Adaptive memory: Greater memory advantages in bilinguals’ first language

Stephanie A Kazanas
Tennessee Technological University, USA

Allison M Wilck
Jeanette Altarriba
University at Albany, State University of New York, USA

Abstract
Aims and objectives/purpose/research questions: In this study, we examined memory performance in a bilingual population, in an effort to compare depth of processing and complexity across first and second languages.

Design/methodology/approach: Complexity was investigated with a pleasantness rating task and an elaborative encoding, scenario-based rating task (i.e. rating words for their survival-relevance). Previous research found word recall largely benefited from an ancestral context that primed participants to think deeply about the survival-relevance of a list of concrete, neutral words. Engaging this more elaborative processing may lead to better memory if the human memory system is particularly tuned toward remembering survival-relevant materials.

Data and analysis: Participants included 127 Spanish-English bilinguals, randomly-assigned to complete survival-relevance or pleasantness ratings in either Spanish or English. Aggregated language history data self-reported by participants (e.g. language-learning environments, age of acquisition, and so on), suggested an L1 of Spanish and L2 of English. An analysis of variance (ANOVA) compared word recall across these tasks and languages.

Findings/conclusions: We hypothesized better recall performance collected from bilingual participants in the survival condition using their first, more often emotional, language. Our results support this hypothesis, with bilinguals replicating the memory advantage for words rated for their survival-relevance in Spanish (their L1), but not in English (their L2).

Originality: While this paradigm has largely been studied with monolingual English-speakers, or in some cases, other languages, no study has explored its replicability in a Spanish-English bilingual population’s two languages.

Significance/implications: These findings speak to the ongoing effort to understand word processing and memory differences—particularly with regards to processing complexity—across bilinguals’ first and second languages.

Corresponding author:
Stephanie A Kazanas, Department of Counseling and Psychology, Tennessee Technological University, Box 5031, Cookeville, TN 38505, USA.
Email: skazanas@tntech.edu
Keywords
bilingual, processing complexity, adaptive memory, recall

Introduction
The majority of research on language processing has been gathered from monolingual populations. Yet, bilingualism has been documented to provide a unique psycholinguistic experience (Bialystok et al., 2012; Valian, 2015). Evidence consistently supports the notion that bilinguals are in a constant state of interacting with both of their known languages (see Wilck et al., 2019 for an overview). While reading in one’s first language (L1), the translations and knowledge about the material in one’s second language (L2) are often simultaneously activated. As such, bilinguals are an interesting population to explore for their complex language-processing skills.

Similarities in L1 and L2
As bilinguals are persons holding knowledge of multiple languages within a single individual, it is not surprising that information is often processed simultaneously in both languages regardless of which language is activated. This pattern has been identified across a variety of cognitive processes, including attention (Eilola & Havelka, 2011), problem-solving (Maekelar & Pfuhl, 2019), and memory (Ayçiçeği-Dinn & Caldwell-Harris, 2009). Research has often indicated proficiency as a key feature in determining the degree of processing similarity between languages (Paap et al., 2014; Yow & Li, 2015). That is, languages known equally well will be processed similarly within a bilingual individual.

Evidence that corroborates the notion of equivalence between a bilingual’s L1 and L2 often comes from tasks measuring early stages of information processing. For example, a number of tests measuring automatic attentional capture (e.g. the Stroop task and rapid serial visual processing) have demonstrated that salient features of observed stimuli, such as emotion, attract interest regardless of the language in which they are presented (Ponari et al., 2015; but see Ong et al., 2017 for language specific considerations). This is particularly relevant for negatively-valenced, unpleasant words (e.g. fear) that typically require longer processing times as compared to neutral information (e.g. leaf) (Eilola et al., 2007; Eilola & Havelka, 2011; Sutton et al., 2007; Williams et al., 1996).

It has been suggested that the unique processing patterns of negative information is the result of a general threat response (McKenna & Sharma, 2004; see Fox et al., 2001 for clinical considerations). When individuals encounter information that suggests danger or threat in the environment, a common response is to slow reactions, a reply akin to defensive freezing behavior (Estes & Verges, 2008). Accordingly, when unpleasant words are encountered, they are processed with special consideration to allow for an evaluation of the potential danger. For such a response to occur, the general valence of the word needs only to be collected. A full understanding of the stimulus or situation can be processed later, as time and resources allow. Thus, the automatic attentional capture by information associated with a potential threat occurs early in information processing and does not necessarily require elaborative consideration for the stimulus itself.

Once information from any language has been attended to, it is stored in memory for later use. Just as in attention tasks, bilinguals have also been shown to perform similarly across languages in memory tasks (see Wilck et al., 2019 for a review of bilingual memory models). When proficient bilinguals are asked to memorize lists of words, they tend to show no differences in their recall ability, regardless of whether the words are emotional or not (Ferré et al., 2010).

However, mimicking the bilingual attention literature just reviewed, such similarities are largely found only for memory tasks requiring less distinctive processing (e.g. counting word letter features) (Ayçiçeği-Dinn & Caldwell-Harris, 2009). The more elaborate and thoughtful cognitions that are
required in a task (e.g. emotional-intensity rating, translations, word associations), the more opportunities there are available for L1/L2 memory differences to emerge (see Rosselli et al., 2017 for an overview). Taken together, the literature suggests that bilinguals process information similarly across their L1 and L2 if a word holds comparable meaning in both languages.

**Differences in L1 and L2**

Although there are many instances demonstrating equivalence in L1/L2 processing, the literature provides evidence to suggest that information is not always understood consistently across languages. Therefore, the way information is processed between a bilingual’s languages can vary. Specifically, later stages of information processing involving understanding the deeper rooted, semantic meaning for words tend to show differences between a bilingual’s languages.

For example, although emotional information is often prioritized in information processing, the experienced emotional intensity has been shown to differ depending on the language of presentation, thus altering a bilingual’s emotional experiences (for a review see Wilck & Altarriba, in press).

Emotional words (e.g. happy, terrified, calm) are thought to be a unique subset of the mental lexicon as they combine the use of the language system and the emotional regulation system. Both systems develop synchronously during childhood, provided words are learned early in life with an enhanced emotional connection (Cole et al., 2010; King, in press). Thus, it is not surprising that words presented in an L1 can be perceived as more emotional due to their deeper rooting than are words presented in an L2 (Dewaele, 2004; but see Ong et al., 2017; Pavlenko, 2014 for language characteristic considerations). Generally, behavioral, physiological, and clinical findings converge on L1 relating to stronger emotional connections (see Kazanas et al., 2019).

Anooshian and Hertel (1994) were the first to use a memory test to report perceived emotional intensity differences between a bilingual’s languages. Individuals who acquired their second language later in life rated a series of emotional (positive and negative valence) and neutral words on a variety of dimensions ranging from elaborative processing (emotionality) to superficial processing (pronunciation). Next, a surprise recall test for the rated words was completed. The words rated in a task that required more meaningful thought were also better remembered when presented in the L1. The authors concluded that words in an L1 are more deeply associated with emotions as compared to words in an L2. Additional research using physiological and neurological methods further corroborate the stronger emotional response to words presented in an L1 versus an L2 (Baumeister et al., 2017; Eilola & Havelka, 2011).

However, other research has suggested cases in which an L2 can produce emotional advantages over an L1. Whereas emotional words of any valence can lead to memory advantages in an L1, only words associated with negative emotions, as compared to neutral words, have been shown to be more memorable in an L2 (Ayçiçegi & Harris, 2004). Such conflicting results further indicate that the specific experiences with a language and nature of a task can influence the cognitive benefits of emotion that produce processing advantages in a first or second language (Ayçiçegi-Dinn & Caldwell-Harris, 2009; Ferré et al., 2013; Kazanas & Altarriba, 2016).

The language experience and task specificity notion can, in part, be explained by work that has suggested that words, in general, learned earlier in life gain greater elaborative strength than words acquired later (Johnston & Barry, 2006). By having had the opportunity to engage with an L1 for a longer time, its words can create stronger associations to a wider range of contexts than can those in an L2. The longer practice time in a native language has also been used to explain why communication is generally processed with greater efficiency and automaticity while communication in a subsequent language is more effortful and deliberate. By having deeper
connections in an L1, new information can more readily be associated with meaning than can information presented in a weaker known language.

This notion of elaboration strength between a bilingual’s first and second languages has been explored throughout the literature (e.g. Anooshian & Hertel, 1994; Ayçiçegi-Dinn & Caldwell-Harris, 2009; Francis & Gutiérrez, 2012). The evidence appears to support bilinguals’ ability to more readily process information presented in their most proficient language with greater meaning and depth, as compared to information presented in subsequent languages. However, tasks that require fewer cognitive resources tend to show no differences based on language presentation. It appears that degree of elaborative encoding can influence how words are understood and remembered in an L1 and L2.

The survival advantage and elaborative processing

Aligning with evolutionary theory, Nairne et al. (2007, 2008) proposed that memory is optimized for information that is processed for its survival relevance. In the typical paradigm to test the “survival processing advantage,” participants are asked to read a scenario that evokes survival needs. The original survival scenario invites participants to imagine themselves stranded in an unknown grassland in need of locating supplies, shelter, and protection from predators. Next, they rate concrete nouns for their relevance to the scenario, thus evoking elaborative processing. During a surprise memory test, typical findings indicate superior performance for words rated for their survival relevance, as compared to words encoded in an alternative fashion (e.g. rated for their pleasantness, self-relevance).

This pattern has been replicated using a variety of alternative methodologies including recall and recognition memory tests; within- and between-subject designs; word and picture stimuli; children and adults; and various survival-evoking scenarios (for reviews see Kazanas & Altarriba, 2015; Nairne & Pandeirada, 2016). Indeed, researchers have found robust support for superior memory due to survival processing as compared to other well-established mnemonic devices such as imagery ratings, generation, self-reference, and intentional learning (Nairne et al., 2008).

Since its initial report, researchers have attempted to delineate the underlying mechanisms of the survival processing advantage. Whereas Nairne et al. (2007, Nairne & Panderiada, 2016) have tied the robust effect to evolutionary relevance, replicability limitations have led others to suggest that any such memory benefit is routed through well-known cognitive components. For example, tests of incidental memory retrieval have failed to replicate the typical findings, indicating the need for effortful and intentional retrieval practices to evoke the effect (Tse & Altarriba, 2010; Wilck & Altarriba, 2019). Furthermore, instances that prevent elaborate encoding of the rated words (e.g. increasing cognitive load) can reduce or even eliminate the effect (Kazanas et al., 2015; Kroneisen & Erdfelder, 2011; Kroneisen et al., 2014; Otgaar et al., 2015).

On the other hand, encoding scenarios that promote elaborate processing and expansive thinking (e.g. stranded in isolation) have been shown to enhance the survival advantage (Leding & Toglia, 2018). Indeed, participants generate more ideas and uses for objects when engaged in survival processing than alternative mindsets (Röer et al., 2013; Wilson, 2016). Furthermore, these generative responses have been shown to be enhanced for both true and false memory in adults and children (Otgaar & Smeets, 2010). Together, the evidence suggests that engaging in a particularly rich and distinctive encoding experience, such as survival processing, may be the driving factor of the memory advantage (Kroneisen & Erdfelder, 2011).

A myriad of evidence has supported the pivotal role of elaborative processing in producing the survival advantage. As such, the survival paradigm is an interesting testing ground for bilingual populations who have been shown to display differences in linguistic connectivity between their
known languages. That is, the reviewed evidence has indicated that bilinguals may engage in more elaborative processing of information within their first language, as compared to their second. The survival paradigm provides an opportunity for participants to engage in elaborate processing during encoding. In addition, the memory advantage has been reproduced in multiple languages including French (Bugaïska et al., 2015), Japanese (Nouchi, 2013), and German (Kroneisen et al., 2014). However, researchers have yet to directly compare performance in a Spanish-English bilingual population’s first versus second language. Therefore, it is unclear if the survival advantage will replicate, with equal magnitude, across these bilinguals’ languages.

The present study

In this experiment, Spanish-English bilinguals were randomly assigned to rate a list of words in one of four ways: either for their survival-relevance or pleasantness, in English or Spanish. A surprise free recall task tested their memory for these rated words. Previous findings indicate survival-relevance boosts a number of cognitive abilities, replicating across several languages (e.g. German; Kroneisen et al., 2014), but it has yet to be tested with a bilingual population’s two languages. Specifically, this experiment assessed whether a memory advantage for words rated for their survival-relevance differs across Spanish and English (their self-reported L1 and L2, respectively).

Regarding this research aim, some previous work would suggest a similar “survival advantage” across both L1 and L2. For example, words can have the same emotional intensity in a proficient bilingual’s languages (e.g. Ferré et al., 2010, 2013). Similarly, emotional and taboo Stroop effects are similar across L1 and L2 (Eilola et al., 2007; Eilola & Havelka, 2011; Sutton et al., 2007). Emotion-memory effects are also similar across L1 and L2, even among bilinguals dominant in their L1 (Ayçiçegi-Dinn & Caldwell-Harris, 2009). On the other hand, other findings would suggest a greater survival advantage in a bilingual’s L1. For example, bilinguals regularly report their L1 to be more emotionally evocative (Dewaele, 2004), which could translate to a more arousing experience when processing survival-relevance in L1. In a similar vein, emotions are more embodied in L1 than in L2, as shown with skin conductance levels and facial motor resonance (e.g. Baumeister et al., 2017; Eilola & Havelka, 2011). Finally, reading emotion-laden texts in L1 provides a stronger, more emotional experience than reading in L2 (e.g. more distributed neural activation; Hsu et al., 2015). Together, these mixed findings highlight the need for additional research investigating bilinguals’ word processing and memory.

Method

Participants

Participants in this experiment (N = 127) were undergraduate students of a public research university located in the United States, all self-reporting they were Spanish-English bilinguals. Participants’ mean age was 20.90 years (SD = 4.85) and all were a minimum of 18 years old.

Quantitative language history information collected from each participant included their acquisition, proficiency, and daily usage of both English and Spanish (see Table 1; Altarriba & Mathis, 1997). Determining participants’ L1 and L2 involved a consideration of several, complex items—both quantitative and qualitative—including participants (1) all specifying they were Spanish-English bilinguals; (2) supplying their age of acquisition data; and (3) responding to qualitative questions about the languages they spoke from birth. These qualitative questions asked participants to describe the languages they know, ages when they began to learn each one, and where they were
learned (e.g. home, school, church, and so on). Participants were also asked about the languages spoken at home, both currently and during their childhood.

An aggregate of language history data was used to determine L1 and L2, with this aggregate suggesting an L1 of Spanish and L2 of English for these participants. First, all participants informed the experimenter they were Spanish-English bilinguals. Age of acquisition data suggested an earlier exposure to Spanish than to English, though this difference was nonsignificant ($p = .263$). Next, of the 127 participants, 111 all reported speaking Spanish since early childhood, at home, and with their families. Language history data from the remaining 16 participants were not as descriptive across these qualitative items, though they too reported they were Spanish-English bilinguals. However, for all participants, English (their L2) had become their functionally dominant language; support for this English-dominance is evident in their larger daily usage approximation (84% English vs. 16% Spanish). Proficiency ratings were made with a 10-point Likert scale, with higher ratings indicating higher proficiency for that ability. Their ratings also indicated English-dominance, with participants rating their English comprehension, writing, and speaking abilities significantly higher than their Spanish abilities (all $p$s < .001).

Each participant gave their informed consent and received either course credit or extra credit for a psychology course or cash compensation. All procedures were approved under the University’s Institutional Review Board.

### Experimental Conditions

Participants were randomly assigned to one of four conditions and received instructions specific to their condition: either survival with relevance-ratings, in English ($N = 30$) or Spanish ($N = 36$), or pleasantness ratings, in English ($N = 29$) or Spanish ($N = 32$). The survival instructions were those originally used by Nairne et al. (2007), presented in English or translated to Spanish by a native Spanish speaker. These instructions read:

In this task, we would like you to imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. Over the next few months, you’ll need to find steady supplies of food and water and protect yourself from predators. We are going to show you a list of words, and we would like you to rate how relevant each of these words would be for you in this survival situation. Some of the words may be relevant and others may not—it’s up to you to decide.

Pleasantness rating instructions were also adopted from Nairne et al. (2007) and read:

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

### Table 1. Quantitative language history data for English and Spanish. Means and SDs.

<table>
<thead>
<tr>
<th></th>
<th>English language</th>
<th></th>
<th>Spanish language</th>
<th></th>
<th>Mean difference</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
<td>$SD$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age of acquisition</td>
<td>4.19 years</td>
<td>4.87</td>
<td>3.50 years</td>
<td>4.00</td>
<td>.69</td>
<td>.263</td>
</tr>
<tr>
<td>Reading age of acquisition</td>
<td>5.33 years</td>
<td>4.35</td>
<td>7.06 years</td>
<td>3.88</td>
<td>−1.73</td>
<td>.003</td>
</tr>
<tr>
<td>Comprehension ability (/10)</td>
<td>9.56</td>
<td>.98</td>
<td>8.58</td>
<td>1.63</td>
<td>.98</td>
<td>.000</td>
</tr>
<tr>
<td>Writing ability (/10)</td>
<td>9.54</td>
<td>.93</td>
<td>8.16</td>
<td>1.73</td>
<td>1.38</td>
<td>.000</td>
</tr>
<tr>
<td>Speaking ability (/10)</td>
<td>9.63</td>
<td>.85</td>
<td>8.59</td>
<td>1.74</td>
<td>1.04</td>
<td>.000</td>
</tr>
<tr>
<td>% of time speaking</td>
<td>83.42</td>
<td>15.61</td>
<td>16.39</td>
<td>15.03</td>
<td>67.04</td>
<td>.000</td>
</tr>
</tbody>
</table>

In this task, we would like you to imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. Over the next few months, you’ll need to find steady supplies of food and water and protect yourself from predators. We are going to show you a list of words, and we would like you to rate how relevant each of these words would be for you in this survival situation. Some of the words may be relevant and others may not—it’s up to you to decide.
Materials

All participants rated the same set of 32 words, presented in the same fixed-random order (from Nairne et al., 2007, Experiments 1 and 2). Three additional words (all concrete nouns, selected from Nairne et al., 2007, Experiment 3) were used for practice ratings; their ratings for these words were not retained for analyses. Participants in the two Spanish conditions rated a translated set of these words (see Appendix A for both sets of words).

Procedure

Participants were run individually, within the Cognition and Language Laboratory. All instructions and words were presented in either English or Spanish. After the instructions were presented, the experimenter assisted with practice trials, after which, the remaining words appeared. Each word was presented on a screen for up to five seconds, during which participants performed either a survival or pleasantness rating, via keypress. After the ratings, all participants performed two minutes of simple mathematical tasks, which were followed by an unexpected free recall task. Each participant was given a maximum of 10 minutes to recall and write as many rated words as they could, in any order. Minor spelling errors were permitted.

After the recall task, participants in the two survival conditions answered the following questions (from Nairne & Pandeirada, 2010): (1) How interesting was the scenario? (2) How easy was it for you to create an “image” of the scenario in your mind? (3) How plausible was the scenario? (4) How emotionally arousing was the scenario? (5) How familiar are you with the situation described? Additional questions were adapted from work conducted by Otgaar et al. (2011) and Sandry et al. (2013): (6) How distinctive, or unusual, was the scenario? (7) How rich in detail would you rate the scenario? (8) How negative would you rate the scenario? In this paradigm, these questions are typically used to determine whether recall differences vary according to cognitive or emotional mechanisms, rather than evolutionary explanations (Kazanas & Altarriba, 2015). For example, our laboratory often finds participants rate the survival scenario high on imageability: a mechanism well-known for facilitating encoding (e.g. Kazanas & Altarriba, 2017; Kazanas et al., 2020).

After answering these questions, participants completed a brief demographic questionnaire, which included questions related to age, gender, and language experience. Each participant received a debriefing form and was compensated for their participation.

Results

First, participants in all four conditions did not differ according to age ($p = .249$) and gender ($p = .171$). In addition, there were no significant differences in response times (RTs) across those performing survival-relevance or pleasantness ratings ($p = .152$). See supplementary materials.

A one-way analysis of variance (ANOVA) was conducted to detect any differences in the proportion of correctly recalled words among the four conditions. This ANOVA was significant, $F(3, 123) = 8.898, p < .001$. Planned contrasts compared recall rates across task languages (English or Spanish) and conditions (survival or pleasantness ratings). Means and standard deviations (SDs) for recall in these conditions are shown in Table 2 and Figure 1. Two of these comparisons were of interest. In the first comparison, recall rates were compared across those performing the tasks in English. Participants performing survival-relevance ratings ($M = .43, SD = .12$) recalled more words than those performing pleasantness ratings ($M = .36, SD = .14$), though this difference was not significant ($p = .160$). In the second comparison, recall rates were compared
across those performing the tasks in Spanish. This difference was significant, with participants performing survival-relevance ratings \((M = .35, SD = .10)\) recalling more words than those performing pleasantness ratings \((M = .28, SD = .07), p = .044\).

Next, two linear regression analyses examined how well the scenario ratings explained recall performance in the two survival conditions. While neither model was significant (for English, \(p = .179\); for Spanish, \(p = .521\)), each yielded a significant bivariate correlation. For the English version of the survival-relevance rating task, familiarity hindered recall, \(r(28) = -.45, p = .007\), suggesting participants who thought the scenario felt familiar were less likely to perform well on the recall task. In the Spanish version of the survival-relevance rating task, arousal facilitated recall, \(r(33) = .34, p = .023\), with those finding the scenario arousing recalling a greater number of words.

Finally, a series of one-way ANOVAs and planned contrasts were conducted to detect any differences in scenario ratings across the English and Spanish versions of the survival-relevance rating task. Two of these ANOVAs were significant. The rating for how “plausible the scenario was” was significant, \(F(1, 63) = 5.294, p = .025\), with planned contrasts revealing participants found the Spanish version more plausible than the English version. The rating for “negativity” was also significant, \(F(1, 63) = 4.085, p = .048\), with participants rating the Spanish version less negative than the English version. The ratings for “interest”, “imageability”, “emotional arousal”, “familiarity”, “distinctiveness”, and “richness” did not differ across the English and Spanish versions. Means for each rating by version comparison are included in Table 3.

Figure 1. A comparison of word recall by condition, with one SD shown.
Table 3. Survival scenario ratings: Means and SDs.

<table>
<thead>
<tr>
<th>Rating dimension</th>
<th>Spanish version</th>
<th>English version</th>
<th>Mean difference</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Interesting</td>
<td>3.91</td>
<td>.82</td>
<td>3.83</td>
<td>.59</td>
</tr>
<tr>
<td>Imageability</td>
<td>4.40</td>
<td>.85</td>
<td>4.37</td>
<td>.77</td>
</tr>
<tr>
<td>Plausibility</td>
<td>3.40</td>
<td>1.14</td>
<td>2.80</td>
<td>.93</td>
</tr>
<tr>
<td>Emotional arousal</td>
<td>2.74</td>
<td>1.22</td>
<td>2.63</td>
<td>1.16</td>
</tr>
<tr>
<td>Familiarity</td>
<td>2.06</td>
<td>1.08</td>
<td>1.77</td>
<td>1.04</td>
</tr>
<tr>
<td>Distinctiveness</td>
<td>2.71</td>
<td>.86</td>
<td>2.90</td>
<td>1.19</td>
</tr>
<tr>
<td>Richness</td>
<td>3.00</td>
<td>.84</td>
<td>2.90</td>
<td>.80</td>
</tr>
<tr>
<td>Negativity</td>
<td>2.37</td>
<td>1.37</td>
<td>3.03</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Discussion

The adaptive memory framework provides a novel, interdisciplinary approach to study elaborative processing within a bilingual population. The purpose of the present study was to integrate this newer approach with what we already know about bilinguals and how they process verbal materials in each of their languages. We presented our Spanish-English bilinguals with a set of concrete nouns, asking them to rate each word according to either its survival-relevance (i.e. how well it could help them survive) or its pleasantness. They performed these ratings in either Spanish (their self-reported L1) or English (their L2, though more dominant language). Importantly, while all our participants descriptively recalled more words after engaging in survival processing, only those performing the task in Spanish recalled significantly more than their peers performing pleasantness ratings.

Demonstrating this elaborative encoding advantage in our bilinguals’ L1 replicates previous findings from the bilingual literature (Ayçiçegi-Dinn & Caldwell-Harris, 2009), most notably, a benefit for processing emotional materials in L1 over L2. The notion of a “more emotional L1” (Altarriba, 2003; Dewaele, 2004, 2011) is replicated in the current study, as recall performance was greatest when participants engaged in the more arousing survival-relevance rating task in Spanish, relative to its counterpart in English and the less arousing pleasantness-rating tasks. Further, correlational analyses revealed this sense of arousal may aid later recall performance. This finding lends support to both behavioral (Anooshian & Hertel, 1994) and physiological (Baumeister et al., 2017; Eilola & Havelka, 2011) data demonstrating L1 advantages, as each of these tasks illustrates an increased ability to engage with task materials in L1, relative to L2. Though to a lesser degree, our bilinguals also replicated enhanced elaborative encoding effects in their L2, with participants recalling descriptively (though not significantly) more words after engaging in survival processing; thus, there are some demonstrated similarities across performance in L1 and L2. We ought to expect this finding, given the emotional and more detailed nature of the survival scenario, the prioritization of negative materials in attention and memory (e.g. Colbeck & Bowers, 2012), and some of the more balanced aspects of their language history data (e.g. age of acquisition data).

The ratings we collected on the survival scenarios (e.g. the scenario’s perceived imageability, familiarity) suggest the L1 advantage in this paradigm could relate to our participants believing the scenario to be more plausible and less negative in Spanish, than in English. Perhaps these factors contributed to deeper processing in Spanish—letting the participants better elaborate on the rated words—and promoted a greater survival advantage. Previous findings do suggest these rating dimensions, or proximate explanations, can explain some portion of these effects. For example, on-going work in our laboratory highlights the importance of imageability in this paradigm (e.g.
Kazanas et al., 2020) and we would argue distinctiveness likely enhances memory, as well (Hunt & Worthen, 2006; Kazanas & Altarriba, 2017). With regards to plausibility, researchers believe that a scenario’s believability relates to how well it fits prior knowledge: A more plausible scenario—even if ambiguous—can then be understood faster (e.g. Speer & Clifton, 1998). Connell and Keane’s (2006) Plausibility Analysis Model (PAM) would argue a more plausible scenario, as was the case with the survival scenario presented in Spanish, could then facilitate many subsequent cognitive processes—including retrieval—but also complex comprehension and reasoning.

On the other hand, perhaps a scenario perceived as highly negative, as was the case for the English version of the survival scenario, could prompt an inhibitory response, reducing elaboration and later recall. While many researchers report general advantages for negative moods and stimuli (e.g. Storbeck & Clore, 2005, 2011), the particular negative emotion most likely experienced by our participants was fear. Notably, induced or measured fear has led to more varied outcomes, with some reporting more accurate and detailed memory performance (e.g. Loftus et al., 1987; Wessel & Merckelbach, 1998) and others reporting poorer memory and increased intrusions relative to other moods (e.g. Lench & Levine, 2005). Overall, differences in these scenario ratings, across the English and Spanish versions, necessitate further research into why these rating dimensions differ, and whether those differences are a function of the tested languages or the participants’ rich language history.

The general pattern of findings—with participants recalling more words processed for their survival-relevance than their pleasantness—replicates original observations by Nairne et al. (2007, 2008). These findings speak to the notion of a general survival optimization system equipped with both cognitive and evolutionary mechanisms (Nairne & Pandeirada, 2016). This theory can help us better understand how and why cognitive processes are recruited when engaging in survival processing. Finally, a recent meta-analysis conducted by Scofield et al. (2018) highlights the replicability of this effect and encourages further work. Researchers now aim to test its generalizability and boundary conditions, for example, finding comparable memory benefits for animacy (VanArsdall et al., 2013), mortality salience (Burns et al., 2014), and contamination (Fernandes et al., 2017). Some mixed findings in these areas further necessitates an updated meta-analysis and additional work (Altarriba & Kazanas, 2019).

Implications and Future Directions

Although we replicated the survival advantage in Spanish, we did not replicate this memory advantage in English, despite our bilinguals’ language history data suggesting early age of acquisition for both Spanish and English. This was surprising, given the robustness of the survival advantage; in our laboratory alone, we have replicated the survival advantage with a recognition task (Cho et al., 2018), varying scenarios (Kazanas & Altarriba, 2017), and paired-associated learning (Kazanas et al., 2020). We ran an additional set of monolingual English-speakers to ensure our materials and procedures could replicate this memory advantage, and that any failure-to-replicate the memory advantage with our bilingual participants was not the result of some procedural differences in this study compared with others. These participants were selected from the same pool of students, with the same options for compensation. All materials and procedures were identical, the only exception being they were all written and presented in English. The memory advantage replicated, with participants performing survival-relevance ratings ($N = 58$) recalling significantly more words ($M = .44, SD = .11$) than those performing pleasantness ratings ($N = 60$) ($M = .32, SD = .10$), $p < .001$. The magnitude of this advantage, while in the same direction as the findings from our bilingual sample, was also a bit larger than the advantages we observed with our bilinguals, in both the Spanish and English comparisons. These advantages are shown in Figure 1.
The specific languages compared in this study could also affect these patterns of findings. For example, some Mandarin-English bilinguals express it’s harder to say things in Chinese (Caldwell-Harris et al., 2011), a remark which would predict an emotion advantage in English, their L2, rather than their native language, Mandarin. Some bilinguals have difficulty expressing or accessing emotions in one of their languages, which could affect how they process a high-arousal scenario, such as the one presented before survival-relevance ratings. Similarly, Dewaele (2010) summarized a multilingual’s preference for “. . . different languages according to the subject [they] deal with. Italian for what happened during the day, . . . English for general feelings, German for love emotions, or deepest and perhaps harshest statements” (p. 90). Thus, cultural or personal preferences may matter, too.

Finally, researchers report both L1 and L2 advantages, depending on the task, stimuli, and level of language proficiency. In some cases, even word recall, participants can also perform similarly in L1 and L2 (Ferré et al., 2010). Because this is an early comparison of adaptive memory in bilinguals’ L1 and L2, we recommend an array of future research. For example, researchers can compare performance across incidental and intentional learning paradigms, words and pictures, balanced bilinguals’ languages, and bilinguals varying in other ways (e.g. L1-dominant). Replications with other sets of words or perhaps different types of words (e.g. emotional v. neutral) are also recommended. Perhaps the most rigorous test could include sampling a comparable group of English-Spanish bilinguals, to determine whether the languages themselves, or their age of acquisition data, better predict memory performance. Each of these comparisons and replications can help us better understand the intersection between bilingualism and cognition.

Conclusions

The current study was designed to extend both the bilingual and adaptive memory literatures, with a primary goal of examining whether elaboration advantages differ across our Spanish-English bilinguals’ two languages. This was investigated by comparing incidental memory following either survival-relevance ratings or pleasantness ratings, performed in Spanish (our bilinguals’ self-reported L1) or English (their L2). Their recall performance significantly benefited from engaging in the more detailed survival-relevance ratings in their first language, Spanish, but not in their second language, English. These results replicate other adaptive memory findings and highlight the role of language history in processing emotional materials. Tapping into bilinguals’ L1 led to stronger encoding overall, though we would recommend future research also investigating additional languages, preferences, and proficiency.

Author note

Portions of these data were presented at the Twelfth International Symposium on Bilingualism (ISB12) and the 60th annual meeting of the Psychonomic Society.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

Stephanie A Kazanas https://orcid.org/0000-0001-5845-2227
Supplementary materials

Research materials can be requested from the authors.

Notes

1. All analyses were run both with and without these additional 16 participants; because the results did not differ, we retained all 127 participants.
2. We conducted post-hoc power calculations with G*Power (Faul et al., 2007) and found the ANOVA to be well-powered (observed power = .995).

References


Wilck, A. M., & Altarriba, J. (in press). Emotion words in monolingual and bilingual cognitive psycholinguis-
tic research. In G. Schiewer, J. Altarriba, & N. B. Chin (Eds.), *Handbook on language and emotion*. de Gruyter.


mind and brain. In J. W. Schwieter (Ed.), *The handbook of the neuroscience of multilingualism* (pp.


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

Yow, W. Q., & Li, X. (2015). Balanced bilingualism and early age of second language acquisition as the
underlying mechanisms of a bilingual executive control advantage: Why variations in bilingual experi-

**Author biographies**

**Stephanie A Kazanas**, PhD, is an associate professor of Psychology and the Interim-Chairperson of the
Department of Counseling and Psychology at Tennessee Technological University. She teaches courses in
experimental psychology, cognition, and critical thinking. Her current research broadly investigates the inter-
section between cognition and emotion.

**Allison M Wilck**, PhD, recently completed her degree at the University at Albany, State University of New
York and is now an Assistant Professor of Psychology at Eastern Mennonite University. Her research explores
learning effectiveness through a variety of avenues including encoding context, emotionality, belief forma-
tion, and second language acquisition.

**Jeanette Altarriba**, PhD, is a professor of Psychology and Dean of the College of Arts and Sciences at the
University at Albany, State University of New York. Her decades-long program of research focuses on bilin-
guialism, second language acquisition, survival memory, and the interplay between cognition, emotion, and
memory.

**Appendix A**

*Word list* (Nairne et al., 2007)

<table>
<thead>
<tr>
<th>English word</th>
<th>Spanish word</th>
</tr>
</thead>
<tbody>
<tr>
<td>truck</td>
<td>camión</td>
</tr>
<tr>
<td>diesel</td>
<td>diesel</td>
</tr>
<tr>
<td>mountain</td>
<td>montaña</td>
</tr>
<tr>
<td>pepper</td>
<td>pimienta</td>
</tr>
<tr>
<td>book</td>
<td>libro</td>
</tr>
<tr>
<td>carbon</td>
<td>carbón</td>
</tr>
<tr>
<td>juice</td>
<td>jugo</td>
</tr>
<tr>
<td>shoes</td>
<td>zapatos</td>
</tr>
<tr>
<td>finger</td>
<td>dedo</td>
</tr>
<tr>
<td>aunt</td>
<td>tía</td>
</tr>
<tr>
<td>chair</td>
<td>silla</td>
</tr>
</tbody>
</table>

(Continued)
### Appendix A. (Continued)

<table>
<thead>
<tr>
<th>English word</th>
<th>Spanish word</th>
</tr>
</thead>
<tbody>
<tr>
<td>catfish</td>
<td>pez</td>
</tr>
<tr>
<td>silver</td>
<td>plata</td>
</tr>
<tr>
<td>orange</td>
<td>naranja</td>
</tr>
<tr>
<td>whiskey</td>
<td>whiskey</td>
</tr>
<tr>
<td>flute</td>
<td>flauta</td>
</tr>
<tr>
<td>snow</td>
<td>nieve</td>
</tr>
<tr>
<td>door</td>
<td>puerta</td>
</tr>
<tr>
<td>broccoli</td>
<td>brócoli</td>
</tr>
<tr>
<td>bear</td>
<td>oso</td>
</tr>
<tr>
<td>cathedral</td>
<td>catedral</td>
</tr>
<tr>
<td>screwdriver</td>
<td>destornillador</td>
</tr>
<tr>
<td>car</td>
<td>auto</td>
</tr>
<tr>
<td>sword</td>
<td>espada</td>
</tr>
<tr>
<td>apartment</td>
<td>apartamento</td>
</tr>
<tr>
<td>soccer</td>
<td>fútbol</td>
</tr>
<tr>
<td>emerald</td>
<td>esmeralda</td>
</tr>
<tr>
<td>silk</td>
<td>seda</td>
</tr>
<tr>
<td>teacher</td>
<td>maestra</td>
</tr>
<tr>
<td>pan</td>
<td>bandeja</td>
</tr>
<tr>
<td>sock</td>
<td>media</td>
</tr>
<tr>
<td>eagle</td>
<td>águila</td>
</tr>
<tr>
<td>stone</td>
<td>piedra</td>
</tr>
<tr>
<td>cabin</td>
<td>cabina</td>
</tr>
<tr>
<td>fire</td>
<td>fuego</td>
</tr>
</tbody>
</table>