CORTEX XXX (2015) 1–15

Available online at www.sciencedirect.com

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Journal homepage: www.elsevier.com/locate/cortex

Research report

Processing emotional words in two languages with one brain: ERP and fMRI evidence from Chinese–English bilinguals

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ARTICLE INFO

Article history:
Received 28 October 2013
Reviewed 18 February 2014
Revised 17 May 2014
Accepted 2 June 2015
Action editor Stefano Cappa
Published online xxx

Keywords:
Bilinguals
Emotional activation
Emotional words
ERPs
fMRI

ABSTRACT

Emotional words in a bilingual's second language (L2) seem to have less emotional impact compared to emotional words in the first language (L1). The present study examined the neural mechanisms of emotional word processing in Chinese–English bilinguals' two languages by using both event-related potentials (ERPs) and functional magnetic resonance imaging (fMRI). Behavioral results show a robust positive word processing advantage in L1 such that responses to positive words were faster and more accurate compared to responses to neutral words and negative words. In L2, emotional words only received higher accuracies than neutral words. In ERPs, positive words elicited a larger early posterior negativity and a smaller late positive component compared to neutral words in L1, while a trend of reduced N400 component was found for positive words than for neutral words in L2. In fMRI, reduced activation was found for L1 emotional words in both the left middle occipital gyrus and the left cerebellum whereas increased activation in the left cerebellum was found for L2 emotional words. Altogether, these results suggest that emotional word processing advantage in L1 relies on rapid and automatic attention capture while facilitated semantic retrieval might help processing emotional words in L2.

1. Introduction

Our daily lives are filled with a variety of emotional experiences, such as happiness, anger, sadness, or fear. Most people are able to freely express their feelings in their native language (L1). However, as second language (L2) speakers, bilinguals frequently report experiencing weaker emotional activation in their L2 compared to their L1 (Pavlenko, 1998). Therefore, L1 is considered emotionally close, whereas L2 is emotionally distant (Bond & Lai, 1986).

Emotional words play an important role in expressing feelings. The emotional connotation of these words is the key

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http://dx.doi.org/10.1016/j.cortex.2015.06.002
0010-9452/

feature that distinguishes them from neutral words (Altarriba, Bauer, & Benvenuto, 1999). Previous studies have used recall tasks to investigate whether bilinguals' weaker emotional experience in L2 is due to different processing mechanisms for emotional words in L2 and in L1. Several studies have found that bilinguals recall more emotional words, of which most were positive, in L1, while there was no such recall advantage for emotional words in L2 (e.g., Anooshian & Hertel, 1994). However, other studies have revealed that bilinguals show better memory for emotional words compared to neutral words both in L1 and L2 (Ayçiçeği & Harris, 2004; Ferré, García, Fraga, Sánchez-Casas, & Molero, 2010), an effect that was not influenced by age of acquisition, context of acquisition, or language similarity (Ferré et al., 2010). Behavioral studies using the emotional Stroop paradigm have also found comparable effects of emotion in bilinguals' L1 and L2 such that negative words were responded to significantly slower than neutral words (Eilola, Havelka, & Sharma, 2007; Sutton, Altarriba, Gianico, & Basnight-Brown, 2007).

Skin conductance response (SCR), a sensitive measure of autonomous arousal (Harris, 2004), has also been used in studies of bilingual emotional word processing. A series of studies comparing late bilinguals and early bilinguals residing in an L1 or L2 environment, showed that late bilinguals had a stronger SCR to emotional words (mainly taboo words and reprimands) in L1 compared to L2, regardless of the language environment they were immersed in (Eilola & Havelka, 2011; Harris, Ayçiçeği & Gleason, 2003). In contrast, early bilinguals showed no differences in SCR to emotional words between L1 and L2 (Harris, 2004). Based on these findings, Harris proposed that only emotional words acquired in emotional contexts could elicit sufficient emotional activation. Accordingly, emotional words acquired outside of an emotional context (e.g., classroom instruction), are unable to evoke autonomous arousal. Therefore, the emotional activation to emotional words in L2 may be weaker than in L1 (Harris, Gleason, & Ayçiçeği, 2006).

In summary, previous behavioral and psychophysiological studies have shed light on emotional word processing in bilinguals' L1 and L2. The SCR studies have found that bilinguals have larger SCRs to extreme negative emotional words in L1 compared to L2, however, differences in processing of common emotional words in two languages are still unclear. The reaction time studies revealed a similar pattern in emotional word processing in L1 and L2. This could be due to the fact that reaction time only reflects an aggregate effect of processing, but is unable to reveal differences that might occur at intermediate stages of processing. Because emotional words in L2 are suggested to evoke less autonomous arousal, there would probably be differences in the time course of processing emotional words in bilinguals' two languages, and processing emotional words in L2 might require more neural activation related to emotional processing. Due to their high temporal and spatial resolution, respectively, event-related brain potentials (ERP) and functional magnetic resonance imaging (fMRI) would be helpful to shed light on these hypotheses. However, as will be reviewed below, previous ERP and fMRI studies have mainly investigated the neural mechanism of emotional word processing in monolinguals.

ERP studies on emotional word processing in L1 have found that both positive and negative words elicit a larger early posterior negativity (EPN), starting around 250–350 msec after stimulus onset compared to neutral words. The EPN has been suggested to reflect an automatic and rapid sub-process in which emotional words capture attention for later sustained processing (Herbert, Junghofer, & Kissler, 2008; Kissler, Herbert, Peyk, & Junghofer, 2007; Kissler, Herbert, Winkler, & Junghofer, 2009; Schacht & Sommer, 2009a; Scott, O'Donnell, Leuthold, & Sereno, 2009). This early emotion effect may reflect the activation of enhanced sensory resources in the visual cortex mediated by the emotional regulation system, including the amygdala and the cingulate cortex (Kissler et al., 2007). In the late time window of 450–700 msec, several studies have reported a larger late positive component (LPC) elicited by positive words compared to neutral words (Herbert, Kissler, Junghöfer, Peyk, & Rockstroh, 2006; Herbert et al., 2008; Kissler et al., 2009; Schacht & Sommer, 2009a, 2009b), or vice versa (Citron, 2011; Hinojosa, Carretié, Valcárcel, Méndez-Bértolo, & Pozo, 2009) while others have found that negative words induce a larger LPC compared to neutral words (Bayer, Sommer, & Schacht, 2010; Hofmann, Kuchinke, Tamm, Võ, & Jacobs, 2009; Schacht & Sommer, 2009a). This late positive component may reflect elaborate processing of the attended information (e.g., task demands) (Fischler & Bradley, 2006; Kissler, Assadollahi, & Herbert, 2006; Kissler et al., 2009; Schacht & Sommer, 2009b). A recent ERP study (Conrad, Recio, & Jacobs, 2011) investigated emotional word processing in highly-proficient German–Spanish and Spanish–German bilinguals using a lexical decision task. Results showed that the EPN and LPC were larger for emotional words than for neutral words in both L1 and L2, but the onset of EPN effect appeared in L2 were 50–100 msec later compared to it in L1, which suggests a general delayed L2 processing rather than a qualitatively different processing of emotional words across L1 and L2. This similar EPN effect, comparable on amplitude between L1 and L2 but delayed in L2, was also found in another study with late but proficient bilinguals (Opitz & Degner, 2012).

Previous fMRI studies on emotional word processing in L1 have shown that negative words, compared to neutral words, increased activation in the left amygdala (Hamann & Mao, 2002; Nakic, Smith, Busis, Vythilingam, & Blair, 2006), the right amygdala (Maddock, Garrett, & Buonocore, 2003; Nakic et al., 2006; Tabert et al., 2001;), the left cingulate cortex (George et al., 1993; Maddock & Buonocore, 1997; Whalen et al., 1998), the right cingulate cortex (Cato et al., 2004; Nakic et al., 2006), and the bilateral medial orbitofrontal cortex (Maddock et al., 2003). Positive words induced more activation in the left amygdala (Hamann & Mao, 2002; Herbert et al., 2009), the dorsal and ventral striatum including the caudate nucleus, the bilateral putamen, the left globus pallidus and the right nucleus accumbens (Hamann & Mao, 2002), the left orbitofrontal cortex (Kuchinke et al., 2005), the right orbitofrontal cortex (Maddock et al., 2003), the left dorsolateral prefrontal cortex (Maddock et al., 2003), and the bilateral cingulate cortex (Cato et al., 2004). Among these brain regions, the left and right amygdalae are usually associated with emotional information processing, especially negative emotion processing (Gläscher & Adolphs, 2003; Hamann & Mao, 2002; Phelps et al., 2001; Wright et al., 2001). The striatum is considered to be

Please cite this article in press as: Chen, P., et al., Processing emotional words in two languages with one brain: ERP and fMRI evidence from Chinese–English bilinguals, Cortex (2015), http://dx.doi.org/10.1016/j.cortex.2015.06.002