



HAL
open science

Ratings of survival-related dimensions for a set of 732 words, their relationships with other psycholinguistic variables and memory performance

Patrick Bonin, Gaëtan Thiebaut, Alain Méot

► **To cite this version:**

Patrick Bonin, Gaëtan Thiebaut, Alain Méot. Ratings of survival-related dimensions for a set of 732 words, their relationships with other psycholinguistic variables and memory performance. *Current Psychology*, In press, 10.1007/s12144-023-04979-2 . hal-04321977

HAL Id: hal-04321977

<https://hal.science/hal-04321977>

Submitted on 7 Dec 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Ratings of survival-related dimensions for a set of 732 words, their relationships with other psycholinguistic variables and memory performance

Patrick Bonin¹, Gaëtan Thiebaut¹, and Alain Méot²

¹Université de Bourgogne, LEAD-CNRS UMR5022, Dijon, France

²Université Clermont-Auvergne, LAPSCO-CNRS UMR6024, Clermont-Ferrand, France

R2 MS CUPS-D-22-04491 – June 2023

Declaration of Interest Statement. The authors declare no competing interests.

Data Availability Statement. The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Acknowledgments. The authors wish to thank Céline Capelier for her help in collecting the data, Prof Richard Ferraro, Dr Lyra Stein and three anonymous Reviewers very much for the helpful comments on a previous version of the article.

Address for correspondence:

Patrick Bonin (Patrick.Bonin@u-bourgogne.fr)

LEAD-CNRS (UMR 5022)

Université de Bourgogne

Pôle AAFE - Esplanade Erasme BP 26513

21065 Dijon Cedex, France

R2 MS CUPS-D-22-04491

21-06-2023

Abstract

When words are processed for their fitness-relevance (e.g., for finding food), they are remembered better than when they are processed for non-fitness issues (e.g., for their pleasantness): the survival processing advantage. In the present research, we investigated memory performance as a function of the level of relevance of words (high versus low) to survival issues (e.g., avoiding predators). In Study 1, a sample of French adults had to rate 732 words on the survival problems of “avoiding predators”, “avoiding contamination” or “finding food and water”. Reliability measures were computed for the ratings and descriptive statistical analyses and bivariate correlations as well as multiple linear regression analyses were performed. The entire set of survival ratings is available as Supplemental Material. Three experiments were then conducted using the collected ratings-to investigate whether the survival processing advantage in memory was moderated by the relation between relevance ratings (high versus low relevance) and survival contexts (“predation” [Experiment 1], “contamination” [Experiment 2], “food and water” [Experiment 3]). Words of high survival relevance were recalled better when encoded either for survival or for pleasantness. Furthermore, a larger survival processing advantage was found for words rated high on survival-related dimensions than for words rated in the pleasantness (control) condition.

Keywords: Survival processing, Relevance ratings, Adaptive memory

Ratings of survival related dimensions for a set of 732 words, their relationships with other psycholinguistic variables and memory performance

Several lines of evidence strongly suggest that human memory is the product of evolution (Nairne et al., 2019; Nairne, 2022). According to the adaptive memory view, memory has been shaped by natural selection to process and retain fitness-relevant information better than non-fitness-relevant information (Nairne, 2010, 2016, 2022; Nairne & Pandeirada, 2008, 2010, 2016).

One well-investigated type of evidence in favor of this view is the finding that processing information according to its survival value improves memory retention compared to the processing of the same information in different non-survival (control) situations (e.g., moving house, pleasantness). More precisely, in the survival processing paradigm (originally proposed by Nairne et al., 2007), participants are instructed to imagine that they are stranded in the grasslands of a foreign land and that they will have to find food and water and avoid predators. A number of (generally unrelated) words are presented to the participants, who are required to rate them according to their relevance for the survival situation. For instance, using Likert scales from 1 (totally irrelevant) to 5 (extremely relevant), the participants rate how relevant the words “rake”, “truck” or “bird” are to the situation of surviving (they will have to find food and water and avoid predators) in the grasslands of a far-off country. After the rating task, they are given a surprise retention test (recall or recognition). The general finding is that words encoded in the survival scenario are remembered better than words encoded in non-survival control scenarios such as moving to another country (Nairne et al., 2007) or in deep-processing tasks such as rating words for their pleasantness (e.g., Nairne et al., 2007, 2008) or for their ease of forming a mental image (Nairne et al., 2008). In the original survival scenario (Nairne et al., 2007), the participants were faced with three survival problems: (1) finding food, (2) finding drinking water and (3) protecting themselves against

predators. The survival problem of avoiding contamination and illness has also been investigated in certain survival scenarios and a survival processing advantage has again been found (Bonin et al., 2019; Kroneisen et al., 2022; Nairne & Pandeirada, 2010).

The survival processing advantage has proven to be a robust memory effect (for a meta-analysis, see: Scofield et al., 2018). It has been replicated a number of times by different research teams around the World (United States, United Kingdom, France, Germany, Japan, to name but a few), with different types of stimuli (e.g., pictures: Otgaar et al., 2010; but not with stories: Seamon et al., 2012, but see Cook et al., 2023, or with faces: Savine et al., 2011, but see Hou & Liu, 2019), and in different age groups (e.g., children: Aslan & Bäuml, 2012; Otgaar & Smeets, 2010; older adults: Nouchi, 2012). However, there is no evidence for this effect in implicit memory tasks (McBride et al., 2013; Tse & Altarriba, 2010; Wilck & Altarriba, 2019).

Relevance ratings and the survival processing advantage

A large number of studies have been designed to address the question of how the survival processing advantage comes about. To mention a few of the factors that might reliably have accounted for this memory phenomenon but in fact failed to do so are the novelty of the scenario as well as its arousing nature (Kang et al., 2008), media exposure (Nairne et al., 2007), thoughts of death (Bugajska et al., 2015), and social isolation (Kostic et al., 2012; Leding & Togliani, 2018)¹. The question of whether survival effects are related to basic memory mechanisms, such as elaboration, has also been investigated (e.g., Bell et al., 2015; Röer et al., 2013; Wilson, 2016), but so far no evidence unambiguously favors any particular proximate explanation of survival effects in memory (see Krause, 2015, for a list of

¹ Interestingly, although survival is generally thought to be an individual issue, the question of whether this memory effect extends to people other than the self has also been discussed (Bonin et al., 2020; Cunningham et al., 2013; Kang et al., 2008; Seitz et al., 2020).

different proximate mechanisms that might potentially account for survival processing effects).

In the present research, we focused on one dimension involved in the survival processing paradigm which has been somewhat controversial and is not completely settled: The role of the fitness-relevance ratings assigned to the words. More precisely, we focused on the level of relevance of the items with a survival-related dimension (e.g., predation) and the survival scenario (“avoiding predators”). This issue is closely related—albeit not identical to—the level of congruency between the word ratings and the encoding scenarios used. To be clear, the principle of congruity is derived from the observation that memory performance is boosted when the encoding context and the to-be-remembered target information constitute an integrated unit. In the classic study by Craik and Tulving (1975), it was found that questions used in orienting tasks that had to be completed by a “yes-response” (e.g., does the target word *lion* fit the sentence “I met a ____ in the savannah”?) resulted in better memorization of the target words than questions that were to be completed by “no-responses”. Words and encoding contexts that are congruent permit the creation of richer and more highly elaborated memory traces. As far as the role of congruency in the survival processing advantage is concerned, it has been claimed to “*act as a powerful within-list moderator*” (Erdfelder & Kroneisen, 2014, p. 177), or to be “*an important boundary condition*” (Palmore et al., 2012, p. 124). However, evidence regarding the impact of congruency in the survival processing advantage is mixed. Butler et al. (2009) used two different encoding scenarios (survival versus robbery) and lists of words that were congruent or incongruent with the scenario in question. The ratings were either given in a single block (Experiment 2) or using a mixed approach (Experiment 3). In neither of their experiments did Butler et al. (2009) find a survival processing advantage. However, a few years later, Nairne and Pandeirada (2011) further explored the congruency issue in the survival processing paradigm. They reported

evidence that the survival processing advantage was found: (1) When the participants had a unique set of words sampled without replacement from a large pool of words, (2) When words preselected to be highly unrelated (or irrelevant) to both the survival and control scenarios by Butler et al. (2009) were used, (3) With words that had been chosen to be highly congruent with both the survival and robbery scenarios, and (4) When congruent and incongruent words were presented together in the same list of words. Finally, Palmore et al. (2012) designed an experiment in which half of the words were highly relevant to a survival scenario (e.g., “wood”) and the remaining half were highly relevant to a bank robbery (e.g., “alarm”). The participants had to rate the words in a survival and a robbery scenario (i.e., scenario was a within-subjects factor). A surprise recall test took place after a distractor task. Here, no survival processing advantage was found in the recall rates, whereas congruency had a reliable effect on memory performance.

As claimed by Nairne and Pandeirada (2011): “*Most survival processing experiments have used unrelated word lists, selected randomly from norms, and survival advantages have generally been found for words irrespective of their assigned relevance rating.*” (p. 542). Furthermore, in a large number of studies in which rating scores have been controlled for statistically, the survival processing advantage has still been found. Finally, Seitz et al. (2020) also reported complex interactions between relevance ratings and encoding scenarios in the survival processing paradigm. In sum, the evidence as to whether relevance ratings have a reliable influence in the survival processing advantage is inconsistent. Indeed, the relation between fitness-relevance ratings and recall rates has been examined after the experiments were run and, to our knowledge, no study has used stimuli selected a priori on the dimension of fitness-relevance to investigate survival processing in memory.

Aims of the present studies

In order to address the issue of survival relevance further, we decided to collect survival-related dimensions for a set of 732 French words. Ratings for words related to survival dimensions are scarce (Alonso et al., 2021; Leding, 2019). Alonso et al. (2021) collected ratings for a set of 750 Spanish words for the dimension of “avoiding death”, i.e., “to find things that can protect you from predators and avoid damage in order to survive” and of “finding nourishment”, i.e., “to find food and drink in order to survive”. Among the different findings, one of particular interest was that words that were related to both survival-related dimensions tended to be more familiar, more concrete, more imageable, and also more likely to be acquired early in life. Study 1 was designed to extend the Alonso et al. (2021) study to the French language. However, unlike these authors, we took account of a third survival-related dimension: avoiding contamination and illness.

In sum, by using ratings on survival-related dimensions, we aimed to investigate whether memory performance (correct recall) for each survival problem (avoiding predators, avoiding contamination and illness, finding food and water) would be modulated by the fitness-relevance level of the items with the survival dimension in question and the survival scenario. It is important to stress that in the memory experiments reported in Study 2, we did not manipulate congruency *per se* because even though the words were chosen to be more or less relevant to/congruent with the survival scenarios, they were not selected to be more or less relevant to/congruent with the pleasantness control condition. In Study 1, we describe the collection of the ratings and their relationships with other psycholinguistic variables (e.g., word frequency). In Study 2, we designed three memory experiments that were aimed at investigating three survival problems as a function of the relevance level of the items (which was either high or low) and the survival problem.

Study 1. Ratings of survival-related dimensions for French words

Method

Participants

383 adults ($M = 23.16$ years; $SD = 7.50$; 317 females) took part. They were recruited online through the Facebook social media platform since there are groups of Facebook psychology students. Most of them were psychology students at the University of xxxx. The participants were all native speakers of French. They received course credits for their participation.

Stimuli

The words were taken from the Bonin, Méot et al. (2003) database, which contains norms for 866 words. 134 words were judged to be ambiguous and were therefore excluded. The final list of words consisted of 732 words, which were subdivided into four sets to make the rating task more manageable. There were 183 words in each set. The different sets were matched on several psycholinguistic variables: (1) Objective word characteristics corresponding to number of letters and syllables, film subtitle and book frequencies; the number of orthographic neighbors was taken from LEXIQUE (New et al., 2004); (2) Subjective norms taken from Bonin, Méot et al. (2003): imageability, concreteness, valence, and subjective frequency. Imageability is a measure of the ease with which a mental image can be formed in response to words. Concreteness is the degree to which concepts denoted by words refer to perceptible entities. Valence is the extent to which an emotion is positive/pleasant, negative/unpleasant or neutral. Subjective frequency is a measure of how often a word is encountered in everyday life (read or heard). The statistical characteristics of the words for the different sets are provided in Table 1A of the Supplemental Material.

Procedure

Written informed consent was obtained from all of the participants before the beginning of the study. The questionnaires were created with Limesurvey (www.limesurvey.com) and were completed online individually by the participants. On the first page of the questionnaire, the participants provided informed consent. On the second page, demographic information was collected: age, gender, native language and educational level. On the third page of the questionnaire, the instructions were presented. The participants had to imagine that they were stranded in the grasslands of a foreign land, without any basic survival materials. Over the next few months, they would, depending on the condition to which they were assigned, have to (1) find steady supplies of food and water, (2) protect themselves from predators, or (3) avoid being contaminated by pathogens and becoming ill. They were told that a long list of words would be shown to them and that they would have to rate how relevant each of these words would be for them in the described survival situation. Likert scales (1 = “totally irrelevant” to 5 = “extremely relevant”) were used and the participants gave their responses by clicking with the mouse. The words were randomly presented on the screen and a different order was used for each participant. The participants were told to rate the words spontaneously, at their own pace, and that there were no right or wrong answers. Finally, the participants were debriefed regarding the research goals. The survey took about 30 minutes to complete.

All the study (Study 1 and 2) procedures were approved by the Statutory Ethics Committee of xxxx.

Results of Study 1

Screening of the data

The mean rating given by each participant was computed and the participant was excluded from further analyses if her/his mean was more than three standard deviations above or below the mean of the participants' means and outside less or more 1.5 interquartile range

from the median of these means. On the basis of these criteria, four participants were discarded (one participant was excluded for the ratings of contamination for the words included in Set 2, one participant for the food and water ratings included in Set 3 and two participants for the predation ratings in Sets 2 and 4). Finally, another participant was excluded from the predation ratings in Set 3 because of the extremely low standard deviation in her/his ratings and the correlation between her/his mean and those of the other participants. Ultimately, each word was rated for each dimension by 29 to 33 participants. The survival ratings are available in the Supplemental Material (xls file).

Data analyses

Several analyses were performed on the rating data and these are reported in the following order. (1) reliabilities, (2) descriptive statistics as well as the distributions of the ratings, (3) bivariate correlations and multiple linear regressions in order to study the relationships between survival ratings and several other characteristics of the words.

Reliability and validity analyses

The correlations between the by-items means obtained from the even and odd participants and the intraclass correlation coefficients (two-way random effects, consistency, multiple raters/measurements conforming to the McGraw and Wong [1996] convention) were computed within each list of words. With the exception of the even/odd correlation for contamination ratings in the second list, which was equal to .79, all coefficients were above .80, which suggests a high level of consistency between the participants' ratings for all sets of words (see Table 1B for detailed statistics in the Supplemental Material).

For “finding food and water”, we computed the correlation between the present ratings and the ratings provided by Alonso et al. (2021). With the two databases having 343 words in common, the correlation amounted to .85, which suggests that the ratings obtained for this dimension are both reliable and possess convergent validity. Alonso et al. (2021) also

provided ratings for the dimension of “avoiding death”. This dimension includes “*protecting from predators*” as well as a more general feature concerning “*avoiding damage in order to survive*”. The “avoiding death” ratings were the most highly correlated with the current ratings of “avoiding contamination” ($r = .66, p < .001$), then with the current ratings of “finding food and water” ($r = .6, p < .001$), and finally with the ratings of “protecting from predators” ($r = .56, p < .001$), a pattern of findings which suggests that “avoiding death” ratings correspond to a wide range of survival-related concerns. Given the high correlation (.75) found between the two dimensions of “avoiding death” and “locating nourishment”, Alonso et al. (2021) pointed out that “*obtaining food can be taken as a particular case of a more general dimension such as avoiding death*” (p. 157). Interestingly and relatedly, the correlation between the “avoiding death” ratings in Spanish and the means of the three current survival-related ratings was equal to .8 (.86 when the first factor scores obtained from a principal component analysis are considered). Again, this finding adds credibility to the claim that our survival-related ratings are valid.

Descriptive statistics

Table 1. *Descriptive statistics for the survival ratings*

	Mean	SD	Q1	Median	Q3	Skew	Kurtosis	Min	Max
Food and water	2.25	.96	1.42	2.07	2.90	.65	-.60	1	4.86
Predators	1.94	.80	1.35	1.69	2.28	1.44	1.69	1	4.78
Contamination	1.93	.61	1.47	1.81	2.27	1.04	.97	1	4.36

Notes. SD = standard deviation; Q1 = 25th percentile; Q3 = 75th percentile.

Descriptive statistics are reported in Table 1 and Figure 1 illustrates the distributions of the ratings. The distributions are all right-skewed with roughly 50% or more of their values

situated in the [1, 2] interval. The “food and water” ratings are distributed across almost the entire scale, with a little marked mode very close to the beginning of the scale, followed by a relatively monotonous decrease in the frequencies of the values until roughly 4.5. By contrast, the “contamination” ratings are largely concentrated in a modal range located roughly between 1.3 and 2. The frequencies of the values then quickly decrease, with only a few of them exceeding 3.5. Finally, the “predation” ratings exhibit both a marked modal range and a long and relatively dense right tail.

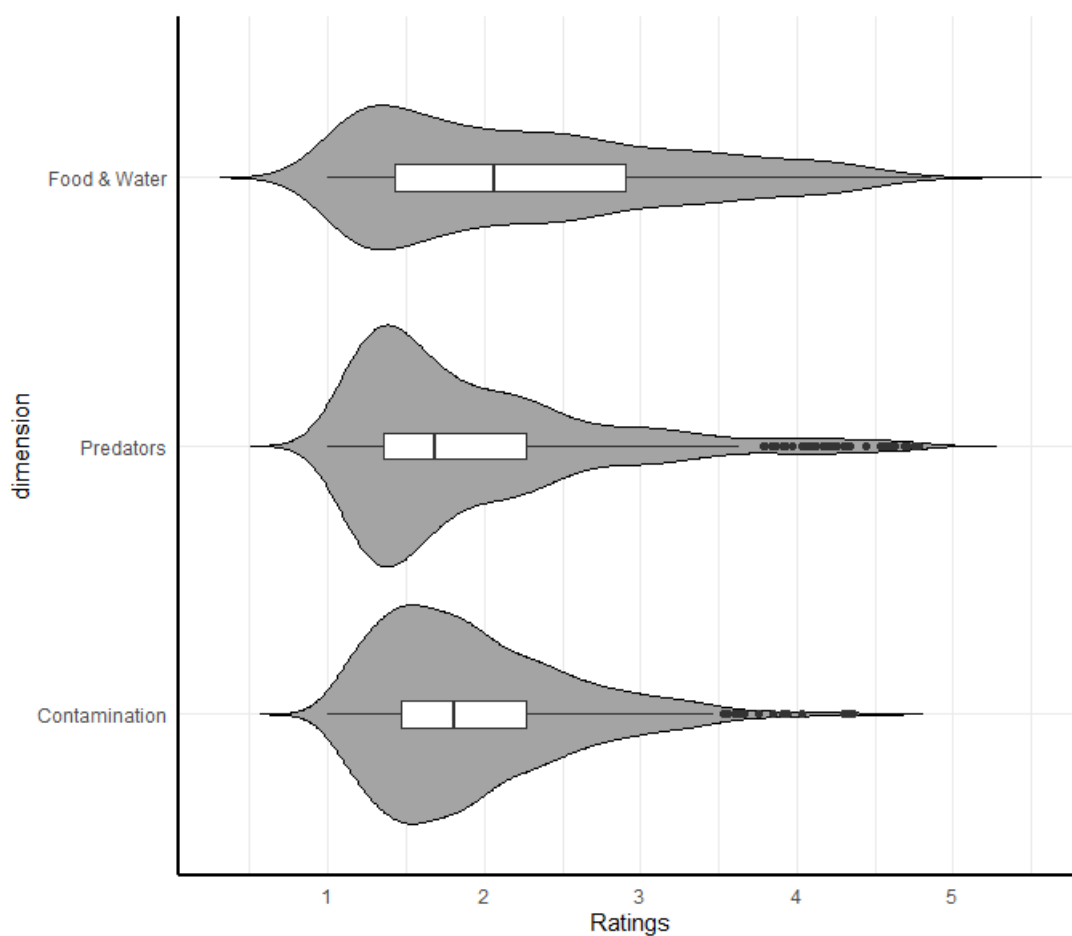


Figure 1. Violin and boxplots of the three types of survival rating scores. Points at the right of the distributions are situated more than 1.5 interquartile range beyond the third quartile.

We also compared the means of the different ratings on the animacy dimension of the words², i.e., words referring either to animates or to inanimate things. With all effect sizes being between low and medium as set out in Cohen's guidelines (Cohen, 1992), there was a trend for animates to be judged as more relevant for "finding food and water" ($M = 2.68$) than inanimates ($M = 2.15$), $t(723) = 6$, $p < .001$, $g = .57$, whereas the reverse was true of the other two survival ratings: "avoiding predators" ($M_{animates} = 1.74$ and $M_{inanimates} = 1.98$), $t(723) = -3.2$, $p < .01$, $g = -.30$; "avoiding contamination" ($M_{animates} = 1.75$ and $M_{inanimates} = 1.97$), $t(723) = -3.94$, $p < .001$, $g = -.37$ ³.

Relationships between survival ratings and objective word characteristics

Table 2 shows the correlations between the survival ratings and the set of objective norms: subtitle and book frequencies (in log) and word length expressed as the number of letters and syllables, respectively. The correlations between the three survival ratings were positive and significant, which suggests that words that are rated as relevant on one survival dimension also tend to be rated as relevant on the other two dimensions. This was particularly noticeable with regard to the correlation between "finding food and water" and "avoiding contamination", which had a value of .58. This correlation suggests that the more useful the words are rated to be for ensuring food and water supplies, the more relevant for protection against contamination they are perceived to be. The same type of relationship was found between the other pairs of survival ratings, albeit to a lesser degree. The correlations of the survival-related ratings with the measures of word length and word frequency were more anecdotal. Nevertheless, they suggest that words that are rated as being more relevant to the

² A word was coded as animate when it referred to a living thing that was able to propel itself autonomously. This broad definition of animacy has often been used in the literature on animacy effects in memory (e.g., Gelin et al., 2019). The coding was done by the three authors of the current paper and there were only a few words for which the classification did not match. These cases were discussed and a consensus was easily reached for each of them.

³ Seven words could not be unambiguously classified as animates or inanimates and were excluded from the analyses.

survival issues of contamination and predation tend to be of higher frequency. For the survival issue of finding food and water, and less so for that of avoiding predators, words with higher ratings were also shorter than words with lower ratings.

Table 2. *Correlations between the three survival-related dimensions and four objective word characteristics*

	Predation	Contamination	Number of letters	Number of syllables	Film frequency	Book frequency
	N = 732			N = 702		
Food & Water	.231 ^{***}	.576 ^{***}	-.146 ^{***}	-.146 ^{***}	.072	.021
Predation		.320 ^{***}	-.091 [*]	-.090 [*]	.164 ^{***}	.142 ^{***}
Contamination			-.042	-.079 [*]	.230 ^{***}	.218 ^{***}

Notes. *** : $p < .001$; * : $p < .05$. Log of the subtitle and book frequencies +1 taken from LEXIQUE (New et al., 2004) (number of words included in the analyses: 702).

Relationships between survival ratings and subjective semantic and emotional variables

We computed the correlations between the survival-related ratings and different types of psycholinguistic variables. First of all, we took into account four subjective norms that were described in the Stimuli section: subjective frequency, imageability, concreteness and valence. In addition to valence, the emotional dimension of arousal—which corresponds to the degree of physiological activation that a word evokes (from calm/relaxed to excited)—was also considered. Second, the correlations of the survival-related ratings were also calculated on the basis of three variables which are generally thought to index the semantic dimensions of words: conceptual familiarity, contextual availability, Age of Acquisition (AoA). Conceptual familiarity corresponds to the degree of physical or mental contact with an object associated with a word, contextual availability is the ease with which a word can be associated with a context or circumstance and AoA is the estimated age at which a word was learned. Finally, we also took the Sensory Experience Rating [SER] into account. SER corresponds to a measure of the extent to which a word evokes a sensory and/or perceptual experience. Context availability, arousal, and SER values were taken from the Bonin et al. (2018) and the Bonin et al. (2015) studies, whereas conceptual familiarity and AoA values

were taken from the Alario and Ferrand (1999) and from the Bonin, Peereman et al. (2003) studies.

The relevance ratings for "food and water" were poorly correlated with all dimensions, the two highest values being for SER ($r = .242, p < .001$) and AoA ($r = -.155, p < .001$), suggesting a tendency for the words judged as being the most relevant to evoke more sensory/perceptual experiences and to have been acquired relatively early in life.

Table 3. *Correlations between the survival-related ratings and other subjective ratings*

	Subjective frequency	Conceptual familiarity	AoA	Imageability	Concreteness	Context availability	Valence	Arousal	SER
Food & Water	.033	.021	-.155 ^{***}	.140 ^{***}	.133 ^{***}	.049	.059	-.095	.242 ^{***}
Predation	-.105 ^{**}	-.180 ^{***}	.061	-.055	-.003	-.012	-.313 ^{***}	.427 ^{***}	-.101
Contamination	.314 ^{***}	.318 ^{***}	-.234 ^{***}	.192 ^{***}	.074 [*]	.110 [*]	.023	-.084	.208 ^{***}

Notes. ***: $p < .001$; **: $p < .01$; *: $p < .05$. Scores for subjective frequency, concreteness, imageability and valence were taken from Bonin, Méot et al. (2003) and covered all 732 words; context availability, arousal and Sensory Experience Ratings [SER] were taken from Bonin et al. (2018) and Bonin et al. (2015) and were available for 369 of the present words. Conceptual familiarity and Age of Acquisition [AoA] correspond to the z-scores computed within the Alario & Ferrand (1999) and Bonin, Peereman et al. (2003) databases and covered 571 of the present words.

The relations between the "avoiding predators" dimension and the other (included) dimensions were generally also small, even though there were two relatively higher correlations concerning arousal ($r = .427, p < .001$) and, to a lesser extent, valence ($r = -.313, p < .001$), thus indicating that words rated as being more relevant for protection against predation were also perceived as activating more excitation and were more negative. A noticeable negative correlation with conceptual familiarity ($r = -.18, p < .001$) was also observed, suggesting that things related to this type of word are associated with less physical or mental contacts. Finally, although not very high, there were numerous noticeable correlations with the "avoiding contamination" ratings. There were positive correlations with subjective frequency ($r = .314, p < .001$), conceptual familiarity ($r = .318, p < .001$), SER ($r = .208, p < .001$), and imageability ($r = .192, p < .001$). Thus, the more relevant the words were judged to be for protecting against contamination, the more they were estimated to be

frequently encountered, associated with physical/mental contacts, have perceptual/sensory features and be easily imageable. They were also judged to be acquired earlier in life than the other types of word.

In order to assess whether the relationships found in the bivariate correlations were still apparent when the other dimensions were controlled for, each survival rating in turn was taken as a dependent variable in a simultaneous multiple linear regression including the other variables as predictors. As this control amounts to studying the effects of each of the predictors individually while keeping the other predictors at a constant level, it makes it possible to avoid potential confounds between effects, which is not the case when only bivariate correlations are taken into account. These analyses were computed from only the 301 words for which all variables were available (note, however, that the pattern of bivariate correlations of this subset of words did not differ substantially from the pattern reported above: see Table 1C in the Supplemental Material). Because book and subtitle frequencies were very highly correlated ($r = .901, p < .001$), we included only subtitle frequency in the equation. Also, only the number of letters was included as a measure of word length ($r = .781, p < .001$ with the number of syllables). Finally, subjective frequency was also highly correlated with conceptual familiarity ($r = .756, p < .001$). However, since these two variables are thought to operationalize two different concepts, they were both retained in the equations. (We provide some comments below whenever different results were obtained when either of the two measures was excluded.) It is worth noting that with a value of 4.98, the highest variance inflation factor was observed for subjective frequency⁴. However, this did not indicate any particularly severe concern regarding multicollinearity (e.g., James et al., 2021).

⁴ Note that the VIF for context familiarity was 2.86 and was the second highest value of its type.

Table 4. Multiple linear regressions using survival ratings as dependent variables

R^2	Food & Water		Predation		Contamination	
	β	t	β	t	β	t
	.107***		.272***		.160***	
Number of letters	-.09	-1.46	-.07	-1.29	-.02	-.27
Film frequency	.02	.19	.31	3.77***	.08	.95
Subjective frequency	-.29	-2.37*	-.08	-.75	.03	.24
Conceptual familiarity	.09	1.00	-.04	-.46	.29	3.16**
AoA	-.13	-1.55	.02	.25	-.04	-.50
Imageability	.02	.29	.01	.10	-.10	-1.17
Concreteness	.05	.81	.05	.83	.02	.33
Contextual availability	-.05	-.59	.06	.88	-.06	-.83
Valence	.00	.02	.08	.98	-.02	-.20
Arousal	-.04	-.53	.45	5.96***	-.02	-.24
SER	.27	3.94***	-.11	-1.76†	.21	3.20**

Notes : *** : $p < .001$; ** : $p < .01$; * : $p < .05$; † < .1. R^2 = R-square; β = standardized partial coefficients.

As can be seen from Table 4, the differences in survival ratings were overall poorly predicted by the dimensions included as predictors in the regression analyses and only a few effects were reliable. The relationships between SER and the ratings for “finding food and water” and “avoiding contamination” found in the bivariate correlations were still apparent when the other dimensions were controlled for: The more words evoke sensory/perceptual experiences, the more they are rated as relevant on these two survival-related dimensions. Furthermore, arousal was still related to “predation”: High-arousal words were rated as being more relevant to this survival dimension.

In line with the findings obtained in the bivariate correlation analyses, the more objectively frequent the words were found to be, the more relevant they were rated to be on the dimension of protecting against predators. Also, the more highly associated the words were with ease of evoking physical or mental contacts, the higher the ratings were on the

dimension of protection from contamination. However, most of the bivariate correlations reported above turned out to be non-significant when other dimensions were controlled for, an outcome which was particularly salient for the relationship between valence and predation, for the relationship between the two frequency measures and contamination, and for that between AoA ratings and contamination.

We explored possible confounds between pairs of predictors in greater depth by excluding predictors one by one. The effect of valence on predation ratings changed the most and was again negatively significant, $\beta = -.23$, $t(290) = -3.78$, $p < .001$, when arousal was excluded from the analysis. This suggests that valence has only a poor explanatory value when levels of arousal are constant. Moreover, excluding conceptual familiarity from the analysis of contamination ratings led to an effect of subjective frequency which was again positive and significant, $\beta = .305$, $t(290) = 3.64$, $p < .001$, a result which is probably due to the strong relationship between these dimensions. Finally, it is worth mentioning that a significant negative effect of subjective frequency on “finding food and water” ratings was found when the other dimensions were controlled for, whereas the bivariate correlation between the two variables was not significant. It was, however, not possible to identify a unique predictor that could explain this divergence.

Discussion of Study 1

The findings from Study 1 can be summarized as follows. First of all, we found that the ratings of the words for the three survival-related dimensions of “finding food and water”, “protecting from predators”, and “avoiding contamination” were highly reliable, an outcome that was also found by Alonso et al. (2021). Second, the bivariate correlation analysis revealed that the three survival-related dimensions were positively correlated (with, however, somewhat lower correlations with the “protecting from predators” ratings), with the result that words relevant on one survival-related dimension were also relevant on the other two

survival-related dimensions. This pattern of correlations could be due to the fact that the participants were simply asked to rate words for survival. One interesting methodological implication is that it is easy for researchers to select fitness-related words. Third, the correlations of the three survival-related dimensions with other psycholinguistic subjective norms revealed that the “finding food and water” ratings were the most highly correlated with SER and AoA, with words that were estimated to be high on this survival dimension being associated with more sensory/perceptual experiences and being judged to be early acquired. Significant positive correlations were also observed with imageability and concreteness, meaning that words estimated to be highly relevant for the “finding food and water” survival-related dimension were also perceived as being more imageable and concrete. The same kind of relations with SER, AoA, imageability and concreteness were also found for “avoiding contamination” ratings. In Spanish, Alonso et al. (2021) also found that words related to survival were more concrete and more imageable, as well as more likely to be acquired early in life. However, “avoiding contamination” ratings were also positively correlated with both subjective frequency and conceptual familiarity, meaning that words judged to be highly relevant for “protecting against contamination and becoming ill” were also more subjectively frequent and conceptually familiar. Finally, arousal and valence were highly correlated with “protecting from predators” ratings. More precisely, words that were highly relevant on the predation dimension had higher levels of arousal and were more negatively valenced. Albeit to a lesser extent, however, “protecting from predators” ratings were perceived as being less familiar and less frequently encountered. Finally, the multiple linear regressions that were run with the survival-related ratings taken as dependent variables and subjective psycholinguistic variables introduced as predictors revealed that survival ratings were, overall, poorly predicted by these variables, and indeed, only a few of these variables had reliable effects.

Study 2. Survival-related dimensions and memory performance

Based on the ratings collected in Study 1 on the three survival-related dimensions of “finding food and water”, “avoiding predators”, and “avoiding being contaminated by pathogens”, three experiments were designed in order to investigate whether, in each survival processing situation, recall performance would be altered by the level of relevance of the words to the survival scenario. Type of Encoding was the independent variable (e.g., survival-predation versus pleasantness) in all three experiments. Participants were randomly assigned to one of the two conditions. For each type of encoding, half of the words were highly related to the survival scenario and the remaining half were very unrelated. We used pleasantness rating as a control condition given that this condition has been widely used as a benchmark control condition in studies on the survival processing advantage (Nairne et al., 2019). Pleasantness is one of the most powerful types of deep encoding that leads to long-term retention (Packman & Battig, 1978). The main dependent variable was the number of correct words that were written down during free recall.

Experiment 1. Survival processing and predation

Method

Participants

For all experiments of Study 2, we planned to have 39 or more participants in the survival and pleasantness conditions. This number was chosen on the basis of Scofield et al.’s (2018) meta-analysis of the survival-processing advantage in memory. Considering an $\eta_p^2 = .075$ —a value situated at the center of the survival η_p^2 effect size interval given by these authors ([.06; .09])—the sample size required to obtain a power of .8 in a unilateral test at the .05 level was equal to 78 (2×39)⁵. Note that as the direction of the survival effect in memory

⁵ The computations were done with G*Power (Version 3.1.9.7, Faul et al., 2007).

is predicted, a one-tailed test is more suitable here (see, for instance, Roelofs & Piai [2017] for this type of application) because it requires less participants per condition (2*50 participants are required to obtain the same power at the same α -level in a bilateral test). The final sample for Experiment 1 consisted of seventy-six students (mean age 19.5 years; 62 females) at the University of xxxx. They were randomly assigned to one of the two groups ($n = 38$ in each group⁶), which experienced different encoding conditions (survival versus pleasantness). All were native speakers of French. None were taking medication known to affect the central nervous system. The participants received course credits for their participation.

Stimuli

The word list was created based on the survival-related ratings collected in Study 1 and in the light of the specific dimension that was to be explored, namely the predation dimension in Experiment 1. We selected 32 words that were divided into two sets of 16 items: The words in the first set were highly relevant to the survival scenario, whereas those in the second set were very irrelevant (see Supplemental Material for the list of the words used in Experiment 1). In the three experiments of Study 2, we selected only inanimate words in order to avoid possible confounds with the animacy dimension. The stimuli were matched on the following variables: number of letters and syllables, film subtitles and book frequencies, subjective frequency, imageability, concreteness and emotional valence. This was also the case for age of acquisition (AoA) and conceptual familiarity, but these latter values were calculated based on the 15 and 12 values which were available for conceptual familiarity and AoA, respectively. The sources of the values of the controlled variables were the same as

⁶ Experiment 1 took place just after an acute phase of the COVID-19 pandemic in xxxx, a period during which it was particularly difficult to recruit participants. However, with this number of participants included in Experiment 1, a priori power at the alpha level of .05 was .79 in a unilateral test, a value which was very close to our objective of having a power of .8.

those described in Study 1. The statistical characteristics of the words are provided in Table 1D of the Supplemental Material.

Apparatus

The script of the experiment was created using PsyScope (Cohen et al., 1993) running on an Apple computer.

Procedure

The participants were tested individually and were seated comfortably in a quiet room. Written informed consent was obtained from all of the participants before the beginning of the experiment. In a first step, demographic information was collected: age, gender, native language, use of neuroleptics, and educational level. Then, the experiment proper began. The participants were randomly assigned to one of the two encoding conditions: “personal survival in the grasslands” or “pleasantness”. Next, the instructions were given for the rating task, which was presented on the computer screen.

For the survival-predation rating task, the participants were asked to imagine that they were stranded in the grasslands of a foreign land without any basic survival materials and told that over the next few months, they would need to protect themselves against predators. In the pleasantness condition, the participants had to rate the words for their pleasantness. The participants in the survival-predation condition were presented with words and were told that their task was to rate the relevance of each item in the corresponding scenario on Likert scales (1 = the word is “totally irrelevant” to 5 = the word is “extremely relevant.”) by pressing a key (labeled 1 to 5) on the keyboard. A Likert scale was also used for the pleasantness condition (with 1 corresponding to “very unpleasant” and 5 to “very pleasant.”). The words were randomly presented to the participants one-by-one, centered on the screen. Stimulus presentation was self-paced, that is to say each word remained on the screen until the participant’s response. The participants were instructed to rate the words spontaneously and

were told that there were no right or wrong answers. After the encoding task, the participants were given three interfering tasks that lasted about four minutes in total: the “X-O” letter-comparison task (Salthouse et al., 1997), the “plus-minus” task from Jersild (1927) and Spector and Biederman (1976), and a barrage task in which the participants had to find a shape among a list of symbols. The surprise recall test took place immediately after the three interfering tasks. The participants had five minutes to write down the previously presented words in any order they liked. Finally, the participants were debriefed regarding the research goals. The whole experimental session lasted about twenty minutes.

Results

Two participants (one in the survival group and the other in the pleasantness group) were excluded because their mean reaction times were more than three standard deviations above the within-condition mean of the participants’ means and outside less or more 1.5 interquartile range from the median of these means. Ratings, mean reaction times and recall rates were analyzed with a two-way mixed analysis of variance including Type of Encoding (Survival scenario versus Pleasantness) as a between-participants factor and Relevance (high versus low) as a within-participants factor. In addition, pairs’ comparisons were performed when the interaction effect was significant.

Reaction times

Mean encoding times differed neither for Type of Encoding (Survival: $M = 2481.45$; Pleasantness: $M = 2434.8$), $F(1, 72) = .08, p > .1, \eta_p^2 = .001$, nor for Relevance (High: $M = 2423.38$, Low: $M = 2492.87$), $F(1, 72) = 1.21, p > .1, ; \eta_p^2 = .017$. There was no interaction effect, $F(1, 72) = .02, p > .1, \eta_p^2 < .001$.

Ratings

The main effects of Type of Encoding, $F(1, 72) = 9.09, p < .01, \eta_p^2 = .112$, (Survival: $M = 2.85$, Pleasantness: $M = 3.1$) and Relevance, $F(1, 72) = 412.27, p < .001, \eta_p^2 = .851$,

(High: $M = 3.46$, Low: $M = 2.48$) were significant. Importantly, there was also a reliable interaction between the two factors, $F(1, 72) = 633.34, p < .001, \eta_p^2 = .898$. In the survival scenario, high-relevance words ($M = 3.94$) were given higher ratings than low-relevance words ($M = 1.75$), $t(72) = 32.15, p < .001, \delta = 5.31^7$ whereas the reverse was true in the pleasantness condition ($M = 2.98$ and $M = 3.21$), albeit to a lesser extent, $t(72) = -3.44, p < .001, \delta = -.57$. In addition, a by-item analysis revealed that the ratings obtained in Study 1 were by and large positively correlated with those obtained here in the survival scenario ($r = .91, p < .001$) and marginally negatively correlated with the ratings given in the pleasantness condition ($r = -.34, p < .1$). It is also worth noting that the ratings obtained in the two encoding conditions were marginally negatively correlated ($r = -.32, p < .1$).

Recall rates

The recall rate was higher in the survival scenario ($M = .42$) than in the pleasantness condition ($M = .33$), $F(1, 72) = 17.65, p < .001, \eta_p^2 = .197$, and high-relevance words were recalled better ($M = .49$) than low-relevance words ($M = .25$), $F(1, 72) = 149.89, p < .001, \eta_p^2 = .676$. Importantly, as illustrated by Figure 2, the interaction between Type of Encoding and Relevance was significant, $F(1, 72) = 14.34, p < .001, \eta_p^2 = .166$, with the result that the recall advantage for the survival scenario was higher for high-relevance words (Survival: $M = .57$, Pleasantness: $M = .41, t(72) = 5.23, p < .001, \delta = 1.32$) than for low-relevance words, for which the difference between the two encoding conditions was not reliable (Survival: $M = .26$, Pleasantness: $M = .24, t(72) = .65, p > .1, \delta = .14$). It should also be noted that the “relevance advantage” was found in the survival scenario, $t(72) = 11.34, p < .001, \delta = 2.49$,

⁷ In order to describe the changes in the original scores (and not in the within-subjects metric, which depends on difference scores), all the reported δ were computed as the ratio of the difference between the observed means over the square root of the mean square error obtained as if a between-participants design had been used (see, e.g. Kline, 2013, p. 199).

and though it was not expected, it was also found in the pleasantness condition, $t(72) = 5.98$, $p < .001$, $\delta = 1.32$.

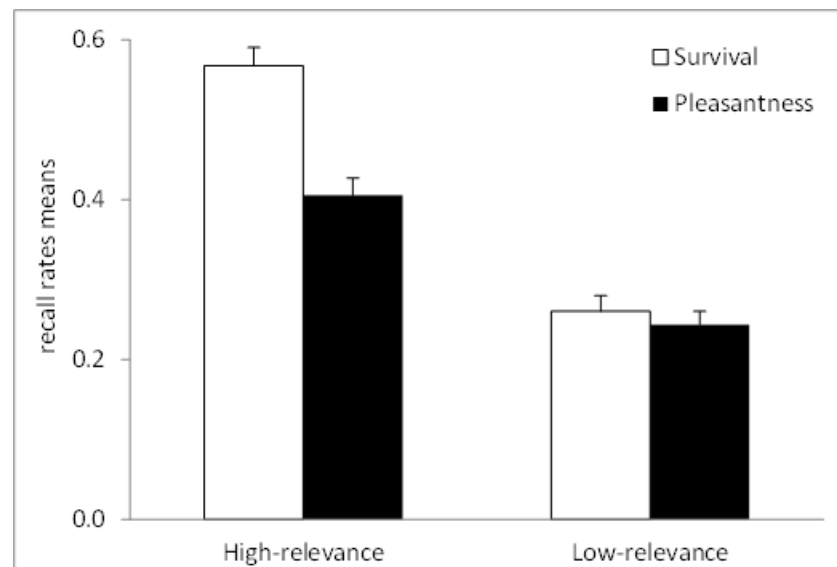


Figure 2. Means and standard errors of recall rates as a function of Type of Encoding (Survival-predation versus Pleasantness) and Relevance (High-relevance versus Low-relevance words) in Experiment 1.

Finally, the numbers of intrusions were low and nearly the same in the two conditions of the Type of Encoding factor (Survival: $M = .84$; Pleasantness: $M = .82$).

Experiment 2. Survival processing and contamination

Method

Participants

86 students (Mean age = 19.2 years; 74 females) at the University of xxxx took part. All were native speakers of French. None were taking medication known to affect the central nervous system. The participants received course credits for their participation. As in Experiment 1, they were randomly assigned to one of the two groups ($N = 43$ in each group, for the rationale used to determine the sample size in this experiment, see the Participants

subsection of Experiment 1), which experienced different encoding conditions (survival versus pleasantness).

Stimuli

The word list was created using the survival-related ratings collected in Study 1 and focused on the survival-related dimension of contamination. Thirty words were selected: Half of the items were rated as highly relevant for avoiding contamination and the remaining half were rated as being of little relevance on this survival-related dimension (see Supplemental Material for the list of the words used in Experiment 2). Both types of item were matched on the same set of variables as described in Experiment 1, namely number of letters and syllables, film subtitle and book frequencies, subjective frequency, imageability, concreteness and emotional valence. We also controlled for conceptual familiarity and AoA, but these latter values were calculated based on the 12 values and 14 values which were available for conceptual familiarity and AoA, respectively. The sources of the values corresponding to these variables were the same as those described in Study 1. The statistical characteristics of the words are provided in Table 1E of the Supplemental Material.

Apparatus and Procedure

These were the same as in Experiment 1. The only exception was that the participants in the survival scenario were told to rate words for their relevance “for protecting against contamination”.

Results

Four participants, two in each condition, were excluded because one or two of their rating means were more than three standard deviations above or below the within-condition mean of the participants’ means and outside less or more 1.5 interquartile range from the median of these means. The same analyses as those run in Experiment 1 were performed.

Reaction times

The main effect of Type of Encoding on reaction times was not significant, $F(1, 80) = .01, p > .1, \eta_p^2 < .001$ (Survival: $M = 2323.5$, Pleasantness: $M = 2339.79$). The main effect of Relevance was significant, $F(1, 80) = 6.05, p < .05, \eta_p^2 = .07$, with high-relevance words taking more time to be rated ($M = 2399.41$) than low-relevance words ($M = 2263.88$). There was no interaction effect, $F(1, 80) = .59, p > .1, \eta_p^2 = .004$.

Ratings

The main effects of Type of Encoding, $F(1, 80) = 35.68, p < .001 ; \eta_p^2 = .308$, and Relevance, $F(1, 80) = 162.57, p < .001, \eta_p^2 = .67$, were significant. As found in Experiment 1, the mean rating was lower in the survival scenario ($M = 2.64$) than in the pleasantness condition ($M = 3.06$) and the ratings for high-relevance words ($M = 3.29$) were higher than for low-relevance words ($M = 2.41$). The interaction effect was reliable, $F(1, 80) = 346.53, p < .001 ; \eta_p^2 = .812$, and, similarly to Experiment 1, high-relevance words were rated higher in the survival scenario ($M = 3.71$) than low-relevance words ($M = 1.57$), $t(80) = 22.18, p < .001, \delta = 4.82$, whereas the opposite was found in the pleasantness condition ($M = 2.86$ and $M = 3.26$ for high and low-relevance words respectively) although the difference was smaller, $t(80) = -4.15, p < .001, \delta = -.9$. In addition, the ratings obtained in Study 1 were strongly positively correlated with those obtained in the survival scenario in the current experiment ($r = .94, p < .001$). As in Experiment 1, they were also marginally negatively correlated with the ratings obtained in the pleasantness condition ($r = -.35, p < .1$). The correlation between the ratings obtained in the two encoding conditions was also negative but not significant ($r = -.29, p > .1$).

Recall rates

The survival scenario yielded higher recall rates ($M = .39$) than the pleasantness condition ($M = .34$), $F(1, 72) = 17.65, p < .001, \eta_p^2 = .05$. A main effect of Relevance was also found, with high-relevance words ($M = .51$) being recalled better than low-relevance words

($M = .21$), $F(1, 80) = 220.56$, $p < .001$, $\eta_p^2 = .734$. As in Experiment 1, the interaction between Type of Encoding and Relevance was significant, $F(1, 80) = 5.28$, $p < .05$, $\eta_p^2 = .062$, indicating that the recall advantage in the survival scenario was greater for highly survival-related words, $t(80) = 2.77$, $p < .01$, $\delta = .67$, than for low-relevance words, for which the difference was not significant, $t(80) = .12$, $p > .1$, $\delta = .02$ (Figure 3). Moreover, as found in Experiment 1, the recall advantage of high- over low-relevance words was significant not only in the survival scenario, $t(80) = 12.13$, $p < .001$, $\delta = 2.43$, but also in the pleasantness condition, $t(80) = 8.88$, $p < .001$, $\delta = 1.78$. There were a small number of intrusions in the two encoding conditions (Survival: $M = .91$, Pleasantness: $M = .86$).

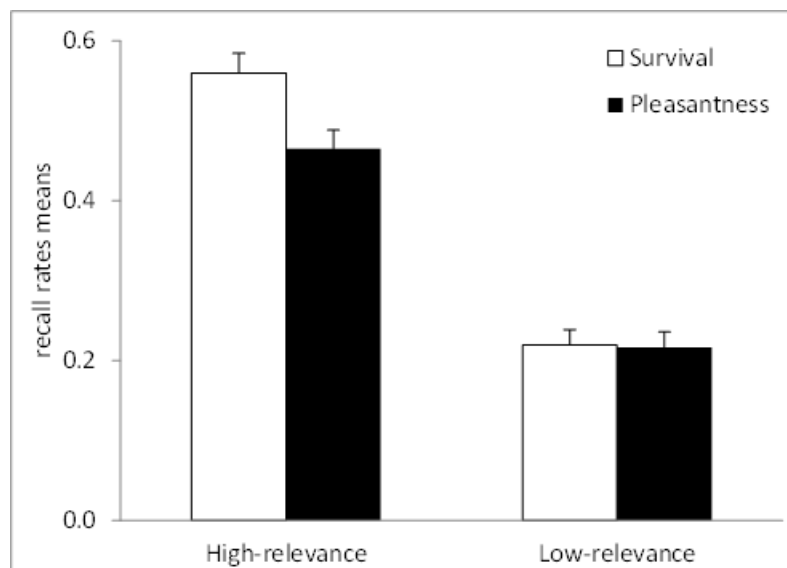


Figure 3. Means and standard errors of recall rates as a function of Type of Encoding (Survival-contamination versus Pleasantness) and Relevance (High-relevance versus Low-relevance words) in Experiment 2.

Experiment 3. Survival processing and finding food/water

Method

Participants

Ninety students (Mean age = 19.8 years; 71 females) at the University of xxxx took part. All were native speakers of French. None were taking medication known to affect the central nervous system. The participants received course credits for their participation. As in Experiment 1, they were randomly assigned to one of the two groups (N = 45 in each group for the rationale used to determine the sample size in this experiment, see the Participants subsection of Experiment 1), which experienced different encoding conditions (survival versus pleasantness).

Stimuli

The word list was created using the survival-related ratings collected in Study 1 with respect to the survival-related dimension of food and water supplies. Thirty words were selected: Half of the items were rated as highly relevant for ensuring food and water supplies and the remaining half were rated as low on this survival-related dimension. The list of the words used in Experiment 3 is available in the Supplemental Material. Both types of item were matched on the same set of variables as described in Experiment 1. More precisely, we controlled for the number of letters and syllables, film subtitle and book frequencies, subjective frequency, imageability, concreteness and emotional valence. Conceptual familiarity was controlled for (calculated from 12 values) as was AoA (calculated from 14 values). As in the previous experiments, the sources of the values corresponding to these variables were the same as those reported in Study 1. The statistical characteristics of the words are provided in Table 1F of the Supplemental Material.

Apparatus and Procedure

These were the same as in Experiments 1 and 2. The only exception was that the participants in the survival scenario were told to rate the words for their relevance “for ensuring food and water supplies”.

Results

One participant was excluded from the survival condition because her/his mean ratings were three standard deviations above the within-condition mean of the participants' means and outside less or more 1.5 interquartile range from the median of these means. The same analyses as those run in Experiments 1 and 2 were performed.

Reaction times

The main effect of Type of Encoding on reaction times was not significant, $F(1, 87) = 1.29, p > .1, \eta_p^2 = .015$ (Survival: $M = 2119.95$, Pleasantness: $M = 2246.99$). The main effect of Relevance was significant, $F(1, 87) = 8.78, p < .01, \eta_p^2 = .092$, with high-relevance words taking longer to be encoded ($M = 2245.01$) than low-relevance words ($M = 2121.93$). There was no interaction effect, $F(1, 87) = .2, p > .1, \eta_p^2 = .002$.

Ratings

The main effects of Type of Encoding, $F(1, 87) = 17.29, p < .001 ; \eta_p^2 = .166$, and Relevance, $F(1, 87) = 359.73, p < .001, \eta_p^2 = .805$, were significant. As found in the previous experiments, the mean rating was lower in the survival scenario ($M = 2.99$) than in the pleasantness condition ($M = 3.26$) and there were higher ratings for high-relevance words ($M = 3.69$) than for low-relevance words ($M = 2.56$). The interaction effect was reliable, $F(1, 87) = 382.43, p < .001 ; \eta_p^2 = .815$, with higher ratings given to high-relevance words ($M = 4.14$) than to low-relevance words ($M = 1.83$), $t(87) = 27.09, p < .001, \delta = 5.47$, in the survival scenario, whereas the difference between the two types of words was not significant in the pleasantness condition, $t(87) = -.42, p > .1, \delta = -0.08$ ($M = 3.25$ and $M = 3.28$, for high and low-relevance words, respectively). In addition, the ratings obtained in the survival scenario in the current experiment were strongly positively correlated with those obtained in Study 1 ($r = .95, p < .001$), whereas the ratings obtained in the pleasantness condition were not significantly correlated with those obtained in the survival condition ($r = -.13, p > .1$) or in Study 1 ($r = -.05, p > .1$).

Recall rates

The survival scenario yielded higher recall rates ($M = .44$) than the pleasantness condition ($M = .32$), $F(1, 87) = 32.56, p < .001, \eta_p^2 = .272$. A main effect of the relevance factor was also found, with high-relevance words ($M = .47$) being recalled better than low-relevance words ($M = .29$), $F(1, 87) = 132.66, p < .001, \eta_p^2 = .604$. The interaction between Type of Encoding and Relevance (see Figure 4) was significant, $F(1, 87) = 5.89, p < .05, \eta_p^2 = .063$, with the survival advantage being larger for high-relevance words, and with pairs comparisons indicating that this advantage was reliable for high-relevance words, $t(87) = 6.37, p < .001, \delta = 1.28$, and in this case, also for low-relevance words, $t(87) = 3.1, p < .01, \delta = .69$. In addition, the effect of the relevance factor was again larger in the survival scenario than in the pleasantness condition, but was significant in both conditions, $t(87) = 9.81, p < .001, \delta = 1.71$, and $t(87) = 6.46, p < .001, \delta = 1.12$.

The numbers of intrusions were low in both encoding conditions (Survival: $M = .82$, Pleasantness: $M = .44$).

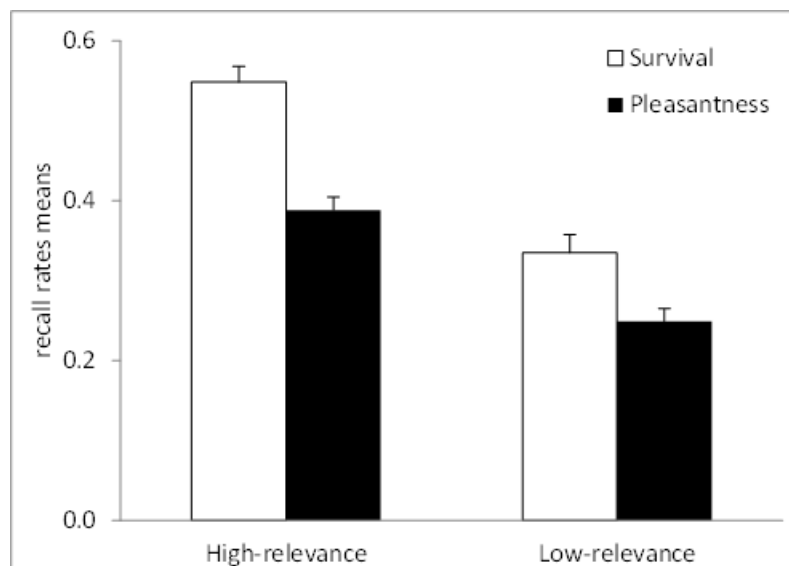


Figure 4. Means and standard errors of recall rates as a function of Type of Encoding (Survival-food and water versus Pleasantness) and Relevance (High-relevance versus Low-relevance words) in Experiment 3.

Combined analyses

The findings from Experiments 1-3 suggest that the survival processing advantage is moderated by the relevance of the items to survival issues (high versus low relevance). In order to compare the survival effect size estimations obtained in the high and low-relevance conditions with the values that can be expected given Scofield et al.'s (2018) between-subjects designs (η_p^2 between .06 and .09), we computed η_p^2 separately for each survival context and type of word. For high-relevance words, the survival effect sizes were largely above the expected values in both the predator ($\eta_p^2 = .273$) and finding food and water ($\eta_p^2 = .318$) contexts, whereas with an η_p^2 equal to .087, the effect size in the contamination context was at the top of the range. The opposite was found for low-survival-relevance words in both the predator and the contamination contexts ($\eta_p^2 = .006$ and $\eta_p^2 < .001$). However, the survival effect was higher than expected in the food-and-water survival context ($\eta_p^2 = .1$).

One further issue which deserves some attention is related to the possibility that the differences in the survival effects were moderated by the type of survival problem. An ANOVA including Type of survival problem (predation versus contamination versus food and water) and Type of encoding (survival versus control) as between-participants factors and Relevance as a within-subjects independent variable revealed that the three-way interaction was not significant, $F(2, 239) = 1.02, p > .1, \eta_p^2 = .008$. It is not therefore possible to take a stance on this possibility. It is important to stress that the interaction effect between Type of survival problem and Type of encoding was also not significant, $F(2, 239) = 2.9, p > .05, \eta_p^2 = .024$, suggesting that the differences in the survival effects obtained in the three different types of survival problem were low (this outcome was expected given the within analyses reported above). The interaction between Type of encoding and Relevance was significant,

$F(1, 239) = 24.58, p < .001, \eta_p^2 = .093$, as was the interaction between Type of survival problem and Relevance, $F(2, 239) = 11.15, p < .001, \eta_p^2 = .085$.

General Discussion

Adopting an evolutionary approach to the study of memory, Nairne and colleagues were the first to report a survival processing advantage, which corresponds to the observation that information processed in relation to survival is remembered better than information not processed for its fitness value (Nairne et al., 2007). Survival processing has been qualified as “(...) *one of the best—if not the best—encoding procedures yet identified in human memory research (...)*” (Nairne et al. 2008, p. 180). In the present research, we attempted to address an issue which, in our view, remains unsettled in the survival processing paradigm, namely the role played by the fitness-relevance of the items with survival scenarios in survival effects in memory. To address this issue further, we first collected ratings on a set of 732 French words for three survival-related dimensions. Participants were asked to rate words for their relevance for “finding food and water”, “avoiding predators” or “avoiding contamination” when in the hypothetical situation of being stranded in the grasslands of a foreign land. From a general standpoint, normative studies are useful because they permit the control—methodological or statistical—of the potential influence of confounding variables when investigating a specific variable in a given task involving the processing of words. Three memory experiments were then designed using these ratings to test whether free recall performance would be modified by the level of relevance of the words to the survival scenarios.

The main findings from the rating data of Study 1 can be easily summarized. First of all, and in the same way as reported by Alonso et al. (2021), we found that the ratings of the words in the three survival-related dimensions of “food and water”, “predation”, and “contamination” were highly reliable, indicating that people mostly agree on the words that

are highly, or in contrast less, related to these specific survival-related dimensions. In addition, the high correlations found between the ratings provided in Study 1, and the ratings obtained for the same dimensions for limited subsets of words in the experiments of Study 2, also argue in favor of the reliability of the current survival-related ratings. Second, the three survival-related dimensions were positively correlated. As claimed earlier, this finding is important from a practical point of view insofar as it indicates that researchers can easily select—depending on their research aims—words that either are or are not related to survival in general when designing their experiments. The findings from Study 1 also provide important information about the relationships between survival-related dimensions and other psycholinguistic variables. Concerning the “finding food and water” dimension, the findings were generally in line with those of Alonso et al. (2021) in Spanish, with survival-related words having psycholinguistic properties that make them more concrete, more imageable, more likely to be early-acquired, and shorter, whereas no reliable relation was observed with objective frequency. In contrast to the “finding food and water” ratings, contamination ratings had the same properties but with, however, a significant positive relation with objective frequency as well as with subjective frequency and conceptual familiarity. As far as predation ratings are concerned, a positive relation was found with objective word frequency (even when several other dimensions were controlled for) as was a salient positive relation with arousal. A recent study has provided evidence that words that are acquired early in life, that are more concrete, and that are also more emotional have better chance to survive retellings (Li et al., 2022). Because it is vital for humans, as “ultra-social animals”, to have words to communicate fitness-related information (Tomasello, 2014), it may well be no coincidence that fitness-related words possess certain of these psycholinguistic properties. Having these properties make these words easier to learn and produce and, indeed, it has been found that early-acquired words are produced more quickly and more accurately than late-acquired

words (Elsherif et al., 2023; Juhasz, 2005 for reviews), that concrete words are easier to learn than more abstract words (de Groot & Keijzer, 2000), and that emotional words are remembered better than more neutral ones (Kensinger & Corkin, 2003).

One question worth asking concerning the survival-related ratings is whether animate words were more numerous than inanimate words at the highest levels of the relevance ratings. In effect, recent work has shown that animates (e.g., *cow*) are remembered better than inanimates (e.g., *mountain*). The animacy advantage is now well-documented in the literature (e.g., Bonin et al., 2014; Nairne et al., 2013; VanArsdall et al., 2013). The ultimate explanation of animacy effects is that animates are of greater fitness value than inanimates. The analyses revealed that animate words were rated as more relevant than inanimates in the “finding food and water” ratings, while the opposite was found for both the “avoiding predators” and “avoiding contamination” ratings. Because animates are remembered better than inanimates, the animacy dimension is potentially a confounding factor that affects the selection of strongly versus weakly survival-related “food and water” words in studies of the “food and water” survival advantage (see below for a discussion of this issue for the current recall data).

Some readers might wonder whether the contamination ratings were impacted by the COVID pandemic. This question makes sense in the light of recent research showing that adult valence ratings for words were altered by the pandemic (Kyröläinen et al., 2022). More precisely, using a highly comparable dataset collected before the pandemic, this study revealed a drop in the average valence ratings obtained from native English speakers during the 2021 COVID pandemic period. In the present study, the ratings on the three survival-dimensions were collected between December 2020 and January 2021, a period during which the pandemic was in an acute phase in xxxx (e.g., a national lockdown took place in xxxx from November until mid-December 2021; no vaccine was available). It is therefore likely

that the ratings on contamination were impacted by the COVID pandemic. For instance, the positive correlation between “contamination” ratings and subjective frequency measures may be related to the fact that the fear of being ill was very salient during that period in xxxx, when people were being told to be very careful when visiting older family members (e.g., wear a mask, maintain a physical distance). However, given that no pre-pandemic contamination ratings are available, it is not possible to say whether and exactly how contamination ratings might have been impacted. At a practical level, we think that the ratings will be useful for future studies on memory by making it possible to control for verbal stimuli.

The main findings from the three memory experiments were that (1) The fitness-relevance of words plays a role in memory, irrespective of whether the words are encoded for survival or for pleasantness; (2) A large advantage for survival over pleasantness was found with the high-relevance words but not with the low-relevance words. It is important to note that the latter finding is actually opposite to what has been found in certain previous studies which have reported a larger survival advantage for words judged to be of low relevance than for words judged to be of high relevance (e.g., Kroneisen et al., 2013, 2014, 2016, 2022)⁸. Indeed, we found a reliable survival effect with low-relevance words only when processing was oriented toward the survival issue of finding food and water, and not when it was related to either predation or contamination. Nairne and Pandeirada (2010) have claimed that “(...) *any stimulus bathed in the spotlight of survival processing will receive some kind of mnemonic boost.*” (p.18) but this claim is not fully supported by the current findings. In

⁸ Two concerns can be raised regarding the observation of a potentially larger survival effect at lower than at higher relevance ratings in certain of the Kroneisen et al. (2014, 2016) studies that are comparable to ours. First of all, a close examination of the studies by Kroneisen et al. (2014, 2016) in which the survival effect was the highest for words rated as being least relevant reveals that the mean relevance ratings were close to the center of the rating scale (= 3) with relatively low standard deviations, an observation suggesting that extreme scores (e.g., 1 and 5) were given to only very few words. Second, computing a survival advantage for each relevance rating level is questionable given that, for any given word, the ratings were probably not the same in the survival condition and in the control condition, respectively (e.g., a word rated 1 (or 5) in the survival scenario is probably not rated 1 (or 5) in the control condition). Words rated 1 or 5 in one encoding condition therefore have different properties in the other encoding condition.

effect, Experiments 1 and 2 revealed no reliable survival effects in memory when words were rated low on the survival dimensions of predation and contamination. It was only with the survival problem of finding food and water that a survival processing advantage was obtained with low-relevance words. It is important to stress that this latter finding is not due to the fact that the words selected for the low-relevance condition in Experiment 3 were somehow higher on this survival-related dimension compared to the other two survival-related dimensions investigated in Experiments 1 and 2. At present, we are not able to provide a satisfactory explanation for the observation of a survival advantage with low-relevance words in Experiment 3. It nevertheless suggests that the “spotlight of survival processing” is “brighter” for the survival issue of food and water than for that of predation or contamination. In other words, perhaps many more different functions are derived from words when the survival problem is related to finding food and water than when other survival issues such as predation or contamination are concerned, with the result that their retrieval is subsequently facilitated. It is clear that future studies are needed to investigate this issue further. Our findings suggest that Nairne and Pandeirada’s (2010) claim that any information “bathed in the spotlight of survival” benefits from a mnemonic enhancement may have been too strong. Finally, it is important to stress that the use of rating scales is not a necessary prerequisite for observing a survival processing advantage in memory. Indeed, several studies have reported a survival processing advantage without using rating scales during the encoding tasks (Nairne et al., 2019; Otgaar et al., 2013).

The recall rates in the pleasantness condition deserve some comments. In all three memory experiments, we found that the recall rates in the pleasantness (control) condition were higher for words that were a priori rated high on survival than for words that were rated low. Indeed, this observation reminds us of an earlier finding obtained by manipulating the animacy dimension of the words. As already mentioned, animates are more important for

fitness than inanimates since they refer to animals or persons and can therefore be potential predators, prey, or rivals (see Nairne et al., 2017, for a review on animacy effects in memory). Gelin et al. (2017) asked participants to encode words for their pleasantness, with half of the words being animates and the remaining half inanimates. Animates were recalled better than inanimates in this encoding condition (as well as in other encoding conditions such as a tour guide or intentional learning condition). This finding led the authors to suggest that animacy effects in memory are independent of the encoding instructions. Here, the same finding was obtained in the pleasantness condition for items having high fitness values on the dimensions of “avoiding predators”, “avoiding contamination” and “finding food/water” and, importantly, for inanimate items.

At a proximate level, the higher memorability of words rated high on survival-related dimensions in the pleasantness condition suggests that these words are able to generate richer memory traces than words rated low on survival (which facilitates their later retrieval). It should be remembered that the difference between the two sets of words cannot be attributable to variables such as imageability, concreteness and emotional valence because these variables were controlled for. Given that arousal has been found to boost memory (e.g., Kensinger & Corkin, 2003; Madan, 2021), it is possible that it is arousal that increased the level of recall of fitness-relevant words in the three memory experiments. Unfortunately, ratings of arousal were not available for all the words used in the memory experiments. Referring to the Bonin et al. (2018) normative study enabled us to find arousal values for only a few of the words (for 8 low- and 9 high-relevance words in Experiment 1; for 10 and 6 of the low- and high-relevance words, respectively, in Experiment 2, and for 10 low- and 10 high-relevance words in Experiment 3). The analyses performed on these words revealed that the mean arousal score was higher for high- than for low-relevance words (2.89 and 2.37, $p = .022$) in the “predation” experiment, whereas the opposite finding was observed in

Experiment 2 (high = 2.23, low = 2.34) and Experiment 3 (high = 2.36, low = 2.40) and the differences were not significant, ($ps > .1$). Thus, even though it cannot be excluded that arousal played a role in the better memorability of words of high survival relevance in Experiment 1 (and it should be recalled that the normative study revealed that arousal was a reliable predictor of predation relevance scores), this does not seem to be the case for the other experiments, especially in the light of the normative study, which indicates that the correlations between arousal ratings and both contamination and food/water relevance scores are low and not reliable.

One aspect of our data deserves some comment because it is related to the issue of elaboration, which has been proposed as one proximate mechanism involved in the survival processing advantage (e.g., Bell et al., 2015; Kroneisen & Erdfelder, 2011; Röer et al., 2013; Wilson, 2016). Kroneisen and Erdfelder (2011) claimed that when the number of survival problems in a scenario is reduced, there is less room for elaboration and distinctive encoding. As a result, one should observe a decrease in the recall rates compared to the original survival scenario including the three survival problems. Indeed, in Kroneisen and Erdfelder's (2011) study, when the survival scenario was reduced to "finding drinking water", the survival processing advantage for this short survival scenario compared to the moving scenario was not significant. However, the present findings and those of Nairne and Pandeirada (2010) tell a different story: A survival processing advantage is also found when only one survival problem is included in the survival scenario, be it "protection from predators", "avoiding contamination" or "finding food and water".

Limitations

It is important to acknowledge some limitations of the present work in order to help and guide future research. Our sample of participants consisted overwhelmingly of psychology students who were also mostly females, and it is justifiable to ask whether our

findings would be similar with participants taken from more diverse populations and with a more balanced sex-ratio. It is worth stressing that there is no evidence to date that the survival processing advantage is different between females and males (Nairne et al., 2009). In all three experiments, we used “pleasantness” as a control condition because this condition has been used as a benchmark control condition in many studies investigating survival effects in memory (Nairne et al., 2019). However, we are aware that future studies should investigate relevance effects in the survival processing paradigm using non-survival scenarios such as moving abroad. Of course, the use of such control conditions would make it necessary to collect ratings for non-survival scenarios, thus complicating the design of such experiments.

Conclusion

We have provided ratings for a subset of 732 French words for three survival-related dimensions. Based on these ratings, we designed three memory experiments which suggested that the fitness-relevance of words plays a role in memory when encoded either for survival or for pleasantness, with high-relevance words being recalled better than low-relevance words. Also, a larger survival processing advantage is found with words rated high on survival-related dimensions. Beyond this memory phenomenon, the ratings should be very useful to researchers investigating episodic memory.

References

- Alario, X., & Ferrand, L. (1999) A set of 400 pictures standardized for French : Norms for name agreement, image agreement, familiarity, visual complexity, image variability, and age of acquisition, *Behavior Research Methods, Instruments, and Computers*, 31(3), 531–552. <https://doi.org/10.3758/BF03200732>
- Alonso, M. A., Díez, E., & Fernandez, A. (2021). A set of 750 words in Spanish characterized in two survival-related dimensions: Avoiding death and locating nourishment. *Behavior Research Methods*, 53(1), 153–166. <https://doi.org/10.3758/s13428-020-01434-z>
- Aslan, A., & Bäuml, K.-H. T. (2012). Adaptive memory: Young children show enhanced retention of fitness-related information. *Cognition*, 122(1), 118–122. <https://doi.org/10.1016/j.cognition.2011.10.001>
- Bell, R., Röer, J. P., & Buchner, A. (2015). Adaptive memory: Thinking about function. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 41(4), 1038–1048. <https://doi.org/10.1037/xlm0000066>
- Bonin, P., Gelin, M., & Bugajska, A. (2014). Animates are better remembered than inanimates: Further evidence from word and picture stimuli. *Memory & Cognition*, 42(3), 370–382. <https://doi.org/10.3758/s13421-013-0368-8>
- Bonin, P., Gelin, M., Laroche, B., & Méot, A. (2020). “Survival processing of the selfish gene?”: Adaptive memory and inclusive fitness. *Evolutionary Psychological Science*, 6(2), 155–165. <https://doi.org/10.1007/s40806-019-00220-1>
- Bonin, P., Méot, A., & Bugajska, A. (2018). Concreteness norms for 1,659 French words: Relationships with other psycholinguistic variables and word recognition times. *Behavior Research Methods*, 50(6), 2366–2387. <https://doi.org/10.3758/s13428-018-1014-y>

- Bonin, P., Méot, A., Aubert, L., Malardier, N., Niedenthal, P., & Capelle-Toczek, M.-C. (2003). Normes de concrétude, de valeur d'imagerie, de fréquence subjective et de valence émotionnelle pour 866 mots [Concreteness, imageability, subjective frequency and emotional valence norms for 866 words]. *L'Année Psychologique*, *103*(4), 655–964. <https://doi.org/10.3406/psy.2003.29658>
- Bonin, P., Méot, A., Ferrand, L., & Bugajska, A. (2015). Sensory experience ratings (SERs) for 1,659 French words: Relationships with other psycholinguistic variables and visual word recognition. *Behavior Research Methods*, *47*(3), 813–825. <https://doi.org/10.3758/s13428-014-0503-x>
- Bonin, P., Peereman, R., Malardier, N., Méot, A., & Chalard, M. (2003). A new set of 299 pictures for psycholinguistic studies: French norms for name agreement, image agreement, conceptual familiarity, visual complexity, image variability, age of acquisition, and naming latencies. *Behavior Research Methods, Instruments, & Computers*, *35*(1), 158–167. <https://doi.org/10.3758/bf03195507>
- Bonin, P., Thiebaut, G., Witt, A., & Méot, A. (2019). Contamination is “good” for your memory! Further evidence for the adaptive view of memory. *Evolutionary Psychological Science*, *5*(3), 300–316. <https://doi.org/10.1002/acp.3604>
- Bugajska, A., Mermillod, M., & Bonin, P. (2015). Does the thought of death contribute to the memory benefit of encoding with a survival scenario?. *Memory*, *23*(2), 213–232. <https://doi.org/10.1080/09658211.2014.881881>
- Butler, A. C., Kang, S. H., & Roediger III, H. L. (2009). Congruity effects between materials and processing tasks in the survival processing paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *35*(6), 1477–1486. <https://doi.org/10.1037/a0017024>

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*(1), 155–159.

<https://doi.org/10.1037/0033-2909.112.1.155>

Cohen, J. D., MacWhinney, B., Flatt, M., & Provost, J. (1993). PsyScope: An interactive graphic system for designing and controlling experiments in the psychology laboratory using Macintosh computers. *Behavior Research Methods, Instruments & Computers*, *25*(2), 257–271. <https://doi.org/10.3758/BF03204507>

Cook, A. M., Klin, C. M., & Westerman, D. L. (2023). Surviving with story characters: What do we remember? *Memory & Cognition*. <https://doi.org/10.3758/s13421-022-01391-2>

Craik, F. I. M., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. *Journal of Experimental Psychology: General*, *104*(3), 268–294. <https://doi.org/10.1037/0096-3445.104.3.268>

Cunningham, S. J., Brady-Van den Bos, M., Gill, L., & Turk, D. J. (2013). Survival of the selfish: Contrasting self-referential and survival-based encoding. *Consciousness and Cognition*, *22*(1), 237–244. <https://doi.org/10.1016/j.concog.2012.12.005>

de Groot, A. M. B., & Keijzer, R. (2000). What is hard to learn is easy to forget: The roles of word concreteness, cognate status, and word frequency in foreign-language vocabulary learning and forgetting. *Language Learning*, *50*(1), 1–56. <https://doi.org/10.1111/0023-8333.00110>

Elsherif, M. M., Preece, E., & Catling, J. C. (2023). Age-of-acquisition effects: A literature review. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. Advance online publication. <https://doi.org/10.1037/xlm0001215>

Erdfelder, E., & Kroneisen, M. (2014). Proximate cognitive mechanisms underlying the survival processing effect. In B. L. Schwartz, M. Howe, M. Toggia, & H. Otgaar (Eds.), *What is adaptive about adaptive memory?* (pp. 172–198). New York: Oxford University Press. <https://doi.org/10.1093/acprof:oso/9780199928057.001.0001>

- Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavioral Research Methods*, *39*(2), 175-91. <https://doi.org/10.3758/bf03193146>.
- Gelin, M., Bugajska, A., Méot, A., & Bonin, P. (2017). Are animacy effects in episodic memory independent of encoding instructions? *Memory*, *25*(1), 2-18. <https://doi.org/10.1080/09658211.2015.1117643>
- Gelin, M., Bugajska, A., Méot, A., Vinter, A., & Bonin, P. (2019). Animacy effects in episodic memory: Do imagery processes really play a role? *Memory*, *27*(2), 209-223. <https://doi.org/10.1080/09658211.2018.1498108>
- Hou, C., & Liu, Z. (2019). The survival processing advantage of face: The memorization of the (un)trustworthy face contributes more to survival adaptation. *Evolutionary Psychology*, *17*(2):1474704919839726. <https://doi.org/10.1177/1474704919839726>
- James, G., Witten, D., Hastie, T., & Tibshirani, R. (2021). *An Introduction to Statistical Learning: With Applications in R* (2nd ed. 2021). Springer-Verlag New York Inc.
- Jersild, A. T. (1927). Mental set and shift. *Archives of Psychology*, *89*, 5–82.
- Juhasz, B. J. (2005). Age-of-Acquisition effects in word and picture identification. *Psychological Bulletin*, *131*(5), 684–712. <https://doi.org/10.1037/0033-2909.131.5.684>
- Kang, S. H. K., McDermott, K. B., & Cohen, S. M. (2008). The mnemonic advantage of processing fitness-relevant information. *Memory & Cognition*, *36*(6), 1151–1156. <https://doi.org/10.3758/MC.36.6.1151>
- Kensinger, E. A., & Corkin, S. (2003). Memory enhancement for emotional words: Are emotional words more vividly remembered than neutral words? *Memory & cognition*, *31*(8), 1169–1180. <https://doi.org/10.3758/bf03195800>

- Kline, R. B. (2013). *Beyond significance testing: Reforming data analysis methods in behavioral research* (2nd ed). Washington, DC: American Psychological Association.
- Kostic, B., McFarlan, C. C., & Cleary, A. M. (2012). Extensions of the survival advantage in memory: Examining the role of ancestral context and implied social isolation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 38(4), 1091–1098. <https://doi.org/10.1037/a0026974>
- Krause, M. A. (2015). Adaptive memory in humans from a comparative perspective. *International Journal of Comparative Psychology*, 28, Article 25667. <https://doi.org/10.46867/ijcp.2015.28.01.06>
- Kroneisen, M., & Erdfelder, E. (2011). On the plasticity of the survival processing effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 37(6), 1553–1562. <https://doi.org/10.1037/a0024493>
- Kroneisen, M., Erdfelder, E., & Buchner, A. (2013). The proximate memory mechanism underlying the survival-processing effect: Richness of encoding or interactive imagery? *Memory*, 21, 494–502. <http://dx.doi.org/10.1080/09658211.2012.741603>
- Kroneisen, M., Rummel, J., & Erdfelder, E. (2014). Working memory load eliminates the survival processing effect. *Memory*, 22, 92–102. <https://doi.org/10.1080/09658211.2013.815217>
- Kroneisen, M., Rummel, J., & Erdfelder, E. (2016). What kind of processing is survival processing? Effects of different types of dual-task load on the survival processing effect. *Memory & Cognition*, 44, 1228–1243. <https://doi.org/10.3758/s13421-016-0634-7>
- Kroneisen, M., Kriechbaumer, M., Kamp, S.-M., & Erdfelder, E. (2022). Realistic context doesn't amplify the survival processing effect: Lessons learned from Covid-19 scenarios. *Acta Psychologica*, 222, 103459. <https://doi.org/10.1016/j.actpsy.2021.103459>

- Kyröläinen, A. J., Luke, J., Libben, G., & Kuperman, V. (2022). Valence norms for 3,600 English words collected during the COVID-19 pandemic: Effects of age and the pandemic. *Behavior Research Methods*, *54*(5), 2445-2456.
<https://doi.org/10.3758/s13428-021-01740-0>
- Leding, J. K. (2019). Adaptive memory: Animacy, threat, and attention in free recall. *Memory & Cognition*, *47*(3), 383–394. <https://doi.org/10.3758/s13421-018-0873-x>
- Leding, J. K., & Toglia, M. P. (2018). Adaptive memory: Survival processing and social isolation. *16*(3), Article 1474704918789297.
<https://doi.org/10.1177/1474704918789297>
- Li, Y., Breithaupt, F., Siew, C., Hills, T., Chen, Y., & Hertwig, R. (2022). *The struggle for life among words: How cognitive selection shape language evolution*. OSF Preprints, December 7, 2022.
- Madan, C. R. (2021). Exploring word memorability: How well do different word properties explain item free-recall probability? *Psychonomic Bulletin & Review*, *28*(2), 583–595.
<https://doi.org/10.3758/s13423-020-01820-w>
- McBride, D. M., Thomas, B. J., & Zimmerman, C. (2013). A test of the survival processing advantage in implicit and explicit memory tests. *Memory & Cognition*, *41*(6), 862–871. <https://doi.org/10.3758/s13421-013-0304-y>
- McGraw, K. O., & Wong, S. P. (1996). Forming inferences about some intraclass correlation coefficients. *Psychological Methods*, *1*, 30–46. <https://doi.org/10.1037/1082-989X.1.1.30>
- Nairne, J. S. (2010). Adaptive memory: Evolutionary constraints on remembering. In B. H. Ross (Ed.), *The psychology of learning and motivation* (Vol. 53) (pp. 1–32). Burlington, MA: Academic Press. [https://doi.org/10.1016/S0079-7421\(10\)53001-9](https://doi.org/10.1016/S0079-7421(10)53001-9)

- Nairne, J. S. (2016). Adaptive memory: Fitness-relevant "tunings" help drive learning and remembering. In C. D. Geary, & B. D. Berch (Eds.), *Evolutionary Perspectives on Child Development and Education* (pp. 251–269). Springer International.
- Nairne, J. S. (2022). Adaptive education: Learning and remembering with a stone-age brain. *Educational Psychology Review*. <https://doi.org/10.1007/s10648-022-09696-z>
- Nairne, J. S., & Pandeirada, J. N. S. (2008). Adaptive memory: Remembering with a stone-age brain. *Current Directions in Psychological Science*, *17*(4), 239–243.
<https://doi.org/10.1111/j.1467-8721.2008.00582.x>
- Nairne, J. S., & Pandeirada, J. N. S. (2010). Adaptive memory: Ancestral priorities and the mnemonic value of survival processing. *Cognitive Psychology*, *61*(1), 1–22.
<https://doi.org/10.1016/j.cogpsych.2010.01.005>
- Nairne, J. S., & Pandeirada, J. N. S. (2011). Congruity effects in the survival processing paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *37*(2), 539–549. <https://doi.org/10.1037/a0021960>
- Nairne, J. S., & Pandeirada, J. N. S. (2016). Adaptive memory: The evolutionary significance of survival processing. *Perspectives on Psychological Science*, *11*(4), 496–511.
<https://doi.org/10.1177/1745691616635613>
- Nairne, J. S., Cogdill, M., & Lehman, M. (2017). Adaptive memory: Temporal, semantic, and rating-based clustering following survival processing. *Journal of Memory and Language*, *93*, 304–314. <https://doi.org/10.1016/j.jml.2016.10.009>
- Nairne, J. S., Coverdale, M. E., & Pandeirada, J. N. S. (2019). Adaptive memory: The mnemonic power of survival-based generation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *45*(11), 1970–1982. <https://doi.org/10.1037/xlm0000687>

- Nairne, J. S., Pandeirada, J. N. S., Gregory, K. J., & Van Arsdall, J. E. (2009). Adaptive memory: Fitness-relevance and the hunter-gatherer mind. *Psychological Science*, *20*(6), 740–746. <https://doi.org/10.1111/j.1467-9280.2009.02356.x>
- Nairne, J. S., Pandeirada, J. N. S., & Thompson, S. R. (2008). Adaptive memory: The comparative value of survival processing. *Psychological Science*, *19*(2), 176–180. <https://doi.org/10.1111/j.1467-9280.2008.02064.x>
- Nairne, J. S., Thompson, S. R., & Pandeirada, J. N. S. (2007). Adaptive memory: Survival processing enhances retention. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *33*(2), 263–273. <https://doi.org/10.1037/0278-7393.33.2.263>
- Nairne, J. S., VanArsdall, J. E., & Cogdill, M. (2017). Remembering the living: Episodic memory is tuned to animacy. *Current Directions in Psychological Science*, *26*(1), 22–27. <https://doi.org/10.1177/0963721416667711>
- Nairne, J. S., VanArsdall, J. E., Pandeirada, J. N. S., Cogdill, M., & LeBreton, J. M. (2013). Adaptive memory: The mnemonic value of animacy. *Psychological Science*, *24*(10), 2099–2105. <https://doi.org/10.1177/0956797613480803>
- New, B., Pallier, C., Brysbaert, M., & Ferrand, L. (2004). Lexique 2: A new French lexical database. *Behavior Research Methods, Instruments, & Computers*, *36*(3), 516–524. <https://doi.org/10.3758/BF03195598>
- Nouchi, R. (2012). The effect of aging on the memory enhancement of the survival judgment task. *Japanese Psychological Research*, *54*(2), 210–217. <https://doi.org/10.1111/j.1468-5884.2011.00483.x>
- Otgaar, H., & Smeets, T. (2010). Adaptive memory: Survival processing increases both true and false memory in adults and children. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *36*(4), 1010–1016. <https://doi.org/10.1037/a0019402>

- Otgaar, H., Howe, M. L., Smeets, T., Raymaekers, L., & van Beers, J. (2013). Memory errors in adaptive recollections. In B. L. Schwartz, M. L. Howe, M. P. Toglia, & H. Otgaar (Eds.), *What is adaptive about adaptive memory?* (pp. 201–214). Oxford University Press. <https://doi.org/10.1093/acprof:oso/9780199928057.003.0011>
- Otgaar, H., Smeets, T., & van Bergen, S. (2010). Picturing survival memories: Enhanced memory after fitness-relevant processing occurs for verbal and visual stimuli. *Memory & Cognition*, 38(1), 23–28. <https://doi.org/10.3758/MC.38.1.23>
- Packman, J. L., & Battig, W. F. (1978). Effects of different kinds of semantic processing on memory for words. *Memory & Cognition*, 6(5), 502–508. <https://doi.org/10.3758/BF03198238>
- Palmore, C. C., Garcia, A. D., Bacon, L. P., Johnson, C. A., & Kelemen, W. L. (2012). Congruity influences memory and judgments of learning during survival processing. *Psychonomic Bulletin & Review*, 19(1), 119–125. <https://doi.org/10.3758/s13423-011-0186-6>
- Roelofs, A., & Piai, V. (2017). Distributional analysis of semantic interference in picture naming. *Quarterly Journal of Experimental Psychology*, 70(4), 782–792. <https://doi.org/10.1080/17470218.2016.1165264>
- Röer, J. P., Bell, R., & Buchner, A. (2013). Is the survival-processing memory advantage due to richness of encoding? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 39(4), 1294–1302. <https://doi.org/10.1037/a0031214>
- Salthouse, T. A., Toth, J. P., Hancock, H. E., & Woodard, J. L. (1997). Controlled and automatic forms of memory and attention: Process purity and the uniqueness of Age-related influences. *The Journals of Gerontology, Series B: Psychological Sciences & Social Sciences*, 52(5), P216–P228. <https://doi.org/10.1093/geronb/52B.5.P216>

- Savine, A. C., Scullin, M. K., & Roediger III, H. L. (2011). Survival processing of faces. *Memory & Cognition*, *39*(8), 1359–1373. <https://doi.org/10.3758/s13421-011-0121-0>
- Scofield, J. E., Buchanan, E. M., & Kostic, B. (2018). A meta-analysis of the survival-processing advantage in memory. *Psychonomic Bulletin & Review*, *25*(3), 997–1012. <https://doi.org/10.3758/s13423-017-1346-0>
- Seamon, J. G., Bohn, J. M., Coddington, I. E., Ebling, M. C., Grund, E. M., Haring, C. T., & Siddique, A. H. (2012). Can survival processing enhance story memory? Testing the generalizability of the adaptive memory framework. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *38*(4), 1045–1056. <https://doi.org/10.1037/a0027090>
- Seitz, B. M., Polack, C. W., & Miller, R. R. (2020). Adaptive memory: Generality of the parent processing effect and effects of biological relatedness on recall. *Evolutionary Psychological Science*, *6*(3), 246–260. <https://doi.org/10.1007/s40806-020-00233-1>
- Spector, A., & Biederman, I. (1976). Mental set and mental shift revisited. *The American Journal of Psychology*, *89*(4), 669–679. <https://doi.org/10.2307/1421465>
- Tomasello, M. (2014). The ultra-social animal. *European Journal of Social Psychology*, *44*(3), 187–194. <https://doi.org/10.1002/ejsp.2015>
- Tse, C.-S., & Altarriba, J. (2010). Does survival processing enhance implicit memory? *Memory & Cognition*, *38*(8), 1110–1121. <https://doi.org/10.3758/MC.38.8.1110>
- VanArsdall, J. E., Nairne, J. S., Pandeirada, J. N. S., & Blunt, J. R. (2013). Adaptive memory: Animacy processing produces mnemonic advantages. *Experimental Psychology*, *60*(3), 172–178. <https://doi.org/10.1027/1618-3169/a000186>
- Wilck, A. M., & Altarriba, J. (2019). An investigation of sex differences, implicit memory, and perceptual identification in the survival memory paradigm. *Evolutionary Psychological Science*, *5*(3), 369–380. <https://doi.org/10.1007/s40806-019-00193-1>

Wilson, S. (2016). Divergent thinking in the grasslands: Thinking about object function in the context of a grassland survival scenario elicits more alternate uses than control scenarios. *Journal of Cognitive Psychology*, 28(5), 618–630.

<https://doi.org/10.1080/20445911.2016.1154860>