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Short Communication

Levels of processing influences both recollection and familiarity: Evidence from a modified remember–know paradigm

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ABSTRACT

A modified Remember/Know (RK) paradigm was used to investigate reported subjective awareness during retrieval. Levels of processing (shallow vs. deep) was manipulated at study. Word pairs (old/new or new/new) were presented during test trials, and participants were instructed to respond "remember" if they recollected one of the two words, "know" if the word was familiar in the absence of recollection, or "new" if they judged both words to be new. Participants were then required to indicate which of the 2 words was old (2AFC recognition). With the standard RK proportions, deeper processing at study increased remember proportions and decreased know proportions, but this dissociation was not shown with the 2AFC proportion correct measure which instead demonstrated robust LOP effects for both remember and know trials, suggesting that the know proportion measure severely distorts the nature of LOP effects on familiarity.

1. Introduction

In the field of recognition memory, the Remember–Know (RK) paradigm was first introduced by Tulving (1985), and later refined by Gardiner (1988), to study subjective states of awareness at the time of retrieval. The RK paradigm is an example of the subjective, or 'claimed awareness', approach to the study of consciousness, because the paradigm requires participants to report on their subjective phenomenal awareness while performing the experimental task. Specifically, participants are asked to classify the test items that they recognize to be "old" (i.e., from the study phase of the experiment) as either *remember* if they experienced the recollection of episodic details for that item (i.e., specific details concerning their previous encounter with the item), or *know* if they experienced familiarity in the absence of recollection. To obtain the paradigm's dependent measures, the overall proportion of recognized old items (hit rate) in each experimental condition is then partitioned based on the subjective classifications provided by participants to form separate remember and know proportions.

A large literature has established that the remember and know proportion measures are differentially affected by a wide range of experimental variables, such that some variables increase one measure but not the other, and other variables have parallel or opposite effects on the two measures (for a review, see Gardiner & Richardson-Klavehn, 2000). These dissociations have been interpreted as evidence that remembering and knowing are driven by two qualitatively different systems or processes, such as the semantic vs. episodic memory systems (Tulving, 1985), distinctiveness vs. fluency processing (Rajaram, 1996), and familiarity vs. recollection (Jacoby, Yonelinas, & Jennings, 1997; for reviews, see Wixted and Mickes (2010), Yonelinas (2002)). However, this dual-process interpretation has been challenged by a competing class of single-process models, which contend that remembering and knowing reflect different response criterions along a continuum of confidence or

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memory strength (e.g., Donaldson, 1996; Dunn, 2004, 2008; Heathcote, Bora, & Freeman, 2010; Hicks & Marsh, 1999; Hirshman & Master, 1997; Inoue & Bellezza, 1998; Malmberg, Zeelenberg, & Shiffrin, 2004; Rotello, Macmillan, Hicks, & Hautus, 2006; Wais, Mickes, & Wixted, 2008; Wixted & Stretch, 2004).

In addition to the dual vs. single process debate, the RK literature has also debated the validity of the paradigm's proportion measures (Brown & Bodner, 2011; Donaldson, 1996; Donaldson, MacKenzie, & Underhill, 1996; Gardiner, Java, & Richardson-Klavehn, 1996a; Higham & Vokey, 2004; Hirshman & Master, 1997; Jacoby et al., 1997; Kurilla & Westerman, 2008; Richardson-Klavehn, Gardiner, & Java, 1996; Sheridan & Reingold, 2011; Yonelinas, 2002; Yonelinas & Jacoby, 1995). In particular, Jacoby et al. (1997) has questioned the validity of the know proportion measure as an index of familiarity. According to Jacoby et al. (1997), it is possible to experience both recollection and familiarity for the same item, but the RK paradigm forces participants to respond either remember or know (but not both). Consequently, if a variable leads to large increases in the proportion of remember responses, there may not be enough trials leftover for the proportion of know responses to also show an increase. In a previous paper (Sheridan & Reingold, 2011), we investigated Jacoby et al. (1997)'s criticism by introducing a modified RK paradigm. Specifically, participants were presented with two words at test (50% of trials = one old word and one new word, 50% of trials = two new words), and they were asked to decide if either word is old by responding remember, know or new. Then, regardless of their response, participants were asked to decide which word was old (i.e., a 2AFC recognition decision). A key advantage of this paradigm is that it yields both the standard RK proportion measures, and an additional measure of 2AFC proportion correct performance that is calculated separately for remember and know trials (for further details, see Sheridan & Reingold, (2011), supplementary materials). Unlike the know proportion measure, proportion correct performance for know trials is not constrained by high levels of remember responses. When this modified RK paradigm was used in conjunction with a generate/read manipulation (Slamecka & Graf, 1978) at study, the paradigm replicated the typical dissociation pattern of a large generate/read effect on the remember proportion measure but no effect on the know proportion measure, while at the same time showing that the generate/read variable increased 2AFC proportion correct performance for *both* remember and know trials. Consistent with Jacoby et al. (1997)'s criticism, this pattern of findings indicates that the generate/read variable produced an effect on familiarity that was not reflected by the standard RK know proportion measure.

To assess the generality of the modified RK paradigm's generate/read findings, the present study examines a variable that is known to produce an even larger increase in the proportion of remember responses. Specifically, we incorporate a levels of processing (LOP) study phase manipulation (Craik & Lockhart, 1972) because "deep" processing of the meaning of a word at study compared to "shallow" processing of perceptual aspects of the word has been shown to produce a large increase in the proportion of remember responses, coupled with a null effect (e.g., Gardiner, 1988; Gardiner, Kaminska, Dixon, & Java, 1996b; Java, Gregg, & Gardiner, 1997) or even a reverse effect (e.g., Gallo, Meadow, Johnson, & Foster, 2008; Gregg & Gardiner, 1994; Perfect, Williams, & Anderton-Brown, 1995; Rajaram, 1993) on the proportion of know responses. These findings suggest that LOP influences recollection but not familiarity, which is inconsistent with findings from other paradigms showing that LOP affects both recollection and familiarity (e.g., Brown & Bodner, 2011; Jacoby et al., 1997; Toth, 1996; Yonelinas, 2001; Yonelinas & Jacoby, 1995). Moreover, the interpretation of past LOP RK findings has sometimes been problematic because of near ceiling levels of remember responses in the deep processing condition (e.g., Java et al., 1997). In the RK literature, it is widely acknowledged, even by proponents of the standard RK paradigm (Gardiner et al., 1996a,b), that ceiling effects for remembering will produce mathematical constraints on the number of leftover trials that can receive know responses (for further discussion of this issue, see Yonelinas, 2002). Consequently, we selected the LOP variable for further investigation because our modified RK paradigm's proportion correct measure may provide a way to separately examine LOP effects on recollection and familiarity in conditions with extreme levels of remembering.

Based on the above considerations, and on our previous generate/read findings (Sheridan & Reingold, 2011), we expect the modified RK paradigm to replicate the standard RK paradigm's findings of a strong LOP effect on the remember proportion measure and a null or reverse effect on the know proportion measure, while simultaneously showing LOP effects on both remember and know 2AFC proportion correct performance. Such a pattern of results would indicate that the know proportion measure's null (and reverse) LOP effects stem from constraints inherent to the measure rather than from a lack of an influence of LOP on familiarity.

Finally, as a follow up to Sheridan and Reingold (2011), the present study also examines recognition memory in the absence of claimed awareness. The modified RK paradigm was originally inspired by an unconscious perception paradigm (Merikle & Reingold, 1990) that was used to demonstrate that participants could perform above chance at deciding which of two stimuli had been presented, even for trials in which they believed that they did not see a stimulus (i.e., claimed null awareness trials). In the present study, we test whether performance under conditions of claimed null awareness (i.e., following a "new" response) is still above chance, and we test whether the LOP manipulation differentially influences proportion correct performance for claimed null awareness trials (i.e., "new" response trials) as compared to claimed awareness trials (i.e., "remember" and "know" response trials).

2. Method

2.1. Participants

All 32 participants were undergraduate students at the University of Toronto. They were given either course credit or $10 (Canadian) per hour. All had normal or corrected-to normal vision. A total of 2 additional participants were replaced due to difficulty in understanding and following the RK instructions.

2.2. Materials

The stimuli were 784 words (50% = four letters, 50% = five letters) with a mean Francis and Kučera (1982) word frequency of 18.1 occurrences per million (range = 8–47). Participants were shown 192 single words at study, and 384 pairs of words at test. In addition, there were three practice trials that were presented at the start of the test phase, and a total of 12 filler study words that were shown at the beginning and end of the study phase blocks, to minimize primacy and recency effects. The order of the study and test phase trials was determined randomly for each participant, and the words were counterbalanced across participants such that each word appeared equally often in each condition.

2.3. Procedure

The participants were not informed about the recognition test until after the completion of the study phase. Instead, prior to the study phase they were told that the purpose of the experiment was to investigate reading. The deep and shallow study trials were presented in separate blocks, and the order of the blocks was counterbalanced across participants. Each study trial began with the presentation of a central fixation cross for 1200 ms, followed by the presentation of a single word. For the deep processing condition (50% of study trials), participants had to produce a meaningful associate of the word, while for the shallow processing condition (50% of study trials), participants had to produce any two letters that were not part of the word. Participants were instructed to provide their responses by speaking out loud into a microphone. After they finished speaking, participants pressed a button to proceed to the next trial.

On each test phase trial, participants were shown a pair of words in the center of the screen, with one word above the other. For half of the trials both words were new (i.e., "new new" trials), and for the remaining half of the trials there was one old word and one new word (i.e., "old new" trials). For the "old new" trials, the old word was equally likely to be presented on the top vs. the bottom, and there was an equal number of old words from the deep and the shallow study phase conditions. Participants were informed that 50% of the trials would contain an old word. During the test phase, participants answered two questions about each word pair. For the first question, participants had to decide if either word was old by giving one of three response options: remember, know, or new. They were told to respond "remember" if they could remember specific details about their past encounter with one of the words, and to respond "know" if one of the words seemed familiar in the absence of recollection of episodic details. They were told to respond, "new", if they believed that neither one of the two words was old. On every trial, regardless of which of the three responses (remember, know or new) was given to question one, participants had to decide which of the two words was old, by pressing the up or the down arrow on the keyboard. The word pair remained on the screen for both questions, and a prompt at the top of the screen reminded the participants of the current question and of the available response options. Prior to starting the test phase, participants were given written instructions, followed by a verbal explanation by the experimenter. To ensure understanding, participants were also asked to explain the test phase procedure in their own words, and to generate their own examples and explanations of remembering and knowing.

3. Results

Using our modified RK paradigm (Sheridan & Reingold, 2011), we examined the influence of the LOP manipulation on both the standard RK proportion measures (i.e., the mean proportion of trials containing an old word that received each type of subjective response) and an additional measure of 2AFC proportion correct performance (i.e., the number of correct trials that received a particular subjective response, divided by the total number of trials that received this subjective response). As shown in Fig. 1panel A, the standard RK proportion measures[1] replicated the dissociation pattern from past RK studies (e.g., Gallo et al., 2008; Gregg & Gardiner, 1994; Perfect et al., 1995; Rajaram, 1993) by showing a large LOP effect on the proportion of remember responses, $t(31) = 20.19$, $p < .001$ and a reverse LOP effect (i.e., shallow > deep) on the proportion of know responses, $t(31) = 4.56$, $p < .001$. However, as shown in Fig. 1panel B, the 2AFC proportion correct measure showed parallel LOP effects for both remember trials, $t(29) = 5.67$, $p < .001$, and know trials, $t(31) = 6.28$, $p < .001$. The presence of the LOP effect on know proportion correct per-

[1] The pattern of results was qualitatively similar when the standard RK proportions were converted to A′ using the formulas provided by Snodgrass and Corwin (1988):
For $H \geqslant FA, A' = 0.5 + [(H - FA)^*(1 + H - FA)]/[(4H^*(1 - FA)]$.
For FA > $H, A' = 0.5 - [(FA - H)^*(1 + FA - H)]/[(4FA^*(1 - H)]$.
For the above formulas, H = hits, and FA = false alarms. Separate H and FA values were calculated for remember and know trials. Specifically, for the present paradigm, the remember hit rate is the proportion of "old new" trials that were given a remember response, and the know hit rate is the proportion of "old new" trials that were given a know response. In a similar manner, the FA values are calculated based on the proportions of "new new" trials that received each type of response. For remember trials A′ values demonstrated a significant LOP effect (deep condition: $M = 0.91$, $SE = .01$, shallow condition: $M = 0.62$, $SE = .03$; $t(31) = 14.14$, $p < .001$), whereas for know trials A′ values showed a reverse LOP effect (deep condition: $M = .38$, $SE = .03$, shallow condition: $M = 0.58$, $SE = .01$; $t(31) = 6.55$, $p < .001$).
Furthermore, following Donaldson (1992), B''_D was calculated as follows:
$B''_D = [(1 - H)^*(l - FA) - H^*FA]/[(1 - H)^*(l - FA) + H^*FA]$
The mean value of B''_D was .027 (range = –.86 to .95). In replication of Donaldson (1996) and Sheridan and Reingold (2011), know sensitivity was significantly correlated with bias, $r(30) = .79$, $p < .001$, but remember sensitivity was not correlated with bias, $r(30) = -.24$, $p = .19$.

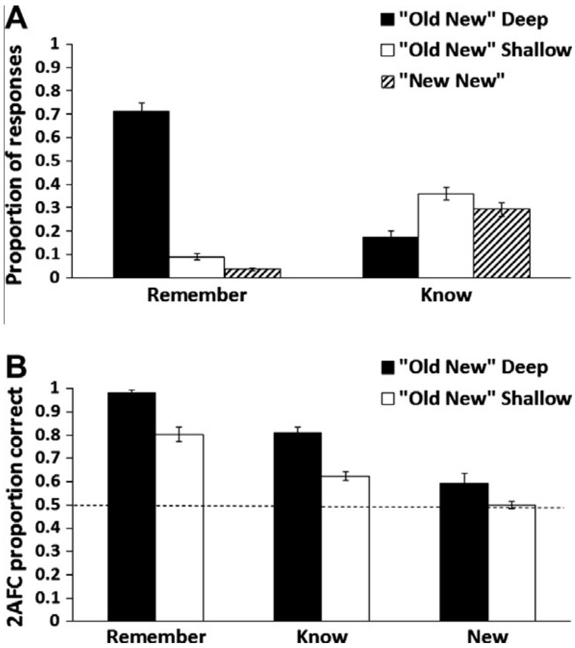

Fig. 1. Panel A: The mean proportions of subjective responses to targets (i.e., "old new" trials in the deep vs. shallow conditions) and lures (i.e., "new new" trials). Panel B: 2AFC proportion correct performance for "old new" trials, by encoding condition and subjective response category. The dotted line indicates chance performance (i.e., 50%).

formance suggests that LOP influences familiarity, and strongly suggests that the reverse LOP effect on the proportion of know responses was due to the constraints imposed by the extremely high proportion of remember responses in the deep condition. Furthermore, as shown in Fig. 1panel A, the proportion of know responses to "old new" trials in the deep condition is less than the proportion of know responses to "new new" trials, $t(31) = 2.84$, $p < .01$. This counterintuitive finding of a higher number of responses to lures than targets has been shown before (e.g., Brown & Bodner, 2011; Jacoby et al., 1997) and is also indicative of constraints inherent to the standard RK know proportion measure (Jacoby et al., 1997; but see also Gardiner et al., 1996a, 1996b).

In addition, the present study examined 2AFC recognition memory performance under conditions of claimed null awareness (i.e., following a new response). As can be seen from Fig. 1panel B, proportion correct performance for new response trials was significantly above chance (i.e., 50%) for the deep condition, $t(30) = 2.18$, $p < .05$, but not for the shallow condition, $t < 1$. Consequently, 2AFC proportion correct performance following a new response showed a marginally significant LOP effect, $t(30)=2.04$, $p = .05$, which was smaller in magnitude but qualitatively similar to the LOP effects on proportion correct performance for know and remember trials.

4. Discussion

The present study's levels of processing (LOP) findings provide strong support for past criticisms that the standard RK paradigm's know proportion measure is constrained by high levels of remembering (Brown & Bodner, 2011; Jacoby et al., 1997; Sheridan & Reingold, 2011). Specifically, deeper processing at study increased remember proportions and decreased know proportions, but this dissociation was not shown by the 2AFC proportion correct measure that was free to vary independently across the different subjective response categories. Instead, the proportion correct measure showed robust LOP effects for both remember and know trials. This pattern of results, as well as our previous findings (Sheridan & Reingold, 2011), indicates that null (or reverse) LOP effects on the proportion of know responses constitute an artifact of the standard RK paradigm due to constraints produced by large increases in remembering, rather than from an absence of LOP effects on familiarity.

Furthermore, the present demonstration of a significant LOP effect on know proportion correct performance is consistent with other findings of LOP effects on familiarity. As reviewed by Yonelinas (2002), a variety of paradigms have shown LOP effects on both recollection and familiarity, including the Process Dissociation Procedure (Toth, 1996; Yonelinas, 2001), and the Independent Remember Know (IRK) paradigm (Jacoby et al., 1997; Yonelinas & Jacoby, 1995). More recently, the independent-ratings variant of the RK task was used to demonstrate LOP effects on both familiarity and recollection ratings (Brown & Bodner, 2011). Importantly, the independent-ratings task avoids the problem of constraints on knowing in the presence of high levels of remembering, by employing two separate ratings scales (one for recollection and one for familiarity) instead of a binary remember vs. know judgment.

In comparing the various methods of studying recollection and familiarity, a key difference is that the standard RK paradigm assumes that recollection and familiarity are mutually exclusive (i.e., the two processes cannot co-occur for the same item), whereas the IRK paradigm and the process dissociation procedure both incorporate the assumption that recollection and familiarity vary independently (as discussed by Yonelinas (2002), a number of dual-process models also adopt this independence assumption). In contrast, similar to the independent-ratings task (see Brown & Bodner, 2011), our modified RK paradigm has the advantage of not requiring an a priori assumption about the relationship between familiarity and recollection. More precisely, the use of the 2AFC proportion correct measure to study the influence of experimental manipulations on recollection and familiarity only requires the assumption that remember trials constitute a representative sample of all trials in which recollection was experienced and know trials constitute a representative sample of all trials in which familiarity was experienced. Regardless of the relationship between familiarity and recollection, remember trials are broadly assumed to reflect all trials in which recollection was experienced. In addition, although in the present paradigm know responses are only expected for trials in which familiarity, but not recollection was experienced, there is no reason to suppose that the experience of familiarity in the absence of recollection is qualitatively different from the experience of familiarity in the presence of recollection. Consequently, we would argue that know trials in the present paradigm constitute a representative sample of all trials in which familiarity was experienced and the 2AFC proportion correct measure computed for such trials is a useful indicator of the influence of experimental manipulations on familiarity.

Furthermore, a unique advantage of our modified RK paradigm is that the standard RK proportion measures and the 2AFC proportion correct measures are simultaneously derived from the same trials under closely matched retrieval conditions. In addition, our modified RK paradigm can also be used to derive the estimates based on the IRK paradigm (Jacoby et al., 1997; Yonelinas & Jacoby, 1995). In the IRK paradigm, the proportion of remember responses is used directly as an estimate of recollection, and a familiarity estimate is obtained by dividing the proportion of know (K) responses by one minus the proportion of remember (R) responses (i.e., $F = K/(1 - R)$). When the present study's know proportion data were converted into the IRK familiarity estimate, we obtained a strong LOP effect, which is in agreement with the present paradigm's 2AFC know proportion correct findings (for deep processing trials $M = .59$, $SE = .04$; for shallow processing trials, $M = .40$, $SE = .03$, $t(31) = 6.13$, $p < .001$). More generally, given that various methods for studying recollection and familiarity incorporate different assumptions and unique advantages, it is useful to seek convergent evidence by investigating the same variables across a variety of paradigms.

Finally, of potential interest to the topic of unconscious (or implicit) memory, the modified RK paradigm's "new" response option provides a way to examine memory performance under conditions in which participants claim to be unaware of the presence of an old word. In the field of unconscious perception, Merikle and Reingold (1990) noted that findings of above chance performance in the absence of subjective claimed awareness are quite prevalent, but it is not possible to interpret such findings as evidence of unconscious processing on an a priori basis. Instead, subjective measures of awareness must first be validated by demonstrating qualitative differences between processing with and without claimed awareness. Consistent with this qualitative differences logic, Sheridan and Reingold (2011) did provide preliminary evidence that the modified RK paradigm's claimed awareness and null awareness states are qualitatively different, by demonstrating a generation effect under conditions of claimed awareness (i.e., following a remember or a know response), but not in the absence of claimed awareness (i.e., following a new response). In contrast to Sheridan and Reingold (2011)'s generate/read variable, the present study's LOP variable exerted a similar influence on memory with claimed awareness (i.e., following a remember or a know response) vs. without claimed awareness (i.e., following a new response). Furthermore, unlike Sheridan and Reingold (2011)'s finding that memory following a "new" response was above chance following a variety of study conditions (i.e., generate, read, visual and auditory), the present study observed above chance performance in the deep condition but not in the shallow condition. We speculate that the instructions in the shallow condition to "name two letters that are not in the word" encouraged participants to examine the word one letter at a time (i.e., analytic encoding) rather than processing the word as a whole unit (i.e., a nonanalytic encoding), and it is possible that a nonanalytic encoding of stimuli is required for producing above chance memory under claimed null awareness (for a related discussion, see Whittlesea & Price, 2001). Further research is clearly required in order to establish the boundary conditions for the occurrence of above chance recognition memory following a claimed null awareness response.

In conclusion, the findings from our modified RK paradigm strongly indicate that caution is necessary in employing the standard RK know proportion measure as an index of familiarity. This is because variables such as LOP and generate/read which produce a null, or reverse, effect on know proportions, have been shown to produce a robust influence on familiarity as measured by 2AFC recognition performance. More generally, the modified RK paradigm shows promise as a method for investigating the processes underlying recognition memory, as well as the relationship between subjective reports concerning phenomenal awareness during retrieval and objective memory performance.

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