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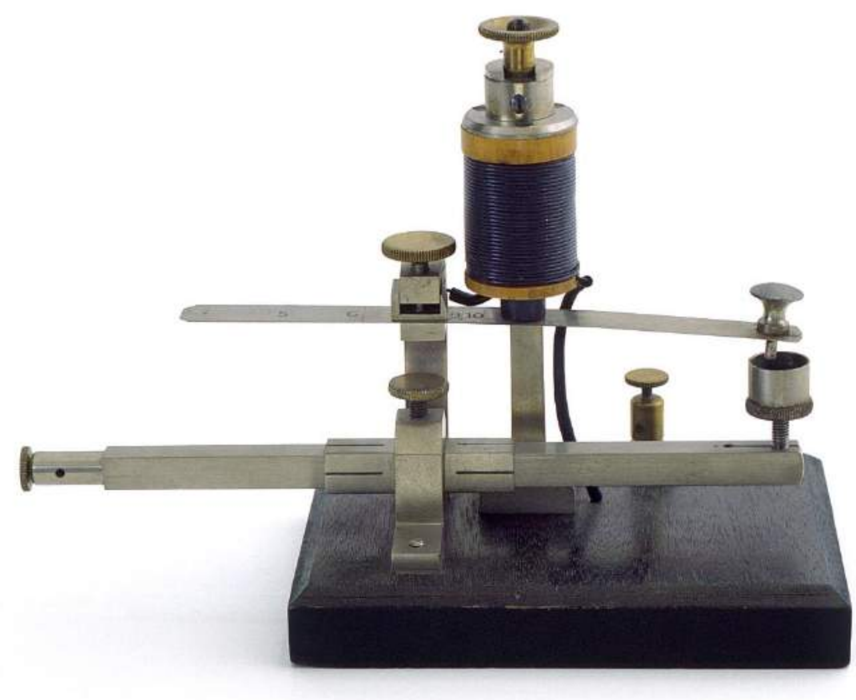
FACULTY OF PHILOSOPHY, UNIVERSITY OF BELGRADE



INSTITUTE OF PSYCHOLOGY

LABORATORY FOR EXPERIMENTAL PSYCHOLOGY

FACULTY OF PHILOSOPHY, UNIVERSITY OF BELGRADE

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Institute of Psychology, Faculty of Philosophy, University of Belgrade

Laboratory for Experimental Psychology, Faculty of Philosophy, University of Belgrade

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Adaptive Memory: The Effect of Danger Signal Frequency on Word Retention

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Abstract

We aimed to investigate whether the frequency of danger signals would affect word retention in the survival-based scenario. The original task (Nairne et al., 2007) was extended by including safety signals (green circle and no tone - G) and danger signals, i.e., predator proximity (red circle followed by a high-frequency sound - R). The signals' ratio varied, resulting in 5 conditions: GGGG, RRRR, GRRR, RGGG, and RRGG. Participants were randomly assigned to groups and were instructed to assess to what extent each of the 32 nouns presented is useful for survival. Upon task completion, participants had 2 minutes to write down items they could remember. ANOVA results indicated no significant differences between the average number of recalled items per group. Levene's test of homogeneity of variance showed the difference between the GGGG and RRRR conditions, where the within-group variability was lower in the RRRR group than in the GGGG group. A visual inspection of the data shows the difference in variability is mainly due to the difference in the upper half of the distribution. Additionally, word retention means for the subsample of the above mean scores differ significantly for the GGGG and RRRR conditions. Our study indicates that a high frequency of danger signals possibly reduces word retention in the survival-based scenario.

Keywords: danger signal frequency; adaptive memory; survival scenario; retention variability

This study was inspired by the research of Nairne (Nairne, Thompson, & Pandeirada, 2007) concerning the evolutive role of memory. Nairne et al. (2007) instructed participants to rate common, neutral nouns for their survival relevance (securing food, water, and protection from predators) in the context of a survival-based scenario (stranded in a foreign land, without basic survival materials). The same words were also rated in non-survival scenarios (pleasantness assessment, relevance of moving to a foreign land, and personal relevance). In surprise retention tests, participants consistently showed the highest retention when words were rated for their survival relevance. These findings suggest that the human memory system might be "tuned" to retain information processed for survival, possibly reflecting an adaptive function.

The survival processing has since been shown to persist across different study designs and recall and recognition tests (e.g., Kostic, McFarlan, & Cleary, 2012; Nairne & Pandeirada, 2010; Otgaar, Smeets, & van Bergen, 2010).

Although survival situations are stressful by nature, the current research suggests that stress is not the mechanism underlying the survival processing advantage. For example, Smeets et al. (2011) found that increased cortisol levels lead to better retention in both survival-based scenarios and control scenarios. These findings are interesting since it has also been shown that retention of stressful situations and stress-related stimuli is enhanced via the HPA axis-based release of adrenal stress hormones acting on brain regions involved in memory formation (Labar & Cabeza, 2006; Phelps, 2004; Quaedflieg & Schwabe, 2017).

Despite stress not being the proximal mechanism of the survival processing advantage, varying degrees of stress might affect retention in the survival-based scenario. This possibility was explored in an experiment in which we manipulated the stress level by varying the frequency of danger signals in the survival-based scenario. We decided to use this manipulation since research on frequency processing indicates that humans are sensitive to various types of frequencies, pointing to their cognitive and ecological relevance (see Zacks & Hasher, 2002).

Method

Design

The independent variable was the presence of a danger signal which was represented by a red circle and a high-frequency sound (R). The absence of danger was represented by a green circle and no additional sound (G). The probability of danger event was a between-subject variable, varied in five conditions - 0, 0.25, 0.5, 0.75, and 1 probability. In other words, the independent variable had five levels: (1) all safety signals – GGGG, (2) one danger and three safety signals - RGGG, (3) two safety and two danger signals – GGRR, (4) one safety and three danger signals – GRRR, (5) all danger signals - RRRR. The order of the signals was random. For example, in the case of one safety and three danger signals, the safety signal could have been placed in four different positions: GRRR, RGRR, RRGR, and RRRG. The dependent variable was the number of reproduced nouns.

Participants

The participants (N = 140, 76.4% female), University of Banja Luka students, were randomly assigned to five groups, with 28 participants per group.

Stimuli

As stimuli, we used the 32 nouns used in the Van Overschelde et al. (2004), translated into the Serbian language: truck, fuel, mountain, pepper, book, charcoal, juice, shoes, finger, aunt, chair, catfish, silver, orange, whiskey, flute, snow, door, cabbage (instead of broccoli from the original list), bear, cathedral, screwdriver, car, sword, apartment, football, crystal, silk, teacher, pan, sock, eagle.

Procedure

Participants received the following on-screen instruction: "Imagine you are in an unknown land, in the age when people survived by hunting and gathering. There is a possibility that you will encounter predators. You will see red and green circles on your screen. A red circle and sound signal predator proximity and a threat to your life. A green circle signals safety and the absence of danger. You will now be presented with a list of words. Please assess how much each word would help you to survive by pressing the numbers on the keyboard. 1 means that a word wouldn't help you at all, and 5 means that a word would be of great help.".

After the instruction, first, a white screen with a black cross was presented for 500 *ms*, and after that, a safety or danger signal was introduced for 1500 *ms*. Following the disappearance of the signal and a 500 *ms* delay, a group of eight words was introduced with the words shown one by one. Each word was presented for five seconds with a 5-point survival-relevance scale. Once a group of nouns was assessed, a signal was again presented, followed by another group of eight nouns. In other words, nouns were split into four groups of eight nouns, with signals preceding them.

In the end, participants were presented with a surprise retention task, where they were given two minutes to write down all the words they could remember.

Results

ANOVA results indicated no significant difference between the number of recalled items per group (*M* range from RRR*R* = 10.96 to GGG*R* = 11.89; Figure 1). However, results of Levene's test of homogeneity of variance indicated a significant difference between the GGGG and RRRR conditions ($F(1, 54) = 7.64$, $p = .008$), with the within-group data variability being lower in the RRRR group ($SD = 2.76$) than in the GGGG group ($SD = 5.50$). A visual inspection of the data indicates that this difference in variability is mainly due to the difference in the upper half of the distribution. In addition, word retention means for the subsample of above the mean scores differ significantly for the GGGG ($M = 14.81$, $SD = 3.64$) and RRRR (M=12.72, $SD = 0.96$) conditions ($t(32) = 2.35$, $p = 0.012$, $g = 0.79$ (one-tail)).

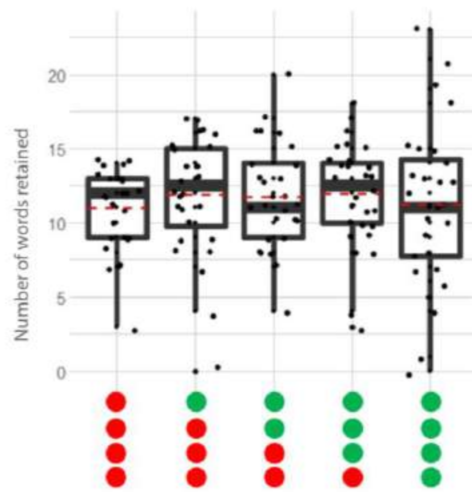

Figure 1: Distribution of retention per experimental group.

Discussion

Our exploratory study points to the possibility that a high frequency of danger signals reduces word retention in comparison to the absence of danger. Namely, word retention means for the subsample of the above mean scores differ significantly between the extreme conditions (GGGG and RRRR). This potential finding is contrary to our intuition that a higher frequency of danger would lead to better retention. We will discuss one possible neurobiological explanation here.

Namely, stressful events direct attentional and memory processes toward stress-related stimuli. Within seconds following stressor onset, the release of catecholamines, including noradrenaline, is triggered. Rapid catecholaminergic and glucocorticoid actions set the brain in a memory formation mode that facilitates the encoding of stressor-related stimuli but impairs the retrieval of stressor-unrelated stimuli (Quaedflieg & Schwabe, 2017). Because the nouns evaluated in terms of usefulness were neutral and therefore not inherently related to the stressor, reduced retention manifested as reduced variability in the number of retained words.

In future studies, we should explore this potential neurobiological explanation by including a stressor-related noun condition, as well as expanding to contemporary scenarios. Also, the length of the experiment should be manipulated since the memory formation mode might take a longer time to reach full effect (Droste et al. 2008). Furthermore, we should address other techniques to manipulate the probability of danger which could be more meaningful from the evolutionary perspective, for example, by using other fear-relevant stimuli (e.g., Lobue & DeLoache, 2008) as danger signals.

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