

Divergent Thinking in Survival Processing: Did Our Ancestors Benefit From Creative Thinking?

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Abstract

The survival processing advantage is a robust mnemonic device in which information processed for its relevance to one's survival is subsequently better remembered. Research indicates that elaborative processing may be a key component underlying this memory effect, and that this mechanism resembles divergent thinking, whereby words with a greater number of creative uses in a given scenario are better remembered. If this particular function underpins adaptive memory, then individual differences in creativity may play a part in the degree to which people benefit from this advantage. We expected that highly creative individuals who engage more in divergent thinking would not necessarily benefit to a greater degree than less creative individuals, due to potential redundant processing. In this between-subjects experiment, participants rated words according to their relevance to the typical grasslands survival scenario or according to their pleasantness (a control common to the survival paradigm and known to enhance memory). While we did find a main effect of both condition (survival v. pleasantness) and creativity (high v. low), there was no interaction. This set of findings suggests that creative individuals may not benefit to a greater degree in survival processing, despite their ability to think divergently.

Keywords

survival processing, adaptive memory, divergent thinking, creativity, elaboration

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When thinking about adaptive function, it is generally agreed that persistent evolutionary features are those that are most useful for survival. This is not a new concept, certainly. However, researchers studying memory in the past have extended their focus to include this evolutionary perspective. If it was advantageous for our ancestors to remember information relevant to their survival, it follows that this prioritization in memory may be preserved. In essence, our memory is tuned to remember that which may ensure our survival better than other kinds of information. The survival processing advantage, originally proposed by Nairne et al. (2007) is the finding that when stimuli are processed for their relevance to one's survival, they are subsequently better remembered in various tests of memory, even as compared to other encoding strategies known to boost retention (e.g., self-reference; Klein et al., 1989). This effect has been shown to be robust and persists across varying types of stimuli (Otgaar et al., 2010), encoding instructions (Nairne et al., 2009; Wilson, 2016), age (Aslan & Bäuml, 2012; Otgaar & Smeets, 2010; Yang et al., 2014), and task

demands (Nairne et al., 2019). Furthermore, the standard survival processing effect has been independently replicated many times over (for a review, see Kazanas & Altarriba, 2015).

What exactly are the major contributors to this effect? While a number of proximate mechanisms have been considered in the context of survival processing (e.g., relational, self-referential processing) it seems likely that this memory effect is the result of particularly varied and rich encoding, which may have been useful in ancestral settings and subsequently encourages increased retention. Kroneisen and Erdfelder (2011) proposed the richness of encoding account, which

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stipulates that the effect occurs simply due to encoding stimuli more deeply in the survival condition, which asks participants to imagine themselves stranded in the grasslands of a foreign land. In Experiment 3 of their study, Kroneisen and Erdfelder (2011) posited that the traditional survival scenario ensures higher recall due to the presence of multiple dimensions through which participants can evaluate the relevance of words (e.g., lack of water, presence of predator threat, securing shelter). When participants were constrained to rate stimuli based on only one dimension (lack of water), the effect vanished (Kroneisen & Erdfelder, 2011). Thus, improved recall may result from richer and deeper encoding afforded by the survival scenario.

While much of the research in this area has focused on proximate mechanisms, as well as the scenario itself, fewer studies have been dedicated to the role of individual differences. In the past, Nouchi and Kawashima (2012) found that the survival advantage persists in participants who experience depressed mood, despite the fact that depression has adverse effects on memory performance (e.g., Austin et al., 2001), even when utilizing strategies that are known to enhance memory such as self-reference or semantic judgment. This finding supports the notion that survival processing is a robust phenomenon, which aligns with the idea that remembering fitness relevant information should be prioritized regardless of mood. Their findings also indicate that depressed participants processing for survival recalled more when compared with non-depressed participants processing autobiographically, which supports the standard survival processing effect in a population with reduced memory performance. However, non-depressed individuals benefitted from survival processing to a greater degree. These findings further support the idea that elaborative processing is a likely mechanism which underpins the effect, as depressed individuals do not recall to the same degree as their non-depressed counterparts (Nouchi & Kawashima, 2012).

Nouchi (2011) sought to investigate the role of imagery ability within the survival paradigm. The judgment tasks typically used by researchers instruct participants to imagine themselves in a given scenario (i.e., stranded in the grasslands, moving to a foreign land), so it follows that an individual's ability to imagine or picture themselves within a context, as well as items used there might play a role in strength of the overall advantage. Nouchi (2011) ultimately found support for the hypothesis that individuals with greater imaging ability recall more regardless of processing task, and critically, that high imagers recall more than low imagers specifically when processing for survival. Thus, evidence does seem to support that individual differences can influence how beneficial survival processing is for participants.

Divergent Thinking as an Advantage

As part of the encoding instructions within the survival memory paradigm, participants for each condition are typically asked to rate each word based on its relevance to a given scenario. Some words are more naturally relevant than others

in survival situations (e.g., “sword” vs. “soccer”). The rating process is likely functional in nature; relevance is based on the number of ways each word may be used in the situation, and furthermore how suited those uses are. A word that has many uses may be rated as highly relevant, whereas a word with less utility, or fewer uses may be deemed irrelevant. Relevance also likely depends on the level of fit a given item has with the scenario (e.g., food is highly relevant, but with a single use). However, the number of uses alone may not entirely dictate relevance or recall. A few novel and distinct uses per item may aid recall more so than many common uses. The implicit generation of plausible uses as part of the act of rating is similar to divergent thinking, a facet of creativity which focuses on people's ability to reach valid, alternate solutions to problems. One of the most common tests to assess divergent thinking is the Alternate Uses Test (AUT; Guilford, 1967), which instructs participants to generate as many distinct uses for everyday objects (e.g., brick) as possible. Each of these uses must be different from each other, as well as from the most common use. Furthermore, they must be feasible—a single brick could be used to hold open a door but could not reasonably be used to build an entire house.

To test the idea that functional thinking underlies the survival processing effect, Wilson (2016) conducted two experiments in which participants responded to variations of the AUT. The grasslands condition instructed participants to generate as many alternate uses to the given object as possible as they related to surviving in the grasslands. Participants also responded to a standard AUT, as well as AUTs with an Ebola context, a new home context, and a bank heist context. Overall, results from Experiment 1 showed that the grasslands AUT resulted in a significantly greater number of valid uses generated when compared with other schematic conditions. Though Wilson reported that this did not result in a greater proportion of uses recalled, it is unclear whether recall for the AUT item prompts themselves might be higher (2016). Wilson (2016) concluded that this is most likely due to the relatively unconstrained nature of the standard grasslands scenario, at least compared with other schematic conditions. If the problem offers fewer constraints (in this case surviving after being stranded in the grasslands), it may provide participants with more opportunity to generate plausible uses. Likewise, the relatively low number of valid uses in control schematic conditions (e.g., bank heist) may have occurred due to a greater constraint, as objects might be used in fewer ways to suit that scenario. This notion aligns with their finding that the standard AUT (least constrained) yielded the highest absolute number of uses.

The concept of generation was further explored by Nairne et al. (2019) by altering the standard rating task used in nearly all prior research within the survival paradigm. In a series of four experiments, the researchers provided evidence that survival processing effects occur in a new task in which participants generated survival situations to suit a given word (e.g., door). The survival processing effect persisted when compared to the standard pleasantness control, an autobiographical

control, and an unusual uses control. This latter result, in particular is counter to the notion that functional thinking is solely responsible for survival processing effects, as generating unusual uses alone did not secure greater recall. The process of functional generation in both Wilson (2016) and Nairne et al. (2019) closely mimic divergent thinking, though the task demands differ. It remains unclear whether divergent thinking as an individual difference may have an impact on recall in survival processing.

If deeper or more elaborative encoding is afforded by survival processing, and the act of rating items is similar to that of generating uses as in divergent thinking, it seems plausible that each individual's creative ability may play a part in recall. Theoretically, this trait would be extremely useful in unfamiliar situations where a problem may have many solutions, such as being stranded in the grasslands where one's survival depends on using materials in unusual ways. However, it is conceivable that a highly creative individual who engages in divergent thinking may not experience any additive benefit in recall, due to the redundant nature of processing (Hunt & Einstein, 1981). To this end, our specific predictions are that for individuals with high creative ability, the survival processing effect should be diminished, but persist for those with low creative ability.

Method

Participants

One hundred and twenty undergraduate students (79 female, 40 male, one nonbinary) participated in the experiment. Each participant was at least 18 years old ($M = 19.02$, $SD = 1.08$) and reported fluency in English. All participants provided written informed consent and received either course credit or extra credit for their participation. Five participants were excluded prior to analysis due to not following directions ($N = 3$) and technical difficulties ($N = 2$). The study was approved by the University at Albany Institutional Review Board.

Design

The experiment consisted of a between-subjects design in which participants were randomly assigned to one of two conditions for the word rating task: survival or pleasantness. Task instructions and the scenario were manipulated depending on the condition. Then, all participants completed the same divergent thinking task (the traditional AUT). Unlike the experiment by Wilson (2016), participants in the current experiment did not generate uses in response to altered encoding instructions (survival or otherwise), but as a measure of individual differences in divergent thinking. Task order was fixed for all participants. In total, the experiment took approximately 45 minutes to complete.

Materials

Word rating tasks. Participants in both the survival and pleasantness conditions were presented with five practice words and 32

target words in the rating task. Practice words were randomly chosen from Experiment 3 of Nairne et al.'s (2007) study, while target words were the same as those used in Experiments 1 and 2. The pleasantness and survival rating task were presented to individual participants via E-Prime 3.0. All words were displayed on screen for 5s with a five-option rating scale. For survival rating, the scale ranged from 1 = "totally irrelevant" to 5 = "extremely relevant." For pleasantness 1 = "not pleasant at all" to 5 = "extremely pleasant." The instructions for the survival rating task were as follows:

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 steady supplies of food and water and protect yourself from predators. 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 for you in this survival situation. Some of the words may be relevant and others may not—it's up to you to decide.

The instructions for the pleasantness rating task were as follows:

In this task, we are going to show you a list of words, and we would like you to rate the pleasantness of each word. Some of the words may be pleasant and others may not—it's up to you to decide.

Creativity Task

Participants in both the survival and pleasantness conditions took the Alternate Uses Test (AUT, Form B; Guilford, 1967) which consisted of two parts, each with three objects. In this task, participants were asked to generate as many alternate uses to common objects as possible within the allotted time. All AUT responses were coded for fluency and creativity using the snapshot scoring method (Silvia et al., 2009). Three undergraduate research assistants coded the entire dataset for fluency (number of acceptable or valid responses) while three others coded the same responses for creativity. Instructions for fluency matched those provided within the AUT, while creativity rating instructions came from Silvia et al. (2008). Both sets of raters were blind to each participant's condition and were instructed not to consult with others when making judgments. Inter-rater agreement for each object (Hass & Beaty, 2018) was computed with intraclass correlation coefficients (ICCs), which were used to confirm the agreement and consistency of judges rating for fluency and creativity. For fluency and creativity, ICCs for each AUT object are displayed in Table 1 and range from $ICC(3,3) = .681$, $CI [.503, .789]$ to $ICC(3,3) = .932$, $CI [.897, .954]$. In all cases, rater agreement was at least moderate (Koo & Li, 2016), so all items were included for subsequent analyses. Average scores were computed for both creativity and fluency and combined to create an overall score for each participant as a measure of their individual creativity.

Procedure

All participants confirmed their age upon entering the lab. After reviewing the nature of the experiment and providing written informed consent, participants were instructed to attend to the computer. Each participant read instructions and the scenario corresponding to their condition (survival or pleasantness) on-screen prior to beginning the task. As part of the instructions, they were informed that there were five practice trials followed by target trials. Participants then used the number pad in order to rate words according to their condition. Participants were not aware that they would later be tested on rated words.

After rating all words, participants were asked to solve mazes of medium difficulty for 2 minutes, which served as a nonverbal distractor task. Next, participants were provided with a lined sheet and instructed to freely recall as many of the previously rated words as they could within 10 minutes, in any order. All participants were provided the full 10 minutes, but were encouraged to keep remembering until at least 5 minutes had passed. Next, participants were instructed to solve mazes for 3 minutes, again serving as a nonverbal distractor task before proceeding forward with the experiment.

After 3 minutes expired, participants were instructed that the next portion of the experiment was a test assessing creative ability; all participants were encouraged to be as creative as possible, as previous research indicated these instructions increased variance and validity of creativity scores (Harrington, 1975). Participants then read the instructions provided within the AUT and relayed them to the experimenter in their own words. Any gaps in the participants' comprehension of instructions were addressed prior to beginning the task. Participants were instructed to come up with alternate uses to each

object in any order they chose (i.e., they could switch between objects in each section), but were not permitted to move on to the next section until instructed by the experimenter. Participants had 4 minutes to generate uses per section. After the first section, participants were offered a brief break (not exceeding 2 minutes) before completing the second section. At the conclusion of the creativity task, participants were asked to fill out a brief demographic questionnaire. After demographic information was collected, all participants were verbally debriefed and given the opportunity to ask questions.

Results

For all analyses, alpha was set at $p < .05$. In order to determine the role of individual creativity in survival processing, participants were designated as either low creativity ($N = 38$, $M = 21.658$) or high creativity ($N = 38$, $M = 38.149$) based on a tertile split. The minimum score possible was 0, and the maximum score possible was 66. The data from participants in the middle third were not analyzed further. Of those in low creativity, 15 were in the survival condition and 23 were in pleasantness condition. For high creativity, 18 were in the survival group and 20 were in the pleasantness group. Means and standard deviations for proportion of recall can be found in Table 2. A 2 (condition: survival, pleasantness) $\times$ 2 (creativity: high, low) ANOVA revealed a significant main effect of condition $F(1, 72) = 4.956$, $p = .029$, $d = 0.54$. A higher proportion of words were recalled in the survival condition ($M = .37$) than in the pleasantness condition ($M = .32$). Additionally, there was a significant main effect of creativity $F(1, 72) = 7.061$, $p = .010$, $d = 0.59$ on proportion correct. Participants who were high in creativity recalled a greater proportion of words ($M = .37$), as compared to participants who were low in creativity ($M = .32$). However, there was no significant interaction $F(1, 72) = 2.103$, $p = .151$, $\eta_p^2 = .028$ (see Figure 1).

These results suggest that proportion of recall can be attributed to both condition and creative ability, but the effects of condition do not differ based on whether an individual is more or less creative. Rating and RTs were also compared between groups (see Table 2). While there were no significant differences in RTs, an ANOVA revealed a significant main effect of condition (survival vs. pleasantness) on rating $F(1, 72) = 30.864$, $p < .000$, $d = 1.28$, such that those rating for pleasantness rated words significantly higher. This finding may not be surprising, as it may have been easier for participants to classify something as highly pleasant than to rate it as highly

Table 1. Intra-Class Correlations and CIs for Inter-Rater Agreement per AUT Item and Coding Type.

Item	Creativity ICC (3,3)	Fluency ICC (3,3)
1	.757 (.551, .857)	.859 (.762, .911)
2	.806 (.697, .873)	.857 (.794, .901)
3	.681 (.508, .789)	.887 (.768, .937)
4	.681 (.503, .789)	.827 (.676, .898)
5	.731 (.618, .812)	.932 (.897, .954)
6	.806 (.683, .877)	.851 (.773, .900)

Note. All ICCs were computed via SPSS version 26 as two-way mixed-effects models with absolute agreement, average measures. Confidence intervals (95%) for each are included in parentheses.

Table 2. Means and Standard Deviations for Recall, Rating, and RT by Condition and Creativity Level.

Task		Recall		Rating		RT	
		Survival	Pleasantness	Survival	Pleasantness	Survival	Pleasantness
High Creativity	<i>M</i> (<i>SD</i>)	.41 (.09)	.34 (.10)	2.54 (.51)	3.16 (.38)	1,976.22 (421.81)	1,897.50 (422.30)
Low Creativity	<i>M</i> (<i>SD</i>)	.33 (.08)	.31 (.08)	2.52 (.67)	3.21 (.49)	2,005.34 (307.60)	1,802.63 (489.98)

Note. *M* = Means, *SD* = Standard deviations, RT = Reaction time (ms). All standard deviations are listed in parentheses.

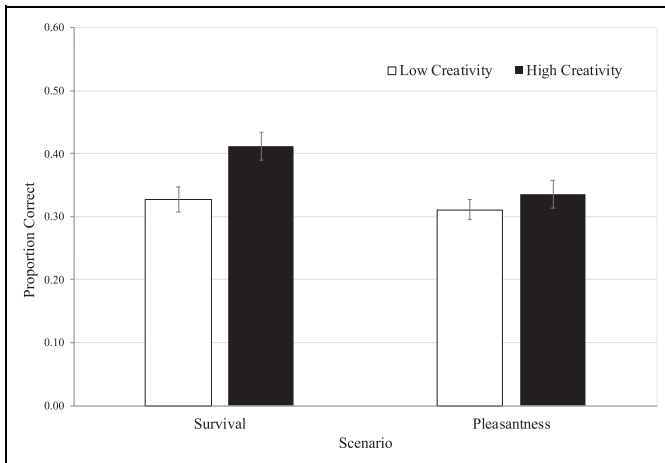


Figure 1. Mean Proportion Correct Recall by Processing Condition and Creativity Level.

relevant in a survival scenario, considering there are more restrictions when rating a word for its utility. However, there was no difference in relevance ratings based on creativity level. This is counter to the idea that highly creative individuals naturally generate more uses in response to items, and thus they are more relevant, otherwise a significant difference in the high and low creative groups would be expected. The overall Means and standard deviations for rating data can be found in Table 2. There were also no significant differences in the number of intrusions (i.e., false recall) between groups.

Discussion

While research has investigated the role of scenarios, task demands, and stimuli in survival processing effects, relatively little has been conducted on how individual differences fit into this area of investigation. In the current study, there was a significant main effect of survival, wherein memory was enhanced for the presented items in the survival condition. Additionally, there was a main effect of creativity on recall, in which highly creative individuals recalled a greater number of items. However, the results of the current experiment are at odds with initial predictions: there was no interaction between survival processing and creative ability, and in particular the survival effect did not persist for those with low ability, with no additional benefit for creative individuals. In fact, numerically it appears to be the reverse (though the interaction was ultimately not significant). Thus, redundant processing seems unlikely. Rather, the main effects of both condition and creativity, and null interaction seems to suggest that these may be independent processes. This finding is somewhat surprising, given the similarity between the task demands of survival processing and divergent thinking. A theoretical possibility for this finding may be that similar processes occur in pleasantness conditions, though to a lesser degree. It may be that highly creative individuals rating for pleasantness are also generating multiple ways in which each stimulus is pleasant, mimicking

divergent thinking. However, given that numerically, recall for creative individuals rating for pleasantness was low by comparison ($M = .34$), this conclusion seems unlikely. Overall, creative individuals recalled a greater proportion than those with lower creative ability, which aligns with the notion that divergent thinking is a useful and adaptive skill, at least in the general sense that it may aid memory.

Previous theories on creativity state that an essential component in creative processes is association (Mednik, 1962). Creative individuals are able to generate increasingly remote associations in response to a given stimulus and also tend to have more flexible semantic networks (Kenett et al., 2016) which could serve to strengthen memory. In traditional divergent thinking tasks such as the AUT this may be especially effective, as each new use must be distinct from previous generations. This offers not only the benefit of multiple memory traces, but also those that are unique, which subsequently expand the semantic space and aid elaborative encoding. This is supported by Hass (2017) who found that semantic clustering occurs less in AUT responses than responses from semantic fluency tasks which only require category associates (e.g., naming animals). In addition to association, research suggests that creativity is also dependent on more general, top-down cognitive processes such as fluid intelligence and broad retrieval ability (e.g., Beaty & Silvia, 2013; Silvia et al., 2013). Our data appear to support this notion, as creative individuals did perform well overall in terms of recall, and perhaps these same top-down factors contributed to recall in the pleasantness condition. However, further research is needed in order to examine the relationship between more general processing ability and survival advantage effects.

Conclusions

Overall, the results presented here seem to suggest that creative ability, and divergent thinking in particular is distinct from survival processing. Main effects of creativity and condition on recall were observed, but the notion that less creative individuals would benefit from survival processing, with no advantage for highly creative individuals due to a redundancy in processing, remains unsupported. Rather, it may be that those able to think more creatively achieve greater recall due to more general cognitive abilities associated with divergent thinking. From an adaptive perspective this is somewhat intuitive, as one would think that the ability to think divergently and creatively—to reach a number of plausible solutions given a problem—would be highly advantageous for our ancestors, especially considering survival situations might be entirely novel and encountered without previous problem-solving schema to rely on.

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