The landscape of emotional language processing in bilinguals: A review

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Abstract

Language is arguably the most complex tool we have to express and convey emotions. The interplay between language and emotion has long captivated the disciplines of linguistics, psychology and cognitive science, and at the heart of this relationship lies the phenomenon of bilingualism. Languages have an inventory of emotionally charged words called the emotional lexicon, which are uniquely processed compared to other various word types (see for reviews Citron, 2012; Hinojosa et al., 2020; Palazova, 2014). Understanding how these words with affective features are processed and the similarities and differences between the first language (L1) and the second or later acquired languages (L2) is relevant for better understanding of the mental architecture of the bilingual mind. In this review, we offer a general overview of the rich and fertile literature published on the topic of emotions and bilingualism, which carries significant implications beyond laboratory settings, manifesting relevance in both

professional and personal domains. The key findings gathered from cognitive psycholinguistic studies employing diverse experimental paradigms including memory tasks, visual word processing (including tasks such as lexical decision, the emotional Stroop task, or affective priming), sentence processing, as well as electrophysiological and neuroimaging research will be discussed. Furthermore, we will examine a noteworthy phenomenon that has garnered substantial attention in the literature on language and bilingualism, the foreign language effect on decision-making and moral judgments. This phenomenon may elucidate intricate dynamics related to the processing of emotions, offering valuable insights into how bilingualism intersects with cognitive and emotional experiences.

Keywords

Emotion, bilingualism, language processing, emotional words, emotion-memory effect, foreign language effect, moral decision making.

Introduction

Current work in the field of language and emotions mainly relies on theoretical proposals that conceive the dimensions of valence and arousal as two aces that structure the emotion lexicon (Bradley & Lang, 1999, Bradley, 2014). These dimensions provide a universal and systematic way to categorise and understand the wide range of emotional words in different languages. Valence refers to the hedonic tone of an emotion or emotional stimulus. It exists in a continuum and represents the degree to which a stimulus is perceived as being positive (e.g., happiness, money) or negative (e.g., anger, gun), be it a word, an image, or a song. Arousal defines the level of physiological activation, energy or intensity associated with an emotion or emotional stimulus. On one end of the arousal continuum, there is low arousal, characterised by a sense of calmness, relaxation, or low energy (e.g., serenity, silence), on the opposite end there is high arousal, characterised by increased physiological activation, heightened alertness, and intensity (e.g., fear, violence). The valence-arousal ace has proven very useful for researchers to map emotions in these two-dimensional spaces and their influence on word processing has been investigated in many studies (see Hinojosa et al., 2020, for an overview).

It is also important to clarify that the literature distinguishes between emotional words that describe specific affective states or feelings, called emotion-label words (e.g., happy), from emotion-laden words. Emotion-laden words do not describe affective states, but have the power to elicit strong emotions due to their lexical meanings or, sometimes, by carrying acquired or contextual connotations. This category of words includes insults, reprimands, endearments (e.g., darling), aversive words (e.g., cancer, snake), or taboo words, swearwords

or interjections (e.g., ouch, yummy). Sometimes a third category is included, known as emotion-related words, which denote concepts related (or caused by) certain emotional states without naming the actual emotion (e.g., tears, to scream) (Pavlenko, 2008). Some studies have shown that emotion-label and emotion-laden words elicit different behavioural and brain responses (Knickerbocker & Altarriba, 2013; Zhang et al., 2017). Most of the studies reviewed here mainly include emotion-laden and emotion-related words, or a mixture of the three different types. This information is not always specified in the description of the materials. For this reason, we adopt the generic denomination of emotional words throughout the text, except in the case of studies in which the distinction between the different types of emotional words has been addressed.

A number of studies have demonstrated that emotional words are processed differently than neutral words (Estes & Verges, 2008; Ferré et al., 2015; Hinojosa et al., 2010; Kissler & Herbert, 2013; Kousta et al., 2009). In terms of processing, once factors such as length and familiarity are considered, positive words are generally processed faster than both negative and neutral words (e.g., Bayer et al., 2012; Kuchinke et al., 2005; Rodríguez-Ferreiro & Davies, 2019; Siakaluk et al., 2016;) but the direction is not clear with negative words, some studies report that negative words are processed faster in comparison to neutral words (Citron et al., 2013; Kuchinke et al., 2007; Vinson et al., 2014), while other studies show the contrary (Estes & Adelman, 2008; Larsen et al., 2008; Yao et al., 2016). These findings from native speakers set the stage for exploring the outcomes within the second language of bilingual populations.

The reader might have heard or experienced that most bilinguals feel their first language to be more emotionally intense than languages acquired later. However, if as some approaches would assume (such as the Revised Hierarchical Model, RHM, Kroll and Stewart, 1994, or the Bilingual Interactive Activation model, BIA+, Dijkstra & van Heuven, 2002, described below), both languages are connected in the lexicon, why shouldn't the bilingual have access to the same emotional experience through words that have shared conceptual representations and evoke the same emotions (e.g., death-muerte)? Indeed, studies spanning as far back as the previous century show that bilinguals feel less anxiety when obscene and taboo words are pronounced in their second language (Gonzalez-Reigosa, 1976), or that bilinguals strategically employ languages and engage in code-switching during therapy sessions to enhance emotional distance (e.g., Altarriba & Santiago-Rivera, 1994). This phenomenon is known as emotional detachment or differential affective processing in the bilingual's L2 and its consequences extend to other interconnected contexts such as decision making and moral reasoning (Costa, Foucart, Arnon, et al., 2014; Costa, Foucart, Hayakawa, et al., 2014; Keysar et al., 2012) among many others.

Current research has shown that the difference in emotional processing between L1 and L2 is not straightforward and is modulated by various variables, such as context of acquisition, among others (see Caldwell-Harris, 2014, 2015; Pavlenko, 2012; Robinson et al., 2018, for comprehensive reviews). Differences between L1 and L2 have been observed when bilinguals are asked to rate the emotionality of words, yielding more extreme values of valence and arousal for L1 than L2 emotional words (Ferré et al., 2022; Garrido & Prada, 2021; Imbault et al., 2021); although as pointed out by Ferré and colleagues, these ratings may have been confounded by the task instructions. In their study, a group of English native speakers and a group of Portuguese-English bilinguals were asked to rate a list of emotion-laden and emotion-label words with a focus on either the feelings elicited by the words or on the meaning. Affective ratings were more intense in the group of native speakers than in the group of bilinguals and, crucially, the difference was larger in the condition with focus on feelings than in the condition with focus on meaning.

The emotion effect on language has been captured in different behavioural measures of cognitive processing performance, and even more convincingly in neural and physiological measures. The literature has proposed different views for understanding the bilingual mental lexicon which can be used to explain the observed differences between L1 and L2. The Revised Hierarchical Model (Kroll & Stewart, 1994; Kroll et al., 2010) proposes that language proficiency and exposure or frequency of language use leads to stronger connections between L2 lexical nodes and conceptual nodes, which are shared with L1 words. Less proficient bilinguals can only indirectly access concepts from L2 words through the lexical connections with their L1 translation equivalents. Therefore, non-proficient bilinguals do not process the affective connotations of words in L2 as automatically as that of words in L1 (Segalowitz et al., 2008; Winskel, 2013). For this theory the key factors are the number and quality of connections between lexical and conceptual nodes (which may include the affective component), regardless of the context of acquisition, since the relevant factor here is proficiency.

Somewhat more recently, some theories emerged with the goal of providing an explanation to the emotion effect phenomenon. This is the case of the Emotional Contexts of Learning Theory (Harris et al., 2006), where the context of acquisition emerges as the most crucial and determining factor. On this view emotional words in L1 are heard, used and experienced across diverse naturalistic learning contexts, potentially enriching their semantic representation and yielding multiple memory connections. By comparison, emotional words in L2 are employed less frequently and in fewer contexts, resulting in less practice or exposure. Therefore, the differences in processing emotional stimuli stem from the context in which the L2 is acquired. The native language acquisition occurs parallel to the familiar and social

development of the emotion regulation system usually in an intense emotional context. Early or simultaneous bilingualism is usually associated with simultaneous acquisition of the two languages in the first stages of life (typically before or around 6 years old, Harris et al., 2006), fostering a closer association with early basic emotions. In contrast, a late bilingual is generally defined as one who was not immersed in a bilingual environment since birth and did not acquire a second language until later stages of language development, typically in instructional contexts.

From the perspective of grounding/embodied cognition proposed by Pavlenko (2012), these instructional contexts have been posited as contributing to the disembodiment of L2 words. In simultaneous or balanced early bilinguals, both languages (L1 and L2) are closely attuned to the emotional content associated with each language. Contrarily, in the case of late bilinguals, the L2 is associated with greater emotional distance, as it is typically learned in formal contexts (e.g., school, university, or workplace) where “the same opportunities for affective linguistic conditioning” are missing compared to childhood (Pavlenko, 2008, p.156). Therefore, the emotional valence of L2 words is considered to be disembodied in the case of late bilinguals as L2 words would be processed semantically but not affectively (Pavlenko, 2012, p. 405). These explanations, while not mutually exclusive, collectively contribute to a comprehensive understanding of the observed phenomenon.

In this review we focus on the relationship between bilingualism and the encoding and understanding of emotions to unravel the complex cognitive processes that underpin the bilingual individual's emotional landscape. The next section presents a summary of the most relevant findings observed in cognitive psycholinguistic studies employing different experimental paradigms, from memory studies and tasks involving visual word processing (lexical decision, the emotional Stroop task, affective priming), sentence processing (eye tracking) to electrophysiological studies and neuroimaging research. The subsequent section, preceding the conclusions, delineates a renowned phenomenon associated with the processing of emotions within the bilingual literature, known as the foreign language effect. Finally, we conclude with a summary of findings and propose directions for future research.

Cognitive Psycholinguistic Studies

Cognitive studies employ behavioural methods to investigate whether emotional words undergo distinct processing compared to neutral words in participants' L1 and in bilingual participants’ L2. The selected materials typically include words with positive and negative valence to compare them with neutral words. The processing of emotional content is presumed to be automatic. The involuntary and immediate emotional effects can be gauged

in tasks that involve facilitation, interference and priming (we will see more on this below). These techniques rely on reaction times, so as faster reaction times imply easiness of processing (facilitation), less interference and in the case of priming, pre-activation of semantic features.

In this section, we examine whether a set of effects identified with emotional words in the L1 are also observed in the L2. The assumption is that if emotional words are accessed and represented identically in the mental lexicons of both L1 and L2, no differences should be found. However, empirical evidence presents a contradictory picture. We will review the outcomes of various studies employing diverse experimental paradigms.

Memory

The first question memory studies seek to answer is whether there is a memory advantage for emotional words with respect to neutral words when presented in the L1 as opposed to the L2, assuming a higher emotional intensity in the former, or whether the magnitude of the effect is similar in both languages. The second question delves into the extent to which this effect is modulated by factors such as age of acquisition of L2 (AoA), proficiency, context of acquisition, among others. In studies conducted in the native language, substantial evidence indicates that emotional words tend to have higher recall rates in memory tasks compared to neutral words, known as the emotion-memory effect (Ferré, 2003; Kensinger, 2008; Reber et al., 1994; Rubin & Friendly, 1986). The common procedure in these studies is that participants first engage in a certain task during the encoding phase, followed by subsequent prompts in the retrieval phase to recall or recognise as many words as possible from the initial task.

In what follows, we summarize some of the most relevant works on the emotion-memory effect in bilinguals. The literature in this topic has shown evidence for the three possible scenarios, that is, an advantage in L1, an advantage in L2, and no differences between both. This is explained by the high heterogeneity and variability across studies in terms of combination of different variables, including: characteristics of the sample (e.g., type of bilinguals), age of acquisition (AoA), context of acquisition (full immersion vs instructional setting), type of task in encoding phase, type of task in retrieval phase (free recall vs recognition), L2 proficiency, proximity between pairs of languages, and type of materials employed (e.g., some studies included taboo words and reprimands, beyond positive, negative and neutral words). Despite the contradictory results, some conclusions can be extracted from the data. For instance, simultaneous bilinguals seem to process the emotional content of both languages similarly in contrast to late bilinguals, but the emotion-memory effect will more likely we observed

depending on the type of task employed in the encoding phase (i.e, emotion-rating tasks tend to favour attention to emotion and increase the emotion-memory effect in L1).

The first empirical study of this kind with bilinguals dates back to the nineties (Anooshian & Hertel, 1994) and showed no effect of emotionally charged words on late bilinguals, that is, the effect was restricted to L1. A decade after Anooshian and Hertel 's study, Ayçiçegi and Harris (2004) reported an emotion-memory effect in both L1 and L2 in a group of Turkish-English late bilinguals tested in a free recall and a recognition task where stimuli were presented auditorily or visually in the encoding phase. The authors hypothesised that auditory presentation might lead to deeper processing possibly enhancing the emotion–memory effect. The type of materials included items in five categories: positive, negative, neutral, taboo words, and reprimands. First, the results showed no auditory/visual modality effect, that is, the emotion memory effect was not affected by modality of presentation. Second, emotion memory effects emerged in both L1 and L2 in both recall and recognition tasks, being even stronger in some cases in L2. Comparing both languages, the emotion advantage in the recall of negative words, taboo words and reprimands was superior in L2 than in L1 in the free recall task, although no differences between both languages were observed in the recognition task. The authors pointed out that the lack of familiarity with some of these words (specially reprimands and taboo words) in L2 might have enhanced their salience, hence increased attention and better recall. In a follow-up study, Ayçiçegi-Dinn and Caldwell-Harris (2009) tested the role of the type of task used during the encoding phase. In this study, the same five categories of items were tested in a group of Turkish-English bilinguals in four different encoding tasks with varying levels of processing: an emotional task (rating the items for emotional intensity), a shallow processing task (counting the number of letters), a translation task, and a semantic task (word association). The emotion–memory effect averaged over the four tasks was equally strong for both languages. However, looking into every task separately a different pattern of results emerged. The translation task showed a higher effect in L2 than in L1, in the emotion-rating task the effect was restricted to L1, and the magnitude of the effect was the same in both languages in the letter-counting and word-association tasks. The type of processing and attentional mechanisms involved in these tasks are important factors to take into account in subsequent research.

Up until to that date, all these investigations have examined individuals characterized as late bilinguals. Ferré et al. (2010) examined different types of bilinguals whilst also factoring in variables that had not been examined before such as language dominance, acquisition type of context, AoA and similarity between pairs of languages. Their study included simultaneous Spanish-Catalan and Catalan-Spanish bilinguals, and sequential late Spanish-English bilinguals. The profile of both types of bilinguals differs in many aspects. For the Spanish–

Catalan bilinguals, both languages exhibit a high degree of similarity, were acquired concurrently prior to the age of three, and remained active in the daily lives of participants within the shared bilingual social context. Even though a potential confound could be the high number of cognates (i.e., words that share orthographic and/or phonological form) shared between both languages, the authors excluded them from the list of materials. In contrast, in the case of Spanish-English bilinguals, the acquisition of the two languages occurred sequentially, L2 was learnt in instructional settings, and the two languages do not belong to the same linguistic family. Furthermore, participants were not immersed in the social context of the second language. The encoding phase for all groups consisted of a pleasantness rating task of positive, negative, and neutral words, followed by a free recall task. Surprisingly, they found an overall recall advantage for emotional words across languages and bilingual groups. The same magnitude of the effect was observed for the two languages in both groups of bilinguals. The authors concluded that language dominance, type of context, AoA, or the similarity between languages do not play a relevant role in determining the emotion-memory effect, but proficiency may be a relevant factor, as both types of bilinguals tested in their study were highly proficient. Ferré and colleagues went further and investigated whether the effect could be modulated by the type of task employed in the encoding phase (Ferré et al., 2013). These authors showed that the recall advantage for emotional words holds across different encoding tasks with different levels of processing (i.e., rating words' concreteness or counting the number of vowels), showing a robust effect for Catalan/Spanish bilinguals in both languages. However, the effect was modulated by valence. The emotion-memory effect for negative words only appeared when participants focused on emotionality (i.e., rating words' concreteness) at the encoding phase. In a different study including different tasks and different groups of bilinguals, Ferré et al. (2018) replicated an emotion-memory effect in both languages in a free recall task when deep processing was involved (i.e., an affective decision task) but not in more automatic tasks (i.e., a lexical decision task). This study also included a lexical decision task which will be described in the next section.

Visual word processing, recognition and interference

In this section we review relevant studies that employed tasks which measure reaction times and tap into automatic processes, such as the lexical decision task, affective priming and the emotional Stroop task.

The affective priming paradigm has proven to be particularly effective in capturing emotion effects in bilingual individuals. Notably, exposure to L2, and in the specific residing in a

predominantly L1-speaking country, emerges as a crucial predictor for the emotion effect in L2.

Ponari et al. (2015) compared early and late L2 learners of English to native L1 speakers in a lexical decision task on negative, positive, and neutral words. In this task participants are asked to decide as quickly as possible whether the sequence of letters that appears on the screen is an existent word or a non-word. The bilingual's L1 belonged to various language families (including sign language) to have different degrees of similarity to the English language. Bilinguals showed the same facilitation in processing emotionally valenced words (i.e., positive and negative words produced a faster reaction time compared to neutral words) as native English speakers. Importantly, this valence advantage was found regardless of their L1, AoA of English, or frequency and context of English use. Ponari and colleagues concluded that the emotional content of words seems to be automatically processed in both languages even for late bilinguals and also bilinguals that are not immersed in their L2 on daily basis.

In another study mentioned earlier, Ferré et al. (2018) tested a group of Catalan-Spanish balanced simultaneous bilinguals in an affective categorization task and a lexical decision task, and a group of Spanish-English bilinguals in a lexical decision task. In both cases, these tasks were immediately followed by a free recall task. First of all, there was an interaction between emotional content and language only in the group of Spanish-English bilinguals, meaning that language status was key to capturing the effect of emotionality. Second, the direction of the emotionality effect observed in the group of Catalan-Spanish balanced simultaneous bilinguals varied across tasks: negative words showed slower reaction times in both the affective and lexical decision tasks, but there was an advantage for positive words in the lexical decision and in the free recall task. The authors concluded that language status is a relevant factor that modulates the degree of emotionality similitude between L1 and L2.

Other studies employed the emotional Stroop task to capture interference effects, which is a variation of the traditional colour Stroop task. In the traditional Stroop task, participants are presented with colour words (e.g., yellow, blue, red) written in different ink colours and participants are asked to name the ink colour as quickly as possible while ignoring the word itself (e.g., if the word RED is written in green, participants' response should be 'green' and not 'red'). In the emotional Stroop task participants are asked to name the colour of neutral and emotional words presented individually (see Phaf & Kan, 2007 for a meta-analysis study). The interference effect in the emotional Stroop task is a result of the emotional content of the words: the higher the interference, the longer reaction times of emotional stimuli in comparison to neutral stimuli because of attentional mechanisms involved in the processing of the emotional content interfering in the colour naming task. The emotional Stroop task taps into

an early lexical level of processing where the semantic meaning of the words is accessed automatically. The central question here is whether bilinguals can automatically activate emotional connotation during emotional word recognition as speakers do. The main hypothesis that has guided this line of research is that if processing is more automatic in L1 than in L2, the magnitude of interference levels would be higher in L1 in comparison to L2. Studies that have used the emotional Stroop task to examine the effects of emotional words in bilingual participants showed contradictory results: while some studies reported similar effects in both L1 and L2 (Eilola et al., 2007), others reported that the emotional Stroop effect was restricted to the native language (Winskel, 2013) or that the effect was even greater in L2 in early bilinguals living in the L2 speaking country (Sutton et al., 2007). To shed light onto these contradictory results, Eilola and Havelka (2011) conducted an emotional Stroop task while monitoring skin conductance in Greek–English bilinguals and English native speakers when presented with neutral, positive, negative, and taboo words in English. While the two groups of participants showed the same pattern of results, i.e., significantly slower response times to negative and taboo words in comparison to neutral and positive words, skin conductance measured while the participants performed the emotional Stroop task appeared to be different between the two groups. English native speakers exhibited a higher electrodermal response to negative and taboo words in comparison to neutral and positive words, but no effect was observed among the bilingual participants. This study suggests that the Stroop task may not be the best behavioural task to capture the nuances discernible by physiological measures. In fact, Liao and Ni (2021) compared Chinese–English late bilinguals in three different tasks: the emotional Stroop task, the lexical decision task, and the emotional categorisation task, finding that the processing of L2 emotional words was sensitive to task type, as the emotion effect only emerged in the lexical decision task, and the emotional categorisation task but not in the emotional Stroop task.

In a different study with the emotional Stroop task, Ahn and Jiang (2023) initially observed comparable interference effects between native Korean speakers and late bilinguals using Korean as their L2 with varying native languages (L1). The study reported no modulation of L2 proficiency, but L2 exposure proved to be significant. Within the bilingual subgroup with limited L2 exposure, no emotional Stroop effect was evident, whereas the subgroup with daily exposure exhibited a similar interference to that of native speakers. These findings suggest that the distinctive characteristics of the various patterns of bilinguals recruited in different experiments play a crucial role in determining the results, with L2 exposure emerging as a particularly relevant factor.

Using a different approach, studies using the affective priming paradigm try to capture semantic activation and congruence effects through the sequential presentation of two stimuli

to participants. Each trial contains a prime and a target stimulus. Participants perform an affective categorisation task with the target word (i.e., to evaluate if its valence is positive or negative). When the prime stimulus is processed, it activates a semantic representation corresponding to its affective meaning, which in turn activates a preparatory response pathway based on its valence (i.e., a negative or positive response) (Fazio, 2001; Klauer & Musch, 2003). If the subsequently presented target turns out to be affectively congruent with the prime, this preparatory response activation has a facilitatory effect on the response to the target, reducing reaction times. On the other hand, if the target is incongruent, the response activation elicited by the prime has an inhibitory effect on the response to the target, increasing reaction times. The effect of the prime is thought to be automatic, and it persists when the prime is presented subliminally and in the presence of mental load introduced by a concurrent task.

Different studies employing the affective priming paradigm have highlighted the effects of immersion and exposure to L2 in order to find differential effects in bilinguals. Degner et al. (2012) tested late French-German and German-French bilinguals. Both groups had equitable L2 proficiency level and AoA, although the French-German group reported significantly increased exposure and current use of their L2. While both bilingual groups revealed similar results in the semantic priming task with non-affective words, and affective priming effect in their respective L1, only the group with increased exposure to L2 (i.e., the French-German bilinguals) exhibited an affective priming effect in their L2, highlighting the effect of L2 exposure.

Tenderini et al. (2022) tested two groups of proficient late bilinguals (German-English and Italian-English). In this study cross-modal affective priming paradigm was chosen, whereby musical excerpts along the two dimensions of valence and arousal were used to prime words, and vice versa, emotional words were used to prime musical excerpts. Bilinguals showed equivalent affective priming of L1 and L2 words when music primed words. That is, both positive and negative L1 and L2 targets were responded to faster when preceded by congruent (positive-positive, negative-negative) than incongruent music (positive-negative, negative-positive), suggesting no difference in deliberate processing of affective meaning between languages. However, when music was preceded by words, the prime-target interaction differed in bilinguals' L1 in comparison to their L2. The authors further explored the influence of L2 exposure, proficiency and AoA, concluding that L2 exposure is the factor that modulates the strength of priming in L2. Once again, the duration of immersion to L2 appeared as a relevant background factor increasing the level of activation/ affective priming strength of L2 words. Affective priming studies prove to be a more reliable paradigm in comparison to the emotional Stroop task to attest to automatic emotion activation in L1 and L2.

Despite the importance of the findings gathered in all these studies, they have faced criticism for predominantly concentrating on individual words out of context. The next subsection examines recent studies that addressed the call to examine the behaviour of emotional words under more ecological reading conditions.

Emotional effect in sentences

Only a few studies have explored the advantage of emotional words embedded in a sentence context. Most of them employed eye-tracking methodology. Tracking eye movements while reading provides a dynamic and real-time measure of how readers visually process and integrate information during sentence reading (see for instance Clifton et al., 2016; Rayner et al., 2006; and see Knickerbocker et al., 2015; Scott et al., 2012 for examples on the native language speakers' literature).

Sheikh and Titone (2016) tested the emotional effect in L1 French-L2 English high proficient bilinguals employing eye-tracking methodology in an experiment with increased ecological validity. Participants read sentences in their L2 containing valenced and neutral words. The task did not imply any conscious decision on the stimulus at a particular level of processing; instead, it simply involved reading sentences in the participant's L2. Participant's eye movements while reading the sentences were recorded and analysed at different stages of processing. Early measures (e.g., first-pass reading times) are typically interpreted as tapping into early stages of processing, while later measures and regressive movements to re-read earlier parts of the sentence are usually involved in subsequent integrative processes (Rayner, 2010). The findings from Sheikh and Titone (2016) indicated quicker reading times in early measures for positive words compared to neutral words, though this emotional advantage was not observed for negative words. The authors posited that in languages acquired during adulthood, there is a restricted exposure to negative emotions, as adult social interactions tend to exhibit a "positivity bias". Consequently, only negative words demonstrate emotional distance, while positive words appear to be emotionally grounded.

A more recent eye-tracking study has additionally contributed to these findings. El-Dakhs et al. (2023) tested Arab-English late bilinguals. Participants read short English sentences with embedded target words. When positive and neutral words were compared, no overall emotional effect was shown, but positive words were read faster than neutral words when both had high-frequency and low arousal. When negative and neutral words were compared, negative words were less likely to be skipped, particularly shorter ones, and negative words with low arousal were read faster than neutral words.

Finally, in another sentence reading experiment conducted with late Chinese-English bilinguals, Tang and Ding (2023) highlighted the role of L2 proficiency. The authors reported no emotion effect in L2 and no general positivity bias. However, when L2 proficiency was factored in, the results showed that the subset of participants with increased L2 proficiency showed greater ease in processing positive words at the late stage compared to those with lower L2 proficiency.

While eye tracking appears to be a promising methodology for studying the effects of emotional L2 detachment at both early and later stages of processing, the existing literature on this topic is limited. More data from diverse bilingual profiles would greatly enhance the depth and breadth of understanding in this area.

Electrophysiological and Neuroimaging studies

Electrophysiological studies (EEG) measure electrical activity on the scalp resulting from neural activity. Because of its high temporal resolution, it is a classic method for recording event-related potentials (ERPs). ERPs are electrical brain responses that are time-locked to the presentation of a stimulus or an event (Kutas & Federmeier, 2012). The ERP waveforms are characterized by key parameters such as latency, scalp distribution and duration which are analysed to understand the timing, spatial distribution, and temporal characteristics of cognitive processes. Latency is the time delay between the presentation of a stimulus and the occurrence of a specific ERP component. Different ERP components have characteristic latencies (e.g., the latency of the N400 component linked to meaning processing is commonly observed in a time window ranging from approximately 300 to 500 milliseconds after stimulus onset; Kutas & Federmeier, 2011) and these can provide information about the timing of cognitive processes. The scalp distribution or topography refers to the spatial distribution of electrical activity across the scalp during the recording of ERPs. The duration refers to the length of time during which a particular ERP component is active.

Studies tackling the native language revealed an enhanced negativity for both positive and negative valenced words compared to neutral words, predominantly at the left temporo-occipital lobes, known as the early posterior negativity effect (EPN) and a late positive component (LPC) (see e.g., Herbert et al., 2018; Hinojosa et al., 2020, for an overview). The EPN occurs relatively early in time, typically within the range of 200 to 300 milliseconds after the presentation of the stimulus, and it is most pronounced over posterior regions of the scalp. The EPN has been related to an automatic attention shift toward words with emotional relevance at early processing stages. The LPC typically occurs in a later time window, usually ranging from around 500 milliseconds to several seconds after the presentation of a stimulus,

depending on the specific experimental paradigm and the nature of the stimuli and it is often distributed over central and parietal regions of the scalp. The LPC is thought to be involved in a higher level of word semantic processing, among other cognitive processes.

In a pioneering work using ERPs to explore emotional processing in L1 and L2, Conrad et al. (2011) found a similar pattern of event related potential waves in both L1 and L2. This study examined emotional word processing in two groups of German-Spanish and Spanish-German late bilinguals in two lexical decision tasks, one in Spanish and one in German. Although both groups of bilinguals were proficient, the group with L1 Spanish had greater L2 exposure as they were living in the L2-speaking country at the moment of the experiment. The behavioural data in German showed neither the commonly reported valence effect (advantage for emotional over neutral words), nor the L1 over L2 emotional advantage. The results of the Spanish lexical decision task showed faster response times for positive words, followed by negative words, and then neutral words were the slowest, indicating an emotional advantage. No difference between L1 and L2 speakers was found. The analyses of the ERP data showed a significant effect of valence whereby both the EPN and LPC components were elicited in L1 and L2 in positive words, although longer latencies were observed in L2, suggesting quantitative but not qualitative differences in processing emotional words between languages.

Similar results were obtained in Opitz and Degner (2012) testing French-German and German-French late bilinguals using a lexical monitoring task, a variant of the lexical decision task where participants have to decide if a certain pseudoword is orthographically similar to a real word. Replicating previous findings, emotional words produced faster reaction times than neutral words in both L1 and L2 reflected in an amplified EPN. While the neural responsivity was similar in both groups, the peak amplitude was delayed for L2 emotional words, modulated by proficiency: less proficient bilinguals produced longer latency waves, perhaps as a result of the greater effort required for linguistic processing. These results suggest that affective emotion is processed similarly but in L2 there is a delayed lexical access. In general, the results from EEG-ERP studies do not seem to capture the emotional detachment reported in L2, just some modulation of latency measures in some studies (see Herbert, 2022).

Beyond ERPs, another approach widely used in cognitive science is the Functional Magnetic Resonance Imaging (fMRI), a non-invasive neuroimaging technique that maps changes in blood flow determined by neural activity in the brain. These patterns of blood flow enable researchers to understand how different areas of the brain respond to various tasks, including cognitive processes and emotional stimuli.

In an intriguing study, Hsu et al. (2015) investigated the neural substrates associated with reading passages from Harry Potter books in L1 or L2 in late German–English bilinguals. The

passages evoked negative, positive or neutral emotions. The results showed a differential pattern of activation in both languages, with overall more differentiated neural responses in L1 than in L2. In particular, although both languages showed activation of the amygdala, the hippocampal and parahippocampal cortex associated to emotional stimuli, the activation of the bilateral amygdala and the left precentral cortex in positive passages were stronger in L1. The results suggest that reading in our native language provides a more emotional experience than reading in a second language. In a different study, Chen et al. (2015) collected behavioural, ERP and fMRI recordings from Chinese–English late bilinguals while performing a lexical decision task. Behavioural results showed faster recognition of positive words compared to negative and neutral words in L1. The ERPs components showed that positive words elicited a larger EPN and a smaller LPC than neutral words in L1. Finally, the fMRI data revealed reduced activation for L1 emotional words in the left mid-occipital gyrus (with no activation in L2) and increased activation in the left cerebellum for L2 emotional words. Altogether, the data appears to indicate distinct mechanisms for the processing of emotional words in L1 and L2. Specifically, quicker and more automatic attention toward emotional stimuli may be the mechanism responsible for the emotional advantage observed in L1. Along these lines, Sulpizio and colleagues used fMRI to investigate taboo words in a lexical decision task. The L2 processing of taboo words involved structures responsible for social-norm representation and evaluation like the anterior cingulate cortex or the insula. The findings revealed that, exclusively in L1 (but not in L2), a reduced effort is required to process taboo words compared to non-taboo words. The authors interpreted this outcome as indicative of the automatic processing of socio-pragmatic information occurring in L1, while in L2, less automated processing involving additional cognitive structures is necessary.

While fMRI studies on this topic are limited, they show convergent evidence of a differential brain activation in bilinguals' processing of L1 and L2 emotional words.

Physiological indicators

Physiological techniques rely on the automatic and involuntary activation of the autonomous nervous system. Emotional stimuli activate the autonomous nervous system which in turn produces bodily responses such as increased skin conductance responses (i.e., electrodermal galvanic response), heart rate, frequency and pupil size (Bradley et al., 2008; Caldwell-Harris, 2014; Harris et al., 2006).

In this section we focus on studies that analysed skin conductance response and pupil size. Overall, the results showed that emotional stimuli such as taboo words and childhood

reprimands elicited larger skin-conductance responses and pupil size, especially when presented auditorily in the L1.

Skin conductance responses were first evaluated by Harris and colleagues in a series of studies. Harris et al. (2003) found that Turkish-English late bilinguals showed higher skin conductance responses when taboo words and childhood reprimands were presented in their L1. Similarly, Eilola and Havelka (2011) measured skin conductance responses in L1 Greek-L2 English bilinguals and in English native speakers while participants performed an emotional and taboo Stroop tasks. While the authors didn't find any effect in the Stroop task, skin conductance responses were different in both groups. There was a greater reactivity to negative and taboo words only in native speakers. This suggests that, although responses from both groups were similar on a behavioural level, the level of arousal produced by the negative and taboo words was greater for native speakers. Follow-up studies replicated the same effect with different L1-L2 pairings and auditory-visual modalities (Caldwell-Harris, 2014; Harris et al., 2006; Jankowiak & Korpal, 2018). Skin conductance responses seem to be robustly elicited by stimuli presented in L1 in comparison to L2, specially for taboo words, showing an accentuated reaction to negative than to neutral or positive stimuli.

Another common physiological reaction to emotion can be observed in the pupil diameter. Pupillary response is sensitive to emotional stimuli (Bradley et al., 2008; Partala & Surakka, 2003) and other cognitive factors (see for an overview Schmidtke, 2014). The bilinguals' difference in pupillary responses between L1 and L2 has been investigated with single words (Toivo & Scheepers, 2019) and sentences (Iacozza et al., 2017). Iacozza and colleagues examined Spanish-English participants using target words with negative valence and high in arousal (e.g., death). These words were embedded in sentences in both L1 and L2. The results revealed an increased pupillary response to emotional in comparison to neutral stimuli in both languages, but the magnitude of the effect was stronger in L1 than in L2. While the results of this study only generalize to negative stimuli, Toivo and Scheepers (2019) tested both negative and positive valenced words with high arousal and low arousal, and neutral distractor words. Three groups of Finnish-English bilinguals, German-English bilinguals and a control group of monolingual English speakers performed a word recognition judgement after reading words presented individually. While the behavioural responses to word recognition judgements yielded no significant results, a stronger pupillary automatic reaction was observed in L1 in comparison to L2 in both bilingual groups.

In a recent study with Russian-German and Turkish-German balanced heritage speakers (i.e., individuals who grow up in a community where a particular language, known as the heritage language, is the dominant language) and German-English and German-French late bilinguals,

Thoma (2023) compared self-reported feelings and pupil responses to emotional audiovisual stimuli. Whereas heritage speakers showed a similar pattern of responses in both L1 and L2, but lower affective ratings in German, bilinguals showed similar ratings in both languages but reduced pupillary response in L2. The authors concluded that both measures tap into different stages of emotion processing, pupillometry being an automatic measure of emotional responsiveness and ratings or self-reported feelings a more introspective and self-conscious measure likely to be influenced by the sociocultural context.

Another recent study investigated this topic including a new phonological factor. Yao et al. (2023) compared the pupil sizes of Cantonese–Mandarin bilinguals while listening to words that shared orthographic but not phonological form (i.e., cognates) in both languages. Pupil size was larger when words with L1 pronunciations were presented, especially with taboo words. The authors highlight the role of the phonological form in the emotionality effects in language processing.

To sum up, the physiological indicators recorded in the studies described in this section seem to reliably and robustly identify weaker responses to emotional contents in L2, including reduced pupillary effects (Iacozza et al., 2017; Toivo & Scheepers, 2019), decreased facial motor resonance and skin conductance responses (Baumeister et al., 2017; Jankowiak & Korpal, 2018).

The emotional component in the Foreign Language Effect

The evidence presented in the preceding sections appears to indicate that, notwithstanding certain conflicting findings in the literature—likely stemming from the heterogeneity and variability of pertinent factors across various studies—there exists an emotionality advantage for native languages over late acquired languages as documented through diverse techniques. Consequently, the pertinent question arises: what implications might this hold for real-world consequences beyond the confines of the laboratory?

Some studies have reported intriguing findings, such as the observation that criticism in the L2 elicits less emotional impact (Gao et al., 2020), or that advertising slogans are perceived as less emotional when presented in L2 (Puntoni et al., 2009). If these effects indeed influence how we receive and interpret information, to what extent can this emotional impact have implications for the way we make decisions??

Traditionally, decision-making has been conceptualized as a logical and reflective process in line with the rationalist tradition. However, various lines of research suggest a less rational underpinning to decision-making. Tracing back to the seminal work of Damasio (1994), which

argued that emotions manifested in bodily signals guide people's decisions, there exists a pervasive influence of emotion in this cognitive process. Building upon this perspective, subsequent works have put forth a dual-process theory positing that moral decision-making is shaped by an intricate interplay between emotional and rational processes (e.g., Greene et al., 2001; Kahneman, 2003).

The emotional system contributes to judgments that prioritize fundamental rights and duties of an individual, leading to deontological decisions. These processes are characterized by speed, automaticity, and affectivity, indicating unconscious and spontaneous reasoning that occurs predominantly involuntarily and is closely tied to emotions. In contrast, rational processes underpin judgments that prioritize the greater good, aiming to maximize benefits and minimize costs across affected individuals, resulting in utilitarian decisions. These processes operate in a more explicit manner, demanding deliberative and effortful reasoning, and are largely detached from emotional influences.

Researchers have explored the influence of emotions on decision-making through the use of moral dilemmas, wherein participants are presented with choices between different options. Green et al. (2001) emphasized the significance of distinguishing between personal and impersonal dilemmas. An example of a personal dilemma is the well-known Footbridge dilemma (Foot, 1978), in which a runaway trolley, destined to kill five people tied to a train track unless action is taken. The only way to prevent the tragedy is to push a man from a bridge onto the tracks, sacrificing him to halt the trolley. This decision is categorized as utilitarian, as it seeks the greatest good for the greatest number despite causing harm to one individual. On the other hand, refraining from taking action aligns with deontological principles, as it adheres to ethical rules regardless of the potential catastrophic consequences. In the impersonal version of this dilemma, the Switch dilemma, the trolley can be diverted to another track where a man is working by manipulating a switch. This alternative allows the trolley to run over one person instead of the five individuals present on the original track. Green and colleagues employed functional magnetic resonance imaging (fMRI) to record participants' brain activation during the moral decision-making process when confronted with the Footbridge and Switch dilemmas. The findings revealed that the personal Footbridge dilemma led to the activation of brain areas associated with emotion, whereas this emotional activation was comparatively less pronounced for the impersonal Switch dilemma. These results provide evidence indicating the involvement of emotional processes in moral decision-making and their potential influence on the decision-making outcome.

The dual-process theory has also been studied in bilinguals, delivering one of the most impacting revelations derived from research on bilingualism: the foreign language effect. The

foreign language effect refers to the psychological phenomenon in which individuals tend to make different decisions when processing information in a language other than their native or first language, underscoring the importance of the language employed in framing problems or dilemmas. This linguistic dimension emerges as a pivotal contextual factor capable of playing an important role on the eventual outcomes of decision-making. While the nature of this phenomenon is still being debated, emotional factors are at the centre of the debate. The effect has been studied in a number of contexts including decision-making, risk perception, and moral judgement.

The effect of language on decision making was first reported by Keysar et al. (2012). In their study, Keysar and colleagues tested the effects of framing effects on different groups of bilinguals using two modified versions of the original “Asian disease”, a problem from Kahneman and Tversky (1979).

The first version the problem was presented with a gain-frame (from Keysar et al., 2012, page 2):

"Recently, a dangerous new disease has been going around. Without medicine, 600.000 people will die from it. In order to save these people, two types of medicine are being made.

If you choose Medicine A, 200.000 people will be saved.

If you choose Medicine B, there is a 33.3% chance that 600.000 people will be saved and a 66.6% chance that no one will be saved. Which medicine do you choose?"

The second version of the problem was the same but presented with a loss-frame, that is, for Medicine A, it read that “400.000 will die” instead of "200.000 people will be saved", and for Medicine B, it read there was a "33.3% chance that no one will die” and a "66.6% chance that 600.000 people will die.”

Participants preferred a probabilistic outcome (i.e., Medicine B) when the problem was framed as involving a loss, but a sure outcome (i.e., Medicine A) in the frame of involving a gain. This framing effect was only observed for the L1. In a second set of experiments on loss aversion, the authors also observed a different decision-making behaviour. Participants were less affected by aversion to losses in their second language and were more willing to take bets. Subsequent studies tested different sorts of dilemmas and problems on bilinguals, but probably the one that gained more attention, even outside academia[1] were the experiments on moral decisions and the footbridge dilemma.

[1] See for instance this BBC post on Instagram https://www.instagram.com/p/CyFtuPPqBW5/

Costa and colleagues (Costa, Foucart, Hayakawa, et al., 2014) presented bilinguals with a version of the footbridge and the trolley dilemma. The results revealed that, in the footbridge dilemma, the participants were twice as willing to push the man from the bridge onto the track (utilitarian option) when the dilemma was presented in their L2 than when it was presented in their L1. However, no differences were observed in the switch dilemma, in which around 80% of the participants decided to divert the train regardless of the language in which the dilemma was presented.

The foreign language effect on moral decisions is a robust and reliable finding in cognitive science. It has been replicated across studies with different linguistic communities and samples of bilinguals with different levels of proficiency and age of acquisition and different methodological choices (i.e., types of task and presentation modality and framing, Brouwer, 2021; Cipolletti et al., 2016; Hayakawa et al., 2017; see Del Maschio et al., 2022 for a meta-analysis). Interestingly, similarity between L1 and L2 seems to diminish the effect (Circi et al., 2021). Furthermore, Kyriakou et al. (2023) found that late bilinguals use a lower number of emotional words in justifying their decision when facing moral dilemmas in the L2 context.

This finding is surprising since, assuming individuals comprehend the dilemma, understand the two options, and grasp their consequences (i.e., ruling out a problem of full comprehension), the choice should be independent of language. Therefore, how is this phenomenon explained from a psychological standpoint?

At least three explanations have been proposed to account for the foreign language effect, which are non-mutually exclusive and probably complementary. First, using an L2 involves a higher cognitive load which reduces the ability to attend to the emotional dimension of certain stimulus or situations, limiting the expression of affect-based intuitions. Second, there is an increased psychological distance (i.e., the ability to separate ourselves from other instances, such as an individual or an event) when using an L2 due to different mental representations during moral decision making in the L1 versus the L2 (Shin & Kim, 2017) or due to disembodiment (Pavlenko, 2008, 2012). Relatedly, Geipel et al. (2015, 2016) suggest that the foreign language reduces intuition and also activation of relevant moral and cultural information, probably limiting the mental accessibility of social and moral rules. Third, diminished emotional activation in the foreign language leads to less automated thinking and minimizes reliance on the affective system (McFarlane et al., 2020). While contemporary perspectives acknowledge the possibility of multiple contributing factors, emotional processing in L2 emerges as a prominent candidate when interpreting the results of both the comprehension and production studies (Kyriakou et al., 2023).

In addition to moral judgements, the foreign language effect has also been investigated in a number of other contexts. In a code-switching experiment (Driver, 2022), late proficient English-Spanish bilinguals were tested in L1, L2 and in a code-switching condition where there was intra-sentential and inter-sentential switching between English and Spanish. Participants exhibited similar behaviour when the dilemma was presented in their L1 and in the code-switching modality, while presentation in L2 increased the frequency of utilitarian decision. In a different study, statements presented in L2 reduced illusions of causality, a cognitive bias that involves perceiving a relationship or a cause-and-effect connection between two unrelated events (Díaz-Lago & Matute, 2019). In an experiment conducted by Geipel et al. (2022), the attitude towards COVID-19 vaccines was influenced by the language in which information was presented. Specifically, presentation in L2 English was associated with a reduction in vaccine hesitancy. The attitude towards contemporary topics such as climate change or biotechnology also varied based on language (Hadjichristidis et al., 2015), with L2 prompting a more positive overall affect and leading to lower judgements of risk and higher judgements of benefit. Somewhat relatedly, Hadjichristidis et al. (2019) found that the use of a foreign language elicited fewer negative feelings towards scenarios involving bad luck and fewer positive feelings towards scenarios involving good luck. But the influence of the foreign language effect is not limited to beliefs. For instance, Grant et al. (2023) employed the Deese-Roediger-McDermott (DRM) paradigm to induce false memories by presenting semantically related lists of words in L1 or L2. Subsequently, participants were asked to recall the words and identify whether each word was presented on the list or merely came to mind but was not on the list. Participants identified false memories more accurately in the foreign language, probably because the foreign language increases the use of memory monitoring. Furthermore, false memories increased with participants' proficiency in their foreign language (Arndt & Beato, 2017). In conclusion, our native language assumes a pivotal role in influencing our judgments, attitudes, and choices, all of which share a significant affective component. The implications of these findings are significant in our modern globalised societies, where a substantial amount of pertinent information exchange occurs in L2.

Conclusions

The studies examined in this review reveal the intricate nature of the literature on emotions and bilingualism. The diversity across studies, encompassing various tasks, materials, and methodologies, along with the heterogeneity within bilingual populations, introduces varying degrees of complexity. Overall, there appears to be an emotional advantage in L1 which extends beyond comprehension and production processes, potentially influencing other

cognitive functions such as reasoning and decision-making when mediated through language. This suggests an emotional detachment akin to what is observed in word and sentence processing, although the specific role of emotions requires further investigation.

For psycholinguistic and neurolinguistics studies on visual word processing, the effect seems to appear more clearly for late bilinguals and when the task taps into automatic processing. The emotional distance between L1 and L2 does not show up, across the board, in the case of simultaneous bilinguals, in bilinguals that acquired both languages in early childhood in an immersion environment, or in bilinguals with great L2 exposure that keep L2 active. Nevertheless, the results in this literature are heterogeneous and some studies reported a lack of an emotional advantage (e.g., Altarriba & Basnight-Brown, 2012; Ferré et al., 2013) or, more rarely, an enhanced emotional effect in L2 in comparison to L1 (Ayçiçegi & Harris, 2004). The divergence of results has been linked to the modulatory effect of individual's differences in AoA and context of learning (Altarriba, 2008), proficiency (Eilola & Havelka, 2011; Imbault et al., 2021), L2 use (Degner et al., 2012; Puntoni et al., 2009; Segalowitz et al., 2008), type of task performed by participants (Segalowitz et al., 2008), or type of stimuli.

Data summarized in our review comes from a variety of different type of tasks employed in the different studies including memory studies, reaction-time tasks (such as lexical decision tasks), or simply reading sentences. There seems to be evidence that tasks with different levels of processing deliver contradictory results (Ayçiçegi-Dinn & Caldwell-Harris, 2009), which is aligned with the findings from neuroimaging studies that emotional processing is more automatic in L1. ERPs and fMRI evidenced different patterns and brain activation in L1 than in L2, also suggesting that emotional processing may be less automated in L2, probably involving additional cognitive structures (Chen et al., 2015; Hsu et al., 2015). Some of the tasks explicitly asked to focus on words' emotional content, which for some authors is problematic and can be confounded by slower semantic processing in L2, depending on L1 proficiency (see Degner et al., 2012; Segalowitz et al., 2008). Additionally, some authors pointed out that studies employing offline methods (such as subjective ratings) and online methods (such ERPs) tap into different stages or dimensions of emotion processing (Thoma, 2023, among other.). Lastly, the experimental measure used to gauge the emotionality effect also plays a role as, in general, ERPs, neuroimaging and physiological measures tend to be more sensitive than behavioral measures or subjective emotionality ratings (Caldwell-Harris et al., 2011; Eilola & Havelka, 2011; Iacozza et al., 2017; Ponari et al., 2015; Segalowitz et al., 2008). Studies measuring pupillary size, facial motor resonance, and skin conductance responses have been consistent and robust in demonstrating diminished responses to emotional stimuli in L2 (Baumeister et al., 2017; Iacozza et al., 2017; Jankowiak & Korpal, 2018; Toivo & Scheepers, 2019).

The results underscore the necessity of conducting further investigations into the ecological validity of the main findings highlighted in this literature, for instance through social media data, which would allow to investigate language choice and code-switching in given contexts, and the nature of the linguistic productions in terms of valence-arousal which would help us answer questions such as: do bilinguals choose words with higher arousal and more extreme valence values when speaking/writing in L1 than in L2?. Future research should delve deeper into understanding the differential effects between positive and negative valenced words, as well as between emotion-label and emotion-laden words. In the specific case of lab settings, tasks combining behavioural, physiological and neurological measures are encouraged to provide a more accurate insight on the interaction between emotion and language as suggested by Thoma (2023), among others. Resolving inconsistent findings may require taking into account a multifactorial and multi-measure approach.

Beyond research and academic purposes, the results are also highly relevant for pedagogical applications, especially for the field of foreign language learning. The findings can offer valuable insights into designing effective language learning strategies that consider the emotional nuances associated with instructional settings and promote a more interactive approach. Moreover, the implications extend to the dynamic environment of bilingual or multilingual communities and families. Parents, as primary language models, play a crucial role in shaping language acquisition and proficiency in their children. The research outcomes provide guidance on the language choices parents make when communicating with their children and how these choices might influence emotional processing. This understanding is particularly pertinent for families navigating the complexities of multiple languages within the household, contributing to more informed decisions regarding language use and fostering effective communication and language development in children.

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