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Surviving in a Second Language: Survival Processing Effect in Memory of Bilinguals

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Human memory likely evolved to serve adaptive functions, that is, to help maximize our chances of survival and reproduction. One demonstration of such adaptiveness is the increased retention of information processed in survival contexts, the so-called Survival Processing Effect (SPE). This study examined this effect in a native (L1) and in a second language (L2). This comparison is relevant to explore if emotionality is involved in the SPE, as emotional activation seems to be larger in L1 than in L2. Following the original survival processing procedure, participants rated the relevance of the information presented to the survival and moving scenarios and performed a recognition (Experiment 1) or a free recall (Experiment 2) task in L1 or L2. In both experiments, the SPE was replicated in L1 but not in L2. The absence of the effect when emotional activation is less likely suggests that emotionality might play a role in the survival processing effect; nevertheless, additional studies are needed to further investigate this hypothesis.

Keywords: survival processing effect; free recall; recognition; emotion; first language; second language

Memory systems have evolved to facilitate the retrieval of information that is fitness relevant, that is, that increases our chances of survival and/or reproduction (Nairne et al., 2007). This idea has been explored using the survival processing paradigm in which participants are asked to imagine that they are stranded in the grasslands and that they need to find food, shelter and protect themselves from predators to survive. Then, they rate a list of words regarding their relevance to that survival scenario. Memory performance in a final surprise recall or recognition task is compared with the performance in other control conditions (e.g., moving scenario). Supporting the above-mentioned argument, participants recalled and recognized words better when these were previously rated for their relevance to a survival scenario than to a moving scenario or on their pleasantness –the Survival Processing Effect (SPE; Nairne et al., 2007).

The SPE has been replicated using different survival scenarios, against various control scenarios (e.g., suicide scenario, Bell et al., 2013; lottery scenario, Yang et al., 2014) and across the lifespan, particularly in explicit memory tasks (for a review see Scofield et al., 2018). Regardless of the relevance of exploring the ultimate mechanisms of memory functioning (in this case the SPE), research has also attempted to identify the underlying proximate mechanisms (Nairne & Pandeirada, 2016). Emotion is one such mechanism, but its role in the SPE remains uncertain.

To further explore whether emotionality is involved in the SPE, we compared the effect in a first (L1) and in a second language (L2). Several studies have shown that the cognitive and affective processes involved in L1 differ from those involved in L2 (see, Costa et al., 2017 for a review). These differences have been documented in clinical (e.g., Santiago-Rivera et al., 2009) and experimental (e.g., Bond & Lai, 1986) studies reporting that bilingual individuals switch to L2 when talking about negative life events or embarrassing topics, to distance themselves from the strong emotional associations of their native language. Other

studies have consistently reported that speakers' own perceptions of language emotionality are higher in L1, particularly for emotional laden language (e.g., Garrido & Prada, 2018; see Pavlenko, 2012, for a review). Memory for emotional words in L1 is also higher than in L2 (e.g., Marmolejo et al., 2015). Additionally, Keysar and colleagues (2012) showed that using a second language reduces decision-making bias suggesting that in L2, decision-making is more deliberate and less intuitive than in L1 (see Hayakawa et al., 2016, for a review). Studies indicating that information processing in L2 recruits more brain areas related to control processes than in L1 (Branzi et al., 2016) also support this idea. Recently, studies using moral dilemmas have also reported that participants using their L2 made more utilitarian decisions than those using their L1 (e.g., Hayakawa et al., 2017), arguably due to a reduction in participants' emotional concerns in L2. While most of these studies did not directly measure emotionality, other research examining the psychophysiological markers of somatic and autonomic activity has shown that emotional words (e.g., taboo words) produce higher physiological arousal when presented in L1 (see Harris, 2004). Other studies using ERP's to tap attention shifts toward words with emotional relevance revealed that L2 affective processing is less immediate than L1 (e.g., Conrad et al., 2011).

One possible explanation for these differences between L1 and L2 is the greater emotional and cognitive distance when using L2. Arguably this occurs because L1 tends to be acquired earlier and used in emotionally-rich contexts (e.g., family) while L2 is often learned in more emotionally neutral contexts (e.g., school/work) (see Caldwell-Harris, 2015; Pavlenko, 2012 for reviews).

But why are the differences between L1 and L2 potentially important for the SPE? Whereas some studies suggest that the SPE cannot be explained by the emotional characteristics of the encoding scenarios (e.g., independent emotional valence and/or arousal evaluations of the scenarios; Bell et al., 2013; 2015; Nairne & Pandeirada, 2010; Yang et al.,

2014), others seem to indicate the opposite. For example, while replicating the SPE, Fiacconi and colleagues (2015) showed that words in the survival scenario were associated with more extensive heartbeat rate deceleration, which typically reflects the initial stage of the defensive engagement. Also, survival scenarios with higher levels of arousal and threat seem to lead to larger SPEs (Fiacconi et al., 2015; Olds et al., 2014). The role of emotionality in the SPE is likely to rest on the link between emotional and cognitive processing (e.g., Conrad, et al., 2011); specifically, we argue that the higher emotionality (e.g., stress, Smeets et al., 2012; fear, Fiacconi et al., 2015; threat, Olds, et al., 2014) involved in the survival scenario (as compared to the control conditions) might enhance subsequent memory performance.

Given that the emotional activation allegedly differs when using L1 and L2, we examined the role of emotionality in the SPE in a recognition (Experiment 1) and in a free recall task (Experiment 2), by manipulating the language in which the task was presented. If the SPE depends, at least to some extent, on a higher emotional involvement, it should be observed in L1 but reduced or even eliminated in L2.

Experiment 1

Experiment 1 replicated the procedure from Nairne and colleagues (2007; Experiment 3): participants rated words in the survival and the moving scenarios and then performed a surprise recognition task. To test our specific hypothesis, some participants performed the task in L1 and others in L2.

Method

Participants. A sample of 120 participants was determined by *a priori* power analysis (G*Power) using as reference a medium to large effect size (η_p^2 = .10) and a power 1-β = 0.95. The final sample included 124 Portuguese native speakers (47 F; M_{age} = 25.54; *SD* =

7.31), who were proficient in English (M = 21. 48; SD = 2.68; Range: 16-25) (for details on the English assessment see Supplemental Material [SM]– 1). Half of the participants responded to the experiment in English (L2 group) and the remaining in Portuguese (L1 group). Participants were recruited using Prolific (www.prolific.co) and compensated with £2.

Materials and design. Stimulus materials consisted of 128 English words (from Nairne et al., 2007; Experiment 3), and their translation into Portuguese. Six new words (in L1 and L2) were used in the training phase (see SM-1).

The words were divided into 4 sets of 32 words matched for imagery, familiarity, and frequency (for details see SM-1). As in the original experiment, two of these sets (64 words) served as targets to be rated and the remaining two sets (64 words) served as distractors in the recognition task. The word sets were rotated across the two scenarios (i.e., all words were rated for survival and moving), and also used as targets and distractors. Each participant rated 32 words in the survival (S) and 32 in the moving (M) scenario; these were randomly selected from the corresponding word sets. The rating condition was blocked in trials of 16 words in the form of MSMS (29 participants in L1 and 35 in L2) or SMSM (33 in L1 and 27 in L2). Participants were randomly distributed into these conditions.

The experiment had a mixed design: Scenario (Survival vs. Moving), within-participants, and Language (L1 vs. L2), between participants.

Procedure. All procedures complied with the ethical guidelines of the host institution. Data were collected online using Qualtrics software (www.qualtrics.com). After consenting to participate, participants provided sociodemographic information (i.e., native language, age and gender) and responded to the English test. If their test score was lower than 16, participants were thanked and dismissed. Otherwise, participants proceeded to the

experimental task and were randomly assigned to one of the groups (L1 or L2). The task was exactly the same in L1 and L2, only the language in which the instructions, scenarios and words were presented was different.

The encoding instructions were as in Nairne et al. (2007) (see SM-1). After the presentation of the scenario, words were displayed one at a time at the center of the screen for 5s. Participants were asked to rate each word on a 5-point scale (1-*totally irrelevant;* 5-*extremely relevant*), presented below each word. The first two blocks began with three practice trials each.

The rating task was followed by a 4min distractor digit-recall task and then by the surprise recognition task in which participants were asked to identify if the presented word was "New" or "Old"; responses were self-paced (see full description of these tasks in SM-1).

Results

The data were analyzed using SPSS V26 and Statistica V13.3; the raw data and the syntaxes used in the reported analyses are available at OSF (https://osf.io/hqfje/?view_only=3614d0558c4e4470bd3b14361cc5d120).

Ratings. The main effect of Scenario was significant as confirmed by a two-way mixed ANOVA, $F(1,122) = 227.76$, $p < .001$, $\eta_p^2 = .651$, 95% CI [.55, .72]. Words were rated significantly higher in the survival ($M = 3.07$, $SD = 0.46$) than in the moving scenario ($M = 2.42$, $SD = 0.56$). The main effect of language and the Scenario X Language interaction were not significant, $F(1,122) = 2.00$, $p = .160$ and $F(1,122) = .038$, $p = .846$, respectively.

Recognition. Recognition hits correspond to items rated during encoding that were classified as "Old". A two-way mixed ANOVA[1] revealed a significant main effect of Scenario, $F(1,122) = 12.21$, $p = .001$, $\eta_p^2 = .091$, 95% CI [.02, .20], indicating a significantly higher recognition in the survival ($M = .90$, $SD = .11$) than in the moving condition ($M = .86$, $SD = .13$), replicating the SPE. The main effect of Language was not significant, $F(1,122) = 2.01$, $p = .159$ nor the Scenario X Language interaction, $F(1,122) = 1.21$, $p = .274$ (see Figure 1).

INSERT FIGURE 1

To specifically examine the SPE in L1 and L2, we conducted planned comparisons that revealed that while in L1 the effect was replicated, $F(1,122) = 10.55$, $p = .002$, $\eta_p^2 = .080$, 95% CI [.01, .18], correct recognition in L2 did not differ significantly between conditions, $F(1,122) = 2.87$, $p = .093$. Additionally, the observed change in the effect sizes (L1: $dz = .436$; L2: $dz = .205$), confirms how much the SPE was reduced from L1 to L2[2].

Influence of L2 proficiency on the SPE. To further test our hypotheses, we examined whether the level of proficiency affected the magnitude of the SPE in L2 (i.e., the difference between the hits proportion in each scenario: S-M). The results of a regression analysis, using the

[1] We conducted this same ANOVA also including block order as a between-subjects variable. The results revealed that the main effect of block order was not significant, $F(1, 120) = 0.546$, $p = .461$. The interactions between language and block order, scenario and block order, and scenario, language and block order were also not significant, $F(1, 120) = 1.168$, $p = .282$, $F(1, 120) = .205$, $p = .652$, and $F(1, 120) = .832$, $p = .364$, respectively. For this reason, block order was not included in the main analysis.

[2] An interaction contrast model comparing the observed group means of the four conditions as a one-way ANOVA (SL1, ML1, SL2, ML2) against the predicted pattern of means revealed a significant interaction effect, $F = 7.716$, $p = .006$ (the R script used to conduct this analysis can be found at the OSF link). Moreover, equivalence tests using as bounds Cohen's medium effect size ($dz = .50$) and the effect size obtained for the SPE in L1 ($dz = .436$) indicated that the observed effect size in L2 ($dz = .205$) was significantly within the equivalent bounds, $t(61) = -2.33$, $p = .012$, and $t(61) = -1.82$, $p = .037$, respectively, suggesting that the absence of an SPE in the L2 is reliable.

English test score as the independent variable, and the SPE as the dependent variable were not significant, β = .12, p = .366, suggesting that L2 proficiency did not moderate the SPE.

Hits and Ratings. Given the significant rating difference between scenarios, we explored whether the difference in ratings predicted the SPE in each language. The results of these regressions were not significant (L1: β = .18, p = .168, L2: β = .13, p = .322).

Experiment 2

The results from Experiment 1 suggest that emotionality might be involved in the SPE as the effect was significant in L1 only. However, reproductive memory tasks, such as recognition, are less sensitive to the influence of emotionality than constructive memory tasks, such as recall (Eich, 1995). This is arguably the case because, during recall, individuals can use their own retrieval strategies, whereas in recognition they use predetermined retrieval cues (Eich & Metcalfe, 1989). Additionally, recognition may be less dependent on language proficiency as words are available to the participants during the test. Thus, using the procedure from Nairne and colleagues (2007; Experiment 2), Experiment 2 examined the SPE in L1 and L2, with a new independent sample, using a free recall task.

Method

Participants. The required sample size, determined by *a priori* power analysis (G*Power), using as reference the smallest effect size reported in a recent meta-analysis (Scofield et al., 2018) for the SPE in free recall using within-subject designs (η_p^2 = .15), and a power 1-β = 0.95, would be 78 participants. However, because the Scenario X Language interaction in Experiment 1 was not significant, in Experiment 2 the sample size was determined by *a priori* power analysis (G*Power), using as reference a medium effect size (η_p^2 = .06; Cohen, 1988)

and a power 1-β = 0.95. With these parameters, the required sample was 208 participants. The final sample was slightly larger than predetermined (N = 226; 88 F; M_{age} = 24.80; *SD* = 6.42). All participants were Portuguese native speakers and proficient in English (*M* = 21.93; *SD* = 2.58; Range: 16-25) following the criteria used in Experiment 1. Half of the participants were randomly assigned to perform the experiment in L1 and the other half to respond in L2. Participants were recruited via Prolific and received £2 compensation.

Materials and design. Stimulus materials consisted of the 32 English words used by Nairne et al. (2007; Experiment 2), and their Portuguese translation (plus six additional words to be used during practice) (see SM-1).

The experiment had a 2x2 mixed design with Scenario (Survival vs. Moving) manipulated within participants and Language (L1 vs. L2) manipulated between participants. Each participant rated 16 words in the survival and 16 in the moving scenario (randomly drawn from the corresponding word set and presented in their corresponding language). Ratings were blocked in trials of 8 words in the form SMSM (*n* = 57 in L1; *n* = 62 in L2) or MSMS (*n* = 56 in L1; *n* = 51 in L2).

Procedure. The procedure of Experiment 1 was used with the following exceptions: the distractor digit-recall task lasted 2min and recognition was replaced by a free recall task. In the later, participants were asked to write as many words as they could remember from those they had previously rated for approximately 10min.

Results

As in Experiment 1, the data were analyzed using SPSS V26 and Statistica V13.3. The raw data and the syntaxes used in the reported analyses are available at OSF (https://osf.io/hqfje/?view_only=3614d0558c4e4470bd3b14361cc5d120).

Ratings. Participants rated the words as more relevant to the survival (M = 2.70, SD = 0.51 than to the moving scenario (M = 2.47, SD = 0.54) as denoted by a significant main effect of scenario on the two-way mixed ANOVA, $F(1,224) = 37.87$, $p < .001$, $\eta_p^2 = .145$, 95% CI [.08, .25]. The main effect of Language and the Scenario X Language interaction were not significant, $F(1,224) = .031$, $p = .861$, and $F(1,224) = 1.71$, $p = .193$, respectively.

Recall. A two-way mixed ANOVA[3] on the proportion of recall revealed a significant main effect of Scenario, $F(1,224) = 4.46$, $p = .036$, $\eta_p^2 = .020$, 95% CI [.00, .07], indicating that recall was significantly higher for the words rated in the survival (M = .43, SD = .15) than in the moving scenario (M = .41, SD = .15), replicating the SPE. The main effect of Language and the Scenario X Language interaction were not significant, F (1,224) = .442, $p = .507$ and $F(1,224) = 2.19$, $p = .140$, respectively (see Figure 2).

INSERT FIGURE 2

To test our main hypothesis, we performed planned comparisons that revealed, as expected, that the SPE was significant in L1, $F(1,224) = 6.46$, $p = .012$, $\eta_p^2 = .028$, 95% CI

[3] We conducted this same ANOVA also including block order as a between-subjects variable. The results revealed that the main effect of block order was not significant, $F(1, 222) = 0.576$, $p = .449$. The interactions between language and block order, scenario and block order, and scenario, language and block order were also not significant, $F(1, 222) = .009$, $p = .925$, $F(1, 222) = 1.914$, and $p = .147$, $F(1, 222) = .469$, $p = .494$, respectively. Therefore, block order was not included in the main analysis.

[.00, .08] but not in L2, $F(1,224) = .199$, $p = .656$. The observed change in the effect sizes (L1: $dz = .235$, L2: $dz = .042$) confirms how much the SPE was reduced from L1 to L2[4].

Influence of L2 proficiency on the SPE. To further examine the role of L2 proficiency in the SPE we conducted a regression analysis similar to that reported in Experiment 1; the result was non-significant $\beta = .021$, $p = .825$.

Recall and Ratings. Given the significant rating difference between scenarios, we explored the relation between ratings and recall as in Experiment 1. The results were not significant in L1 ($\beta = .097$, $p = .307$) and in L2 ($\beta = -.018$, $p = .846$).

General Discussion

Several studies have established a memory advantage for information when encoded in a survival scenario as compared to several other scenarios – the Survival Processing Effect. However, the role of emotion in this effect remains equivocal. This study adopted an innovative way to further examine this issue by using the survival processing paradigm in L1 and in L2. This argument rests on studies revealing that the emotional system is less recruited (e.g., Harris, 2004; Hayakawa et al., 2016) and there is a greater emotional distance when L2 is used (e.g., Keysar et al., 2012). Therefore, if the SPE depends, at least to some extent, on the emotional activation triggered by the survival condition, the lower emotionality involved in L2 should lead to a decrease, or even eliminate the SPE in L2. To test this hypothesis, we

[4] The interaction contrast model was significant, $F = 4.342$, $p = .038$ (the R script used to conduct this analysis can be found at OSF link provided earlier). The equivalence tests using as bounds the Cohen's medium effect size ($dz = .50$) and the effect size obtained for the SPE in L1 ($dz = .235$) indicated that the observed effect size in L2 ($dz = .042$) was significantly within the equivalent bounds, $t(112) = -4.87$, $p < .001$, $t(112) = -2.05$, $p = .021$, respectively, suggesting that the absence of an SPE in L2 is reliable.

investigated the SPE in L1 and in L2 using recognition (Experiment 1) and free recall tasks (Experiment 2).

The results from Experiment 1 replicated the SPE using a recognition task. While the interaction between scenario and language was not significant, the planned comparisons revealed a robust SPE in L1 but not in L2. However, recognition constitutes a form of reproductive memory that is less emotion dependent (Eich, 1995) and arguably less determined by language proficiency. To overcome this potential caveat, in Experiment 2 we employed a free recall task. Again, the SPE was replicated, the Scenario x Language interaction was not significant, but the planned comparisons revealed the effect only in L1. Together, the results from these two experiments suggest that the lower emotional activation when in L2 hinders the memory advantage in the fitness relevant context[5]. Despite the interaction between language and scenario was not significant in any of the experiments, the effect sizes decreased from L1 to L2, and the results from interaction contrast models and equivalence tests, further indicated that the SPE in L1 and its absence in L2, are reliable.

Additionally, the proficiency in L2 did not moderate the SPE in recognition or recall. Proficiency is also known to enhance lexical entrenchment (Diependaele et al., 2013), which likely leads to a more effective generation of retrieval cues when the task is performed in L1 than in L2. Moreover, some studies have argued that semantic processing in L2 appears to be cognitively more demanding than in L1 (Van den Noort et al., 2006) and that cognitive load can reduce the size of the SPE (Kroneisen et al., 2016). Likewise, it has been suggested that the survival scenario naturally affords a more elaborated processing of the rated items - the richness of encoding hypothesis (Kroneisen & Erdfelder, 2011). Taken together these assumptions would suggest that participants performing the task in L1 could be more efficient

[5] The results of two independent experiments, previously conducted with a different sampling procedure, largely replicated the ones here presented (see SM-2).

in generating these multiple cues, particularly in the survival scenario, than those performing the task in L2. However, in neither of the experiments, significant main effects of language or L2 proficiency were observed.

In both experiments, words were considered more relevant to the survival than to the moving scenario. Following a congruency argument (e.g., Nairne et al, 2007), a better fit between the words and the scenario could enhance memory performance. However, the association between relevance ratings and performance was not significant across experiments. These results challenge the congruency argument and converge with studies reporting the SPE when ratings favor the control condition (e.g., Misirlisoy et al., 2019) or when no ratings are made during encoding (e.g., Nairne et al., 2019).

Finally, while the differences in emotional processing between L1 and L2 are well documented in the literature (e.g., Conrad et al., 2011; Harris, 2004), in the current studies these differences were only inferred. Future studies using concomitant psychophysiological measures (e.g., HBR, SCR) and/or arousal ratings to directly tap emotional processes could further strengthen the reported findings.

Overall, these experiments represent a first attempt to explore the role of emotional processes in the SPE using a language manipulation. While the examination of the proximate mechanisms of the SPE is of relevance to understand the phenomenon, one should not lose sight of the importance of investigating the ultimate goals of memory functioning (Nairne & Pandeirada, 2016). Capitalizing on the argued differences in the emotionality involved in L1 and L2, our results suggest that these differences might moderate the effect. However, additional studies are required to further explore the emotional mechanisms underlying the SPE in particular, and adaptive memory in general.

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