TEMPORAL CONTIGUITY EFFECTS IN FREE-RECALL REVEAL DIFFERENTIAL RELIANCE ON CONTEXTUAL PROCESING FOR REMEMBER VS. KNOW JUDGMENTS

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Abstract

Dual-process models postulate that recognition-memory is driven by a contextual process termed Recollection and a non-contextual process termed Familiarity. Contrary to recognition, free-recall is assumed to rely only on a contextual process. We question this assumption and, using the Remember/Know paradigm, explore whether—in addition to the long-established contextual component—recall also involves a component which relies less on context. We capitalized on the temporal-contiguity effect whereby successively-retrieved items tend to be from adjacent serial-positions in the study-list. Temporal-contiguity has been shown to be mediated by the similar context that adjacent words share. Thus, because temporal-contiguity is driven by context, we hypothesized that for Remember judgments—presumably estimating contextual processing—the established temporal-contiguity effect would be demonstrated. For "Know" judgments—presumably estimating non-contextual processing—the temporal-contiguity effect would be reduced. Results confirmed these hypotheses thus suggesting that free-recall involves two components which differ with regard to their reliance on context.

Introduction

A widely-accepted notion in the study of episodic memory, put forth by dual process models, is that recognition memory is driven by two underlying processes, often referred to as familiarity and recollection (Jacoby, 1991; Yonelinas, 2002; but see Heathcote et al., 2006). Familiarity refers to the feeling that a studied item is old, in the absence of retrieving associated, contextual details of the study episode. In contrast, recollection entails not only retrieval of the studied item, but also of contextual details which accompany it. The recollective process involves a conscious, strategic search mechanism for the memory trace, akin to that occurring during recall, and is, in fact, often referred to as a "recall-like" process (e.g., Yonelinas, 1997). Importantly, the analogy of the contextual, recollective process with recall reflects a largely unquestioned assumption that recall—and specifically free-recall—relies solely on contextual-based, conscious processes. The current study questions this assumption by exploring whether recall also involves a non-contextual familiarity-like process.

Sporadic indications for familiarity-like processes in recall have been provided by several studies which used the Remember-Know (R/K) procedure in free-recall paradigms (Hamilton & Rajaram, 2003; McCabe, Roediger, & Karpicke, 2011; Read, 1996; Tulving, 1985). In these studies, for each of the recalled words, participants made a subjective judgment indicating whether the word was recollected—namely, whether its retrieval was accompanied by retrieval of associated, contextual details (a "Remember"; R judgment), or whether the word was familiar—namely, whether it evoked a sense of familiarity, with no accompanied contextual details ("a "Know"; K judgment). These studies find that a certain, fairly consistent, proportion of the recalled words are given a "Know" judgment, which is believed to tap familiarity. Furthermore, two of these studies found that encoding manipulations that are known to affect recollection but not familiarity in recognition—i.e.

levels of processing (Hamilton & Rajaram, 2003) and dividing attention (McCabe, et al., 2011)—show similar effects in free-recall.

While these studies provide compelling evidence that recall involves two underlying processes, we wished to more directly test the notion that these two processes differ with regard to their reliance on contextual detail. Thus, we hypothesized that in addition to a recollective, contextual retrieval process, which is known to drive recall, recall may also be driven by an additional familiarity-like process which relies less on contextual processing

To test our hypothesis, we capitalized on a seminal finding regarding the effects of context during retrieval—known as the temporal-contiguity effect. The *temporal-contiguity* effect refers to the consistent finding whereby the closer two words are presented during the study phase, the higher the probability that these two words will be retrieved one after the other during the test phase (Howard & Kahana, 1999; Kahana, 1996). Thorough investigations of this effect (Howard & Kahana, 1999) converged on the notion that it is mediated by the fact that words closer to each other in the study list are bound to relatively more similar contexts. It follows, therefore, that reinstatement of the context of one word will trigger retrieval of another word with higher probability the closer the two words were at study. Note that the temporal-contiguity effect has been shown to occur over a wide variety of conditions, and over both small and large timescales thereby eliminating alternate, non-contextual mechanisms which could have otherwise accounted for this effect (such as local associations between adjacent stimuli whose representations are co-activated in working memory).

Because temporal-contiguity effects have been shown to be a product of contextual processing, we hypothesized that if recall includes a non-contextual process, retrieval relying on this process would show a reduced temporal-contiguity effect. In contrast, retrieval relying on contextual, recollective processing would show the known temporal-contiguity effect. We followed previous studies (Hamilton & Rajaram, 2003; McCabe, et al., 2011; McDermott, 2006; Tulving, 1985) and used the R/K paradigm for free-recall. We hypothesized that for R judgments, the established temporal-contiguity effect would be observed and that for K judgments the temporal-contiguity effect would be significantly reduced.

Method

Participants

Participants were 88 native Hebrew speakers (59 women) aged 19-31 years.

Materials

Stimuli consisted of 25 lists of 12 words. Each word was a 3-6 letter long Hebrew noun.

Procedure

Prior to the experiment, participants were given standard R/K instructions (Gardiner & Java, 1990), which were modified slightly to apply to the free-recall test. In order to tap only long term memory, we used a delayed free-recall paradigm in which short term memory effects are eliminated (Davelaar, Goshen-Gottstein, Ashkenazi, Haarmann, & Usher, 2005; Postman & Phillips, 1965). Thus, for each of the test lists, 12 study-words were presented, followed by a 30-second arithmetic distractor task (overtly counting backwards in steps of three following an arbitrary 3-digit number) and concluded by a free-recall test in which R/K judgments were given following the retrieval of each word.

Each word in the study lists was presented visually for 1350 milliseconds followed by an asterisk for 400 milliseconds. For each word presented, participants made a subjective abstract-concrete judgment regarding the word.

During the retrieval phase, five question marks appeared on the screen for 90 seconds. The question marks signaled participants to start recalling as many words as possible, in any order, until a notice preparing them for the next list appeared on the screen. Participants typed the words they recalled using the computer keyboard. Following each word recalled, the words "Remember" and "Know" appeared at the center of the screen, signaling participants to make an R/K judgment regarding the last word they had typed.

Results and Discussion

Participants recalled correctly an average of 4.6 words per list (SEM = 0.14). 76% percent of the correctly-recalled words were given an R judgment, and the remaining 24% were given a K judgment (SEM = 2.23).

To measure the temporal-contiguity effect, we calculated the temporal percentile score for each participant (Polyn, Norman, & Kahana, 2009). The *temporal percentile score* measures the tendency of a participant to successively retrieve items in short lags—namely, from nearby study serial positions. For each transition between two successively-retrieved items, the lag of that transition is compared to the distribution of all possible lags for that transition, thereby generating a percentile score for that lag. To illustrate, consider a list of 6 items, from which the items from serial positions 4 and 5 had been successively retrieved. Following retrieval of item from serial position 5, the possible items left to be retrieved are from serial positions 1,2,3,6 which correspond to lags -4, -3, -2, +1 (the lags are calculated by subtracting the serial position of the just-retrieved item from the serial position of the possible to-be-retrieved item). If the next item retrieved was from lag -2 (i.e. serial position 3), its temporal percentile score would be 66.7% because the absolute value of its lag is smaller than the absolute values of 66.7% of the possible remaining lags (i.e., 2/3 lags; the lags of -3 and -4). The larger the temporal percentile score, the higher the tendency of a participant to successively retrieve items from short lags, with a chance score of 50% indicating no effect of temporal contiguity.

The temporal percentile score was calculated for each participant, separately for transitions following R and K judgments. Our a-priori hypothesis was that the temporal percentile score for R judgments would be larger than that of K judgments. Indeed, our results revealed that the average temporal percentile score for R judgments was 60%, whereas for K judgments the average temporal score was 55%. A single-sample t-test revealed that both R and K scores were significantly greater than the chance score of 50% ($t_{87} = 13.16$, $p < 0.0001$; $t_{87} = 3.46$, $p = 0.0008$ respectively), indicating that for both conditions a temporal contiguity effect was found. Most importantly, a paired t-test conducted on the percentile scores confirmed that the difference between R and K scores was statistically significant ($t_{86} = 2.69$, $p = 0.009$). These results support the notion the for K judgments a reduced temporal contiguity effect is observed, as compared to R judgments. Importantly, because the temporal percentile score is not affected by the absolute number of trials entered into the calculation, the higher proportion of R responses (as compared to K responses) could not account for the observed differences between temporal contiguity effects.

Next, we wished to examine whether the differences in temporal contiguity effects were confounded by differences in serial-position effects between R and K judgments. Thus, consider, for instance, a situation in which items given R judgments tended to be from later serial positions than items given K judgments. In such a case, R recalls would tend to made be in shorter lags because many of the transitions would be between items from nearby, late serial positions. To examine the effects of serial position, we calculated—for each participant—the proportion of items recalled from each serial position out of the entire number of items that participant recalled. These proportions were submitted to an Analysis of Variance (ANOVA) with condition (R/K) and serial position (1..12) as within-subject factors.

The ANOVA revealed no significant differences in serial position effects between R and K judgments. Therefore, the differences we found between temporal-contiguity effects of the two conditions could not be interpreted by differential serial-position effects.

To conclude, our findings of differential temporal contiguity effects for R and K judgments indicate that the retrieval process underlying free-recall is not uniformly dependent on contextual processing. Rather, free-recall may be driven by two underlying processes which differ with regard to the relative amount of contextual processing. Future studies are needed to determine whether, and to what extent, these two processes map onto the recollective and familiarity processes known to drive recognition memory.

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