts < 0.66, ps = 1.00, ds < 0.16. All other differences were significant, ts > 4.56, ps < .001, ds > 0.63. The proportion of "know" responses also differed based on cue type, $F(2.12, 71.94) = 33.88$, $p < .001$, $\eta_p^2 = .50$. Knowing was higher in the five-letter condition than in all other conditions, ts > 5.67, ps < .001, ds > 0.85. None of the adjacent differences (e.g., the difference between the two- and three-letter conditions), except for the difference between the four- and five-letter conditions, were significant, ts < 2.71, ps > .10, ds

TABLE 1. Recall, "Remember," "Know," "Guess," and Familiarity Across Cuing Conditions

	Free recall	2 Letters	3 Letters	4 Letters	5 Letters
Recall	.31 (.21)	.32 (.18)	.56 (.18)	.79 (.15)	.95 (.14)
Remember	.27 (.21)	.24 (.18)	.41 (.23)	.58 (.26)	.60 (.26)
Know	.03 (.06)	.06 (.07)	.10 (.11)	.14 (.13)	.29 (.21)
Guess	.01 (.02)	.01 (.03)	.05 (.07)	.07 (.09)	.05 (.09)
Familiarity	.04 (.09)	.08 (.09)	.16 (.17)	.31 (.32)	.68 (.32)

Note. Standard deviations are reported in parentheses. The "remember," "know," and "guess" proportions simply decompose overall recall into its components, although changes in overall recall affect the number of possible responses. Familiarity is calculated with these "remember" and "know" proportions via the Independence Remember/Know procedure ($K/[1 - R]$).

< 0.47, but knowing differed significantly between all other conditions, ts > 4.04, ps < .004, ds > 0.76. The gradual increase in recall when more letter cues were provided was accompanied by increased remembering and knowing (especially with all letters presented). Yet the increase in knowing did not mirror the gradual increase in recall levels.

The raw level of "know" responses represents an underestimate of familiarity because remembering and knowing are not process-pure response categories (Jacoby et al., 1997). We obtained familiarity estimates by transforming the proportion of "know" responses via the IRK procedure, and these are shown in Table 1. According to the IRK analysis, the contribution of familiarity to overall responding increased as more letter cues were provided, $F(2.63, 89.50) = 67.26$, $p < .001$, $\eta_p^2 = .66$. Despite the increase, none of the adjacent differences, except that between the four- and five-letter conditions, $t = 6.24$, $p < .001$, $d = 1.16$, were significant, other ts < 3.29, ps > .02, ds < 0.59. The remaining nonadjacent differences were significant, ts > 4.38, ps < .001, ds > 0.88. Thus, when analyzed in the manner suggested by Jacoby et al., the results revealed that both increased experiences of recollection and familiarity contribute to overall responding.

Recollection ("remember" responses) and familiarity (according to the IRK procedure) are plotted together in Figure 1, and the patterns suggest that familiarity increased at a higher rate from recall to recognition than did recollection. To statistically test this claim, we checked whether there was nonlinearity in the data by using a hierarchical linear model to account for the dependence between our measures at each cue level (i.e., within-subject data). We let only intercepts vary, and we predicted recollection and familiarity separately by the number of letter cues and a nonlinear squared term. The nonlinear component significantly predicted familiarity, $\beta = 0.05$, $t = 6.25$, $p < .001$, but it did not predict recollection, $\beta = 0.01$, $t = 1.13$, $p = .26$. Therefore, the provision of additional letter cues increased the contributions of familiarity at a greater rate relative to recollective processes (see Figure 1).

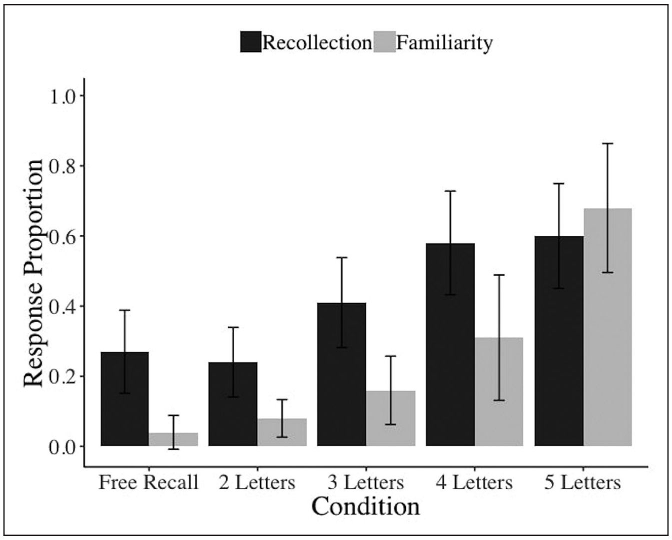

FIGURE 1. Recollection (proportion of "remember" responses) and estimates of familiarity ("know" responses transformed via the Independence Remember/Know procedure) across the different conditions. Error bars represent 99.9% confidence intervals

Relative "Remember" and "Know" Responses

Instead of asking what proportions of all items are remembered or known, we can also ask what proportions of correctly recalled items are remembered or known. To compute these relative proportions, the number of times a participant selects "remember" (or "know" or "guess") on the trials they correctly recall an item is divided by the total number of correct responses from that participant. These proportions are sometimes preferred instead of the absolute proportions reported previously to account for large differences in accuracy across conditions in an experiment (Chan & McDermott, 2006; Dewhurst & Conway, 1994; Rajaram, 1993), as was the case in our study.

Table 2 presents relative proportions in each cue condition. Analyzed this way, the proportion of "remember" responses stayed roughly the same across conditions, $F(2.49, 84.68) = 1.13$, $p = .35$, $\eta_p^2 = .03$, replicating findings reported by Hamilton and Rajaram (2003), who also analyzed relative proportions. However, the relative proportion of "know" responses increased when more letter cues were provided, $F(4, 136) = 9.62$, $p < .001$, $\eta_p^2 = .22$. Knowing was significantly different only between the four- and five-letter conditions, and the free recall and five-letter conditions, both ts > 4.79, ps < .001, ds > 0.58. None of the other differences were significant, ts < 3.33, ps > .02, ds < 0.52. After accounting for recall differences across cuing conditions, we found

TABLE 2. Relative Proportions of "Remember," "Know," and "Guess" Responses Across Cuing Conditions

	Free recall	2 Letters	3 Letters	4 Letters	5 Letters
Remember	.69 (.37)	.70 (.30)	.70 (.27)	.71 (.25)	.62 (.26)
Know	.09 (.19)	.22 (.25)	.19 (.21)	.18 (.18)	.31 (.23)
Guess	.05 (.11)	.05 (.12)	.10 (.14)	.10 (.13)	.06 (.09)

Note. Standard deviations are reported in parentheses. The relative proportions are calculated by dividing the number of responses in a condition by the number of correctly recalled items in that condition.

that recollection-driven responding remained constant across cuing conditions, whereas familiarity-driven responding increased. Critically, the increase in relative proportions of knowing did not reflect the gradual increase in accuracy, a finding similar to that obtained with absolute proportions of knowing and the IRK analysis. We do not report IRK analysis on relative proportions of knowing, because the IRK analysis can be done only with absolute proportions of remembering and knowing.

One important consideration is that six of the 35 participants in our sample had no accurate recall in the free recall condition, and one also had no accurate recall in the two-letter condition. In these cases, relative proportions of remembering, knowing, and guessing were coded as zeros to include participants' complete data from other conditions in the analyses (see Chan & McDermott, 2006, for a similar procedure). Given that almost all of the zeros were applied in the free recall condition, the mean proportion of "remember," "know," and "guess" responses decreased, and these did not add up to 1 (see Table 2). An alternative approach is to analyze data only from participants who have complete data across all conditions (see Barber, Rajaram, & Marsh, 2008, for a similar approach). We present relative proportions calculated this way in our supplementary materials. Critically, the findings from relative "know" proportions were consistent with those reported previously. For relative "remember" proportions, though, we obtained a significant overall effect of cue condition, $F(4, 112) = 6.31$, $p < .001$, $\eta_p^2 = .18$. However, this effect is driven by the significant difference between the free recall and the five-letter conditions ($p < .001$), because none of the other differences were significant at our set alpha level.

Additionally, we performed all the analyses discussed previously on the full set of 47 participants (rather than the 35 who correctly explained the distinction between remembering and knowing), and we confirmed the same patterns in overall recall, remembering and knowing, and recollection and familiarity as a function of increasing the number of cues (see https://osf.io/qmztk). Our results suggest that recall and recognition differ in the extent to which they rely on knowing or experiences of familiarity as a function of cue strength (i.e., number of letter cues, in this case).

DISCUSSION

The goal of this study was to explore the continuity between recall and recognition uncovered by Tulving and Watkins (1973) by measuring retrieval experience. We examined whether experiences of recollection and familiarity, as assessed by the remember/know paradigm, changed in parallel with more powerful retrieval cues. We replicated Tulving and Watkins's finding that participants recall more with more letters of a word provided as cues, although overall recall in our experiment was higher. The replication is no surprise; even Tulving and Watkins described their primary result as "trivial" because "few people would have doubted the general nature of the outcome even before the experiment was done" (p. 743). Nonetheless, they thought the data called into question the need to make a distinction between recall and recognition: Recognition just provides stronger cues than recall. Our finding that accuracy gradually increases from free recall to recognition with increasing number of letter cues fully supports the continuity hypothesis.

Even though we replicated Tulving and Watkins's result in terms of accuracy, our use of the remember/know paradigm shows that a distinction might be needed. By asking participants to provide "remember," "know," or "guess" responses after each word they recalled, we were able to infer underlying retrieval experiences across different explicit memory tasks that differed in the number of letter cues provided. We demonstrated that "remember" and "know" responses calculated as a proportion of all items (absolute proportions) increased as more letter cues were provided, along with overall recall. When we used Jacoby et al.'s (1997) logic to analyze how experiences of recollection and familiarity independently contribute to retrieval, we also found that both increased with the number of letter cues. However, absolute proportions of "know" responses and estimates of familiarity (calculated with the IRK procedure) did not mirror the gradual increase in accuracy that absolute proportions of remember responses (i.e., proxy for recollection) did. Furthermore, familiarity-driven processes increased across cue strength more greatly than did recollection. That is, the increase in responding was nonlinear for familiarity but linear for recollection (see Figure 1). These findings also imply that recollection made a larger contribution than familiarity in all conditions except the five-letter condition. Because the five-letter condition was essentially a recognition test with a response requirement to type in a word instead of saying "old" or "new," our results suggest that recognition, compared to recall, relies more equally on both recollection and familiarity (i.e., the confidence intervals for recollection and familiarity in the five-letter condition in Figure 1 overlap). Our results support the continuity hypothesis when examining recollection but not when examining familiarity-driven processes. These findings provide a more nuanced understanding of how recall and recognition relate to each other and demonstrate the utility of the remember/know procedure.

In addition to breaking down accuracy into "remember," "know," and "guess" responses, we also compared what proportion of correctly recalled words were given "remember" or "know" responses (relative proportions). These results revealed that remembering remained constant across conditions, conceptually replicating the work of Hamilton and Rajaram (2003), who also reported relative proportions. That is, when we accounted for participants' accuracy at each cue level, there was no difference in reports of remembering (although this outcome depended on treating remembering and knowing as 0 when recall was 0 in a particular condition for a participant). Once participants could recall a studied word, they did not report more or less remembering based on differing strength of retrieval cues (also see Yonelinas, 1994, for a threshold account of recollection). This finding provides converging evidence with the results reported by Hamilton and Rajaram, suggesting that explicit memory tasks that vary in the number of letter cues (i.e., lexical cues, as opposed to other cue types such as semantic cues) can also show constant rates of remembering with increasing cue strength (as a proportion of correct responding). The constant rates of remembering, when we account for accuracy differences across conditions, also supports the continuity hypothesis that describes the relationship between recall and recognition.

In contrast to remembering, relative proportions of knowing showed a striking increase from free recall to the five-letter condition. According to the distinctiveness/fluency framework, fluency or ease of processing increases knowing (Rajaram, 1996). Arguably, the five-letter condition provides the most fluent processing among the conditions we examined, because it essentially represents a recognition test (even if participants had to write down the word to indicate that it had been recognized). These findings demonstrate independent contributions of knowing across explicit memory tests, unlike those of Hamilton and Rajaram, who could only draw conclusions about remembering because their "remember" and "know" measures were statistically dependent. Similar to the absolute proportions of knowing and estimates of familiarity, relative proportions of knowing did not reflect the gradual increase in accuracy across conditions, thus providing no support for the continuity hypothesis. Even after we account for accuracy levels across cue conditions, it is clear that knowing does not support the continuity between recall and recognition (because it changes as the number of letter cues increases), whereas remembering does support the continuity hypothesis (because it remains constant).

When using the remember/know paradigm, it is important to consider how proportions of "remember" and "know" responses should be calculated. Although most studies that used the remember/know procedure reported the proportion of all items given a "remember" or "know" response (i.e., absolute proportions), some studies also reported the proportion of correctly recalled items given a "remember" or "know" response (i.e., relative proportions) to avoid scaling issues (e.g., Chan & McDermott, 2006; Hamilton & Rajaram, 2003; Rajaram, 1993). That is, if conditions within an experiment differ largely in terms of accuracy, it may be informative to report relative proportions in addition to absolute proportions. In our experiment, for instance, accuracy in the five-letter condition was almost triple that of accuracy in the free recall and two-letter conditions. Even if all participants provided "remember" responses on all correct trials in the latter two conditions, the absolute proportion of "remember" responses may have never exceeded that in the five-letter condition. In such situations, using relative proportions, and therefore accounting for these large differences in accuracy, may be necessary.

Using the remember/know paradigm also requires instructions to participants on how to differentiate "remember," "know," and "guess" responses. In our experiment, we examined whether participants could correctly explain the distinction between remembering, knowing, and guessing in a postexperimental questionnaire, and we excluded participants who did not correctly explain the distinction. Our results are based on a sample who explained the instructions correctly; however, analyses based on the full sample yielded the same results reported here. It is possible that participants understood the verbal instructions provided at the beginning of the experiment and made "remember," "know," and "guess" responses accordingly, but they were not able to explain the distinction in their own words after the experiment. Our conclusions were the same whether we included those participants or not.

In sum, our results confirm Tulving and Watkins's (1973) conclusion that recall and recognition lie on a continuum in terms of how retrieval behaves as a function of the number of letter cues presented at test. Our new contribution is to use the remember/know/guess paradigm to infer the underlying processes of recollection and familiarity to elucidate the relationship between recall and recognition. Our findings demonstrate that as the number of letter cues increases, processes underlying both recollection and familiarity increasingly drive responding. Nevertheless, the changes in these processes do not closely follow the continuous changes in accuracy. Hence, there is a distinction to be made between processes involved in recall and recognition, despite the continuity in overall accuracy and recollection with increasing number of cues. Recall relies more heavily on recollection, and recognition relies more equally on recollection and familiarity.

NOTES

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