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Effects of Survival Processing and Retention Interval on True and False Recognition in the DRM and Category Repetition Paradigms

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Effects of Survival Processing and Retention Interval on True and False Recognition in the DRM and Category Repetition Paradigms

Two experiments examined the effects of survival processing and delay on true and related false recognition. Experiment 1 used the Deese-Roediger-McDermott paradigm and found survival processing to increase true and related false recognition. Extending the delay from 5-mins to 1-day reduced true, but not false memory. Measures of the characteristics of true and false memories showed survival processing increased ‘remember’ and ‘know’ responses for related false memory, ‘know’ responses for true memory and gist processing. Experiment 2 made use of the category repetition procedure and found a broadly similar pattern of results for true memory. However, related false memory was decreased by survival processing. Except for one result, no interactions were found between encoding task and delay. Overall, survival processing produced similar or different effects on true/false memory depending on the nature of the list. The mechanisms that might underpin these are evaluated and considered in relation to future work.

Keywords: survival processing; false memory; DRM paradigm; category repetition paradigm; remember-know procedure

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The experiments presented here are concerned with the influence on memory of processing information for its survival value. In particular, how such processing has consequences for both true and false recognition in different paradigms over short and extended retention intervals. To date, no research has considered the joint impact of these variables and consequently, the current work addresses this omission together with related theoretical details.

Evolution, the adaptive nature of memory and survival processing

Survival processing refers to the cognitive functions operational when evaluating stimuli regarding their fitness or survival relevance in an evolutionary context (Nairne, Thompson, & Pandeirada, 2007). The basic tenet is that if memory systems have evolved, just like physical attributes, they would serve functions that reflect the outcomes of ancestral selection pressures to promote adaption (Nairne & Pandeirada, 2008).

Recent cognitive research has centred on the extent to which survival processing influences memory. For example, Nairne et al., (2007) asked participants to process a set of randomly selected words (with no inherent relevance to survival) under one of three conditions. In the survival condition, participants were asked to rate the referent of each word for survival purposes as if they were stranded in the grasslands of a foreign place and had to obtain water, food and protect themselves from predators. This was compared to two other conditions that involved self-referent processing (moving house) and deep processing (rating words for pleasantness). The results in a surprise memory test indicated superior free recall for the survival condition.

Other research has produced similar findings across a range of encoding tasks, Nairne, Pandeirada, and Thompson, (2008), stimuli (Otgaar, Smeets & van Bergen, 2010), and test-types including recognition and free recall (Kang, McDermott, & Cohen, 2008), and for source/location memory (Kroneisen, & Bell, 2018; Nairne, VanArsdall, Pandeirada, & Blunt, 2012). Work has also found survival memory advantages in children (Aslan & Bäuml, 2012; Otgaar & Smeets, 2010), older participants (Yang, Lau, & Truong, 2014; but see Stillman, Coane, Profaci, Howard, & Howard, 2014) and in depressed individuals (Nouchi & Kawashima, 2012). Although there are some exceptions to the survival advantage with implicit memory (Tse & Altarriba, 2010) and face memory (Savine, Scullin, & Roediger, 2011), the findings are typically robust and well documented. The present work extends previous work, however, prior to outlining the particulars of the current experiments, background research on delay and related false memories are introduced separately, followed by their integration to set the basis for Experiment 1.

Retention interval and survival processing

If survival processing bestows an evolutionary advantage on memory, then presumably the effects should outlast a short delay. For example, Abel and Bäuml (2013) assessed the survival advantage across a short delay or a longer delay of 12 hours that did or did not include sleep. They found a processing advantage in cued-recall and recognition across the longer delay irrespective of whether the subjects slept. Similarly, Raymaekers, Otgaar, and Smeets (2014) studied the effects of delay across 24 or 48 hours and found the survival advantage to be preserved in both free recall and recognition. More recently, Clark and Bruno (2016) found survival processing enhanced both the free recall of studied items and detailed location memory at both short and long

(96 hour) delays. In general, research indicates that although some forgetting does occur following survival processing (at the same rate as in control tasks), the superiority is maintained across longer delays.

Associative false memory & survival processing

False memories arising from related word lists have used two paradigms; Firstly, the Deese-Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995), in which subjects often falsely remember non-presented critical lures words (e.g., needle) following the study of a set of related words (e.g. thread, pin, eye, sew). Secondly, the category repetition paradigm, in which subjects experience false memories for non-presented exemplars (e.g., apple) following exposure to a list of words from the same taxonomic category (e.g., fruits). Both paradigms produce robust false memories and are considered to arise because of either: (i) the associative activation of non-presented lures from presented items, as specified by the activation-monitoring framework (Roediger, Balota, & Watson, 2001) or, (ii) the extraction of gist information that represents the general theme of the list, as described by Fuzzy Trace Theory (Brainerd & Reyna, 2005). Although differences between these two paradigms have been found (Smith, Gerkens, Pierce, & Choi, 2002), research broadly supports the idea that false memories in both procedures result from similar mechanisms (e.g., Dewhurst, Bould, Knott, & Thorley, 2009).

Use of related word lists in conjunction with survival processing has led to the surprising finding that such processing *increases* false memory (Howe & Derbish, 2010; Luo & Geng, 2013; Otgaar & Smeets, 2010, Otgaar, Howe, Smeets, & Garner, 2014). For instance, Otgaar and Smeets (2010) found survival processing to increase related false recall using both DRM and category lists. Although this may seem incompatible with the nature of adaptive memory, it is argued that false memories are an outcome of other cognitive activities (such as *gist* extraction), that are themselves adaptive and promote survival. (e.g., Garner & Howe, 2014; Howe & Derbish, 2010; Otgaar and Smeets, 2010; Savine et al., 2011; Schacter, Guerin, & St. Jacques, 2011). Interestingly, like survival processing, related false memories have also been found to be robust to the effects of delay and decay at a slower rate compared to true memory (e.g., Howe, Candel, Otgaar, Malone & Wimmer, 2010; Knott & Thorley, 2014). In this context, both related false memories and survival processing effects are: (i) resilient to the passage of time and, (ii) the outcome of adaptative processes in the service of some other activity or by itself. Consequently, together they represent an important combined avenue of exploration.

Survival processing, retention interval and associative false memory

Following from the above, the current experiments go beyond previous research by the joint consideration of survival processing and retention interval on the characteristics of true and false memory in both the DRM and category-repetition paradigms. As presented here, these characteristics pertain to memorial awareness and specificity as these have been shown to represent important qualities of retrieved information (Koustaal & Cavendish, 2006; Tulving; 2002).

Characteristics of memory 1: states of memorial awareness

Thus far, little work has been conducted on the states of memory awareness following survival processing and *none* in the context presented here. One way to assess states of awareness in memory is the remember-know procedure. A ‘remember’ response involves the conscious retrieval of elaborative details of an event, whilst a ‘know’ response denotes a memory in the absence of details but is familiar and somewhat vague (e.g., Gardiner 1988; Yonelinas, Aly, Wang, & Koen, 2010).

These ideas have been developed further based on dual-process theories of memory (Yonelinas, 2002). One of these processes (*familiarity*) produces a sense of general awareness of items devoid of specific details. The other leads to the retrieval of detailed information that provides a basis for conscious remembering (called *recollection*) (Diana, Reder, Arndt, & Park, 2006; Eichenbaum, Yonelinas, & Ranganath, 2007). These processes are considered to operate in an *independent* manner and can be derived algebraically from 'remember' and 'know' responses[1] (Yonelinas, 2002; 1999; Yonelinas & Jacoby, 1995). These analytic approaches possess particularly important measurement advantages, within the context of the current experiments in which encoding processes and retention interval were manipulated.

For example, deep encoding primarily increases true 'remember' (vs. 'know') responses (Gardiner, 1988; Khoe, Kroll, Yonelinas, Dobbins, & Knight, 2000; Rajaram, 1993; Jacoby, 1991; Jennings & Jacoby, 1993), and can also increase false 'remember' responses in the DRM and category-repetition paradigms (Dewhurst, Barry, & Holmes, 2005; Toglia, Neuschatz, & Goodwin, 1999). In relation to retention interval, true 'remember' (vs. know) responses have been shown to decline more rapidly over various delays (Dudukovic & Knowlton, 2006; Gardiner & Java, 1991; Hockley, & Consoli, 1999), whilst false 'know' responses are more resilient to delays (e.g. Knott & Thorley, 2014; Payne, Elie, Blackwell, & Neuschatz, 1996).

With respect to survival processing, only two experiments have assessed remembering/recollection and knowing/familiarity (Cho, Kazanas, & Altarriba, 2018; Munetsugu & Horiuchi, 2015) and both found survival processing to increase recollection for a set of *un*related words. In addition, Munetsugu & Horiuchi, (2015) found that after a delay, familiarity and recollection decreased after survival processing, but to a lesser degree than the semantic and shallow tasks. However, neither experiment examined related (associative) false memory.

Characteristics of memory 2: item-specific vs. gist-based memory

The qualities of item-specific and gist-based memory, in part, map onto the distinction outlined above (Gardiner, 2001; Tulving, 2002). However, a more precise definition is item-specific memories contain rich details that allow for efficient pattern separation between similar representations (Burns, 2006; Hunt & Einstein, 1981; Pidgeon & Morcom, 2016). In contrast, gist memories lack specificity and encode more general overlapping features of a stimulus or event (Brainerd & Reyna, 2005; Reyna, Corbin, Weldon, & Brainerd, 2016). These characteristics can be investigated by making use of signal-detection theory (SDT) in which different measurements (derived from responses to studied, related and unrelated items) can be calculated that index item-specific and gist-based memory (Koustaal & Cavendish, 2006; Koutstaal & Schacter, 1997; Schacter, Israel, & Racine, 1999; Tussing & Green, 1997). The details of these measurements are provided in the results section. In relation to survival processing, only one experiment has employed these measurements (Luo & Geng, 2013). Using related lists, survival processing (vs. pleasantness) was found to enhance gist-based memory. However, the effects of delay were not manipulated in this experiment.

The advantage of using these measurement procedures is that they provide a more fine-grained examination of recognition memory responses compared to old-new recognition. Use of these measures within the current paper provides a basis for assessing whether survival processing enhances true and false memory by influencing detailed recognition (remembering, recollection or item-specific memory) or more general forms of recognition (knowing, familiarity or gist-based memory).

Experiment 1. Survival processing, delay & false memory with DRM lists

The first experiment examined the effects of survival processing and retention on true and false memories using the DRM paradigm. During the encoding phase, participants were presented with DRM lists under one of three encoding conditions; survival, moving or pleasantness. After a delay of either five minutes or one day, an old/new recognition memory test was administered with remember-know instructions.

The research questions for true memory were to assess whether survival processing would: (i) enhance the hit rate, “remember” responses, process recollection, and the SDT measure of item-specific processing and (ii) interact with delay across any of these measures. For false memory, the questions posed were whether survival processing would: (i) increase related false memory, (ii) increase responses considered to be based on gist information or those lacking in item-specific detail (‘know’ responses, familiarity, and the *d*’gist measure), and (iii) interact with delay across any of these measures.

Experiment 1: Method

Design

The design was a 3(Encoding condition; Survival, vs. Moving, vs. Pleasantness) between-subjects by 2(Delay; 5 minutes vs. 1 day) between-subjects factorial. The dependent variables were the hit rate, false alarm rate to critical lures, and the false alarm rate to unrelated lures from non-presented lists. Each of these was further sub-divided into Remember, Know & Guess responses. Finally, signal detection measures of true (verbatim) memory, false (gist) memory and response bias (β) were used.

Participants

Participants were 150 students (*M* = 25.72, *SD* = 5.41, 70 females and 80 males) from Manchester Metropolitan University. Twenty-five were tested in each experimental condition. The participants came from the Psychology subject pool and from opportunistic sampling. Participation was voluntary and none had taken part in any similar research.

Materials & Apparatus.

The stimuli comprised of the first 10 words from 14 lists taken from the published norms of Stadler, Roediger and McDermott (1999). These were divided randomly into two groups of 7 lists (A and B) that were used for counterbalancing (studied vs. unstudied). Consequently, half the participants were exposed to A and half to B. The non-exposed group was used to create unrelated distractors of the recognition test. This occurred for all encoding conditions.

The recognition test booklet consisted of items taken from the studied and unstudied groups. Those from the studied lists were 7 critical lures and 14 list words from serial positions 4 and 7. For the unstudied group the items were 7 critical lures and 14 list words, again from positions 4 and 7. The stimuli were randomly ordered for each participant throughout the booklet with words listed down the left-hand side of the page. Next to each word were the response options of “yes” and “no”. Adjacent to these were the further response options of “R” (remember), “K” (know) and “G” (guess).

An additional booklet was provided in which Likert types scales were displayed for participants to write down their rating to each of the stimulus words during the encoding phase (see procedure). A computer with software compiled for the experiment was used to present the words during the encoding phase.

Procedure

Participants were tested individually and allocated randomly to the experimental conditions. Following the signing of consent forms, participants were seated in front of a computer and informed that they would be presented with a list of words on the screen and their task was to read and rate each word in accordance with the assigned instructions. The rating task was described as evaluating presented words on a five-point Likert scale ranging from 1, ‘Totally irrelevant’ to 5, ‘Totally relevant’ (except for the pleasant scenario where the scale consisted of 1,’Totally unpleasant’ to 5 ‘Totally pleasant’). The instructions and scenarios provided were in accordance with previous research and taken from Nairne et al., (2007).

Participants were asked if they understood the instructions and if so the experiment began. The DRM words were presented list by list in descending order of backward associative strength to the critical lure. Each word was presented for five seconds before changing to a blank screen in which the participant wrote down their response in the booklet provided. Each list was preceded by the title “List N” where N designated the number of the list from 1 to 7. There was a total of 10 trials per list and thus 70 trials in total. After the last word had been presented and rated, a short distractor task was implemented that consisted of writing down as many towns and cities in Great Britain that they could generate in 5 minutes.

For participants allocated to the 5-minute delay condition, they were then presented with the recognition test booklet. For those allocated to the 1-day delay condition, a time was scheduled for them to return the following day.

In the recognition test, participants were informed that within the booklet there was a list of words of which some had been presented in the encoding phase and some were new. Their task was to indicate if they recognised the words by circling either the yes or no response options. If they responded no, they were told to move onto the next word. If they responded yes, they were asked to indicate how they recognised the word. It was explained that recognition can subjectively be experienced in several forms. The distinction between remember, know and guess responses were then outlined based on previous work (Gardiner & Richardson-Klavehn, 2000). A remember response was one associated with the conscious recollection of a studied word. A know response was described as a memory in which a word is recognised because it appears or feels familiar within the context of the experiment but lacks more distinctive details linked to remembering or recollection. Finally, a guess response was defined as one where they partly felt they were presuming that a word had been studied because the item was not associated with recollection or familiarity. Before moving onto the actual test, the experimenter ensured that the participants fully understood the response requirements. Upon finishing the experiment, participants were debriefed and thanked for taking part in the experiment.

Experiment 1: Results & summary

Overview of results

Separate analyses were performed for each of the DVs that took the form of a series of 3(encoding task; survival vs. pleasant vs. moving) between-subject by 2(delay; 5-mins vs. 1-day) between-subject ANOVAs. For clarity and conciseness, the numerical outcomes of the analyses are presented in tables with additional information placed in the supplementary materials.

Proportion analyses: true memory

Descriptive statistics for all proportion measures to studied items can be seen in Table 1 and the ANOVA outcomes in Table 2 and subsequent comparisons in Table 3.

INSERT TABLE 1, 2 and 3 ABOUT HERE

The analyses of proportion true memory revealed several significant outcomes. The encoding task main effect was significant for the overall hit rate, and for 'know' and 'guess' responses. Further analyses of the main effects showed that survival processing produced higher hit rates and a greater proportion of 'know' responses compared to the other conditions. The proportion of 'guess' responses was reduced by survival processing. Remember responses were not significantly influenced by the encoding task, although there was a numerical trend to more 'remember' responses in the survival condition.

The main effect of delay was significant for the overall hit rate and 'remember' responses; in both cases, lower after 1 day. There was no interaction for any of the analyses.

Proportion analyses: related false memory

These analyses revealed significant main effects for the encoding task for the overall related false alarm rate and for 'remember' and 'know' responses. In all subsequent comparisons, rates of responding were higher under survival conditions. Guess responses were not influenced by the encoding task. The effects of delay and the interaction were not significant in any of the analyses.

Proportion analyses: unrelated false memory

These analyses indicated a significant effect of the encoding task for the overall unrelated false alarm rate and for 'know' responses. The effect was marginally significant for 'remember' responses (p = .06). The analysis of the comparisons showed lower unrelated scores following survival processing. There was no effect of the encoding task on ‘guess’ responses.

The main effect of delay was significant for the overall unrelated false alarm rate and marginally significant for ‘remember’ responses; lower after 1 day in both instances. None of the interactions for any measure reached traditional levels of significance, although a marginal effect was found for ‘remember’ responses.

Independence process-based analyses

Process based analyses based on the assumption of independence were calculated in the manner described earlier and detailed in the supplementary materials section. These calculations produced recollection estimates that were derived by subtracting the unstudied-unrelated false alarm rate, from the hit rate and related false alarm rate. Familiarity estimates were computed for true memory and related false memory. The descriptive statistics can be found in Table 4 and the ANOVA outcomes in Table 5 (upper third). Subsequent comparisons can be found in Table 3.

INSERT TABLE 5 and 5 ABOUT HERE

The main effect of encoding task was significant for false recollection, true familiarity and false familiarity. Further comparisons revealed these values to be higher after survival processing. The effect of delay was significant for only true recollection; lower after 1 day. None of the interactions achieved significance.

Signal detection analyses

Measurement of verbatim and gist recognition were computed based on details described in previous research (e.g., Koutstaal & Schacter, 1997; Seamon, Lee, et al., 2002; Seamon, Luo, et al., 2002). In summary, overall accuracy and response bias were calculated using the hit rate to presented words and the false alarm rate to unrelated unstudied words. SDT measures for item-specific memory used the hit rate to studied items and the false alarm rate to unstudied related items. The SDT measure for gist memory used the false alarm rate to unstudied related items and the false alarm rate to unstudied-unrelated items. The means and SDs can be found in Table 4, the ANOVA outcomes in the lower two-thirds of Table 5 and subsequent comparisons in Table 3. For accuracy scores, the main effect of encoding task was significant for *d*' overall and *d*' gist only. For the overall score, survival processing increased discrimination between studied and unstudied-unrelated items. For the gist score, survival processing decreased discrimination between studied and unstudied-related items. The main effect of delay was also significant for the overall score and for the item-specific score. In both instances, discrimination accuracy was reduced after a delay. None of the interactions were significant.

The criterion measure, β, was positively skewed and thus log transformed values were used for all analyses. For response bias scores, a main effect of encoding task was found for bias overall and item-specific bias; more liberal after survival processing. There was also a main effect of delay for the item-specific score with a higher score after 1 day. No other effects were significant.

Analyses of Ratings Data

Typically, in survival processing studies, the rating data are analysed to assess if there are any differences in rating scores among the conditions. These findings can be found in the supplementary materials file. Although differences were found between the encoding tasks, a series of ANCOVAs using the ratings as a covariate (e.g., Otgaar & Smeets 2010; Soderstorm & McCabe, 2011) did not result in any substantive changes to the ANOVA findings.

Summary

Experiment 1 replicated the survival processing effect in true memory and demonstrated that related false memories can also increase (Howe & Derbish, 2010; Otgaar & Smeets, 2010). To be more particular, for true memory, survival processing increased the hit rate and overall *d*' (studied – unrelated) that was reduced over the retention interval. It was also associated with an increase in 'know' responses and process familiarity and in contrast to recollection and *d*', these did *not* decrease over time.

Related false memory was enhanced by survival processing and did not decrease over the delay. Instead, overall levels remained constant over the 1-day interval across all encoding conditions. Interestingly, survival processing enhanced false 'remember'/'know' responses, processes estimates of recollection/familiarity, and the *d*' measure of gist. These were also insensitive to delay. In this respect, adaptive memory processing appears to increase the false recall of episodic details and familiarity. To extend these findings, Experiment 2 was performed using the category repetition paradigm.

Experiment 2. Survival processing, delay & false memory with category exemplar lists

As noted in the introduction, the category repetition paradigm reliably produced false memories for unstudied category exemplars (e.g., apple) following the presentation of a list of related items from the same taxonomic category. Using this paradigm, Otgaar and Smeets (2010) found survival processing to increase related false recall in a similar manner to the DRM procedure. However, they did not assess the simultaneous effects of delay nor make use of the range of dependent measures as employed in this research. Consequently, to provide converging evidence for the findings of Experiment 1, the second experiment made use of the same independent and dependent variables as the first study but used lists of category exemplars as studied items and related non-presented exemplars as critical lures.

Experiment 2: Method

Design

The design was the same as Experiment 1 with both the encoding conditions and delays manipulated between-subjects. The dependent variables were identical to the first experiment to allow comparisons across the two studies.

Participants

One hundred and fifty students from Manchester Metropolitan University were recruited on a voluntary basis. The ages in each category were[2]: 18-20 = 50, 21-25 = 68, 26-30 = 19, 31-35 = 13. There were 78 females and 72 males. Twenty-five were tested in each experimental condition. The participants came from the Psychology subject pool and opportunistic sampling. None had taken part in any similar research.

Materials & Apparatus.

The stimuli comprised of the first 11 words from 14 lists taken from the published norms of Van Overschelde, Rawson, and Dunlosky, (2004). The first word in each list was removed and used as the critical lure, the remaining words were used as list words. The 14 lists were divided randomly into two groups of 7 lists (A and B) that were used for counterbalancing (studied vs. unstudied). Consequently, half the participants were exposed to A and half to B. The non-exposed group was used to create unrelated distractors of the recognition test. This occurred for all encoding conditions.

The recognition test was constructed to align with that of the first experiment and consisted of exemplars taken from the studied and unstudied list. From the studied lists were the 7 most dominant exemplars (critical lures) and 14 list words from serial positions 4 and 7. The same selection principles applied to the unstudied lists. All other aspects of the test booklet construction were the same as Experiment 1.

Procedure

The procedure was the same as Experiment 1, only the category exemplar lists replaced the DRM lists. The exemplar lists themselves were presented in decreasing order of dominance similar to the procedure used in the first experiment. The presentation timings, number of trials, and all other aspects of the procedure were the same as Experiment 1.

Experiment 2: Results & Summary

Overview of results

Like Experiment 1, separate 3(encoding task; survival vs. pleasant vs. moving) between-subject by 2(delay; 5-mins vs. 1-day) between-subject ANOVAs were performed for the overall proportion scores, proportion RKG scores, independent process analyses and SDT measures.

Proportion analyses: true memory

Descriptive statistics for all proportion measures and ANOVA outcomes can be found in Table 6, the ANOVA outcomes in Table 7 and subsequent comparisons in Table 8.

INSERT TABLE 6, 7 & 8 ABOUT HERE

Analyses revealed a main effect of encoding task for the overall hit rate and ‘remember’ responses only, with survival processing producing the highest scores for each. The effects of delay were significant for the overall hit rate, and for both ‘remember’ and ‘know’ responses. In all instances, the proportion of each response type was lower after a delay. None of the interactions achieved significance.

Proportion analyses: related false memory

For related false memory, the main effect of encoding task was significant for the overall related false alarm rate and for 'remember' responses. The effect on 'know' responses was marginally significant. The effects arose due to survival processing decreasing the proportion of each response type. There were no significant effects of delay or any interactions.

Proportion analyses: unrelated false memory

For unrelated false memory, the only significant main effect of encoding task was on the overall false alarm rate that was lower under survival processing. A marginal effect was obtained for guess responses. Significant influences of delay were found for the overall false alarm rate and for 'remember' responses; more false alarms after one day. None of the interactions were significant.

Independence process-based analyses

Process based analyses were computed in the same manner as Experiment 1. The descriptive findings can be seen in Table 9, the ANOVA outcomes in Table 10 (upper third) and subsequent comparisons in Table 8.

INSERT TABLES 9 & 10 ABOUT HERE

Significant main effects of the encoding task were observed for true recollection and true familiarity only, with survival processing leading to an increase in these scores. Significant effects of delay were also found for true recollection and true familiarity, with a 1-day interval reducing scores in both instances. There were no interactions.

Signal detection analyses

Measurement of verbatim and gist recognition were computed in the manner as in Experiment 1 and outlined in the introduction. The descriptive statistics can be found in

Table 9, the ANOVA outcomes in the lower two-thirds of Table 10 and the subsequent comparisons in Table 8. In terms of response accuracy, there was a significant effect of encoding task on all three measures; however, the nature of the effects differed. For overall *d*’ and item-specific *d*’, survival processing enhanced discrimination. For the gist-based score, *d*’ was lower following survival processing. There were also main effects of delay on the overall and item-specific scores that were both lower after 1-day. None of the interactions were significant.

The criterion measure, β, was positively skewed and thus log transformed values were used for all analyses. For this measure, the only significant effect of encoding task was for the item-specific measure. Further examination demonstrated that this was due to a more conservative response bias after survival processing compared to the moving condition. There was a marginal effect of delay on the overall score. The interaction between encoding task and delay was also significant for the overall score. Simple main effects analyses at each level of encoding task indicated this to be due to no difference between the delay conditions for survival or pleasant comparisons. However, the effect of delay was significant for the moving condition, showing a liberal response bias after one day.

Analyses of Ratings Data

Like Experiment 1, the rating data were analysed and the results presented in the supplementary materials file. Although differences were found between the encoding tasks, a series of ANCOVAs using the ratings as a covariate did not result in any substantive changes to the ANOVA findings.

Summary

In relation to true memory, the second experiment found survival processing effect to increase the hit rate, the SDT measure of accuracy (*d*' overall), and 'remember' responses together with process recollection. The effects of delay were similar to those of the first experiment in that it produced reductions in true remembering/recollection and a decrease in item-specific recognition. For true memory, 'know' responses and process familiarity also showed a decline, however, the magnitude of the decline was less than that for 'remember' responses and recollection. In contrast to Experiment 1, survival processing also decreased related false memory, as well and unrelated false memory. This finding also contrasts with Experiment 3 of Otgaar and Smeets (2010), who found survival processing to reduce memory errors using both DRM and category-exemplar lists.

General Discussion

The experiments reported here revealed several similarities and differences as a function of encoding task and retention interval. The main points of similarity and difference are assessed in turn below.

True memory

In relation to the research questions outlined in the introduction, survival processing enhanced the hit rate and the general measure of *d*'. In addition, survival processing enhanced the contribution of familiarity/knowing for studied information and remembered/recollective details (although the latter reached significance only in Experiment 2). In addition, for both experiments, retention interval produced greater reductions on true remembering and recollection compared to knowing and familiarity. The encoding task did not interact with delay even for those that measured selective components of recognition memory. Thus, the main effects of encoding task and retention interval (with no interaction) found in previous work (Abel & Bäuml, 2013; Clark & Bruno, 2016; Raymaekers, et al., 2014) were still evident when more ‘fine-grained’ assessments of mnemonic performance were employed.

Related false memory

Related false memory effects were found in both experiments however, the influence of the encoding task differed according to the composition of the list (DRM vs. category exemplars). In Experiment 1, survival processing increased related false memory. In contrast, the second experiment found survival processing to decrease related false memory. Signal detection measures of item-specific processing and gist also differed across the experiments. When DRM lists were used, gist-based processing increased and item-specific processing decreased after survival processing. When category exemplars were used, the opposite pattern of results was found. This was accompanied by an increase in false recollection and familiarity (Experiment 1), and true recollection and familiarity (Experiment 2). In both studies, gist-based processing was relatively less influenced by time delay compared to item-specific memory or recollection.

Comparable to true memory, main effects of encoding task and retention interval were found for related false memory, with no interaction (apart from the overall beta score for Experiment 2). This was irrespective of whether the assessments were overall responses or component measurements.

Related false memory: Consideration of differences between Experiments 1 and 2

The present research found survival processing enhanced related false memory for DRM lists but reduced it for category exemplar lists and suggests the encoding task interacts with list type. Some caution needs to be exercised with this conclusion though as this proposal is based on a cross experiment comparison. Nevertheless, the similarity of other findings across both studies provides some degree of confidence for the comparison. Consequently, outlined here are some possible explanations for why the effects of survival processing on false memory might differ as a function of list-type.

One reason could be differences in the types of associations between DRM and exemplar lists and how false memories arise from these. For example, Smith, et al., (2002), argue false memories arise because of processes occurring during encoding (vs. retrieval) for DRM (vs. category) lists respectively. This claim is based on two of their findings; firstly, the critical lures for DRM (vs. category) lists are more often given as responses in a free association task. Secondly, DRM lists produce indirect priming effects on word-stem completion. This was taken to indicate the activation of the lure during encoding and its subsequent production during on the word-stem completion task. Such indirect priming effects were not found for categorised lists of exemplars. Accordingly, the results of the current experiments could be explained by enhanced gist-based or associative processing for DRM lists during encoding, increasing activation of the lure. This would not occur to the same extent for category-exemplar lists as the locus of the false memory effect is different. The consequence would be increased false memory for DRM but not exemplar lists.

However, other work has found that variations in encoding instructions or presentation format influence related false memory in a similar manner for both types of list (Dewhurst, et al., 2009). In addition, it would not explain the findings of Otgaar and Smeets (2010), who found survival processing to increase false memory for both DRM *and* category-exemplar lists.

Another possibility is that although there are qualitative differences between the lists (i.e., associative vs. taxonomic), a more important feature is backward associative strength (BAS). This represents the strength of the association between the list items and the critical lure. The higher the value, the greater the probability that the list item will elicit the lure. Typically, the BAS for DRM lists are much higher than that of exemplar lists (Dewhurst et al., 2009; Smith et al, 2002). Consequently, the magnitude of related false memory effects is higher for DRM (vs. exemplar lists) (Gallo, 2006). In Experiment 1, the mean BAS score was .196. In Experiment 2, the mean BAS score for the exemplar lists was .03. Thus, an explanation for the findings obtained here is that survival processing is more likely to enhance related false memory effects high (vs. low) BAS lists. In comparison, the Otgaar and Smeets (2010) experiments used DRM and exemplar lists with BAS scores of .14 and .05 respectively. Hence again, the DRM lists had a higher BAS score and produced greater related false memory effects. However, they still found survival processing increased related false memory for the exemplar lists, although the magnitude was rather small. Accordingly, determining the precise reason for why survival processing decreased related false recognition memory for exemplar lists in Experiment 2 compared to Experiment 1 and Otgaar and Smeets (2010) remains something for future work.

Theoretical implications regarding associative memory and mechanisms of survival processing

While the experiments reported here were not designed to distinguish between theoretical accounts of related false memory effects (e.g., associative activation vs. gist formation), the measures and findings can be evaluated in the context of existing theories. One account of false memories is that they arise from an overreliance on gist as opposed to verbatim representations. Verbatim memory is more precise and contains item-specific features, whilst gist memory encodes the general features or thematic sense of the event (Brainerd & Reyna, 2005; Koutstaal, 2006; Reyna., et al., 2016). Experiment 1 found related false memory was enhanced by survival processing, and moreover, this effect to be dependent on 'know' responses, process familiarity and *d*'. This suggests survival processing enhances related false memory by influencing the extent of gist extraction during encoding or, use of the gist trace during retrieval and is congruent with the proposal of Otgaar and Smeets (2010).

Interestingly, false 'remember' responses were also higher following survival processing. As these responses are considered to measure vivid and item-specific detail, it may seem unusual for such effects to arise. However, gist-representations can sometimes acquire similar characteristics to verbatim memory when gist-based information is repeatedly strengthened in situations where many studied items possess conceptual overlap as is the case with DRM lists (Reyna et al., 2016). These conditions produce 'phantom' recollection (Brainerd et al., 2001) in which non-studied, but related items, can produce vivid recollection[3]. Despite this, phantom recollection differs from true recollection in that the former is more resilient to the effects of time (Reyna, et al., 2016). This was borne out in the current experiments, where true 'remember' and recollection responses were reduced by a delay whereas false 'remember' and recollection were uninfluenced. Thus, one explanation of the findings is that false remembering/recollection is dependent on a gist-based trace whilst true remembering/recollection is based primarily on the verbatim trace (Brainerd & Reyna, 2005; Reyna et al., 2016).

Another account of related false memories is that they are produced by automatic activation within an associative memory network (Roediger, et al., 2001; Roediger & McDermott, 2000) and that survival processing increases this (Howe & Derbish, 2010).

This could explain the increase in knowing/familiarity after survival processing as these have been hypothesised to be the outcome of automatic activation processes (Dewhurst, et al., 2005, Dewhurst, Barry, Swannell, Holmes, & Bathurst, 2007; Roediger, McDermott, & Robinson, 1998; Seamon et al., 1998; 2002). The increase in remembering/recollection that was found could then represent the outcome of such activation processes culminating in conscious awareness of activated words (Dewhurst, et al., 2005; 2007; Roediger et al., 1998). However, one problem with the activation-based account is that related false memories and their phenomenological characteristics are long-lived and difficult to explain by short-lived activation mechanisms (Flegal & Reuter-Lorenz, 2014; Huff, McNabb, & Hutchinson, 2015; Reyna et al., 2016).

Considering the above therefore, it could be argued that the mechanisms by which survival processing influences retention and produces false memories is by increased processing and extraction of gist information (Otgaar & Smeets, 2010; Nairne et al., 2007).

Limitations & future work

It was noted that a possible explanation of the different outcomes of survival processing on related false memory between Experiments 1 and 2 could be due to differences in BAS; typically, DRM lists possess higher BAS compared to exemplar lists. Future work could test this by a combination of both matching and manipulating BAS for different lists. For example, DRM and exemplar lists could be constructed with similar (vs. different) BAS scores. Indeed, if the reason for the effects obtained here is solely dependent on BAS, then this could be assessed with DRM lists alone as these have been normed for this index (e.g., Stadler, Roediger, & McDermott, 1999).

The measures of gist used here are not exhaustive of those that could be employed. For example, gist-based memory has been studied using the conjoint recognition paradigm (e.g., Brainerd, Reyna, & Mojardin, 1999; Brainerd, et al., 2001; Stahl & Klauer, 2008) or meaning-based retrieval tasks (e.g., Koutstaal, 2003, 2006; Koutstaal, & Cavendish, 2006). Both could be used in future work to examine the extent to which survival processing promotes an increase in the amount of gist encoded or retrieved.

Conclusions

For true memory, the present research demonstrated that survival process effects are robust and can still be observed after a significant delay. This supports previous findings and extends them using related word lists (both DRM and exemplar lists). Importantly, ‘finer-grained’ measurements of true memory showed a similar pattern of results in that, the survival advantage was still present but still subject to forgetting. For related false memory, survival processing had opposite effects depending on list-type; increased for DRM lists and decreased for exemplar lists. Where survival processing increased false memory, it was accompanied by an increase in gist-based memory. Where survival processing reduced false memory, it was accompanied by lower measures of gist and higher estimates of item-specific memory. Future work is needed to assess why these two patterns of results were obtained.

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Footnotes

1. See section 1 of the supplementary materials in which these calculations are described.
2. The subject form on which biographical information was collected differed from Experiment 1. In this instance, individuals were required to tick a box to indicate their age cohort.
3. Another interesting possibility, suggested by a reviewer, is that remember/recollection responses to critical lures come about because they receive more item-specific processing, in contrast to the more usual explanation that lures are dependent on relational processing (Burns, Jenkins & Dean, 2007; Burns, Martens, Bertoni, Sweeney, & Lividini, 2006). An example provided is that the critical lure “cold” might initially receive activation form associated list words. The lure could in turn activate related concepts such as “beer” that are not associated with the list. Consequently, the lure is processed more distinctively by this unique association. Later, during testing, the lure is reactivated together with its item-specific association and thus receives a remember response. To contextualise, survival processing could lead to more widespread activations that encompass such unique associations and thus bring about greater false recollection.

TABLE 1

Experiment 1: Mean (SE) proportion scores as a function of encoding conditions and retention interval

	Encoding Condition		
Response Type & Retention Interval	Survival	Pleasant	Moving
	Studied Items – True Memory		
Overall			
5 mins	.93 (.02)	.83 (.02)	.76 (.02)
1 day	.86 (.02)	.73 (.03)	.66 (.03)
Remember			
5 mins	.52 (.06)	.49 (.06)	.49 (.05)
1 day	.48 (.06)	.35 (.05)	.35 (.05)
Know			
5 mins	.38 (.06)	.25 (.05)	.21 (.05)
1 day	.36 (.06)	.32 (.05)	.23 (.05)
Guess			
5 mins	.03 (.01)	.09 (.03)	.05 (.02)
1 day	.02 (.01)	.05 (.02)	.07 (.02)
	Related Items – Associative False Memory		
Overall			
5 mins	.76 (.04)	.55 (.05)	.46 (.04)
1 day	.79 (.03)	.56 (.04)	.55 (.04)
Remember			
5 mins	.33 (.05)	.19 (.04)	.20 (.04)
1 day	.29 (.06)	.20 (.04)	.17 (.03)
Know			
5 mins	.41 (.07)	.30 (.05)	.21 (.04)
1 day	.47 (.07)	.31 (.05)	.31 (.05)
Guess			
5 mins	.02 (.01)	.07 (.03)	.04 (.02)
1 day	.03 (.01)	.05 (.02)	.06 (.02)
	Unstudied Items – Unrelated False Memory		
Overall			
5 mins	.12 (.02)	.12 (.01)	.26 (.05)
1 day	.18 (.03)	.27 (.03)	.29 (.04)
Remember			
5 mins	.07 (.02)	.03 (.01)	.10 (.03)
1 day	.06 (.02)	.12 (.02)	.12 (.03)
Know			
5 mins	.03 (.01)	.06 (.01)	.12 (.03)
1 day	.06 (.01)	.11 (.02)	.11 (.02)
Guess			
5 mins	.03 (.11)	.04 (.01)	.04 (.01)
1 day	.06 (.02)	.05 (.02)	.05 (.02)

Table 2

Experiment 1. Summary of ANOVA results for proportion measures

Response Type & Source of Effect	*df*	*F*	*MSE*	*p*	η_p^2
Proportion Responses to Studied Items – True Memory					
Overall					
Main Effect Encoding Task	2, 144	26.51	0.02	< .001	.27
Main Effect Delay	1, 144	18.33	0.02	<.001	.11
Interaction	2, 144	0.31	0.02	= .73	.004
Remember					
Main Effect Encoding Task	2, 144	1.28	0.08	= .28	.02
Main Effect Delay	1, 144	5.27	0.08	= .02	.03
Interaction	2, 144	0.58	0.08	= .56	.008
Know					
Main Effect Encoding Task	2, 144	3.43	0.08	= .03	.05
Main Effect Delay	1, 144	0.23	0.08	= .63	.002
Interaction	2, 144	0.36	0.08	= .70	.005
Guess					
Main Effect Encoding Task	2, 144	3.29	0.01	= .04	.04
Main Effect Delay	1, 144	0.28	0.01	= .59	.002
Interaction	2, 144	0.98	0.01	= .38	.01
Proportion Responses to Related Items – Related False Memory					
Overall					
Main Effect Encoding Task	2, 144	25.30	0.04	< .001	.26
Main Effect Delay	1, 144	1.56	0.04	= .21	.01
Interaction	2, 144	0.63	0.04	= .54	.009
Remember					
Main Effect Encoding Task	2, 144	4.70	0.05	= .01	.06
Main Effect Delay	1, 144	0.31	0.05	= .57	.003
Interaction	2, 144	0.15	0.05	= .86	.002
Know					
Main Effect Encoding Task	2, 144	5.47	0.08	= .005	.07
Main Effect Delay	1, 144	1.55	0.08	= .21	.01
Interaction	2, 144	0.28	0.08	= .75	.004
Guess					
Main Effect Encoding Task	2, 144	1.22	0.01	= .30	.01
Main Effect Delay	1, 144	0.07	0.01	= .79	<.001
Interaction	2, 144	0.53	0.01	= .59	.007
Proportion Responses to Unrelated Items – Unrelated False Memory					
Overall					
Main Effect Encoding Task	2, 144	6.79	0.03	= .002	.09
Main Effect Delay	1, 144	7.55	0.03	= .007	.05
Interaction	2, 144	2.11	0.03	= .12	.02
Remember					
Main Effect Encoding Task	2, 144	2.93	0.01	= .06	.04
Main Effect Delay	1, 144	3.28	0.01	= .07	.02
Interaction	2, 144	2.83	0.01	= .06	.04
Know					
Main Effect Encoding Task	2, 144	7.64	0.01	= .001	.096
Main Effect Delay	1, 144	2.61	0.01	= .11	.02
Interaction	2, 144	1.09	0.01	= .34	.01
Guess					
Main Effect Encoding Task	2, 144	0.06	0.01	= .94	.001
Main Effect Delay	1, 144	2.55	0.01	= .11	.01
Interaction	2, 144	0.15	0.01	= .86	.002

Table 3

Experiment 1. Summary of comparisons across encoding tasks

Response Type & Comparison	*t*	*p*	*Cohen's d*
Proportion Response Comparisons			
True Memory - Overall			
Survival vs. Pleasant	4.45	<.001	0.92
Pleasant vs. Moving	2.48	.01	0.48
Survival vs. Moving	6.93	<.001	1.40
True Memory - Know			
Survival vs. Pleasant	1.42	.16	0.26
Pleasant vs. Moving	1.23	.22	0.26
Survival vs. Moving	2.59	.01	0.51
True Memory - Guess			
Survival vs. Pleasant	2.41	.02	0.50
Pleasant vs. Moving	0.37	.71	0.09
Survival vs. Moving	2.43	.02	0.50
Related False Memory - Overall			
Survival vs. Pleasant	5.48	<.001	1.09
Pleasant vs. Moving	0.15	.21	0.28
Survival vs. Moving	6.80	<.001	1.39
Related False Memory - Remember			
Survival vs. Pleasant	5.48	<.001	0.51
Pleasant vs. Moving	0.15	.88	<.001
Survival vs. Moving	2.62	.01	0.52
Related False Memory - Know			
Survival vs. Pleasant	2.26	<.001	0.46
Pleasant vs. Moving	0.83	.41	0.17
Survival vs. Moving	3.03	.003	0.62
Unelated False Memory - Overall			
Survival vs. Pleasant	1.58	.12	0.35
Pleasant vs. Moving	2.03	.05	0.37
Survival vs. Moving	3.37	.001	0.65
Related False Memory - Know			
Survival vs. Pleasant	2.75	.007	0.65
Pleasant vs. Moving	1.50	.14	0.28
Survival vs. Moving	3.70	<.001	0.84
Process Comparisons			
False Recollection			
Survival vs. Pleasant	2.47	.01	0.52
Pleasant vs. Moving	1.00	.32	0.17
Survival vs. Moving	3.46	.001	0.72
True Familiarity			
Survival vs. Pleasant	2.49	.01	0.51
Pleasant vs. Moving	1.69	.09	0.33
Survival vs. Moving	3.91	<.001	0.78
False Familiarity			
Survival vs. Pleasant	2.62	.01	0.52
Pleasant vs. Moving	0.99	.32	0.19
Survival vs. Moving	3.51	.001	0.68
Signal Detection Comparisons			
d' - Overall			
Survival vs. Pleasant	4.21	<.001	0.83
Pleasant vs. Moving	2.52	.01	0.51
Survival vs. Moving	6.56	<.001	1.31
d' - Gist			
Survival vs. Pleasant	5.36	<.001	1.09
Pleasant vs. Moving	2.49	.01	0.49
Survival vs. Moving	7.27	<.001	1.44
Beta - Overall			
Survival vs. Pleasant	2.77	.007	0.50
Pleasant vs. Moving	0.99	.33	0.20
Survival vs. Moving	3.69	<.001	0.75
Beta - Gist			
Survival vs. Pleasant	1.82	.07	0.37
Pleasant vs. Moving	1.61	.11	0.31
Survival vs. Moving	3.46	.001	0.75

Note. The *df* was 98 in all comparisons.
*These findings were not altered when familiarity was calculated with both 'know' and 'guess' responses as the numerator. See supplementary materials for an

TABLE 4

Experiment 1: Mean (SE) process and SDT scores as a function of encoding conditions and retention interval

Response Type & Retention Interval	Encoding Condition: Survival	Pleasant	Moving
Process Scores			
True Recollection			
5 mins	0.45 (.06)	0.67 (.06)	0.39 (.07)
1 day	0.43 (.05)	0.23 (.07)	0.23 (.06)
False Recollection			
5 mins	0.26 (.05)	0.16 (.04)	0.10 (.05)
1 day	0.23 (.05)	0.08 (.05)	0.05 (.04)
True Familiarity			
5 mins	0.63 (.09)	0.39 (.07)	0.33 (.06)
1 day	0.56 (.07)	0.45 (.05)	0.30 (.06)
False Familiarity			
5 mins	0.51 (.08)	0.35 (.06)	0.25 (.05)
1 day	0.55 (.07)	0.37 (.05)	0.37 (.05)
Signal Detection Measures - Accuracy			
d' studied / unrelated-unstudied (gist + item-specific)			
5 mins	2.64 (.13)	2.19 (.10)	1.54 (.21)
1 day	2.15 (.12)	1.35 (.17)	1.11 (.15)
d' studied / related-unstudied (item-specific)			
5 mins	0.71 (.11)	0.85 (.16)	0.89 (.14)
1 day	0.34 (.13)	0.50 (.12)	0.33 (.12)
d' related / unrelated-unstudied (gist)			
5 mins	1.93 (.17)	1.33 (.13)	0.65 (.16)
1 day	1.81 (.14)	0.84 (.13)	0.79 (.16)
Signal Detection Measures - Response Bias			
Log β studied / unrelated-unstudied (gist + item-specific)			
5 mins	-0.40 (.13)	0.05 (.12)	0.18 (.09)
1 day	-0.22 (.15)	0.05 (.12)	0.16 (.13)
Log β studied / related-unstudied (item-specific)			
5 mins	-0.67 (.10)	-0.40 (.13)	-0.22 (.08)
1 day	-0.34 (.12)	-0.21 (.07)	-0.07 (.08)
Log β related / unrelated-unstudied (gist)			
5 mins	0.28 (.12)	0.46 (.09)	0.40 (.11)
1 day	0.12 (.11)	0.25 (.11)	0.24 (.11)

Table 5

Experiment 1. Summary of ANOVA results for process and SDT measures

Response Type & Source of Effect	*df*	*F*	*MSE*	*p*	η_p^2
Process Measures					
True Recollection					
Main Effect Encoding Task	2, 144	2.01	0.10	= .13	.03
Main Effect Delay	1, 144	7.13	0.10	= .008	.047
Interaction	2, 144	1.38	0.10	= .25	.02
False Recollection					
Main Effect Encoding Task	2, 144	6.48	0.06	= .002	.08
Main Effect Delay	1, 144	1.77	0.06	= .19	.012
Interaction	2, 144	0.16	0.06	= .85	.002
True Familiarity*					
Main Effect Encoding Task	2, 144	8.57	0.11	< .001	.12
Main Effect Delay	1, 144	0.07	0.11	= .79	< .001
Interaction	2, 144	0.50	0.11	= .61	.007
False Familiarity*					
Main Effect Encoding Task	2, 144	7.29	0.09	= .001	.09
Main Effect Delay	1, 144	1.47	0.09	= .23	.01
Interaction	2, 144	0.35	0.09	= .71	.005
Signal Detection Measures - Accuracy					
d’ Overall					
Main Effect Encoding Task	2, 144	24.84	0.58	≤ .001	.26
Main Effect Delay	1, 144	21.85	0.58	<. 001	.13
Interaction	2, 144	1.05	0.58	= .35	.01
d’ Item-Specific					
Main Effect Encoding Task	2, 144	0.69	0.43	= .54	.009
Main Effect Delay	1, 144	15.95	0.43	< .001	.13
Interaction	2, 144	0.41	0.43	= .66	.006
d’ Gist					
Main Effect Encoding Task	2, 144	30.89	0.56	< .001	.30
Main Effect Delay	1, 144	1.58	0.56	= .21	.01
Interaction	2, 144	2.19	0.56	= .12	.03
Signal Detection Measures - Response Bias					
β Overall					
Main Effect Encoding Task	2, 144	7.72	0.40	= .001	.09
Main Effect Delay	1, 144	0.20	0.40	= .65	.001
Interaction	2, 144	0.40	0.40	= .67	.006
β Item-Specific					
Main Effect Encoding Task	2, 144	6.17	.26	= .003	.08
Main Effect Delay	1, 144	7.06	.26	= .009	.05
Interaction	2, 144	0.45	.26	= .64	.006
β Gist					
Main Effect Encoding Task	2, 144	1.09	0.31	= .34	.01
Main Effect Delay	1, 144	3.69	0.31	= .06	.02
Interaction	2, 144	0.03	0.31	= .97	< .001

*These findings were not altered when familiarity was calculated with both ‘know’ and ‘guess’ responses as the numerator. See supplementary materials for an explanation of this.

TABLE 6

Experiment 2: Mean (SE) proportion scores as a function of encoding conditions and retention interval

Response Type & Retention Interval	Encoding Condition: Survival	Pleasant	Moving
	Studied Items – True Memory		
Overall			
5 mins	.81 (.02)	.64 (.04)	.56 (.04)
1 day	.56 (.04)	.47 (.04)	.38 (.05)
Remember			
5 mins	.53 (.04)	.38 (.04)	.36 (.05)
1 day	.34 (.05)	.22 (.05)	.20 (.05)
Know			
5 mins	.21 (.04)	.18 (.03)	.14 (.03)
1 day	.13 (.02)	.14 (.02)	.10 (.02)
Guess			
5 mins	.07 (.01)	.07 (.02)	.06 (.01)
1 day	.08 (.02)	.11 (.02)	.09 (.02)
	Related Items – Associative False Memory		
Overall			
5 mins	.23 (.03)	.43 (.05)	.48 (.05)
1 day	.35 (.06)	.46 (.05)	.50 (.05)
Remember			
5 mins	.09 (.02)	.18 (.04)	.22 (.03)
1 day	.16 (.04)	.20 (.04)	.20 (.04)
Know			
5 mins	.06 (.02)	.11 (.03)	.13 (.04)
1 day	.09 (.03)	.14 (.04)	.17 (.04)
Guess			
5 mins	.07 (.02)	.15 (.04)	.13 (.03)
1 day	.11 (.03)	.13(.03)	.13 (.04)
	Unstudied Items – Unrelated False Memory		
Overall			
5 mins	.03 (.01)	.09 (.02)	.05 (.01)
1 day	.06 (.01)	.10 (.02)	.13 (.02)
Remember			
5 mins	.02 (.01)	.03 (.01)	.03 (.01)
1 day	.03 (.01)	.04 (.01)	.05 (.01)
Know			
5 mins	.01 (.01)	.03 (.01)	.02 (.01)
1 day	.03 (.01)	.03 (.01)	.04 (.01)
Guess			
5 mins	.02 (.01)	.04 (.01)	.01 (.01)
1 day	.02 (.01)	.04 (.01)	.05 (.01)

Table 7

Experiment 2. Summary of ANOVA results for proportion measures

Response Type & Source of Effect	*df*	*F*	*MSE*	*p*	η_p^2
Proportion Responses to Studied Items – True Memory					
Overall					
Main Effect Encoding Task	2, 144	13.73	0.04	< .001	.16
Main Effect Delay	1, 144	38.72	0.04	<.001	.21
Interaction	2, 144	0.89	0.04	= .41	.01
Remember					
Main Effect Encoding Task	2, 144	6.64	0.05	= .002	.08
Main Effect Delay	1, 144	20.75	0.05	< .001	.13
Interaction	2, 144	0.08	0.05	= .92	.001
Know					
Main Effect Encoding Task	2, 144	1.72	0.02	= .18	.02
Main Effect Delay	1, 144	5.37	0.02	= .02	.036
Interaction	2, 144	0.19	0.02	= .83	.003
Guess					
Main Effect Encoding Task	2, 144	0.46	0.01	= .63	.006
Main Effect Delay	1, 144	2.78	0.01	= .10	.02
Interaction	2, 144	0.42	0.01	= .65	.006
Proportion Responses to Related Items – Related False Memory					
Overall					
Main Effect Encoding Task	2, 144	9.56	0.07	< .001	.12
Main Effect Delay	1, 144	2.08	0.07	= .15	.014
Interaction	2, 144	0.95	0.07	= .39	.013
Remember					
Main Effect Encoding Task	2, 144	3.42	0.03	= .03	.045
Main Effect Delay	1, 144	0.74	0.03	= .39	.005
Interaction	2, 144	0.78	0.03	= .46	.011
Know					
Main Effect Encoding Task	2, 144	2.84	0.03	= .06	.038
Main Effect Delay	1, 144	0.94	0.03	= .33	.006
Interaction	2, 144	0.01	0.03	= .99	< .001
Guess					
Main Effect Encoding Task	2, 144	1.40	0.03	= .25	.02
Main Effect Delay	1, 144	0.13	0.03	= .71	.001
Interaction	2, 144	0.39	0.03	= .67	.005
Proportion Responses to Unrelated Items – Unrelated False Memory					
Overall					
Main Effect Encoding Task	2, 144	5.07	0.01	= .007	.066
Main Effect Delay	1, 144	9.82	0.01	= .002	.064
Interaction	2, 144	2.30	0.01	= .10	.03
Remember					
Main Effect Encoding Task	2, 144	1.25	0.01	= .29	.017
Main Effect Delay	1, 144	5.06	0.01	= .03	.034
Interaction	2, 144	0.46	0.01	= .63	.006
Know					
Main Effect Encoding Task	2, 144	1.39	0.01	= .25	.019
Main Effect Delay	1, 144	1.74	0.01	= .19	.012
Interaction	2, 144	0.65	0.01	= .52	.009
Guess					
Main Effect Encoding Task	2, 144	2.93	0.01	= .06	.039
Main Effect Delay	1, 144	2.98	0.01	= .09	.02
Interaction	2, 144	1.93	0.01	= .15	.026

Table 8
Experiment 2. Summary of comparisons across encoding tasks

Response Type & Comparison	*t*	*p*	*Cohen's d*
Proportion Response Comparisons			
True Memory - Overall			
Survival vs. Pleasant	2.96	.004	0.60
Pleasant vs. Moving	1.78	.08	0.34
Survival vs. Moving	4.52	<.001	0.91
True Memory - Remember			
Survival vs. Pleasant	2.77	.007	0.44
Pleasant vs. Moving	0.46	.64	0.08
Survival vs. Moving	3.11	.002	0.60
Related False Memory - Overall			
Survival vs. Pleasant	3.28	.001	0.65
Pleasant vs. Moving	0.81	.42	0.15
Survival vs. Moving	4.21	<.001	0.83
Related False Memory - Remember			
Survival vs. Pleasant	1.92	.06	0.41
Pleasant vs. Moving	0.59	.55	0.11
Survival vs. Moving	2.65	.01	0.51
Unelated False Memory - Overall			
Survival vs. Pleasant	2.84	.005	0.55
Pleasant vs. Moving	0.25	.80	0.15
Survival vs. Moving	2.80	.006	0.56
Process Comparisons			
True Recollection			
Survival vs. Pleasant	2.88	.005	0.57
Pleasant vs. Moving	0.53	.60	0.12
Survival vs. Moving	3.29	.001	0.68
True Familiarity			
Survival vs. Pleasant	1.97	.05	0.41
Pleasant vs. Moving	1.41	.16	0.25
Survival vs. Moving	3.01	.003	0.61
Signal Detection Comparisons			
d' - Overall			
Survival vs. Pleasant	3.83	<.001	0.76
Pleasant vs. Moving	1.33	.19	0.27
Survival vs. Moving	4.75	<.001	0.95
d' – Item-Specific			
Survival vs. Pleasant	4.66	<.001	0.93
Pleasant vs. Moving	2.03	.04	0.40
Survival vs. Moving	6.75	<.001	1.34
d' - Gist			
Survival vs. Pleasant	1.85	.07	0.36
Pleasant vs. Moving	1.14	.26	0.23
Survival vs. Moving	2.95	.004	0.59
Beta – Item-Specific			
Survival vs. Pleasant	1.01	.31	0.20
Pleasant vs. Moving	1.82	.07	0.36
Survival vs. Moving	2.48	.02	0.49
Beta – Overall*			
Survival (5 min vs. 1 day)	0.56	.58	0.15
Pleasant (5 min vs. 1 day)	0.36	.72	0.10
Moving (5 min vs. 1 day)	3.57	<.001	0.99

Note. The *df* was 98 in all comparisons with the exception of Beta overall which was 48. The latter assessed an interaction rather than main effects.
*The ANOVA revealed an interaction, thus the comparisons here were performed at each level of encoding task to assess the effects of delay.

TABLE 9
Mean (SE) process and SDT scores as a function of encoding conditions and retention interval

Response Type & Retention Interval	Encoding Condition: Survival	Pleasant	Moving
	Process Scores		
True Recollection			
5 mins	0.51 (.04)	0.35 (.04)	0.33 (.05)
1 day	0.30 (.05)	0.18 (.05)	0.14 (.05)
False Recollection			
5 mins	0.06 (.02)	0.15 (.04)	0.19 (.03)
1 day	0.12 (.05)	0.16 (.04)	0.15 (.04)
True Familiarity			
5 mins	0.41 (.06)	0.29 (.04)	0.21 (.04)
1 day	0.26 (.06)	0.18 (.03)	0.15 (.03)
False Familiarity			
5 mins	0.07 (.02)	0.14 (.03)	0.18 (.04)
1 day	0.12 (.04)	0.16 (.04)	0.19 (.05)
	Signal Detection Measures - Accuracy		
d' studied / unrelated-unstudied (gist + item-specific)			
5 mins	2.65 (.11)	1.86 (.15)	1.80 (.16)
1 day	1.72 (.16)	1.28 (.14)	0.88 (.16)
d' studied / related-unstudied (item-specific)			
5 mins	2.08 (.16)	0.73 (.21)	0.25 (.20)
1 day	0.73 (.17)	0.08 (.20)	-0.31 (.21)
d' related / unrelated-unstudied (gist)			
5 mins	0.58 (.21)	1.13 (.20)	1.55 (.15)
1 day	0.99 (.23	1.20 (.18)	1.18 (.18)
	Signal Detection Measures - Response Bias		
Log β studied / unrelated-unstudied (gist + item-specific)			
5 mins	0.92 (.12)	0.89 (.15)	1.10 (.12)
1 day	1.02 (.14)	0.82 (.13)	0.47 (.14)
Log β studied / related-unstudied (item-specific)			
5 mins	0.47 (.31)	0.30 (.20)	-0.01 (.09)
1 day	0.46 (.19)	0.19 (.15)	-0.02 (.09)
Log β related /unrelated-unstudied (gist)			
5 mins	0.45 (.29)	0.58(.22)	1.10 (.11)
1 day	0.56 (.24)	0.63 (.13)	0.49 (.11)

Table 10

Experiment 2. Summary of ANOVA results for process and SDT measures

Response Type & Source of Effect	*df*	*F*	*MSE*	*p*	η_p^2
Process Measures					
True Recollection					
Main Effect Encoding Task	2, 144	7.50	0.06	= .001	.09
Main Effect Delay	1, 144	23.99	0.06	< .001	.14
Interaction	2, 144	0.11	0.06	= .89	.001
False Recollection					
Main Effect Encoding Task	2, 144	2.36	0.03	= .10	.03
Main Effect Delay	1, 144	0.08	0.03	= .78	.001
Interaction	2, 144	0.92	0.03	= .40	.01
True Familiarity*					
Main Effect Encoding Task	2, 144	5.73	0.06	= .004	.07
Main Effect Delay	1, 144	7.50	0.06	= .007	.05
Interaction	2, 144	0.40	0.06	= .67	.006
False Familiarity*					
Main Effect Encoding Task	2, 144	2.66	0.04	= .07	.036
Main Effect Delay	1, 144	0.68	0.04	= .41	.005
Interaction	2, 144	0.14	0.04	= .87	.002
Signal Detection Measures - Accuracy					
d' Overall					
Main Effect Encoding Task	2, 144	16.96	0.56	< .001	.19
Main Effect Delay	1, 144	43.87	0.56	< .001	.23
Interaction	2, 144	0.90	0.56	= .41	.01
d' Item-Specific					
Main Effect Encoding Task	2, 144	28.64	0.94	< .001	.28
Main Effect Delay	1, 144	28.62	0.94	< .001	.17
Interaction	2, 144	2.47	0.94	= .09	.03
d' Gist					
Main Effect Encoding Task	2, 144	4.68	0.95	= .01	.06
Main Effect Delay	1, 144	0.05	0.95	= .82	< .001
Interaction	2, 144	1.97	0.95	= .14	.027
Signal Detection Measures - Response Bias					
β Overall					
Main Effect Encoding Task	2, 144	1.02	0.43	= .36	.014
Main Effect Delay	1, 144	3.52	0.43	= .06	.024
Interaction	2, 144	4.26	0.43	= .02	.056
β Item-Specific					
Main Effect Encoding Task	2, 144	3.20	0.89	= .05	.04
Main Effect Delay	1, 144	0.11	0.89	= .74	.001
Interaction	2, 144	0.05	0.89	= .96	.001
β Gist					
Main Effect Encoding Task	2, 144	1.11	0.99	= .33	.01
Main Effect Delay	1, 144	0.85	0.99	= .36	.006
Interaction	2, 144	2.04	0.99	= .13	.028

*All but one of the findings were not altered when familiarity was calculated with both 'know' and 'guess' responses as the numerator (see supplementary materials for an explanation of this). The only exception was that the marginally significant main effect of encoding task for false familiarity became significant ($F(2, 144) = 3.63$, $MSE = 0.08$ $p = .03$, $\eta_p^2 = .04$). Subsequent comparisons revealed survival producing to produce lower scores compared to pleasant ($t(98) = 2.19$, $p = .03$, Cohen's $d = .43$) or moving ($t(98) = 2.53$, $p = .01$, Cohen's $d = .52$) with no difference between the latter two ($t(98) = 0.38$, $p = .71$, Cohen's $d = .10$)

Scroll down for supplementary material

Supplementary Material: Further Details of Process Calculations and Analyses in the Main Report:

"Effects of Survival Processing and Retention Interval on True and False Recognition in the DRM and Category Repetition Paradigms"

By

Andrew Parker*Neil Dagnall & Ashley Abelson

Contents of Supplementary Materials

The information presented below extends some of the coverage of the main report by providing additional information on the independence-based process estimates of familiarity/recollection and details of analyses pertaining to the rating scores.

1. Supplementary information on the independence calculations for process familiarity.

The main text introduced the distinction between 'remember' and 'know' responses as reflecting two forms of memorial awareness. It was also indicated that these responses can be used to derive dual-process estimates of *process recollection* and *process familiarity* (Yonelinas, 2002). To be more specific, process familiarity (F) can be estimated from a combination of 'remember' and 'know' responses (K and R) by the equation F=K/(1-R). The calculation of process recollection can be computed by the subtraction of the 'remember' responses to non-studied items from 'remember' responses to studied items. In the present experiments, both 'remember' and 'know' responses and process-based estimates were assessed for comprehensiveness. For further information on the derivation of process estimates see Yonelinas, (2002) and Yonelinas & Jacoby, (1995).

The independence process formula for familiarity (F = K/(1-R)) has been employed in many previous experiments in which the remember-know procedure follows item-recognition and comprises of just two options (remember vs. know). In the current research, a 'guess' option was also included alongside 'remember' and 'know'. However, the equation as noted above, does not take into account contribution of 'guess' responses. One solution is to incorporate guess responses into the analyses. This can be achieved by noting that 'know' responses vary on a continuum of confidence strength (e.g., Diana, et al., 2007; Ranganath, 2010; Yonelinas, Aly, Wang, & Koen, 2010). Accordingly, one interpretation is that (i) 'guess' responses represent very low confidence 'know' responses and (ii) a 'know' response would probably have been assigned if a guess option was not made available (Knott & Dewhurst, 2007; Migo, Mayes, & Montaldi, 2012; Parker & Dagnall, 2018; Wixted & Mickes, 2010). In the present experiments, the 2-step recognition procedure was used in which RKG responses are required after the overall recognition decision that the item was studied. Consequently, it is reasoned that guess responses are not simply 'wild' guesses and made without any evidential (mnemonic) basis. Instead, they represent very low confidence recognition responses. Hence, the calculation of process familiarity can be derived by combining 'know' and 'guess' responses prior to dividing by the denominator, 1-R. In the results, both procedures were used to calculate process familiarity. The traditional method (K/1-R) was used initially, with these values placed in the tables. If a difference arose as a function of the calculation method, this was noted; largely however, there were no differences.

2. Supplementary analyses for the results of Experiment 1.

Analysis of rating scale scores and ANCOVAs.

The encoding phase rating scores were placed into a 3(encoding task; survival vs. pleasant vs. moving) between-subject by 2(delay; 5-mins vs. 1-day) between-subject ANOVA. The descriptive statistics can be found in Table S1.

TABLE S1
Mean (SE) encoding phase ratings as a function of encoding conditions and retention interval

	Encoding Condition		
Retention Interval	Survival	Pleasant	Moving
5 mins	2.78 (.09)	2.64 (.05)	2.38 (.11)
1 day	2.72 (.10)	2.74 (.07)	2.54 (.09)

This analysis produced a significant effect of encoding task, $F(2, 144) = 6.28$, $p = .002$, $\eta_p^2 = .08$, no effect of delay $F(1, 144) = 1.03$, $p = .31$, $\eta_p^2 = .08$, and no interaction, $F(2, 144) = 0.83$, $p = .44$, $\eta_p^2 = .01$. For the main effect of encoding task, the difference between the survival and pleasant conditions was not significant, $t(98) = 0.73$, $p = .47$, Cohen's $d = 0.15$, however there was a significant difference between the pleasant and moving conditions, $t(98) = 2.84$, $p = .005$, Cohen's $d = 0.57$, and the survival and moving conditions, $t(98) = 2.98$, $p = .004$, Cohen's $d = 0.60$. In both comparisons, the mean rating for moving was lower. Because of this difference, it is important to assess if the rating scores themselves had any influence on the results as described above. Following previous research, this was evaluated by conducting a series of ANCOVAs for each DV in which the rating score was entered as covariate alongside encoding task and delay as IVs. This did not result in any substantive differences to the findings reported using ANOVAs. Thus, the main effects and absence of interactions were preserved when rating scores were taking into consideration.

3. Supplementary analyses for the results of Experiment 2.

Analysis of rating scale scores and ANCOVAs

The encoding phase rating scores were placed into a 3(encoding task; survival vs. pleasant vs. moving) between-subject by 2(delay; 5-mins vs. 1-day) between-subject ANOVA. The descriptive statistics can be found in Table S2.

TABLE S2
Mean (SE) encoding phase ratings as a function of encoding conditions and retention interval

	Encoding Condition		
Retention Interval	Survival	Pleasant	Moving
5 mins	3.30 (.24)	3.66 (.17)	2.52 (.21)
1 day	3.31 (.27)	3.43 (.21)	2.33 (.20)

This analysis produced a significant effect of encoding task, $F(2, 144) = 6.28$, $p = .002$, $\eta_p^2 = .08$, no effect of delay $F(1, 144) = 1.03$, $p = .31$, $\eta_p^2 = .08$, and no interaction, $F(2, 144) = 0.83$, $p = .44$, $\eta_p^2 = .01$. For the main effect of encoding task, the difference between the survival and pleasant conditions was not significant, $t(98) = 0.73$, $p = .47$, Cohen's $d = 0.21$, however there was a significant difference between the pleasant and moving conditions, $t(98) = 2.84$, $p = .005$, Cohen's $d = 1.12$, and the survival and moving conditions, $t(98) = 2.98$, $p = .004$, Cohen's $d = 0.75$. In both comparisons, the mean rating for moving was lower. Because of this difference, it is important to assess if the rating scores themselves had any influence on the results as described above. As in Experiment 1, this was evaluated by conducting a series of ANCOVAs for each DV in which the rating score was entered as covariate alongside encoding task and delay as IVs. This did not result in any substantive differences to the findings with ANOVAs, with the exception of the response bias score for item-specific memory. In this case, the significant effect of encoding task found with the ANOVA, became only marginally significant ($F(2, 144) = 2.68$, $p = .07$, $\eta_p^2 = .03$. Thus, in general, the main effects and absence of interactions were preserved when rating scores were taking into consideration.

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