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Daniel P. A. Clark[a] & Davide Bruno[a]
[a] Department of Psychology, Liverpool Hope University, Liverpool, UK
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Fit to last: Exploring the longevity of the survival processing effect

Daniel P. A. Clark & Davide Bruno

Department of Psychology

Liverpool Hope University, Liverpool, UK

Corresponding Author:
Daniel Clark
Department of Psychology,
Hope Park,
Liverpool,
L16 9JD.
Telephone: 0151 291 3820.
Email: clarkd@hope.ac.uk.

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Abstract

Mounting evidence indicates that processing items for their survival value produces superior recall compared to a number of other well-known memory-enhancing techniques, and that this mnemonic advantage remains up to 48 hours after encoding (Raymaekers et al., 2013). However, little attention has been dedicated to the survival processing effect in location memory, which may represent a better test of adaptive memory than retrieval of verbal information. The current study aims to fill this gap by exploring the longevity of the survival processing effect with both word list (Experiment 1) and location based (Experiment 2) stimuli. Participants rated target items using a single incidental encoding scenario, either Survival versus Pleasantness (word stimuli) or Survival versus Scavenger Hunt (location stimuli). They were then asked to complete a surprise recall task immediately after the ratings and a second recall task 96 hours later. The results demonstrated that, despite a general reduction in memory performance across time, the survival processing advantage was detected at both test times for both stimuli types. These findings provide further support for the survival processing effect and extend the observed effect duration for both word lists and location to 96 hours.

Introduction

Nairne and colleagues (e.g., Nairne, Thompson & Pandeirada, 2007) adopted a functional approach to the study of memory, suggesting that our memory systems have been tuned by the process of natural selection (Nairne & Pandeirada, 2010; Nairne, 2005) and have subsequently been subject to the pressures of evolution and survival. For example, remembering where a dangerous animal may be, or where food is located, is adaptive, and therefore a healthy memory function will increase our chances of survival. To test this hypothesis, Nairne et al. (2007) asked participants to rate a series of concrete nouns with regards there relevance to their survival in a foreign grassland, relevance in facilitating a move to a foreign country, or there perceived pleasantness. A subsequent surprise free recall task demonstrated significantly higher levels of recall in the survival scenario as compared to the other conditions. Following these findings, there has been a surge of interest in adaptive memory. Research appears to show consistently that survival processing is a more effective encoding task than other types of semantic processing paradigms, including imagery and self-reference (Kang, McDermott & Cohen, 2008; Nairne, Pandeirada & Thompson, 2008; Nairne, Pandeirada, Gregory & Van Arsdall, 2009; Nairne & Pandeirada, 2010; Burns, Burns & Hwang, 2011; Otgaar et al., 2011; Soderstrom & McCabe, 2011; Seamon et al., 2012; Bröder, Krüger & Schütte, 2011; Klein, 2012; Nairne, VanArsdall, Pandeirada & Blunt, 2012; Nouchi & Kawashima, 2012; Howe & Otgaar, 2013; Pandeirada, Pinho & Faria, 2014; but for exceptions, see Butler, Kang & Roedier, 2009; Klein, Robertson & Delton, 2010; Klein, Robertson & Delton, 2011). All in all, it has been suggested that survival processing may be "the 'best of the best' of known encoding procedures" (Nairne, Pandeirada & Thompson, 2008, p. 180).

Despite this increased popularity, the majority of the survival processing literature has focused on the recall of lists of words, with memory for others types of stimuli receiving little attention (for exceptions see Otgaar, Smeets & van Bergen, 2010; Nairne et al., 2012). Nevertheless, it could be argued that recalling the *location* of objects, i.e., food, shelter, would serve a more direct survival-promoting function than the recall of words, thus potentially providing a more direct test of the survival processing hypothesis. However, only one study has so far has reported survival processing effects within a location memory paradigm. Nairne *et al*. (2012) asked participants to rate either food items or animals in separate experiments, with regards to either ease of collection/capture in a survival scenario (i.e., survival scenario), or ease of collection in a scavenger hunt/hunting scenario (i.e., non-survival scenario). In both experiments, results indicated that participants were more accurate, as measured by deviation from the target location, at locating target objects in space in the survival processing scenario than in the scavenger hunt/hunting scenario.

The longevity of the survival processing advantage is another area of the literature which has received little attention. This issue is particularly important because for an encoding procedure to be considered effective, especially to facilitate one's survival, information must be retained and be usable over a relatively lengthy period of time. Raymaekers, Otgaar and Smeets (2014) explored the longevity of the survival processing effect between groups with participants completing a free recall task immediately after encoding, after a 24 hour, or after a 48 hour delay. The free recall findings demonstrated that, despite general forgetting across time, more items were recalled when survival processing was employed at encoding as opposed to a moving scenario at all three test times. Similar findings were reported by Abel and Bäuml (2013) who compared the levels of recall and recognition between a survival processing condition and a pleasantness rating. These findings provide evidence that the survival processing effect endures for at least 48 hours after encoding.

Both Raymaekers et al. (2014) and Abel and Bäuml (2013) explored the longevity of the survival processing effect using a between-participants design. However, if our memory systems are "tuned" to recall survival-relevant information, this information ought to be stored not just for a "single use", but for access on multiple occasions across time. Therefore, it is of interest to test whether the survival processing advantage is maintained within participants across time. A within participants delay is particularly salient for location memory, when recalling the location of static survivally salient resources (such as the location of a water source or food) which could continue to promote survival across a larger time frame.

Following the above considerations, the current study aims to explore the longevity of the survival processing advantage in both word lists (Experiment 1) and with object location as target stimuli (Experiment 2). Both experiments employed a within participants design and explored the survival processing effect across a period of 4 days. A four day delay was chosen based on Ebbinghaus' (1964) suggestion that the majority of forgetting occurs during the first 4-5 days after encoding. In Experiment 1, we attempted to replicate and transpose the findings of Raymaekers et al. (2014) and Abel and Bäuml (2013) to a longitudinal paradigm using word lists as target stimuli. We predicted that a comparable pattern of recall to Raymaekers et al. (2014) and Abel and Bäuml (2013) would be observed. In Experiment 2, we adapted Experiment 1's design to a location memory paradigm and attempted to 1), replicate the survival processing effect in location memory, and 2), further explore the longevity of the survival processing effect in location memory using a within participants design. Again, we predicted that we would observe the survival processing benefit in location memory and that the benefit would be maintained across the delay period.

Experiment 1

Method

Participants

A total of 40 participants (13 male, 27 female) naive to the true aims of the experiment took part in the current study. The sample size was calculated using an a priori power analysis conducted using G*Power 3.1.7 (Faul, Erdfelder, Lang & Buchner, 2007) with an alpha =.05, power =0.80 and an effect size f = 0.40. The participants were predominantly students and staff at Liverpool Hope University with a mean age of 21.98 years (*SD* = 5.17). The participants received £10 for completing both test sessions and were all native English speakers.

Design

The study had a 2 x 2 mixed factorial design with a within-participant factor (Time; two levels: Day 0 and Day 4) and a between-participant factor (Encoding Scenario; two levels: Survival and Pleasantness). The dependent variable was the number of correctly recalled target words on both days.

Materials

Encoding Scenarios

In the current study each participant was assigned to one of two groups and each group was given a different encoding condition. These conditions were Survival and Pleasantness.

The Survival scenario was replicated from Nairne and Pandeirada (2010). The other scenario was a simple pleasantness judgement which has been shown to be a deep encoding process that promotes high levels of memory recall (e.g. Packman and Battig, 1978). These conditions are outlined below.

The Survival Scenario:

In this task, please imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. You have recently received word that a dangerous predator has been seen in the area. You will need to avoid and/or escape the predator to ensure your survival. We are going to show you a list of words, and we would like you to rate how relevant each of these words would be in your attempt to avoid the predator.

The Pleasantness Scenario:

You are going to be presented with a number of words. You are asked to rate each word as to how pleasant you perceive it to be.

Target Stimuli

The study used 32 concrete nouns as target stimuli (see Appendix 1), taken from Nairne and Pandeirada (2010). All participants were tested using the same 32 words although the order of display was randomised. The stimuli were displayed using Eprime 2.0 and the target words were all presented at the top of the screen (font size 32) with a Likert scale displayed below ranging from 1-9.

Procedure

Encoding

At the start of the study phase, each participant was randomly allocated to one of the two encoding conditions and they were asked to read the relevant scenario on the computer screen. In the Survival condition, participants were asked to rate how relevant each item was to their survival (1 = No relevance; 9 = Vital); in the pleasantness condition, participants were asked to rate the pleasantness of each item (1 = Not pleasant at all; 9 = Very pleasant). Participants were asked to indicate their response by pressing the relevant number key on the computer keyboard. There was no time limit for each individual judgement and participants continued until they had rated all of the 32 words.

Retrieval

Once the participants had completed the ratings, they were asked to complete a surprise memory task. Participants were given 5 minutes to list as many of the words they had seen in the encoding task as possible. Participants then returned 96 hours (4 days) after the initial test to complete the same retrieval task. To preserve the accuracy of the time delay, participants were asked to return for testing at approximately the same time of day (±1 hour). To limit the influence of repeat testing on recall (the Testing Effect), participants were not provided with any feedback on their performance in the recall task at time 1 (Day 0), nor were the participants explicitly told that they would repeat the memory task at time 2 (Day 4). Instead, they were asked to return to complete an additional cognitive task on day 4. An informal debrief after the Day 4 test session suggested that the participants were naïve to the true aims of the second test session.

Results and Discussion

Data from one participant was not included in the statistical analysis as they represented an outlier in the recall dataset (> 2 SD from the mean). The excluded participant was from the Survival condition and removing their data increase the mean level of recall by 0.35 items. Thus data were analysed from 39 participants.

Encoding Ratings

The first stage of analysis was to explore whether there was a difference in the encoding ratings and response times between the two encoding conditions (see Table 1 for descriptive statistics). An independent t-test was conducted to test for a difference in ratings between the Survival and the Pleasantness Conditions. The test revealed a significant difference between the ratings in the Survival and Pleasantness conditions, $t(38) = 2.98$, $p=.005$, $d = 0.98$, indicating significantly higher ratings in the Survival condition than those in the Pleasantness condition. It is, however, important to note that whilst significant, the mean difference in ratings between conditions was relative small (0.77). An additional analysis was conducted to explore the time taken to make a response in each condition. As, the response time data violated the assumptions of a parametric test, a Mann-Whitney U test was used to test for a difference between the Survival and Pleasantness response times. The test revealed no significant difference in the response times between two conditions, $U = 153$, $p=.208$. These analyses suggest that whilst participants rated the items moderately higher in the survival condition, that there was no significant difference in the time taken to make these ratings.

(Table 1 about here)

Free Recall

Figure 1 shows the mean number of correctly recalled words in both conditions on both test days.

(Figure 1 about here)

Figure 1 shows that the Survival condition yielded a higher level of recall than the Pleasantness condition at day 0 and, despite a general reduction in the number of items recalled over time, this advantage was still present at day 4. This effect was formally tested using a 2 x 2 ANOVA with a single within participants factor (Time –with 2 levels, Day 0 and Day 4) and a single between participants factor (Encoding Scenario, with 2 levels, Survival and Pleasantness). The ANOVA revealed a main effect of Time, $F(1,37)=54.87$, MSE = 308, $P<.001$, $\eta^2 = 0.60$, and a significant main effect of Encoding Scenario, $F(1,37) = 7.82$, MSE = 108, $p=.008$, $\eta^2 = 0.18$. However, the data showed no significant Time vs. Encoding Scenario interaction, $F(1,37) = 0.02$, MSE = .12, $p = .886$. These results provide further evidence for the longevity of the survival processing advantage.

As the delay period in the current study was manipulated within participants, it is interesting to investigate the pattern of both repeated recall (items recalled on both Day 0 and Day 4) and new recall between conditions on Day 4. The descriptive statistics can be seen in Table 1. An independent t-test was conducted to explore the survival processing effect in the repeated item recall, revealing a significant difference between conditions, $t(37) = -.95$, $p = .03$, $d = 0.71$. This suggests further evidence of the survival processing effect in the repeated items, with more items being recalled in the Survival condition than in the Pleasantness condition. Table 1 also shows the number new items recalled on Day 4. A Shapiro-Wilk's test indicated that these data were not normally distributed, as such a Mann Whitney test was conducted to formally test the survival processing effect in the new items. The test revealed no significant difference between the number of items recalled in each condition, U=-.65, p=.515. This suggest that there was no evidence of the survival processing effect in the new items recalled at Day 4, although it should be noted that comparatively few new items were recalled in either condition (Survival Mean = 1.26 versus Pleasantness Mean = 1.50).

Total number of extra-item intrusions were low (see Table 1), with the majority of participants making no intrusions on either test day. As data were not normally distributed, we conducted two Mann-Whitney U tests to explore differences between the two encoding scenarios on both days and found no significant effect of encoding scenario on the number of intrusions on either Day 0 (U =184, p>.05) or Day 4 (U = 163, p>.05). These results suggest that there was no significant difference in the number of intrusions generated between groups on both test days.

Correlation Analysis

A number of studies (e.g. Nairne et al. 2007; Otgaar and Smeets, 2010) have demonstrated that words with a higher mean item rating are recalled with a greater frequency. To assess this relationship, we conducted a correlation analysis between the mean rating for each item and the frequency with which that item was recalled. We predicted that items that had been rated higher in the survival processing scenario would be recalled a greater proportion of the time. Figure 2 shows this relationship for both conditions at both times.

(Figure 2 about here)

A Pearson's correlation test was used to formally explore these relationships. These data showed no significant correlation between the mean item encoding ratings and proportion recalled in the Survival condition at Day 0 (r=-.06, p=.761) or at Day 4 (r=-.11, p=.550), nor was there a significant relationship in the Pleasantness condition at Day 0 (r=-.11, p = .550) or at Day 4 (r=-.17, p=.334). This analysis suggests that the mean item encoding rating was not related to the frequency with which the item was recalled in either condition at either test time.

The results of Experiment 1 demonstrated analogous patterns of recall to those reported by both Raymaekers *et al*. (2014) and Abel & Bäuml (2013), providing further evidence of the longevity of the survival processing advantage. Interestingly, Experiment 1 produced only low levels of extra-item intrusions (see Table 1). This is in contrast with higher intrusion rates reported elsewhere (e.g. Nairne et al., 2007). Whilst we observe the same pattern in intrusion rates (with pleasantness ratings providing lower levels of intrusions at both Day 0 and Day 4), these differences were not statistically significant. It could also be predicted that as general levels of recall decrease across the time period, the number of intrusions could increase. The current study did not provide any evidence of this and whilst there was a small increase in the number of intrusions observed in both the Survival and Pleasantness conditions (0.72 and 0.032 respectively), this increase was not statistically significant. It is possible that the low levels of intrusions could be a result of the shorter recall period employed in the current study which was significantly shorter than that in Nairne et al. (2007) who gave participants 10 minutes to retrieve the target items as opposed to the 5 minutes used in the current study. However, it should be noted that other studies have also reported no significant differences in intrusion rates using a 10 minute, 5 minute and 4 minute recall period (e.g. Butler et al., 2009; Klein, 2013; Klein, Robertson, Lax & Delton, 2012 respectively), suggesting that the duration of the retrieval interval is unlikely to be the determining factor.

Experiment 2

Methods

Participants

A total of 65 participants (25M: 40F) took part in the current study. The participants were predominantly staff and students (who received course credit for participation) at Liverpool Hope University and had a mean age 24.15 (SD = 9.22). The participants were all naïve to the true aims of the experiment and had not participated in Experiment 1.

Design

Experiment 2 employed a 2 x 2 x 2 mixed factorial design two within participants factors, Time (with two levels: Day 0 and Day 4) and Distance (with two levels: near and far). There was also a single between participants factor (Encoding Scenario; two levels: Survival and Scavenger Hunt). The dependant variable was the deviation (measured in pixels) between the centre of the target object and the recalled location.

Materials

Encoding Scenarios

Experiment 2 employed two encoding Conditions both of which were adapted from Nairne et al. (2012). These conditions were a Survival Scenario and a Scavenger Hunt Scenario which can be seen below.

The Survival Scenario:

In this task we would like you to imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. Over the next few months, you'll need to find a steady supply of food in order to survive. We are going to show you pictures of food items that will be displayed in various locations of the screen and we would like you to rate how easy this item is to collect to help your survival. You should consider your initial position is at your camp site at the centre of the screen, as indicated by a circle containing a tent. You should also take the items distance from the campsite and ease of collection (e.g. items up a tree maybe harder to collect than ones growing on smaller plants) into account when rating how easy the item is to collect. Remember, your goal is to collect as many items as possible to help you survive.

The Scavenger Hunt Scenario:

In this task we would like you to imagine that you have been invited to take part in a scavenger hunt in which you have to collect a number of food items. Your goal is to win this contest and as such you will need to collect as many food items as possible. We are going to show you pictures of food items that will be displayed in various locations of the screen and we would like you to rate how easy it is to collect. You should consider your initial position is at a camp site located at the centre of the screen (indicated by a circle containing a tent). You should take each items distance from the campsite and ease of collection (e.g. items up a tree maybe harder to collect than ones growing on smaller plants) into account when rating how easy the item is to collect. Remember, your goal is to collect as many items as possible to help you win the contest.

Stimuli

In the current study participants were shown 8 scenes. Each scene was 1280 x 1024 pixels in size. At the centre of each scene, there was an image that represented the participants "Campsite" (depicted by an image of a tent in a circle) around the campsite image a target item was displayed. All of the target items were pictures of common fruit and vegetables (Apple, Banana, Carrot, Grapes, Mushrooms, Pear, Pineapple and a Pumpkin). The target item images can be seen in Appendix 2. Each target image was 120 x 120 pixels in size and the target stimuli could be positioned at anywhere on the screen, however, half of the items were presented within a 358 pixels radius of the centre of the screen and the remaining half were presented outside of this radius. This means that stimuli could be broadly classified as being displayed near (<358 pixels) or far (>358 pixels) from the centre of the screen. The stimuli used in the test phase of the experiment were the same scenes as at encoding but only displayed the campsite location (with the target items removed). An example of the encoding and test stimuli can be seen in Figure 3.

(Figure 3 about here)

Procedure

Encoding

Experiment 2 utilised a similar methodology to that employed in Experiment 1. At the beginning of the encoding phase, participants were randomly allocated to one of the two encoding conditions (Scavenger Hunt or Survival) and were asked to read the relevant scenario on the computer screen. Participants were presented with a stimulus on the screen for 5 seconds. After 5 seconds had lapsed the stimulus was replaced by a screen displaying the rating scale. In the survival condition, the participants were asked to rate how easy the item was to collect to help them to survive and in the Scavenger Hunt scenario participants were asked to rate how easy it was to collect each item to help them win the contest (rating scale 1-9, 1 = Very Difficult; 9 = Very Easy). Participants indicated their selection by pressing the relevant number key on the computer keyboard. There was no time limit to complete the rating and the cycle was repeated until the participant had rated all 8 food items.

Retrieval

Once the ratings were completed the participants were asked to complete a surprise recall task. In this task, participants were first shown a screen that displayed one of the target food items for 5 seconds. The screen then changed to the retrieval screen (a blank screen with only the campsite marked at the centre). On this screen the participants were asked to recall the target items location and indicate this location using the computer mouse. This process was repeated for each of the 8 food items and the order that the stimuli were presented was randomised to prevent order effects. Participants then returned 96 hours (4 days) later after the initial test to complete an additional cognitive task (the second retrieval task). Again, to preserve the accuracy of the time delay, participants were asked to return for the second test at approximately the same time of day (± 1 hour). .

Results and Discussion

Encoding ratings

The first stage of the analysis was again to explore whether there was any difference in the ratings between the two encoding conditions and the target distances (near or far). Table 2 shows the descriptive statistics for the two encoding conditions at both distances.

(Table 2 about here)

Table 2 indicates that the ratings in the Scavenger Hunt condition were higher than those in the Survival condition and in both conditions items were rated easier to collect when they were presented nearer to the participant's imagined location. These findings were formally tested using 2 x 2 mixed ANOVA with a single between participants factor (Encoding Scenario with two levels: Survival and Scavenger Hunt) and a single within participants factor (Distance, with two levels: Near and Far). The analysis demonstrated a significant effect of Condition, $F(1,62)=8.28$, $MSE=34$, $p=.005$, $\eta^2 = .12$ and a significant effect of Distance, $F(1,62)=15.68$, $MSE=14$, $p<.001$, $\eta^2 = .20$. The analysis demonstrated no significant Condition x Distance interaction, $F(1,62)=.15$, $MSE=.14$, $p=.701$, $\eta^2 = .01$. These results indicate that items were rated easier to collect in the Scavenger Hunt condition than the Survival condition. In addition, items that were presented closer to the participants imagined starting location were rated easier to collect, suggesting that the distance of the target was considered during the rating task.

Recall

The first stage of the recall analysis was to use the X and Y coordinates to calculate the deviation from recalled location to the centre of the target object. The deviation scores were the Euclidean distance computed as:

$$\sqrt{(X_1 - X_2)^2 + (Y_1 - Y_2)^2}$$

Where X_1 and Y_1 represent the X and Y coordinates of the target object and X_2 and Y_2 represent the coordinates of the recalled location. The deviation scores are a measure of recall accuracy, where larger values are indicative or poorer memory performance. Figure 4 shows the average recall performance for both near and far target locations in both the Survival and Scavenger Hunt Scenarios on both test days.

(Figure 4 about here)

Figure 4 suggests that there is evidence of the survival processing effect in both near and far target locations on both Day 0 and Day 4. This effect was formally tested using a 2 x 2 x2 Mixed ANOVA with a single between participants factor, Encoding Scenario (with 2 levels, Survival and Scavenger Hunt) and two within participants factors, Distance (with 2 levels, Near and Far) and Time (with 2 levels, Day 0 and Day 4). The analysis revealed a main effect of Encoding Scenario, $F(1, 63)=6.36$, $MSE=196197$, $p=.014$, $\eta^2=.09$, a main effect of Distance, $F(1,63)=59.57$, $MSE=869588$, $p<.001$, $\eta^2=.49$ and a main effect of Time, $F(1,63)=19.04$, $MSE = 283431$, $p<.001$, $\eta^2=.23$. These data also revealed a significant Time x Distance interaction, $F(1, 63) = 5.33$, $MSE=31218$, $p=.024$, $\eta^2=.08$. There were no significant Distance x Condition interaction ($p>.05$), no significant Time x Condition interaction ($p>.05$) and no significant Time x Distance x Condition interaction ($p>.05$). These results provide evidence of the longevity of the survival processing effect in location memory. In addition, the results also suggest that items that were located 'near' to the centre of the stimulus array were recalled with greater recall accuracy than items that were further away (far), replicating the findings of Nairne et al. (2012).

Correlation Analysis

As the dependent variable in Experiment 2 is the observed recall accuracy (the deviation from target location), it is possible to directly explore the relationship between the encoding rating and retrieval accuracy at the level of the individual target (as opposed to exploring pooled data in Experiment 1). We predicted that the target ratings would be directly related to recall accuracy, where items rated easier to collect to facilitate survival rating are recalled with greater accuracy. Figure 5 shows the correlations between the individual encoding ratings for each target object in both conditions and at both times (Day 0 and Day 4).

"(Figure 5 about here)"

As the Shapiro-Wilk test indicated that these data were not normally distributed Spearman's correlation test was used to formally explore these relationships. These data showed no significant correlation between the encoding ratings and recall accuracy in the Survival condition at Day 0 ($r=-.062$, $p=.299$) or at Day 4 ($r=-.077$, $p.201$), nor was there a significant difference between the encoding ratings and recall accuracy in the Scavenger Hunt condition at Day 0 ($r=-.032$, $p = .617$). There was, however, a significant correlation between the encoding ratings and recall accuracy in the Scavenger Hunt condition on Day 4 ($r=-.267$, $p<.001$, $r^2 = 0.07$), indicating that if the items were rated higher in the encoding task they were recalled with greater accuracy on Day 4. However, this is a small effect which accounts for approximately 7% of the overall variation.

The results of Experiment 2 provide further support for the survival processing effect in location memory and replicate the findings of Nairne et al. (2012). These data also clearly demonstrate the longevity of the survival processing effect in location memory. In addition, the pattern of recall in Experiment 2 mirrors that observed in Experiment 1, showing the survival processing effect is present on Day 0 and despite general forgetting across time the same pattern of recall is demonstrated on Day 4.

One interesting finding was the significant difference observed in the initial rating task (where the target items were rated easier for collection in the Scavenger Hunt condition as opposed to the Survival condition). This finding is surprising as whilst both conditions provide a different context, the encoding rating is essentially the same; rate the items regarding their ease of collection. Given that the target objects were displayed in the same places for each condition, we would predict no difference in these ratings. Indeed, Nairne et al. (2012) who employed the same task showed no significant difference between the two conditions ratings. At this point it is unclear why there is a difference in the ratings between the two conditions; however, this finding adds further support for the survival processing effect as the higher mean ratings in the Scavenger Hunt condition should promote a Scavenger Hunt mnemonic advantage, not the Survival Processing benefit observed.

General Discussion

The survival processing paradigm has been hailed as one of the most effective, if not the most effective, forms of encoding. However, few studies have investigated its longevity with language based stimuli (Raymaekers et al., 2014; Abel & Bäuml, 2013) and no studies have explored the effect duration in location memory. The results of our study show that the survival processing advantage is still present 4 days after encoding in both language based and location memory. These findings are the first to demonstrate the longevity of the effect in location memory.

The current studies are the first to explore the longevity of the survival processing effect within participants. As argued earlier, it is unlikely that survival relevant information would only be retained for recall on a single occasion and as such exploring the survival processing effect using a within participants design is an interesting extension to previous works. A potential limitation of this approach, however, is that repeat testing can inflate recall rates in subsequent sessions (test-enhanced learning; e.g., Roediger & Karpicke

(2006)). Indeed, recall performance on Day 4 in the Survival condition (Experiment 1) was higher than that reported by Raymaekers et al. (2014) in their 48 hour condition (recall proportion of 0.43 versus approximately 0.28 respectively), despite comparable levels of recall after the immediate test (0.55 versus approximately 0.58 respectively). To further explore the influence of repeated testing, we split the Day 4 analysis to explore the survival processing effect in both repeated items and new items. This analysis revealed evidence of the survival processing effect in the repeated items but not in the new items, suggesting that the survival processing effect was carried by higher recall of the repeated items. Therefore, it is possible that Day 4 recall performance was, at least in part, inflated by test-enhanced learning. However, few new items were recalled in either condition on Day 4 (a mean of 1.26 and 1.50 in the Survival and Pleasantness conditions respectively), which limits the ability to detect a survival processing effect with those words. Finally, of note, the principal findings of our study still suggest that a similar pattern of recall was found across time in our within-participants design and in the between participant designs (i.e., Raymaekers et al., 2014), thus generally providing support for the longevity of survival processing advantage.

Nairne et al. (2007) reported that the average levels of recall increased monotonically with the average survival ratings. Similar findings were reported in other studies (e.g. Butler et al., 2009; Kroneisen & Erdfelder, 2011), who also demonstrated higher levels of recall for items that were awarded higher ratings. However, our data did not replicate this finding. In Experiment 1, we pooled data across participants and demonstrated no significant relationship between the mean encoding rating for each target item and the frequency with which that target was recalled in either condition at either time interval. In Experiment 2, we explored the relationship between the initial encoding ratings and the target's recall accuracy at the level of the individual target, again failing to find a correlation in both conditions on

Day 0 and the Survival condition on Day 4. The only significant correlation observed was in the Scavenger Hunt condition at Day 4. The correlation results from Experiment 2 are particularly surprising, especially given that the near versus far analysis demonstrated that when target items were positioned near to the central starting point, they were recalled with greater accuracy and were rated as easier to collect. Thus the current findings suggest that whilst the proximity of the target item influences the accuracy with which it is recalled, the ratings do not. This discrepancy is possibly the result of the ratings including the consideration of two separate factors, 1) a judgement of the distance to the target and 2) a judgment of the ease of collection (suck as picking the item from a tree or collecting it from the ground). Thus, in this instance, it is possible that the judgment of distance seems to predict recall accuracy but considering the ease of collection does not. This is purely speculative and it is clear that further research would be required to fully tease apart this discrepancy.

The current data also contribute to the debate surrounding elaboration as the proximate mechanism of the survival processing hypothesis. Kroneisen and Erdfelder (2011) argued that the survival processing scenario produced high levels of elaboration which subsequently generated the mnemonic benefit, hence when a shorter survival scenario was utilised, the advantage disappeared. Experiment 1 demonstrated evidence of the survival processing advantage using a shortened survival scenario. This suggests that simply shortening the scenario length did not remove the survival processing effect at either test time. These findings are in keeping with recent reports which have argued that the shorter set of survival processing encoding instructions is equally effective in generating a survival processing effect (Nairne & Pandeirada, 2010; Otgaar, Howe, Smeets & Garner, 2014). However, it remains an empirical question whether the original set of instructions would have produced different results in our study. Of note, it could be predicted that if the shorter scenario limits levels of elaboration at encoding it could shorten the longevity of the effect.

A final consideration of the current study refers to the terminology of location memory. In the current study we refer to Experiment 2 as assessing location memory in replication of the terminology employed by Nairne et al. (2012). Whilst the methodology employed provides a measure of location memory, it is limited to objects being presented at different spatial positions within the 2 dimensional space represented by the computer screen. Although this provides a measure of location memory, which we believe to be most relevant for assessing the survival processing effect, it needs to be acknowledged that it represents a limited approach to assessing location memory. As such, whilst our findings suggest evidence of the survival processing effect in location memory, future research should consider expanding to larger spatial frameworks.

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Appendix 1

Experiment 1 stimuli

(Table 3 about here)

Appendix 2

(Figure 6 about here)

Figure Captions

Figure 1. The average number of items recalled in each condition at both testing times. Error bars represent ± 95% confidence intervals.

Figure 2. The relationship between the mean item encoding ratings and the frequency with which the item was recalled in both conditions at both test times. The coloured bands represent 95% confidence intervals.

Figure 3. An example of the encoding and retrieval stimuli employed in Experiment 2.

Figure 4. The average deviation from target location for both near and far target locations in both encoding Scenarios at both retrieval times. The error bars represent ± 95% confidence intervals.

Figure 5. The relationships between the encoding ratings and recall accuracy for both groups at both times. The colour bands represent 95% confidence intervals.

Figure 6. The target food items used in Experiment 2.

Table 1. The average rating, response time, new and repeated recall and extra-items intrusions for both condition

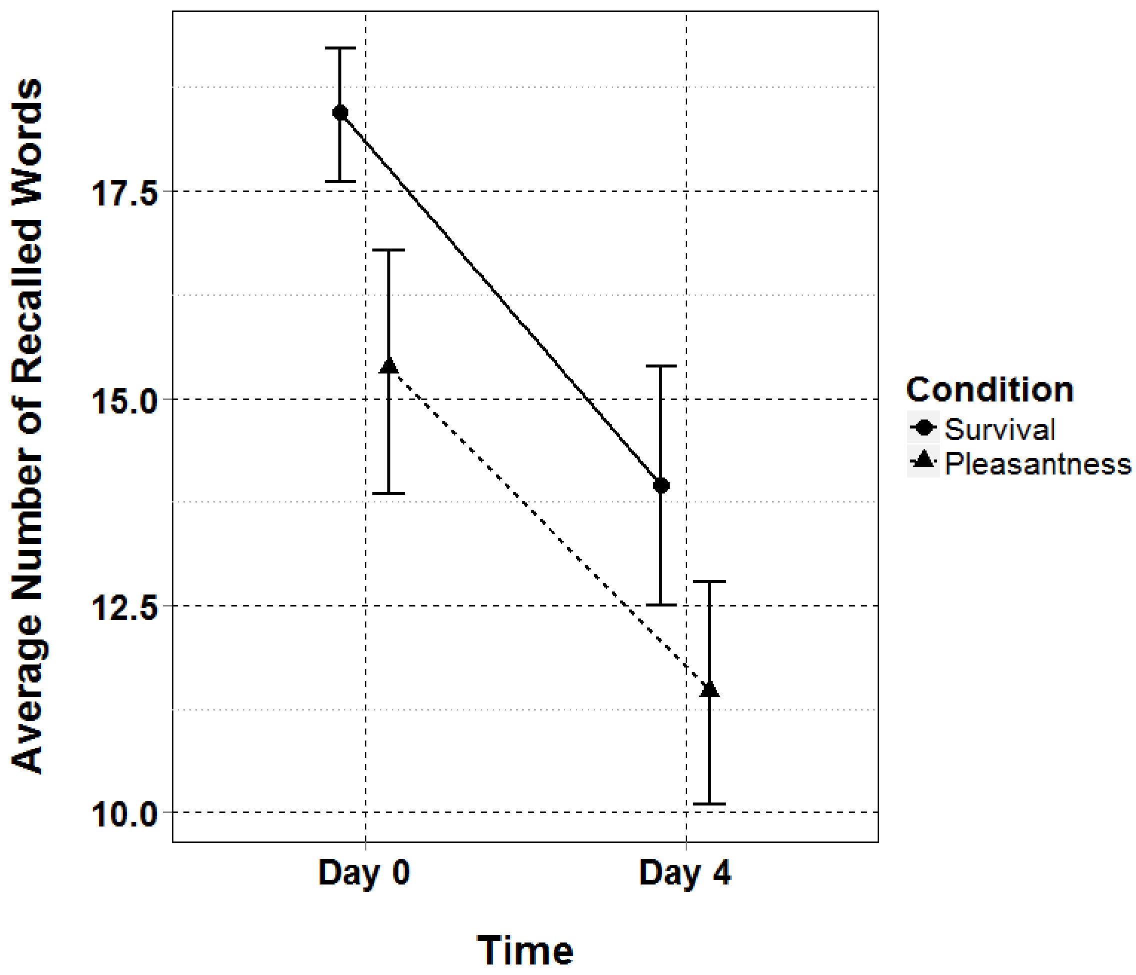
	Encoding Ratings		Encoding Response Time (seconds)		Repeated Items Recall Day 4		New Items Re Day 4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Survival Processing	5.19	1.04	4.35	1.7	12.68	3.25	1.26	1.7
Pleasantness	4.45	0.47	3.91	1.61	10.3	3.42	1.50	1.5

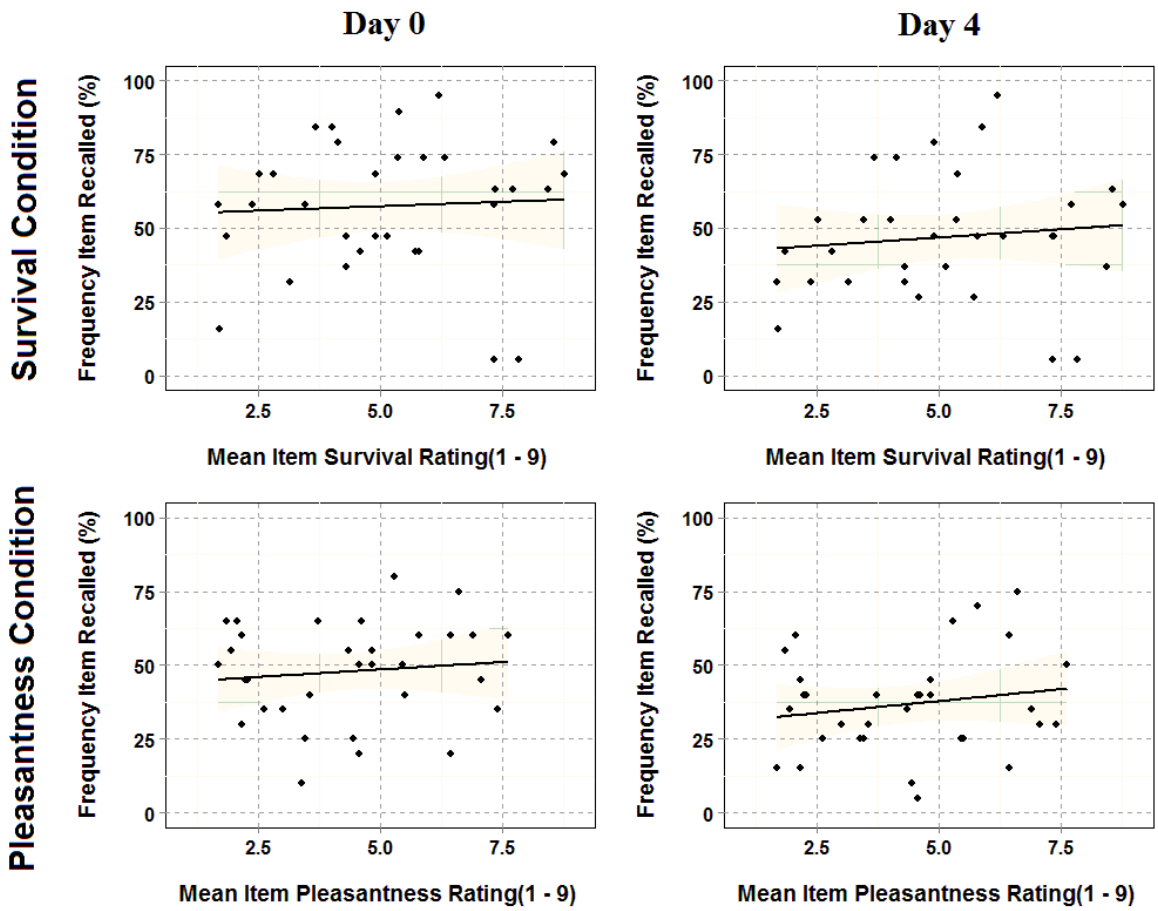
Table 2. The mean encoding ratings for target objects positioned both near and far in both conditions.

	Survival	Scavenger Hunt
Near	5.57 (1.53)	6.68 (1.66)
Far	4.95 (1.61)	5.94 (1.63)
Average	5.27 (1.38)	6.32 (1.50)

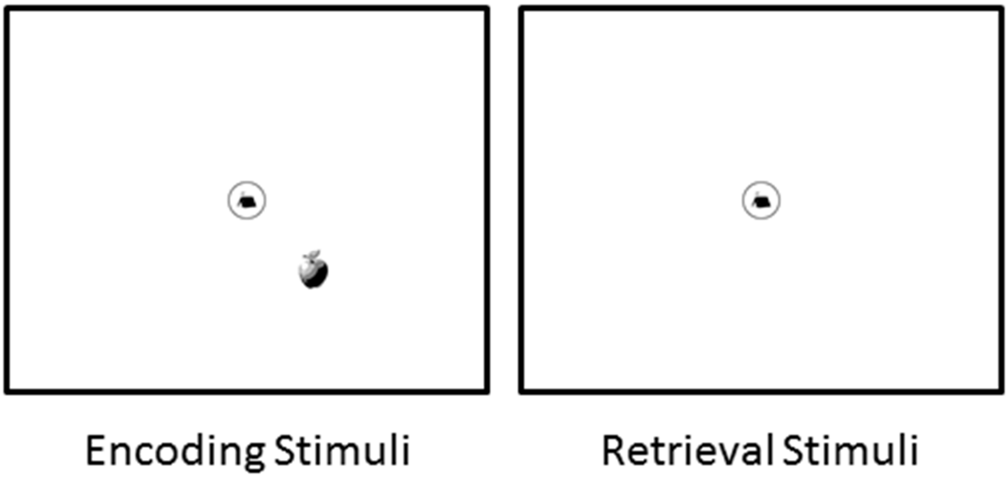
Table 3. The target words used in Experiment 1.

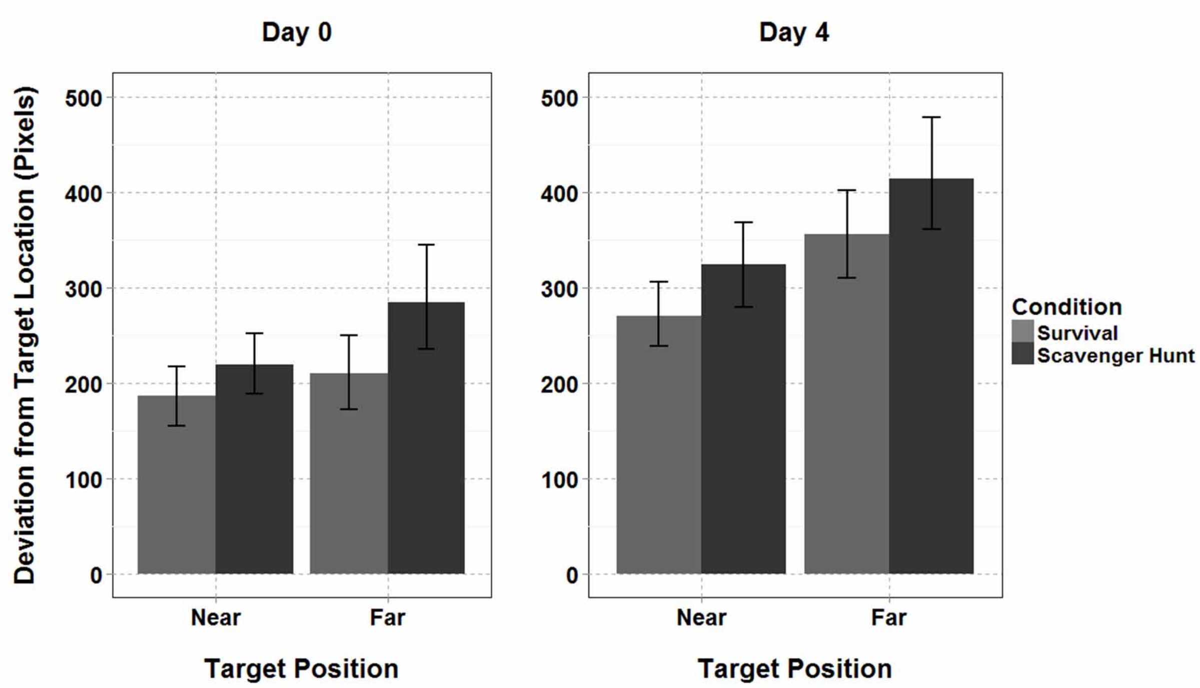
ANT	EMERALD	OAK	RIVER
ARM	FATIGUE	ODOR	ROAD
BLOOD	IDEA	ORANGE	ROSE
BOY	LIGHT	OXYGEN	SHADOW
BUILDING	MAP	PLANK	SKULL
CARROT	MOSQUITO	POLE	STRING
DUST	MOSS	RAIN	SUNBURN
EAGLE	MOUNTAIN	REFLEX	WEAPON

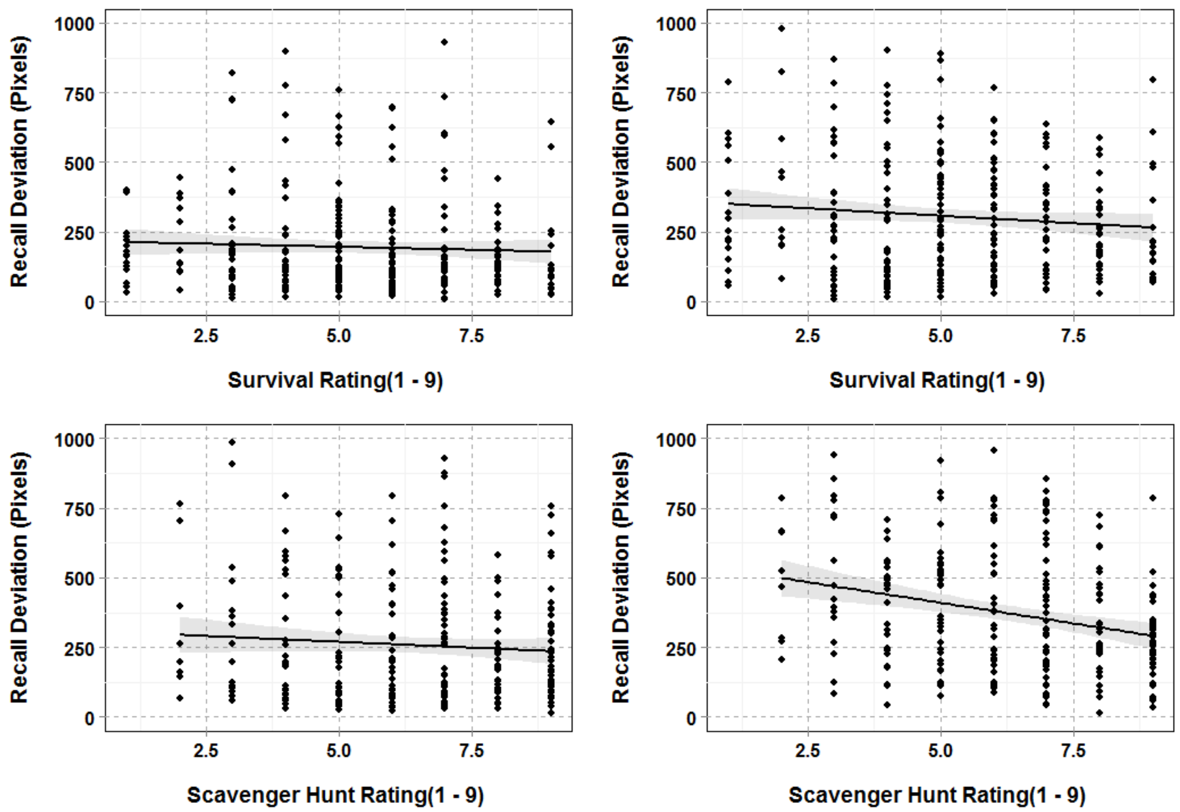

Average Number of Recalled Words
17.5
15.0
12.5
10.0
Day 0
Day 4
Time
Condition
Survival
Pleasantness

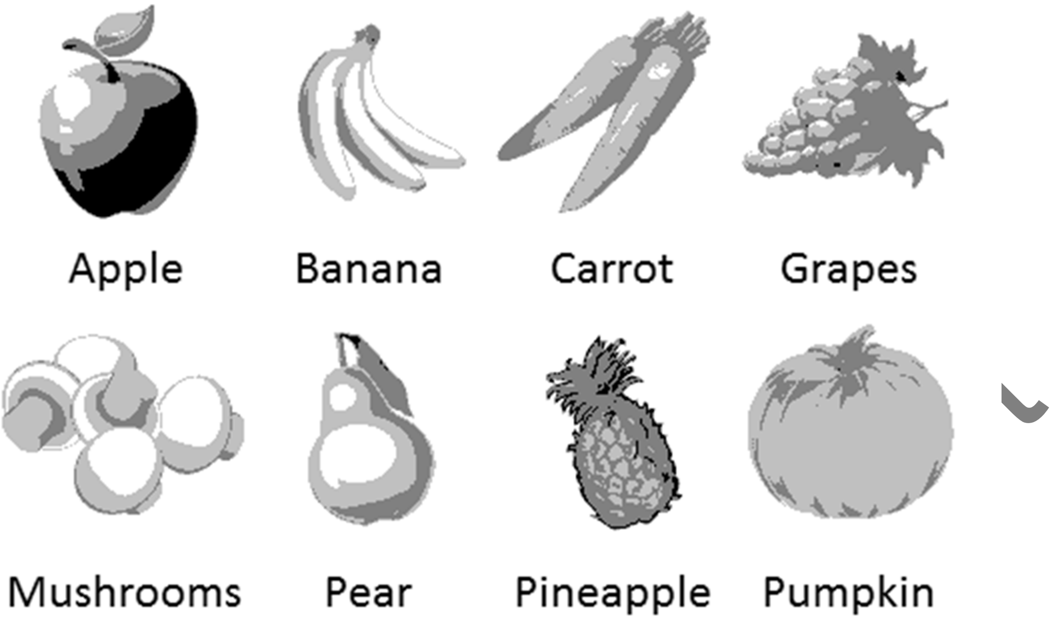


Day 0
Day 4
Survival Condition
Pleasantness Condition
Frequency Item Recalled (%)
100
75
50
25
0
2.5
5.0
7.5
Mean Item Survival Rating(1 - 9)
Mean Item Pleasantness Rating(1 - 9)


Encoding Stimuli
Retrieval Stimuli


Day 0
Day 4
Deviation from Target Location (Pixels)
500
400
300
200
100
0
Near
Far
Target Position
Condition
Survival
Scavenger Hunt


Recall Deviation (Pixels)
Survival Rating(1 - 9)
Scavenger Hunt Rating(1 - 9)
0
250
500
750
1000
2.5
5.0
7.5


Apple
Banana
Carrot
Grapes
Mushrooms
Pear
Pineapple
Pumpkin