Labeling emotions in a native and foreign language:

An ERP study on emotion regulation in bilinguals via affect labeling

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List of Abbreviations

L1	Native language
L2	Second language
FLE	Foreign Language Effect
AoA	Age of Acquisition
CoA	Context of Acquisition
EPN	Early Posterior Negativity
LPP	Late Positive Potential

Table of Contents

List of Tables

List of Figures

Abstract

Recent research on the Foreign Language Effect (FLE) suggests that bilinguals tend to experience a larger attenuation of emotion in their second language (L2) than in their native language (L1). Clinically, the use of L2 has been proposed as an emotional detachment tool for bilingual patients to distance themselves from negative emotions. However, to date, there is very little experimental evidence that compares the neural dynamics of L1 and L2 use in emotion regulation. The current study used the event-related potential (ERP) technique to investigate implicit emotion regulation elicited by negative faces (angry, sad, fearful) via "affect labeling" in L1 and L2, an emotion regulation technique proved to down-regulate emotions. Chinese-English bilinguals completed the experiment under three conditions (passive viewing, labeling negative emotions in Chinese/L1, and labeling emotions in English/L2), while their brain activity was recorded and time-locked to the onset of displayed emotional faces. Early, middle, and late ERP components (N170, EPN, LPP respectively) were analyzed and compared across conditions. Results revealed that, labeling emotions in L2, but not in L1, decreased the amplitude of the early components (N170, EPN) compared to passive viewing, suggesting a reduction in the automatic attentional allocation to emotional stimuli in L2. For the later component, L2 labels had no impact on the LPP amplitude, but L1 labels increased LPP for angry faces relative to passive viewing, implying a heightened processing of emotions in L1. Further, in line with the FLE, ERP amplitudes were attenuated in the L2 label condition compared to the L1 label condition at all stages. Finally, frequency of L2 use in daily life (but not L2 proficiency) predicted ERP differences at the later stage, such that lower usage of L2 led to a more reduced LPP in the L2 label condition relative to passive viewing and L1 label condition. Overall, the current study confirmed the FLE phenomenon in non-dominant bilinguals' emotion regulation. In particular, it suggests that frequency of L2 usage has an important influence on bilinguals' emotion regulation outcome. The study only partially supports the effectiveness of affect labeling, and implications of our findings are discussed.

Chapter 1: Introduction

Bilinguals' emotional experience can vary drastically depending on the language they are using. Anecdotally, many bilingual writers described their later-acquired language as cold and less genuine (e.g. Hoffman, 1989; Huston, 2002). Some bilinguals even reported a change in identity and personality when switching between languages (Pavlenko, 2006). The poet Paul Celan went as far as saying, "only in the mother tongue can one speak one's own truth, in a foreign language the poet lies" (Joris, 2005).

The intricate connection between language and emotion also intrigued psychologists to explore the mechanism underlying bilinguals' emotion processing. In fact, growing empirical evidence suggests that many bilinguals do experience a larger attenuation of emotionality in their second language (L2) than in their native language (L1). This has been termed as the "Foreign Language Effect" (FLE). Understanding the different emotionality associated with language use has critical implications for clinical practice. In particular, the decreased emotional reactivity to negative stimuli in L2, termed the *L2 advantage,* has been proposed as a therapeutic tool for bilinguals to distance themselves from painful feelings and traumatic memories (Pavlenko, 2012; Martinovic & Altarriba, 2012). However, to date, there is very limited empirical research on the role of L2 in emotion regulation and control (Morawetz, Oganian, Schlickeiser, Jacobs, & Heekeren, 2017).

In this chapter, I first introduce the main models and theories for interpreting the emotional effects in L2. Next, I describe the event-related potential (ERP) technique, which offers great temporal resolution to study the exact time course of emotion processing. This is followed by an in-depth examination of the current empirical evidence on the reduced emotionality in L2. Crucially, I aim to connect different areas of research to discuss the role of language in emotion regulation, with an emphasis on the possible advantage of using L2 in suppressing negative emotions. Finally, I propose the rationale and hypothesis for the present study.

1.1 Theories for the L2 Emotionality Effects

In this section, I outline several models/theories that aim to explain the mechanism of emotion processing in bilinguals at both a linguistic and a cognitive level, featuring the Revised Hierarchical Model (Kroll & Stewart, 1994), language-specific episodic trace theory of language emotionality (Puntoni, Langhe, & Osselaer, 2009), the emotional contexts of learning theory (Harris, Gleason, & Ayçiçeği, 2006), and the theory of L2 disembodiment (Pavlenko, 2012). All of these theories attempt to explain the emotionality differences between L1 and L2.

The *Revised Hierarchical Model* (RHM) was initially designed to account for the separate storage and processing of L1 and L2 words in bilingual memory (Kroll & Stewart, 1994). The RHM describes two levels of representation in the bilingual lexicon: *lexical* and *conceptual*, the former containing the word forms and the latter representing their meanings (de Groot, 2011) (See Fig. 1). According to the RHM, an L2 word needs an indirect mediator (i.e. its translation in L1) in order to access its conceptual representation, so the connection between words and their abstract meanings are much weaker in L2 than in L1. Recently, some researchers attempted to use the RHM to explain the bilingual emotional experience, positing that the lexico-semantic representation of emotion words in L2 is weaker in the bilingual mental lexicon (e.g. El-Dakhs & Altarriba, 2019; Ni & Jin, 2020). Crucially, the RHM predicts that as L2 proficiency increases, the connection between the two representation levels (i.e. lexical and conceptual) in L2 will become stronger (de Groot, 2011). That is, bilinguals who are fluent in both languages (i.e. balanced bilinguals) may experience emotions similarly in their two languages, whereas unbalanced bilinguals may show deeper or more biased emotional processing in their L1 (Freeman, Shook, & Marian, 2016).

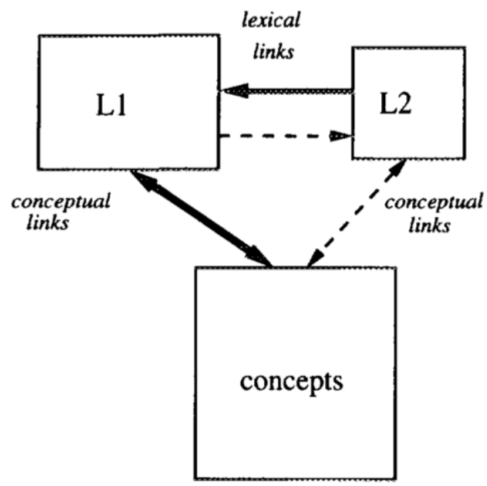

Figure 1: Revised Hierarchical Model (Kroll & Stewart, 1994). This version of the model assumes later acquisition or lower proficiency in L2 compared to L1.

Based on the RHM, Puntoni et al. (2009) proposed a *language-specific episodic trace theory of language emotionality*. In their theory (See Fig. 2), L1 and L2 words trigger episodic memory traces experienced in their corresponding context. Usually, with unbalanced/late bilinguals, there are more emotional events experienced in L1 than in L2, so L1 words tend to be perceived as more emotional. However, according to Puntoni et al. (2009), L2 words can also indirectly and partially activate the corresponding words in the L1 lexical store, as illustrated by the bold black arrow in Fig. 2. That is, L2 words not only activate the "echo" content from events experienced in L2, but also benefit from the emotionality of experiences triggered by the echo content from L1 events. This will lead to a reduced difference in the emotionality of L1 and L2 words, as one gains more accessibility to L1 translations. Importantly, the episodic trace theory emphasizes the relationship between the frequency of using a word and emotionality associated with that particular word. Thus, this model predicts that, in rare situations, L2 words could be experienced more emotionally than L1 words, if those words were encountered more frequently (i.e. more episodic traces) in an L2 language context than in L1.

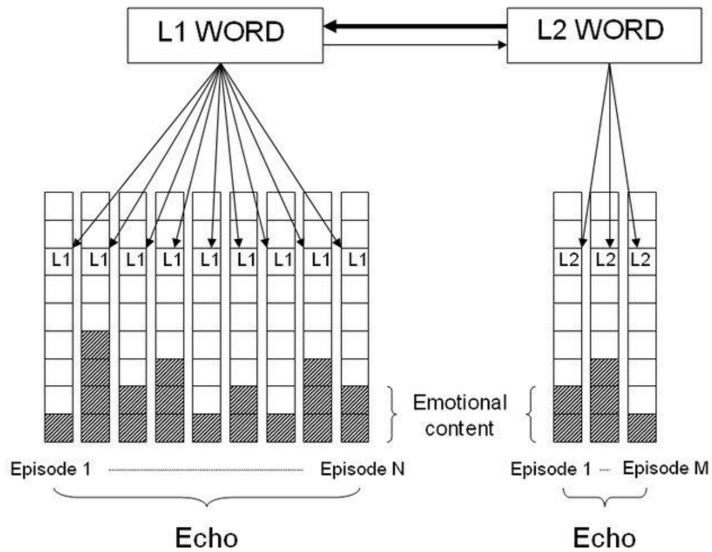

Figure 2: Language-specific episodic trace theory of language emotionality (Puntoni, Langhe, & Osselaer, 2009)

In the *emotional contexts of learning theory*, Harris et al. (2006) hypothesized that the context of acquisition (CoA) and usage is the primary causal factor that accounts for the emotionality differences between languages. Since L1 was usually acquired in an emotionally rich setting that involved the attachment to caregivers and peers, it is more likely to be perceived as the most emotional language than L2. The theory also predicts that, for L2 learners who did not initially acquire L2 in an emotional context, if they later learned and used L2 in highly immersive and emotional interpersonal interactions (e.g. immigrate to another country and married to a native speaker), they are likely to experience higher emotional resonances in L2. According to this theory, neither age of acquisition (AoA) nor proficiency is a causal factor that explains the L1-L2 emotionality difference. That is, contrary to the central role of proficiency in the RHM, the emotional contexts theory only considers increased proficiency as a *consequence* of language learning in an emotional setting. On the other hand, increased L2 proficiency further helps facilitate access to emotional contexts of learning, since higher fluency enables a speaker to interact more with native speakers of that language (Harris et al., 2006). Connecting the emotional contexts theory to Puntoni et al.'s (2009) episodic trace theory, Caldwell-Harris (2014) argued that the two theories are actually highly similar, since frequent usage usually entails emotional contexts. Finally, this theory accommodates the individual differences (e.g. cultural background, personalities) in the learning histories of bilingual speakers (Caldwell-Harris, 2014). For instance, an endearment statement such as “I love you” in two languages can elicit different emotions depending on the distinct cultural attitudes associated with such expression.

Finally, in the *theory of L2 disembodiment*, Pavlenko (2012) highlighted that the major difference in emotionality between L1 and L2 is due to the emotionally “decontextualized” nature of the language classroom, which inhibits integration of all sensory modalities and verbal conditioning. That is, words acquired in the L2 classroom were thus “disembodied” and failed to reach the full emotional impact of the L1 words. Further, Pavlenko (2012) divided the emotion processing in L2 into four types: (1) categorization of linguistic stimuli, (2) attribution of affective qualities to linguistic stimuli, (3) processing of affective valence, and (4) approximation of somato-visceral responses. The first two types are considered as interpretive processes at a higher level of cognition. During categorization, speakers interpret and convey their feelings by categorizing and identifying emotional reactions of others via content, prosody, and context. In the process of attribution, speakers attribute emotional qualities to verbal stimuli and to the person they interact with. In contrast, access of affective valence and triggering of heightened arousal (affective processing) occur more automatically at a lower level of cognition. Pavlenko (2012) proposed that, with higher L2 proficiency and more frequent L2 use, it’s possible for late bilinguals to resemble monolinguals in the semantic retrieval of valence information, but still differ from them in the subtle somato-visceral responses.

The four models/theories discussed above reflect the two mechanisms underlying the L2 emotionality effects. The first mechanism is purely *linguistic*, and confines the L2 emotionality effects to the processing of emotional verbal materials (e.g. reading words, sentences) as a result of the weaker link between lexical-semantic representations and affect (Morawetz et al., 2017). In contrast, the second mechanism is not limited to linguistic tasks, such that the L2 emotionality effects can be observed more broadly when bilinguals perform *cognitive tasks* in an L2 context, such as during empathy pain perception (Wu et al., 2020), decision-making (e.g. Hayakawa et al., 2017), problem solving (Keysar, Hayakawa, & An, 2012), and gambling (Gao, Zika, Rogers, & Thierry, 2015). Since bilinguals frequently encounter non-verbal emotional inputs (e.g. faces, scenes) in their day-to-day L2 context (Morawetz et al., 2017), the second mechanism explains how language context shapes bilinguals' emotional experience in the physical world (e.g. making judgements, perceiving a distressful scene), beyond the processing of linguistic stimuli alone (Barrett, Lindquist, & Gendron, 2007). There are several possibilities by which an L2 context can affect bilinguals' emotional perception. First, L2 context may reduce the automaticity of information processing in general (Pavlenko, 2012; Morawetz et al., 2017), thereby increasing cognitive load and reducing emotional reactivity. In particular, one possibility is that L2 processing demands more cognitive resources, which limits the available resources allocated for automatic emotion processing (Dylman & Bjärtå, 2019). Additionally, bilinguals need to display more enhanced cognitive control in an L2 setting to inhibit their L1, which may also contribute to the overall reduced emotionality (Morawetz et al., 2017).

In general, the *linguistic* and *cognitive* mechanisms usually contribute together to the dampened emotionality in L2. Further, among all the current models and theories, language dominance, context of L2 acquisition, frequency of L2 usage, and L2 proficiency seem to be key factors that predict whether a bilingual will experience reduced emotions when they perform linguistic and non-linguistic tasks in L2 (see Section 1.3 for empirical evidence).

1.2 EEG and ERPs

Before I present and discuss the empirical evidence on the L2 emotionality effects, I will describe electroencephalography (EEG) and the Event-Related Potentials (ERPs) technique to help the reader better understand the brain recording methodology commonly used in the field of cognitive neuroscience, neurolinguistics, and cognitive psychology.

When a neuron fires, an *action potential* propagates from the beginning of the axon to the axon terminal where neurotransmitters are released. This process usually lasts about a millisecond. When the released neurotransmitters bind to the receptors of the post-synaptic cell, neurons produce another kind of electrical activity, termed *post-synaptic potentials*, which could last tens or hundreds of milliseconds. EEG mainly records the summation of post-synaptic activity generated by the millions of cortical pyramidal neurons oriented perpendicularly to the surface of the scalp (Luck, 2014). The raw EEG is recorded from multiple electrodes on the scalp, with a saline-based conductive gel applied to each electrode. Typically, experimenters use the wooden end of a Q-tip to gently abrade some skin under each electrode to establish good electrode-skin connection.

ERPs are averaged EEG activity timed-locked to the presentation of a stimulus or any particular event. Researchers usually design their experiments to include many presentations (e.g. 50-100 trials) of the same type of event, so they can average out electrical activity unrelated to the event of interest to isolate the brain electrical activity (ERPs) specifically related to that event (Luck, 2014). The ERP technique provides temporally precise information of the brain activity (~1 msec) compared to functional magnetic resonance imaging (fMRI), which measures the change in cerebral blood oxygen level that can take a few seconds. On the other hand, compared to the millimeter-level resolution of fMRI, the spatial resolution of EEG is relatively poor (~1cm). Therefore, EEG is better suited for studies that investigate the time course of stimulus processing rather than the exact location of the brain areas involved.

The ERPs are graphed by plotting time (msec) on the x-axis and electrode potential (µV) on the y-axis (Ward, 2020). Some researchers prefer to plot the positive voltage upwards (e.g. Fig. 3), whereas others prefer to have the negative voltage upwards. Each peak in the graph is labeled with its polarity ("N" for negative, "P" for positive) and a number that indicates the order of the peak (e.g. P1 for the first positive peak) or the approximate timing of the peak (e.g. N400 for the negative peak at around 400ms). The researchers usually overlay averaged ERPs by condition to observe the ERP effect between an experimental and a control condition. For instance, Fig. 3 is comparing the amplitude of N170, an indicator of facial structural perception, for human faces (purple), animal faces (blue), and objects (green). There is a clear N170 effect for both human and animal faces compared to the control condition (objects), and the human faces also elicited a larger N170 compared to the animal faces. Different ERP effects can also vary in scalp distribution. For example, the N170 effect is typically observed in right-lateralized occipital-temporal electrode sites, while the N400 effect (i.e. an indicator of the ease in semantic processing) is usually largest over central-parietal electrode sites (Luck, 2014).

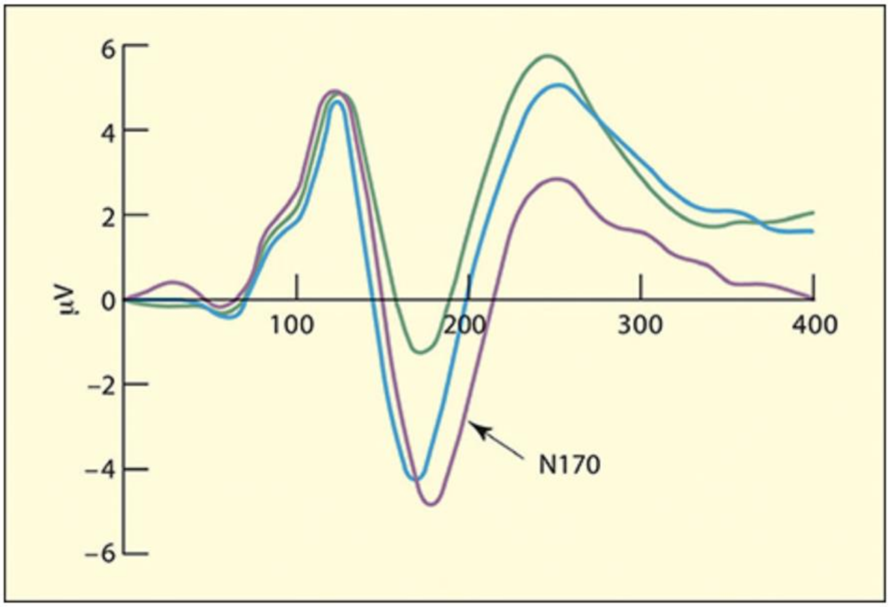

Figure 3: The N170 effect for human faces (purple) and animal faces (blue), as compared to objects (green) (Ward, 2020)

1.3 Empirical Evidence for the L2 Emotionality Effects

In this section, I present findings for the reduced emotionality associated with L2 use, as evidenced by a multitude of behavioral and electrophysiological measures, including introspective reports, self-ratings, cognitive tasks, physiological measures, and brain recordings.

Behavioral evidence

The first type of evidence consists of introspective self-reports from bilinguals. Responses from the largest web-based questionnaire on bilingualism and emotions (Bilingualism and Emotions Questionnaire, BEQ) revealed four different factors that influence perception of language emotionality and choice of language for emotion expression: order of acquisition, language dominance, age of acquisition (AoA), and context of acquisition (CoA) (Pavlenko, 2012). In the BEQ survey, respondents rated their L1 as significantly more emotional and associated with a decrease in emotionality with each later-acquired language. Language dominance also plays a role in perceived language emotionality, such that L1-dominant respondents reported using L1 more frequently for emotional expression. Further, respondents who learned L2 in naturalistic contexts judged their L2 as more emotional than those who acquired a language in an instructed context. As for the effect of AoA, early L2 learners rated their perception of L2 as more emotional compared to late L2 learners. Here, I want to clarify that the definition of "early" varies between researchers, but many defined early bilingualism as L2 acquisition before 12 years old (Ardila et al., 2017).

Besides questionnaire reports, a few laboratory experiments have directly examined the role of language use on affective suppression in bilinguals via self-ratings. In Dylman & Bjärtå (2019), Swedish-English bilinguals read negative texts in their L1 Swedish or L2 English and rated their feeling of distress. Then, they were instructed to answer questions about the texts in either L1 or L2 and provided the rating of distress again. It turned out that, bilinguals' distress was only significantly reduced when they first read texts in L1 and switched to L2 to answer questions, whereas reading texts in L1 and responding in L1 increased their distress. Crucially, switching from L2 to L1 or from L2 to L2 did not reduce distress. This implies that the direction of language switching matters in emotion reduction. Another study by Morawetz, Oganian, Schlickeiser, Jacobs, & Heekeren (2017) examined whether language context influenced the effectiveness of emotion regulation strategies in bilinguals. In their study, German-English bilinguals followed instruction texts in their L1 or L2 and used different regulation strategies (cognitive reappraisal, labeling contents of pictures, labeling their own emotions) in response to extremely negative pictures. They also rated their experience of negative emotions after each picture. Cognitive reappraisal (i.e. reframing a negative stimulus in a different way to alter its emotional impact) and labeling emotions were equally effective in reducing stress in L1 and L2, whereas labeling content of the emotional pictures in L2 reduced stress more significantly than in L1. This was the first study that suggested an L2 advantage in emotion regulation via labeling (see Section 1.4.2 for more discussion on Morawetz et al., 2017).

Another branch of evidence comes from the decision-making research literature. Initially, the "Foreign Language Effect" (FLE) was termed to describe the phenomenon that people make systematically different decisions in their L1 and L2 when faced with a moral dilemma (Brouwer, 2019). Now, the FLE is used more broadly to refer to the blunted emotionality in L2 across various situations. Numerous studies reported that, when using L2, bilinguals tend to make less emotionally biased judgements in moral dilemma tasks (Hayakawa et al., 2017), demonstrate decreased self-bias effects (Shin & Kim, 2017), and display more risk aversion in gambling (Gao et al. 2015). Notably, the FLE seems more prominent in bilinguals with late L2 acquisition (i.e. late bilinguals) or lower L2 proficiency (i.e. unbalanced bilinguals) (Brouwer, 2019). To account for the moral FLE effect in bilinguals, Hayakawa, Tannenbaum, Costa, Corey, & Keysar (2017) distinguished two possibly independent processes in L2 decision making: a decrease in the heuristic and intuitive emotional reaction (System 1 or "feeling less"), and/or an increase in the slow and deliberate thinking (System 2 or "thinking more"). In their study, they concluded that L2 affects moral choice by blunting emotions related to the violation of deontological rules (i.e. "feeling less"), but not through increased deliberation.

Behaviorally, researchers have used the bilingual emotional Stroop task to investigate the interference effect of emotions in bilinguals. In a typical emotional Stroop paradigm, participants are given an emotion word colored in a certain ink, and their task is to name the color of the ink. Typically, people show a longer latency in naming the ink of an emotion word compared to that of a neutral word, known as the interference effect (Ben-Haim et al., 2016). Applying this task to bilingualism research, Sutton, Altarriba, Gianico, & Basnight-Brown (2007) showed that highly proficient Spanish-English bilinguals experienced equal interference effects in L1 and L2. This provides evidence for the automatic activation of emotional words in L2. However, using the same paradigm, Winskel (2013) reported an absence of interference effects in L2 in late Thai-English bilinguals. The conflictive evidence is likely related to the difference in L2 proficiency, frequency of L2 usage, and L1-L2 similarity between the two studies. Finally, Degner, Doycheva, & Wentura (2012) used both semantic priming (judging the relatedness of two words, e.g. *doctor-nurse*) and affective priming (e.g. judging the valence congruency of two words, e.g. *profit-fun*) to study the automatic processing of semantic and affective meanings for L1 and L2 words. In their study, the semantic priming effect (faster reaction times to related than unrelated pairs) was significant in both L1 and L2, whereas the affective priming effect (faster reaction times to valence-congruent than incongruent pairs) was only observed in L1, but not in L2. This implied that the less automatic affective processing in L2 is not related to a generally slower semantic processing. Further analyses revealed that, only participants with a frequent use of L2 showed affective priming effect in L2, suggesting that increased L2 usage activates the affective connotations of L2 words more spontaneously and efficiently.

Physiological evidence

The differential emotionality between L1 and L2 has also been examined at a physiological level. In Harris, Ayçiçeği, & Gleason (2003), late Turkish-English bilinguals demonstrated increased autonomic arousal, as reflected by a higher skin conductance response (SCR), to taboo words and childhood reprimands in L1 than in L2. However, in Caldwell-Harris, Tong, Lung, & Poo (2011), Chinese-English bilinguals with good proficiency in both Mandarin and English showed similar SCRs while listening to emotional expressions (e.g. taboo words, insults, reprimands) in their L2 English, with the exception of a higher SCR to endearment statements such as “I love you” and “I miss you” in English. This unexpected finding can be explained by a cultural difference. The expression of endearment is more encouraged and common in the English-speaking culture than in the

Chinese culture. Thus, it might be easier for the bilinguals in their study to retrieve personal memories linked to those positive L2 statements, which resulted in their higher SCR (Caldwell-Harris et al., 2011). Using pupillary response as a measure, Iacozza, Costa, & Duñabeitia (2017) found that Spanish-English bilinguals showed larger pupil dilation while reading aloud emotional sentences in their L1 than in the L2. This is consistent with the study of Thoma & Baum (2019), in which German-English bilinguals showed smaller pupil dilation to highly emotional video advertising in L2, possibly due to reduced lexical access automaticity.

Neuroimaging and electrophysiological evidence

Brain recording techniques were also used to examine the spatial and temporal dynamics of emotion processing in bilinguals. Using fMRI, Chen et al. (2015) reported opposite patterns of the hemodynamic response to L1 and L2 emotion words when Chinese-English bilinguals performed a lexical decision task (i.e. judging whether a word is a real word or not). There was a weaker activation of L1 emotion words (relative to neutral words) in the left cerebellum and the middle occipital gyrus, whereas the activation of L2 emotion words was greater in the left cerebellum. In the same study, ERP evidence also revealed an enhanced early posterior negativity (i.e. EPN, an index of rapid emotional attention capture) for emotion words in L1, but not in L2. The presence of EPN in L1 suggests that emotion words captured attention automatically, consistent with the reduced activation (i.e. less processing effort) in the left cerebellum and the middle occipital gyrus. Additionally, they found a trend of a reduced N400 effect for reading positive words in L2, but not in L1. Together, Chen et al. (2015) suggested that the greater activation for L2 emotion words in the left cerebellum enhanced semantic processing, which led to a slightly smaller N400 that reflects the easier integration and retrieval of positive semantic content in L2 (see below for an alternative interpretation in Jończyk et al., 2016). Thus, it is likely that the later facilitation of semantic retrieval of L2 emotion words compensates for the initially less automatic access of emotional connotation (i.e. the lack of an EPN effect), but this should be taken with caution, since the N400 effect was only a trend in their study.

Another fMRI study by Hsu, Jacobs, and Conrad (2015) measured German-English bilinguals' neural responses while reading text passages from Harry Potter books in their L2

English (as compared to reading them in L1). They found that positive emotions elicited from the text were processed more deeply in L1, as reflected by stronger hemodynamic responses in bilateral amygdala and the left precentral cortex. Further analyses indicated that reading different emotional content in L1 elicited more differentiated and classifiable patterns of brain activity compared to that in L2.

In a number of ERP studies, bilinguals showed reduced or slightly delayed neural responses to emotional words in L2. In Conrad, Recio, & Jacobs (2011), German-Spanish bilinguals and Spanish-German bilinguals performed a visual lexical decision task (i.e. is this a word or not?) using emotional and neutral words in their L1 and L2. Both groups of bilinguals showed qualitatively similar ERP responses across emotional word processing in L1 and L2, as reflected by an EPN and a late positive complex (LPC) for emotional words compared to neutral words. However, compared to word processing in L1, the onset of EPN was delayed about 50-100ms in the L2 condition. Despite the small latency delays, the similar amplitudes and distributions of the ERP effects across conditions seemed to suggest no qualitative differences in emotion processing between L1 and L2. Interestingly, Spanish-German bilinguals only showed effects for positive words compared to neutral words in their L2, but not for negative words. It's worth noting that this group of bilinguals was tested in their L2 country (i.e. Germany). Therefore, their lack of effects for negative words potentially reflected a "positivity bias" in L2 processing, since they were currently being exposed to more enriching and stimulating events in the new culture (Conrad, Recio, & Jacobs, 2011).

Similarly, in Opitz & Degner (2012), for both German-French and French-German bilinguals, a significant EPN effect for emotion words (relative to neutral words) was observed in both L1 and L2, but the onset of EPN was delayed in L2. This further implies that sensing emotional connotations in L2 may not be immediately available and require more processing time, but the processing of emotion words in L2 is not qualitatively different from that in L1, in line with Conrad et al. (2011). However, the findings of Opitz & Degner (2012) and Conrad et al. (2012) seem inconsistent with the lack of an EPN effect for L2 emotion words in Chen et al. (2015). This discrepancy is possibly due to different levels of L2 immersion/frequency of L2 usage across studies. That is, the Chinese-English bilinguals in Chen et al. (2015) were tested in their home country and had never been to their L2-

speaking country, unlike the German, French, and Spanish bilinguals who were currently living in or had lived in their L2-speaking country. Further, it is also possible that Chinese is lexically more distant from English compared to German, French, and Spanish, and the cross-linguistic difference contributes to the less automatic emotion processing for L2 English words in Chen et al. (2015) (Bromberek-Dyzman et al., 2021).

Jończyk, Boutonnet, Musiał, Hoemann, & Thierry (2016) used sentential stimuli to study bilinguals' semantic integration of affective content in a more natural context. In their study, Polish-English bilinguals showed increased N400 in L1 compared to L2, possibly reflecting a greater emotional salience of sentences in L1. In contrast, the N400 was reduced for negative sentences in L2. The authors interpreted the smaller N400 as a "shallower" processing of content in L2 (i.e. suppression of L2 semantic access) instead of an actual decrease in difficulty of semantic integration as suggested by Chen et al. (2015).

Overall, considering all the evidence mentioned above, emotional information in L2 seems to be processed less automatically and affectively (at a quantitative or/and qualitative level) than in L1. It seems reasonable to associate this L2-related emotional suppression with potential clinical benefits (Morawetz et al., 2017), especially for counseling and therapies that involve immigrants, refugees, and international students who fall into the category of late or unbalanced bilinguals. In fact, in therapeutic settings, codeswitching to L2 is often considered as an emotional detachment tool for bilingual patients to discuss and evaluate traumatic events objectively (Martinovic & Altarriba, 2012; Santiago-Rivera & Altarriba, 2002). However, to date, there is very limited experimental evidence on the role of L2 in emotion regulation (Morawetz et al., 2017). In the next section, I will first describe the relationship between language and emotion regulation in general, and then review research on emotion regulation in L2.

1.4 Language and Emotion Regulation

Emotion regulation refers to the process by which individuals implicitly or explicitly modify the quality, duration, or intensity of their own emotional experiences (Gross, 1998). Explicit emotion regulation requires conscious effort to rephrase or reevaluate an event (i.e.

cognitive reappraisal) to regulate emotions. In contrast, implicit emotion regulation often occurs automatically without the intentional goal of regulation.

Recently, *affect labeling*, also known as "putting feelings into words", has been shown to be an implicit emotion regulation technique in down-regulating emotions. Across numerous studies, people consistently report reduced distress after labeling emotions for highly arousing pictures (Lieberman, Inagaki, Tabibnia, & Crockett, 2011). However, when being asked explicitly to predict the effectiveness of affect labeling in regulating feelings, people constantly report no benefit with this technique (Lieberman et al., 2011). Therefore, affect labeling qualifies as an "incidental" emotion regulation technique because it can regulate emotions without people being aware of such process occurring. This implies that we need to consider both objective and subjective measures to evaluate the effectiveness of affect labeling. It should be noted that "implicit" and "incidental" have been used interchangeably by researchers, and I will use the word "implicit" to describe the automatic effects of affect labeling from now on.

One possible mechanism of affect labeling is *distraction.* Indeed, affect labeling has been shown to elicit similar neural responses as distraction techniques (Lieberman et al., 2007; McRae, Hughes, et al., 2010), so putting emotions into words might help direct attention away from the emotional source. Another possible mechanism is *psychological distancing* from converting a physical stimulus into abstract language (i.e. symbolic conversion) (Lieberman et al., 2007). That is, abstract thinking about emotional states might help people reflect upon feelings without experiencing negative impact (Torre & Lieberman, 2017). Finally, labeling can also lead to *reduction of uncertainty* through the use of emotion concepts, thereby increasing the discreteness of an emotion experience and facilitating regulation (Lindquist, MacCormack, & Shablack, 2015). This is in line with the psychological constructionist *Conceptual Act Theory* (CAT), which suggests that language helps people use emotion concepts to shape the ongoing sensory processing of information from the body and the world (Lindquist, MacCormack, & Shablack, 2015).

As an emotion regulation strategy, affect labeling has real-world significance. For instance, social media users constantly engage in posting feeling statements. In particular, Lieberman (2019) focused on Twitter and analyzed the valence of tweets before and after affect labeling (e.g. "I feel…"). It turned out that Twitter users' negative emotions were most intense before the labeling tweet but reduced to the baseline level immediately after the tweet.

In the section below, I will present fMRI and ERP evidence to discuss the effectiveness of affect labeling, and how the type of labels might differently impact the outcome of emotion regulation. Finally, I will connect affect labeling to the research on bilinguals' emotion regulation in L2.

1.4.1 Neural Correlates of Affect Labeling

In recent years, some researchers explored the neural mechanisms underpinning affect labeling. Lieberman et al. (2007) found that, when labeling emotional faces, the response of the amygdala and other limbic regions was diminished. Furthermore, affect labeling increased activity in the right ventral lateral prefrontal cortex (RVLPFC). The inverse relationship between amygdala and RVLPFC activity was mediated by medial prefrontal cortex (MPFC) activity. Together, Lieberman et al. (2007) proposed that affect labeling may reduce emotions along a neural pathway from RVLPFC to MPFC to the amygdala.

Using ERPs, Herbert, Sfärlea, & Blumenthal (2013) found that brain activity is sensitive to both unintentional and intentional affect labeling as well as labels with minor linguistic manipulations such as self- vs. other-related labels. In experiment 1, they examined the unintentional effect of affect labeling. On each trial, self-related or sender-related emotional labels (e.g. "my fear" vs. "his fear") were presented as cues, and an emotional face was shown subsequently (e.g. a fearful face). The task was to attend to each label and picture, so this was considered as unintentional or spontaneous affect labeling. In their analyses, Herbert, Sfärlea, et al. (2013) focused on the face-specific N170, the early posterior negativity (EPN), and the late positive potential (LPP). They found that self-related labels (e.g. "my fear") increased EPN compared to passive viewing, reflecting the enhanced motivational relevance of the emotional faces, but the labels did not modulate N170. Sender-related labels ("his fear") improved emotion recognition, as shown by an increased N170 amplitude (only for fearful faces), but they did not modulate EPN. As for later stages of emotion processing, both types of emotion labels reduced LPP for fearful, happy, and angry faces relative to the passive viewing condition, reflecting a decrease in the depth of cortical processing. However, at a subjective experiential level, none of the participants in experiment 1 reported dampened emotions after labeling.

In experiment 2, Herbert, Sfärlea, et al. (2013) made the affect labeling task intentional. On each trial, the participants were asked to use the label provided to distance themselves from the emotional picture. They found that intentional labeling did not modulate early components (N170 and EPN). Interestingly, intentional labeling increased the LPP when subjects used self-related emotional labels compared to both passive viewing and sender-related label condition. At a subjective level, the participants only reported experiencing more intense emotions in the condition with self-related labels. Overall, Herbert, Sfärlea, et al. (2013) reported that affect labeling may even increase emotions (i.e. larger LPP) when the regulation is intentional and self-relevant. It's possible that the self-related labels prompted participants to focus internally on their subjective feelings, which could up-regulate emotions (McRae, Taitano, & Lane, 2010).

Several studies have also explored the effect of affect labeling in Chinese. Yue, Du, Bai, & Xu (2015) compared the effectiveness of affect labeling versus gender labeling. Their study used a classic affect labeling paradigm, in which a picture (e.g. an angry face) was presented along with two labels (e.g. "angry" or "sad"). Participants' task was to choose the appropriate label for the emotion expressed in the picture. In the gender labeling task, participants were provided with two labels that correspond to the gender of the face (e.g. "man" or "woman"). In their study, they found no difference in the early LPP (300-800ms, time-locked to the picture onset) between gender labeling and affect labeling. However, late LPP (300-1000ms, time-locked to the moment of labeling) was significantly smaller for affect labeling compared to gender labeling. The authors concluded that the emotional down-regulation associated with affect labeling occurred only after the selection of a label. Also, it's important to note that their study did not include a passive viewing condition, so it's unclear whether affect labeling decreased emotions compared to no labeling. In contrast, Deng, Jiang, Ma, Ji, & Zhu (2013) reported an increased LPP in the affect labeling condition compared to the gender labeling condition, and Deng & Li (2020) found that objective affect labeling (e.g. label the content of a picture) elicited a larger LPP compared to the passive viewing condition, whereas subjective affect labeling (e.g. label the feeling elicited by the picture) did not modulate any ERP components. The authors interpreted the increased LPP as a byproduct of the symbolic processing of emotions involved in affect labeling, which could initially enhance the amplitude of LPP before decreasing it eventually (Deng et al., 2013; Deng & Li, 2020).

Overall, although the ERP findings are mixed, it seems that in most cases, using affect labels might facilitate the down-regulation of emotions. Further, unintentional labels tend to have an influence on the early ERP components (e.g. N170, EPN), and sometimes on the later LPP component. On the contrary, intentional labels seemed to have more of an effect on the late component (e.g. LPP), but not on the early ones.

1.4.2 Emotion Regulation in L2

Recently, more researchers have suggested that bilingualism might facilitate emotion regulation by producing emotional distance when speakers are using their non-dominant language (Lindquist, MacCormack, & Shablack, 2015). It's possible that the combination of affect labeling and L2 use could create an even larger distance between the raw emotion and the individual, resulting in more effective emotion regulations than labeling in L1.

Morawetz et al. (2017) is the only study that directly examined the effectiveness of emotion labeling, content labeling, and cognitive reappraisal in a second language. In the two labeling conditions, participants labeled negative pictures based on the content (*content labeling*) or their feeling (*emotion labeling*) about the picture by selecting a content label (e.g. "animal" or "human") or an emotion label (e.g. "sad" or "angry"). In the *cognitive reappraisal* condition, participants were asked to decrease their emotions by distancing themselves from the pictures. In the control condition, participants were instructed to passively watch the pictures without doing any specific task. On each trial, participants were asked to rate their current emotional state on a scale from -5 (very negative) to +5 (very positive) as a measure of emotion regulation success.

The results revealed that, compared to the control condition, *cognitive reappraisal* reduced distress ratings equally well in L1 and L2. *Content labeling* regulated distress better in L2 than in L1 for both high and low arousal pictures, possibly via increased distraction related to performing a non-emotional task in a L2 context (i.e. categorize stimuli). However, *emotion labeling* only reduced distress for low arousal pictures, and the overall distress reduction did not differ between L1 and L2. Given that the *emotion labeling* condition required participants to label their subjective emotions instead of the objective emotions displayed in the pictures, it's likely that the direct focus on internal feelings counteracted the emotional distance induced by the L2 context, resulting in the lack of difference between L1 and L2 (Morawetz et al., 2017). Indeed, it's been suggested that, compared to subjective labels (e.g. label your own emotional reaction), objective emotion labels (e.g. label the emotion of a face) are more effective in down-regulating emotions at a physiological level (McRae, Taitano, et al., 2010).

Further, Morawetz et al. (2017) did not find a significant relationship between L2 proficiency and measures of regulation success, but the lack of an effect could be due to the small sample size and the homogenous L2 proficiency levels of the German-English participants in their study.

In general, it's still unclear whether affect labeling in L2 does have a better regulatory effect on emotion than in L1, and more research is needed to explore language history factors that contribute to differential emotion regulation outcomes in bilinguals.

1.5 The Current Study

The aim of the current study was to use the ERP technique to investigate the temporal dynamics of regulating emotions in L1 and L2 via affect labeling. The overall design included a passive viewing condition and two labeling conditions in L1 and L2 respectively. In the passive viewing block, participants watched pictures of negative emotional faces without labeling. In the labeling conditions, an emotion word (e.g. furious) appeared before the picture as a cue for participants to label the subsequent emotional face (e.g. an angry face). ERPs were time-locked to the onset of the emotional face. Three ERP components (early, intermediate, and late) were the focus of analysis: N170 (120-180ms), EPN (200-400ms), and LPP (400-1000ms). Additionally, the study included periodic self-ratings of emotional experience as a subjective measure of reduction in negative emotions.

Importantly, the study included L1-dominant Chinese-English bilinguals who acquired their L2 English in a classroom setting before puberty. Thus, by controlling for the language dominance, CoA of L2, and AoA of L2, I could isolate the effect of L2 proficiency and frequency of L1/L2 usage on the regulatory outcome across languages.

I hypothesized that, in general, labeling emotions in either language (i.e. both L1 and L2 label conditions) would reduce subjective negative emotions triggered by the emotional faces compared to the passive viewing condition. In addition, in line with the Foreign Language Effect (FLE) mentioned above, I predicted that, using L2 labels would lead to more successful down-regulation of negative emotional faces than using L1 labels. That is, participants' subjective negative emotion experience would be reduced in the L2 label condition compared to that in the L1 label condition. Alternatively, since some studies reported no change in self-reports after affect labeling (Herbert, Sfärlea, et al., 2013), it is possible that the subjective rating of negative emotion experience would be the same across conditions.

The N170 is an indicator of structural encoding of facial features, but it's still debated whether N170 is an early index of emotion regulation. Some researchers showed that a larger N170 amplitude (i.e. a more negative N170) correlates with a reduction in negative emotion ratings (Liu, Wang, & Li, 2018), some reported a smaller N170 due to cognitive reappraisal (Blechert, Sheppes, Di Tella, Williams, & Gross, 2012), while others reported the lack of any modification of N170 in emotion regulation (Herbert, Deutsch, Platte, & Pauli, 2013). If the N170 amplitude is different between conditions in the current study, this might suggest that the language context can impact early implicit processing of emotional faces. If so, this would further support the "language-in-context" hypothesis, which suggests that "language actively influences emotional perception by dynamically guiding the perceiver's processing of structural information from the face" (Wieser & Brosch, 2012).

EPN is often considered to reflect the automatic allocation of attentional resources for emotional stimuli. It has been suggested that an attenuation of the EPN (i.e. a less negative EPN) is related to successful emotional down-regulation (Herbert, Deutsch, et al., 2013; Blechert et al., 2012; Liu et al., 2018). Therefore, I predicted that labeling negative facial expressions in L2 would lead to a larger reduction of EPN than labeling in L1. Additionally, the EPN elicited in both labeling conditions would be smaller than that observed in the passive viewing condition.

LPP is an indicator of a more strategic, high-level processing of emotional expressions (Liu et al., 2018), and it is usually found to be larger for emotional stimuli than neutral stimuli (Schindler & Bublatzky, 2020). Most studies have found a reduced LPP for emotion regulation compared to passive viewing, while a few reported no difference or even an increased LPP (e.g. Herbert, Sfärlea, et al., 2013). I predicted that labeling negative emotions in L2 would lead to a larger reduction of LPP than labeling in L1. Further, if affect labeling is effective in down-regulating emotions, the LPP amplitude in both labeling conditions would be smaller than that in the passive viewing condition.

Finally, I aimed to obtain the ERP difference waves between L1 and passive viewing (the effect of affect labeling in L1, i.e. L1-viewing), L2 and passive viewing (the effect of affect labeling in L2, i.e. L2-viewing), and between L2 and L1 conditions (the Foreign Language Effect, i.e. L2-L1) for the three ERP components. This would allow me to examine the role of L2 proficiency and frequency of language usage on the amplitude of the difference waves.

In line with the RHM (Kroll & Stewart, 1994), I hypothesized that L2 proficiency would predict the difference in amplitude between the L2-viewing waveforms, as well as the difference between the L2-L1 waveforms. That is, higher L2 proficiency would strengthen the lexico-semantic connection for emotional words in L2 and decrease the L2-induced emotional distance, leading to reduced effectiveness of affect labeling in L2 and a smaller FLE at a neural level.

In line with the language-specific episodic trace theory of language emotionality (Puntoni et al., 2009) and the emotional contexts of learning theory (Harris et al., 2016), I hypothesized that frequency of L2 usage in daily life would predict the difference in amplitude between the L2-viewing waveforms, as well as the difference between the L2-L1 waveforms. That is, higher frequency of L2 usage would also make a bilingual experience more intense emotions in L2, resulting in reduced effectiveness of affect labeling in L2 and a smaller FLE. Finally, based on the finding of Degner et al. (2012), I hypothesized that frequency of L1 usage would not predict the regulatory outcome in L2 nor the FLE.

However, it’s unclear whether frequency of L1 usage would predict the regulatory outcome in L1 (i.e. L1-viewing).

Overall, if L2 use in affect labeling does reduce negative emotions at both a subjective and a neural level, this might imply that bilinguals can strategically adopt L2 labels for therapeutic use or for day-to-day emotional regulation.

Chapter 2: Methods

2.1 Participants

Twenty-two Chinese-English bilinguals participated in this experiment. The study was conducted at Reed college (Portland, Oregon, USA). Participants were Chinese international students who currently study at or recently graduated from Reed College. All participants have normal or corrected-to-normal vision and no history of brain injury. Participants were compensated with $20 for their participation. All procedures were approved by the Reed College Institutional Review Board.

Prior to the experiment, participants completed a language history questionnaire to indicate their language dominance, age of acquisition (AoA), context of acquisition (CoA), and rated their overall proficiency in L1 and L2. They also rated their proficiency for writing, speaking, listening, and reading in each language on a 7-point scale. These measures aimed to help us validate that participants are indeed Chinese-English bilinguals.

Additionally, participants answered the Beck Depression Inventory (BDI) (Hautzinger et al., 1994) and the Toronto Alexithymia Scale (TAS-20) (Bagby, Parker, & Taylor, 1994). This was to make sure that participants' scores on these two scales did not differ from population norms (Morawetz et al., 2017), which could have affected our findings. Two participants were excluded due to alexithymia (TAS-20 score ≥ 61) and one was excluded due to depression (BDI ≥ 18). One participant was excluded due to excessive eye blinks during EEG recording.

The language profile of the remaining 18 participants (mean age = 21.3 years, *SD* = 1.71, 11 female) is summarized in Table 1. All participants reported "Chinese" as their dominant language. On average, participants' AoA of English is 5.56 years (*SD* = 2.06, range = 3-10), and their AoA of Chinese is 0.39 years (*SD* = 0.50, range = 0-1). All participants reported "school" as the CoA for English and "home" as the CoA for Chinese.

All questionnaires were presented in Chinese to ensure the consistency of the main language context in the lab. It is important to note that the experiment was conducted in the U.S., so the larger language context was English. We decided to use Chinese for preexperimental interactions, since the main experimenter and participants all shared Chinese as their dominant L1, so the interaction in L1 would be more natural.

Table 1: Self-reported language proficiency in L1 and L2 (1= minimal, 7= native speaker)

	Self-reported L1 Chinese proficiency	Self-reported L2 English proficiency
Overall	6.94 (0.24)	5.00 (0.84)
Reading	6.83 (0.38)	5.39 (0.98)
Writing	6.72 (0.57)	4.61 (1.09)
Speaking	7.00 (0.00)	4.89 (0.90)
Listening	6.89 (0.32)	5.28 (1.07)

After the experiment, participants completed the Lexical Test for Advanced Learners of English (LexTALE) (Lemhöfer & Broersma, 2012) as an objective measure of their general proficiency in L2 English. LexTALE is a quick 5-min vocabulary test that requires participants to identify whether a word is real or not. The English version of LexTALE has been validated as a good predictor of English vocabulary knowledge and general English proficiency, and it is better than self-ratings in its predictions (Lemhöfer & Broersma, 2012). The average score of the participants is 77.8 (*SD* = 8.21, range = 65-90, note: the highest possible score is 100), which is slightly higher than the mean score (70.7) reported by LexTALE for a large group of Dutch and Korean advanced learners of English.

Additionally, participants also provided ratings on their frequency of usage of L1 and L2 in everyday life on a 7-point scale (1= never, 7= exclusively). The mean frequency of usage for L1 is 4.56 (*SD* = 0.78), and for L2 is 4.17 (*SD* = 0.79). Finally, participants answered a short survey about their preferred language to express their deepest emotions; 61.1% participants chose Chinese (N = 11) as the language in which they express their deepest emotion, 22.2% chose both (N = 4), and 16.7% chose English (N = 3).

2.2 Stimuli

Sixty facial emotion pictures with negative valence (20 anger, 20 sadness, 20 fear) were obtained from Tsinghua Facial Emotion Database (Yang et al., 2020). To elicit emotions most effectively, the selected pictures contained only Chinese faces to avoid the "other-race" effect (i.e. poorer recognition of facial emotions expressed by other races) (Tanaka, Kiefer, & Bukach, 2004). The pictures were presented in color with a size of 300 X 400 pixels, which resulted in a visual angle of 7° by 9°.

The experiment used 5 synonymous emotion labels for each emotion in both, English and Chinese. For anger, the labels were angry, furious, irritated, outraged, and enraged. For sadness, the labels were sad, depressed, heartbroken, sorrowful, and melancholy. For fear, the labels were fearful, frightened, afraid, scared, and terrified. Chinese labels were rough translations of the English labels, and each label contains 2 characters.

2.3 Procedure

In this experiment, we adapted and modified the paradigm used by Herbert, Sfärlea, et al. (2013) (See Fig. 4), including a passive viewing block, a block using L2 English labels, and a block using L1 Chinese labels. In each block, 20 angry faces, 20 sad faces, and 20 fearful faces were presented randomly (60 trials per block) one at a time. All stimuli were presented using the program Presentation (Neurobehavioral Systems, Berkeley, CA). Participants completed 6 practice trials before doing the real task in every block. They were given breaks every minute.

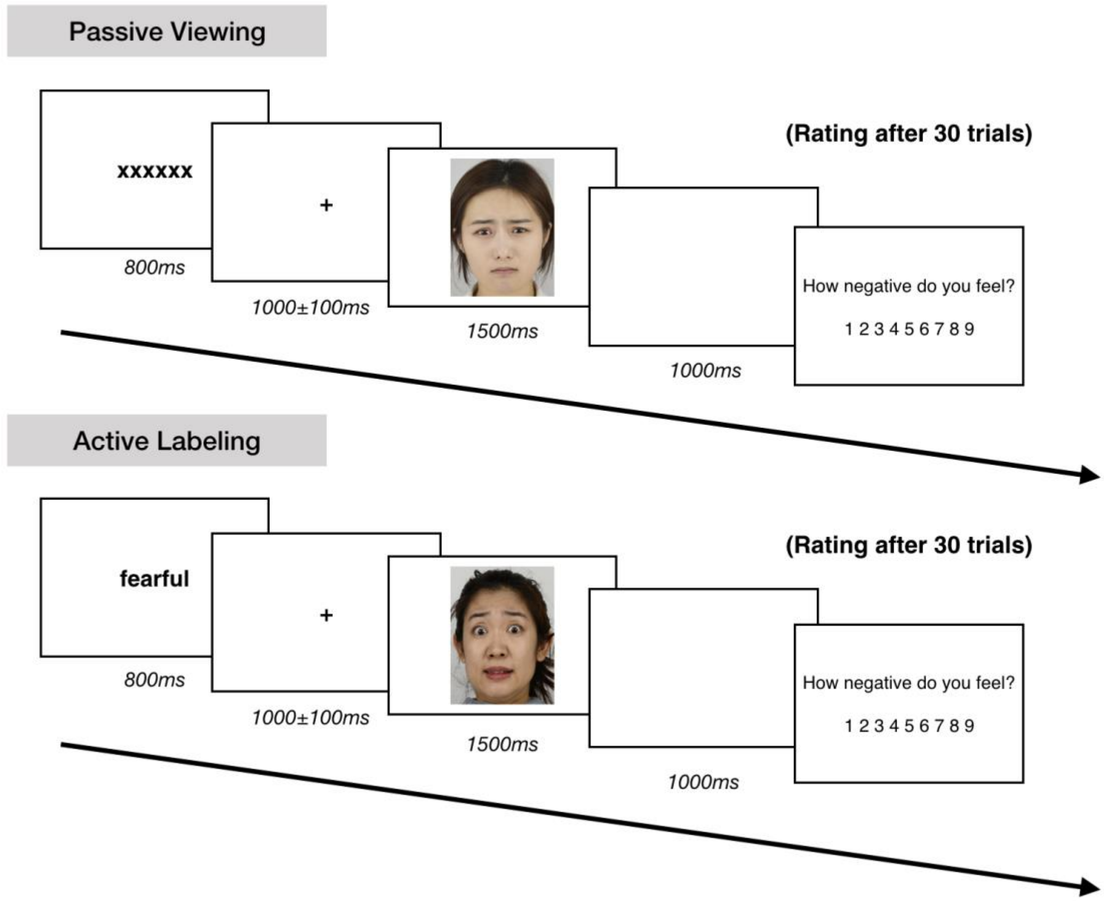

Figure 4: Diagram of typical trials in passive viewing and labeling conditions

The experiment always started with a passive viewing block. This is in line with the previous study (Herbert, Sfärlea, et al., 2013) to establish a baseline measure of emotional reactions to the pictures. If the passive viewing block were presented later (i.e. after a labeling condition), participants may start labeling the face in their head, which defeats the purpose of the passive viewing (control) condition. On every trial of the passive viewing, a string of nonsensical letters ("xxxxxx") (font: 'Times New Roman'; font size = 40) was presented for 800ms as a cue to signal the onset of the picture.

This was followed by a fixation cross (~1000ms) before the presentation of the emotional face. Each picture was presented for 1500ms. Participants were instructed to passively watch and attend to each face. The intertrial interval (ITI) was set to 1000ms before the onset of the next trial.

The experimental conditions used Chinese and English labels (font: 'Times New Roman'; font size = 40) for the same 60 emotional faces. The order of L1 label and L2 label conditions was counterbalanced across participants. Before each experimental block, participants were familiarized with the labels to avoid the effect of novelty (Morawetz et al., 2017). On every trial, an emotional word was presented before the onset of the emotional face. Participants were instructed to use the emotional word provided on each trial to label the subsequent emotional face. Crucially, they were instructed to use the label to silently name the emotion in their head while looking at the face. This was to ensure that participants were actively labeling the emotional faces instead of ignoring the provided labels. To avoid intentional emotional regulation, no instruction about reducing negative emotions was given.

After every 30 trials, participants were asked to indicate their negative emotion experience ("How negative are you feeling right now?") on a 9-point scale (1= very unpleasant, 9= very pleasant) in both passive viewing and experimental conditions. That is, in every condition, participants rated their emotion experience twice. The average of the two scores was used as the measure of their negative emotions in a particular condition to be compared later with the other conditions (Liu et al., 2018).

As a post-experimental manipulation check, participants were asked about whether they consciously regulated emotions during the experiment. Additionally, they provided valence and intensity ratings for all of the English and Chinese labels used in the study on a computerized version of the Self-Assessment Manikin (SAM) (Bradley & Lang, 1994). The SAM is a picture-based instrument containing images for affective dimensions (e.g. valence, arousal) on a 9-point scale. The post-experimental rating was used to test whether Chinese and English labels were equivalent in valence and intensity. Participants first rated all the 15 labels used in one language, then the 15 labels in the other language. The order of the rating conditions (e.g. English first, Chinese second; Chinese first, English second) was counterbalanced across participants.

2.4 EEG Recording

The EEG was recorded from 64 electrodes (see Fig. 5) using the EasyCap system (Brain Products, Garching, Germany) with a right mastoid electrode ("Ref") as a reference, and re-referenced offline to an average reference. Two electrodes were placed adjacent to the left and right eyes (HEOG: 62, 63) to detect horizontal eye movement artifacts. One electrode was placed below the left eye (VEOG: 61) to detect eye blink artifacts.

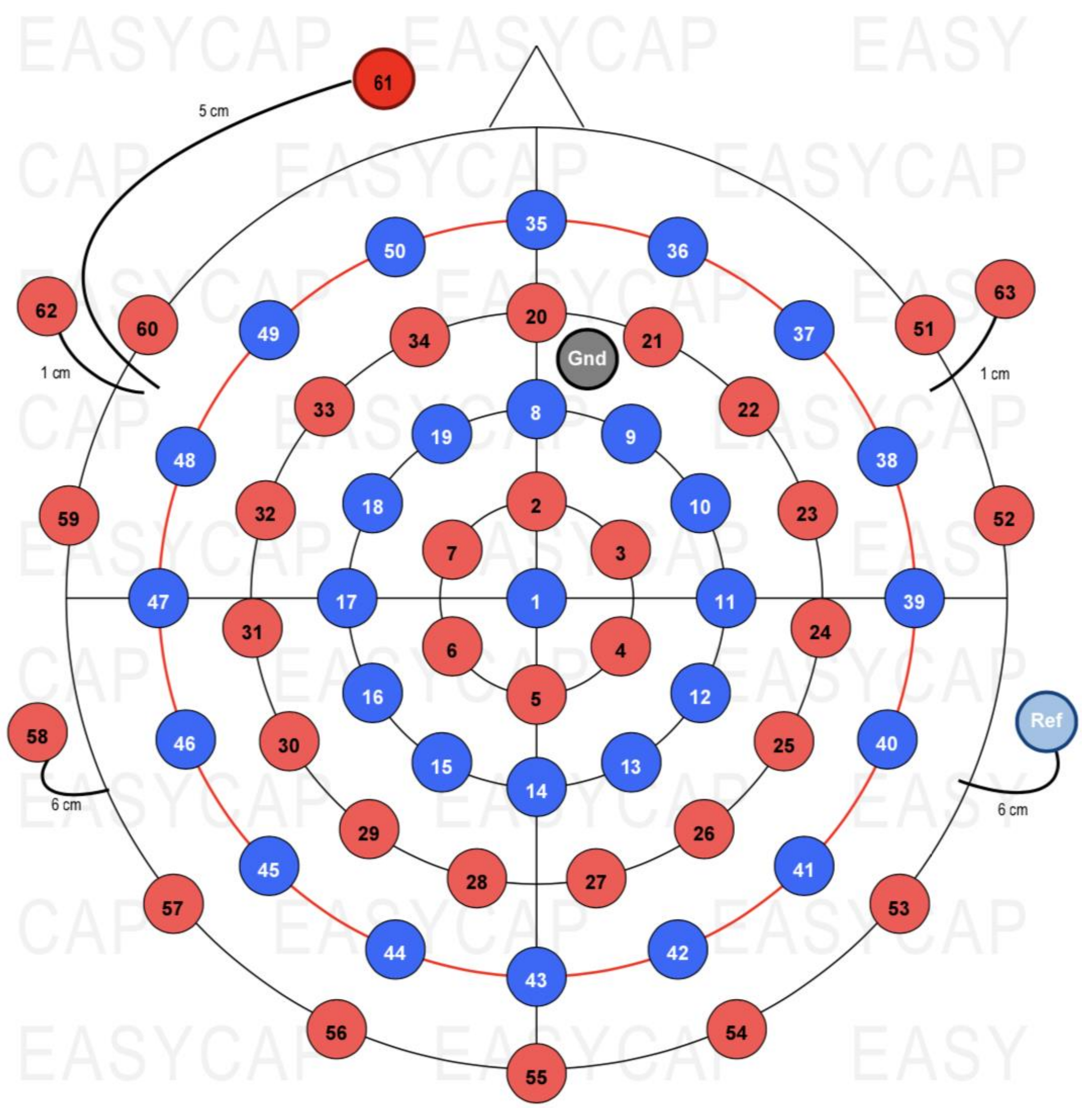

Figure 5: Electrode locations of the 64-channel electrode cap

The ERP data were segmented from -200ms to 1000ms relative to the onset of the emotional face. The 200ms interval before the onset of the face was used for baseline correction. The EEG was acquired at a 500 Hz sampling rate, and impedance levels were kept below 10 kΩ. The raw EEG was filtered with a 25 Hz high cutoff filter. All data was processed using BrainVision Analyzer Software (Brain Products, Germany).

Chapter 3: Results

3.1 Behavioral Data

3.1.1 Rating of Negative Emotion Experience

A one-way ANOVA (Condition: viewing/L1/L2) revealed a marginally significant main effect of Condition on the subjective ratings of negative emotion experience, $F(2,34) = 2.43$, $p = 0.10$. Planned comparisons showed that, the rating of negative emotion experience in L2 (M = 4.47, *SD* = 1.59) was significantly higher (i.e. less negative) compared to that in L1 (M = 4.06, *SD* = 1.58), $t(17) = -2.95$, $p < 0.01$ (see Fig. 6), but no significant difference was found between L1 and passive viewing (M = 4.28, *SD* = 1.69), $t(17) = -1.22$, n.s., or between L2 and passive viewing, $t(17) = 0.84$, n.s.

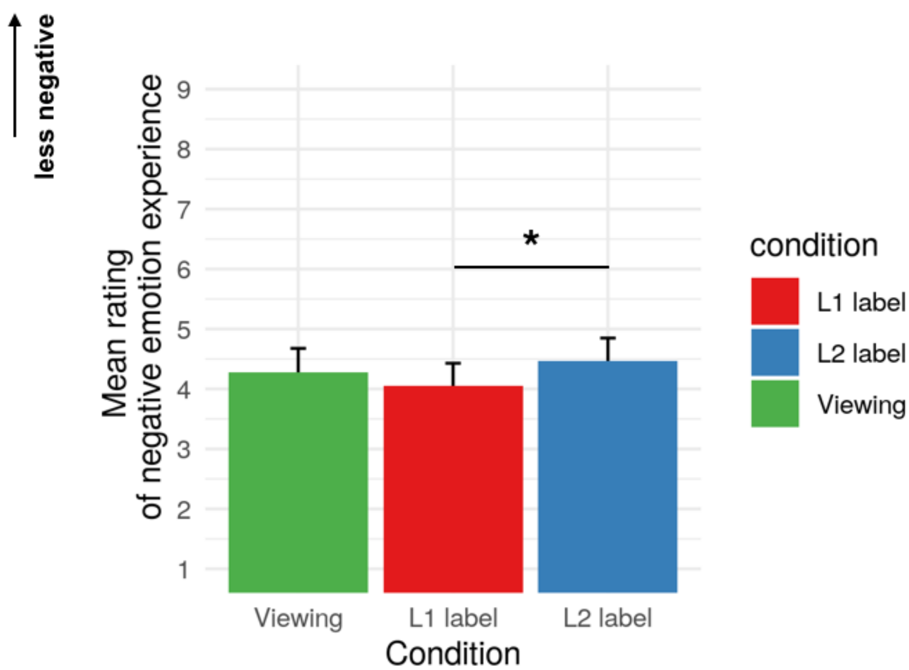

Figure 6: Subjective rating of negative emotion experience in the passive viewing, L1 label, and L2 label conditions (NOTE: higher rating indicates less negative)

3.1.2 Valence and Intensity Rating for Labels

For valence of the emotional labels, a 2-way ANOVA (Language: English/Chinese; Emotion: sadness/anger/fear) revealed no significant main effects of Language, $F(1,102) = 0.01$, n.s., or Emotion, $F(2,102) = 0.457$, n.s. The interaction between Language and Emotion was not significant, $F(2,102) = 0.243$, n.s.

For intensity ratings, a 2-way ANOVA (Language: English/Chinese; Emotion: sadness/anger/fear) revealed a significant main effect of Emotion, $F(2,102) = 9.84$, $p < 0.001$, but no main effect of Language was found, $F(1,102) = 0.05$, n.s. The interaction between Language and Emotion was not significant, $F(2,102) = 0.27$, n.s. Post-hoc t-tests revealed that anger-related words ($M = 6.42$, $SD = 1.40$) received a significantly higher intensity rating compared to fear-related words ($M = 5.81$, $SD = 1.28$), $t(17) = 3.87$, $p < 0.01$, and sadness-related words ($M = 5.01$, $SD = 1.33$), $t(17) = 4.65$, $p < 0.001$. Further, fear-related words were also rated as more intense than sadness-related words, $t(17) = 3.41$, $p < 0.01$. A detailed table of valence and intensity rating for each word can be found in the Appendix.

3.1.3 Manipulation Check

No participants reported noticing the purpose of the experiment or consciously regulating emotions during the experiment.

3.2 Electrophysiological Data

For the ERP analyses, I first used a two-way (Condition: viewing/L1/L2; Emotion: sadness/anger/fear) repeated measures ANOVA for each of the three ERP components (N170, EPN, LPP), and followed up with post-hoc t-tests if any main effect or interaction turned out significant. Then, I explored the relationship between the language history variables (L2 proficiency, frequency of usage of L1 and L2) and the ERP results.

The ERP waveforms at selected electrodes can be found in Fig. 7. The scalp distribution of the ERP difference waves between each of the three conditions can be found in Fig. 8. I would recommend the reader to look at Fig. 7 and Fig. 8 together to better visualize the polarity of components and understand the direction of effects. For example, in Fig. 7, for the N170 component, the black line (passive viewing) is more negative than the blue line (L2 label condition), and this comparison is reflected as the deep blue (negative), statistically significant difference in the "Viewing-L2" scalp map in Fig. 8 (top left).

3.2.1 N170

The mean amplitude during the time window of the N170 (120-180ms) was computed from a pool of occipital-parietal electrodes (41, 42, 44, 45). The selection of electrodes was based on the scalp distribution observed in this study (see Fig. 8) and the distribution of N170 in some previous research (e.g. Dennis, Malone, & Chen, 2009). The N170 has a slightly earlier peak (~130ms), probably due to the larger stimulus size used in my experiment. To validate that the selected electrodes indeed reflected N170-related activity, I also examined the vertex positive potential (VPP) at central electrodes. VPP and N170 are considered to manifest the same brain processes but have precisely inverse amplitudes (Joyce & Bossoin, 2005), and this was the case in the current study.

The 2-way ANOVA revealed a significant main effect of Condition on the mean N170 amplitude, $F(2,34) = 5.53$, $p < 0.01$. The main effect of Emotion was not significant, $F(2,34) = 0.02$, n.s., and there was no interaction between Condition and Emotion, $F(4,68) = 0.97$, n.s.

Post-hoc t-tests revealed that, there was a significant reduction of the N170 amplitude in the L2 label condition (M = 3.95, *SD* = 3.63) compared to the passive viewing condition (M = 2.98, *SD* = 3.59), $t(17) = -3.14$, $p < 0.01$. Additionally, the N170 amplitude in the L2 label condition was significantly smaller than that in the L1 label condition (M = 3.43, *SD* = 3.76), $t(17) = -2.71$, $p < 0.05$. However, there was no significant difference in the mean N170 amplitude between the L1 and the passive viewing condition, $t(17) = -1.32$, n.s.

3.2.2 EPN

The mean amplitude during the time window of the EPN (200-400ms) was computed from the same electrodes as the N170 analysis, in line with previous research (Herbert, Sfärlea, et al., 2013; Liu et al., 2018). The 2-way ANOVA revealed a significant main effect of Condition on the mean EPN amplitude, $F(2,34)= 5.91$, $p < 0.01$. The main effect of Emotion was not significant, $F(2,34) = 0.39$, n.s., and there was no interaction between Condition and Emotion, $F(4,68) = 1.1$, n.s.

Post-hoc t-tests revealed that, there was a significant reduction of EPN amplitude in the L2 label condition ($M = 5.99$, $SD = 2.90$) compared to that in the passive viewing ($M = 5.10$, $SD = 2.49$), $t(17) = -3.00$, $p < 0.01$. The EPN amplitude in the L2 label condition was also marginally significantly smaller than that in the L1 label condition ($M = 5.55$, $SD = 3.13$), $t(17) = -2.03$, $p = 0.058$. Again, there was no significant difference in the mean EPN amplitude between the L1 and passive viewing condition, $t(17) = -1.71$, n.s.

3.2.3 LPP

The mean amplitude during the time window of the LPP (400-1000ms) was computed from frontal, central, and parietal electrodes along the midline (1, 2, 5, 8, 14), based on previous research (e.g. Moser et al., 2006; Yue et al., 2015) and on our observed scalp distribution. The 2-way ANOVA revealed a near significant interaction between Condition and Emotion on the mean LPP amplitude, $F(4,68) = 2.05$, $p = 0.098$. However, there were no significant main effects of Condition, $F(2,34) = 2.26$, n.s., or Emotion, $F(2,34) = 0.33$, n.s.

Post-hoc t-tests revealed that, for angry faces, the mean LPP amplitude in the L1 label condition ($M = 2.21$, $SD = 1.30$) was significantly higher than that in the passive viewing condition ($M = 1.32$, $SD = 1.21$), $t(17) = -2.92$, $p < 0.05$. In addition, the mean LPP amplitude in the L1 label condition was also higher than that in the L2 label condition ($M = 1.13$, $SD = 1.13$), $t(17) = 2.73$, $p < 0.05$, whereas there was no difference in the mean LPP amplitude between the L2 and passive viewing condition, $t(17) = 0.02$, n.s. Importantly, none of the comparisons reached significance for fearful and sad faces.

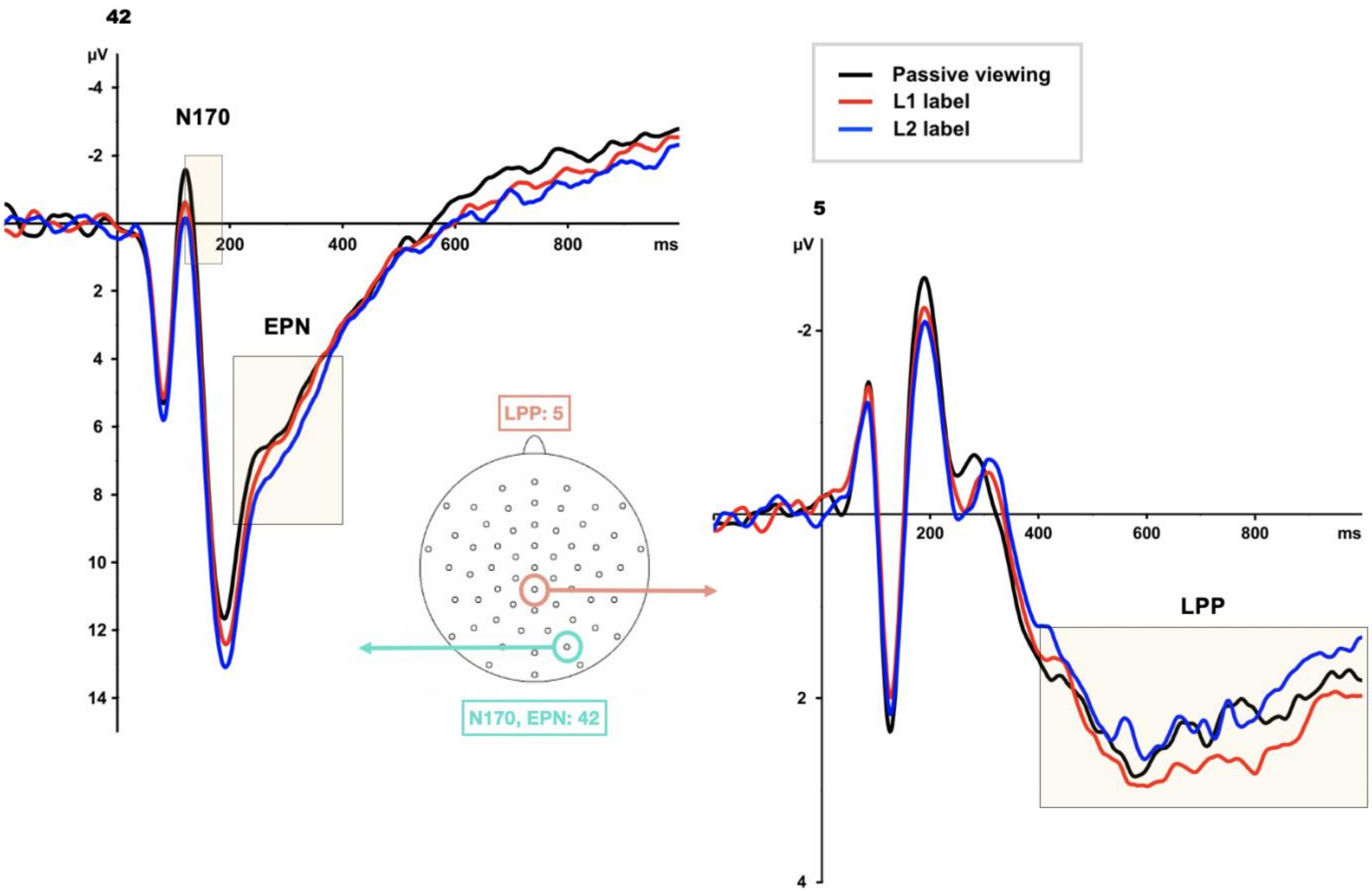

Figure 7. ERP waveforms at two selected electrodes (left: N170, EPN; right: LPP).

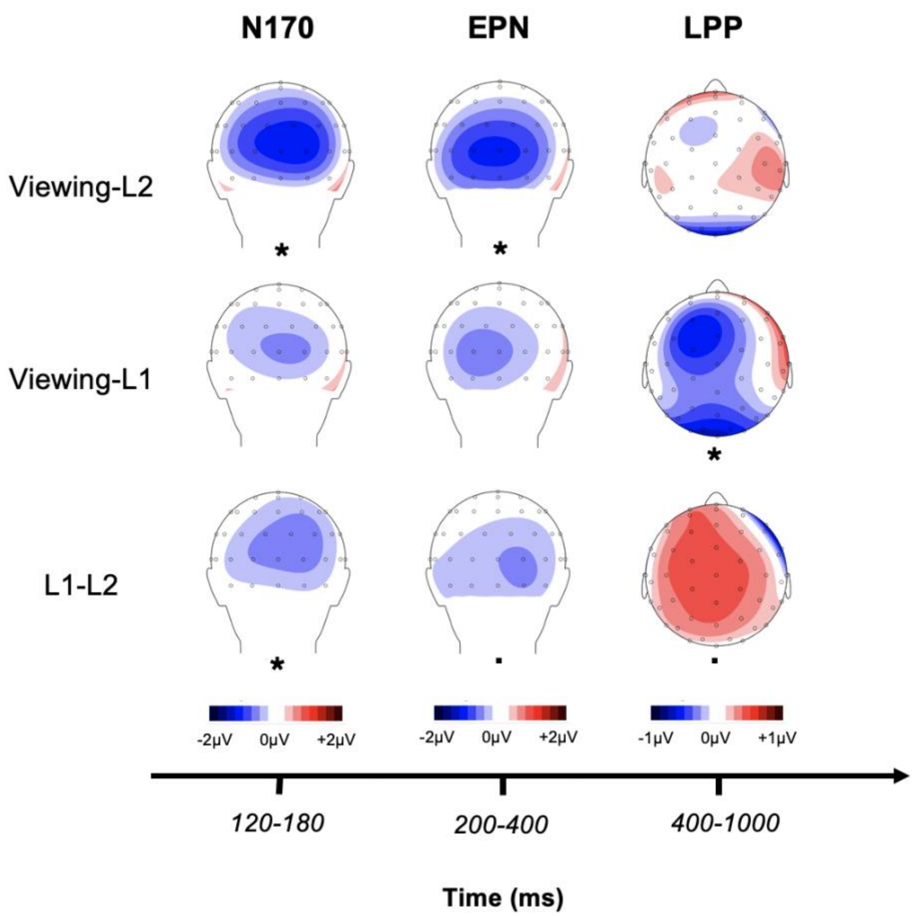

Figure 8. Difference maps for each ERP component: Viewing-L2, Viewing-L1, and L1-L2, by ERP components (NOTE: * indicates < 0.05, · indicates < 0.1). N170 and EPN were plotted on a scale from -2 μV to +2 μV; LPP was plotted on a scale from -1 μV to +1 μV (NOTE: blue indicates negative values, red indicates positive values).

3.2.4 The Role of Proficiency and Frequency of Usage

Multiple regression analyses with LexTALE score, frequency of L1 usage, and frequency of L2 usage as predictors were used for each of the ERP difference waves (L2-viewing, L1-viewing, L2-L1). For the LPP component, L2 frequency use significantly predicted the L2-viewing difference ($\beta = 0.93$, $p < 0.05$) and the L2-L1 difference ($\beta = 0.88$, $p < 0.01$), but not the L1-viewing difference ($\beta = 0.06$, n.s.).

None of the language history variables significantly predicted the ERP results for N170 and EPN (all p > 0.1). Bivariate correlations and multiple regression coefficients for the language history predictors and LPP difference waves were summarized in Table 2.

Table 2: Bivariate correlations and multiple regression coefficients for the language history predictors and LPP difference waves (NOTE: bold font indicates $p < 0.05$)

	L1 frequency	L2 frequency	L2-viewing LPP	L1-viewing LPP	L2-L1 LPP
LexTALE score	-0.3	0.28	0.2 (β = 0.05)	0.11 (β =0.02)	0.18 (β = 0.03)
L1 frequency		**-0.54**	-0.08 (β = 0.24)	-0.13 (β =-0.15)	0.01 (β = 0.39)
L2 frequency			**0.43 (β = 0.93)**	0.08 (β =0.06)	**0.52 (β = 0.88)**

As shown in Fig. 9 (left), participants with more frequent L2 use showed increased LPP in L2 compared to passive viewing, and participants with less frequent L2 usage showed no difference or a reduced LPP in L2. In Fig. 9 (right), participants with more frequent L2 use showed slightly increased LPP or no difference compared to the L1 label condition, and participants with less frequent usage showed reduced LPP in L2.

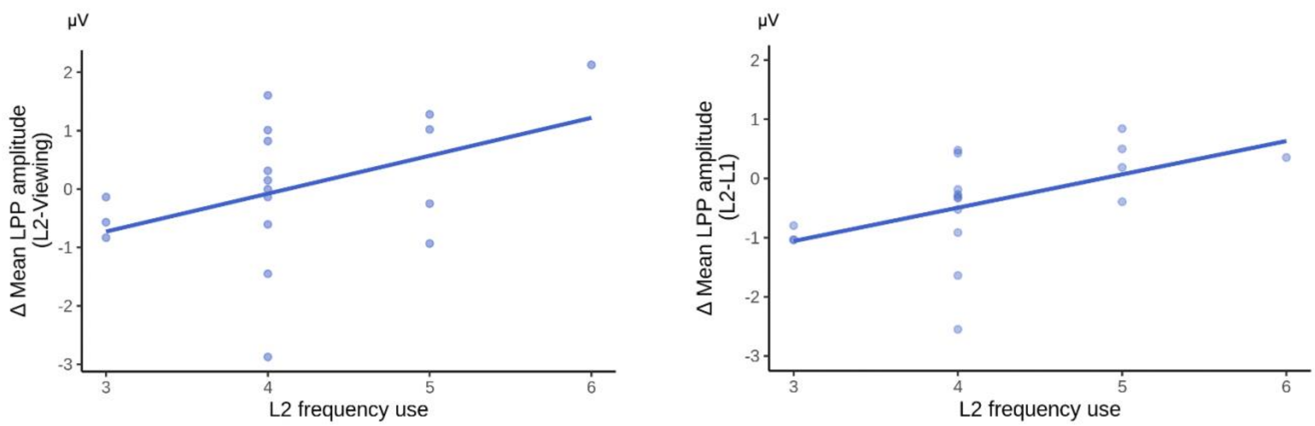

Figure 9: Relationship between L2 frequency use and change in mean LPP amplitudes (left: L2-passive viewing, right: L2-L1)

3.2.5 Correlations between Subjective Ratings and ERPs

For every participant, we calculated three differences in subjective rating of negative emotion experience by subtracting the average rating score in L2 minus the passive viewing (L2-viewing), L1 ratings minus the passive viewing (L1-viewing), and L2 minus L1 ratings (L2-L1). The correlation between subjective rating for L2-viewing and the L2-viewing LPP difference wave was nearly significant ($r = -0.42$, $p = 0.08$), suggesting that a larger reduction in subjective negative emotions indicates a larger reduction of LPP in L2, compared to passive viewing. The correlations were non-significant for the other comparisons.

Chapter 4: Discussion

The present study compared the outcomes of affect labeling in L1 and L2 on the regulation of negative emotions. L1-dominant Chinese-English bilinguals were presented with unpleasant facial pictures and performed tasks under different instructions: passively viewing the picture, labeling the picture using the verbal emotion cue provided in their L1 Chinese, or labeling the picture using the verbal emotion cue in their L2 English.

In line with our hypothesis, at both a subjective and a neural level, labeling in L2 led to reduced negative emotions and significantly (or marginally significantly) smaller ERP amplitudes compared to labeling in L1. Compared to passive viewing, labeling emotions in L2, but not in L1, decreased the amplitude of the early components (N170, EPN), suggesting a reduction in the automatic attentional allocation to emotional stimuli in L2. Contrary to the hypothesis that affect labeling would reduce the late ERP component, L2 labels had no impact on the LPP amplitude, and in fact L1 labels increased LPP for angry faces, implying a heightened processing of emotions in L1. Furthermore, frequency of L2 usage in daily life (but not L2 proficiency) predicted ERP differences at this later stage. That is, less frequent usage of L2 led to a larger reduction of LPP in the L2 label condition compared to passive viewing and L1 label condition.

In the next section, I will discuss the outcomes of affect labeling and how my findings support the Foreign Language Effect (FLE). Then, I will relate the current results to the previous models/theories mentioned in Section 1.1, with an emphasis on the role of frequency of L2 usage in determining the emotionality of L2. Finally, I will discuss strengths and limitations of the current study, and suggest directions for future research.

4.1 The Effectiveness of Affect Labeling

In the present study, affect labeling in L1 and L2 influenced the neural activity at different temporal stages. Specifically, labeling in L2 mostly affected early (N170) and middle (EPN) ERP components, whereas labeling in L1 seemed to mostly affect the late component (LPP) and in the opposite direction to my prediction. In previous research, implicit emotion regulation (e.g. regulation-related priming) is found to mostly alter N170 and EPN, whereas explicit emotion regulation (e.g. consciously decreasing emotions) is more likely to alter EPN and LPP. The current study used a methodology that lies in between implicit and explicit, since participants were not explicitly asked to down-regulate emotions, but the labeling task requires a deliberate naming process. Therefore, it is interesting that the labeling task modified all three ERP components to a different extent.

N170 is a face-specific component that reflects the implicit structural encoding of faces. N170 is usually found to be larger for negative than neutral faces, but it's still debated whether it indexes emotion regulation. In Blechert et al. (2012), participants showed a reduced N170 for angry faces (relative to passive viewing) after cognitive reappraisal (e.g. priming the participants with "imagine he just had a bad day, it's not about you" before presenting an angry face). Other researchers suggested that a reduced N170 is related to less attention allocated to facial stimuli (Zhu et al., 2019), possibly due to increased task demands (Morgan et al., 2008). Thus, the reduced N170 in the L2 label condition (relative to passive viewing) might be due to an increased cognitive load during L2 processing, which left fewer attentional resources available for the emotion face processing, resulting in effective distraction and distancing. Finally, I should point out that the N170 distribution in my study (see Fig. 8) does not perfectly resemble a typical N170 distribution that is maximal over occipital-temporal electrode sites. It's likely that the selected time window also included some activity of N1, an early visual component elicited by visual stimulation. Previous studies have reported a smaller N1 related to reduced attentional engagement during emotion regulation (e.g. Dennis et al., 2009), which is similar to the interpretation of the reduced N170 in my study.

EPN reflects facilitated attentional capture for emotionally salient stimuli. Like N170, EPN is reported to be larger for negative than neutral faces, and most studies found reduced EPN after successful emotion regulation (Herbert, Deutsch, et al., 2013; Blechert et al., 2012; Liu et al., 2018). Further, Schupp et al. (2007) suggested that emotion processing can be interfered by competing task demands, such that the EPN amplitude was attenuated for unpleasant stimuli during difficult attention task conditions in their study. Thus, the reduced EPN in the L2 label condition (relative to passive viewing) possibly also indicates a reduction of attentional resources allocated to emotional stimuli due to increased cognitive load in L2. On the contrary, in the L1 label condition, neither N170 nor EPN was significantly modulated by affect labeling. Thus, labeling in L1 did not effectively reduce early attention for emotion processing.

LPP is considered to reflect selective attention for emotional stimuli at later stages, or the depth of cortical processing of emotions. Labeling in L2 did not affect the LPP amplitude compared to passive viewing, suggesting that the faces were not being processed at a deeper level, possibly due to the already attenuated emotional attention at the earlier stages (i.e. smaller N170 and EPN). In contrast, labeling in L1 significantly increased the LPP amplitude, implying a deeper processing of emotions. A possible explanation could be that, without the early attentional reduction (i.e. no significantly reduced N170 and EPN in the L1 label condition), the emotional faces were being evaluated more intensely and attentively at the later stage. Despite that previous studies mostly reported reduced LPP after emotion regulation, a few did report no modulation or increased LPP. For instance, in Herbert, Sfärlea, et al. (2013), using intentional subjective labels (e.g. “my anger”) increased LPP compared to passive viewing, whereas intentional objective labels (e.g. “his anger”) did not modulate LPP. Finally, in Deng & Li (2020), objective labels briefly increased LPP compared to passive viewing in the time window of 550-600ms, but the LPP amplitude did not differ from the viewing condition afterwards. However, in the current study (see Fig. 7), the LPP amplitude in the L1 label condition was consistently higher during the entire time window (~400-1000ms). It should be noted that, the current study adopted a slightly different affect labeling paradigm with a top-down approach to regulate emotions (i.e. see the label first before the emotional stimulus) instead of a bottom-up approach in Deng & Li (2020) (i.e. see the emotional stimulus first before choosing a label). Thus, there is a possibility that the difference in paradigm could affect the effectiveness of affect labeling.

Crucially, the increased LPP in the L1 label condition (compared to passive viewing and the L2 label condition) was only significant for angry faces, but not for sad and fearful faces. One possible explanation for this up-regulatory effect for the angry faces might be that anger-related labels received the highest intensity ratings than sadness-related and fear-related labels (see Section 3.1.2). Thus, using a label with a very high intensity probably counteracted the down-regulatory effect of affect labeling, since processing the label alone can activate negative emotions. Importantly, participants rated anger-related labels with the same perceived intensity in L1 and L2 (i.e. they know “angry” has the most intense associations in both languages at a semantic level). However, they did not experience anger-related words in L2 as deeply emotional at a more subtle electrophysiological level, as reflected by a lack of LPP modulation for labeling angry emotions in L2. That is, despite *knowing* the valence of L2 words, bilinguals may not actually *feel* it (Degner et al., 2012; Pavlenko, 2012). This discrepancy between semantic knowledge and affective processing is in line with Caldwell-Harris et al. (2011). In their study, bilinguals provided similar subjective ratings but differed in skin conductance responses for emotional expressions in L1 and L2.

At a subjective level, neither L1 nor L2 label condition significantly changed the rating of negative emotion experience compared to passive viewing. Previous research on affect labeling has mostly reported reduction (e.g. Constantinou et al., 2014) or no change (e.g. Herbert, Sfärlea, et al., 2013) in subjective ratings, and rarely, some even reported an increase in subjective emotions (e.g. Herbert, Sfärlea, et al., 2013). However, subjective self-reports should be taken with caution, considering the implicit and unaware nature of affect labeling (Yue et al., 2012). For instance, in Lieberman et al. (2011), participants still predicted that affect labeling would increase distress in the future, despite showing reduced distress after labeling. Further, some studies did not find correlations between self-reports and objective measures (e.g. Constantinou et al., 2014). This is also the case in the current study, since there was only a marginally significant correlation between the L2-viewing rating score and the L2-viewing LPP amplitude, and all the other correlational comparisons were non-significant.

Overall, the current study partially supports the effectiveness of affect labeling in reducing negative emotions. However, since research on affect labeling is still in early stages, there are mixed results about affect labeling as a down-regulatory emotion regulation technique. As suggested by Morawetz et al. (2017), some sub-processes associated with affect labeling might not be beneficial to emotion regulation. In particular, when labeling emotions, attention might be directed to the affective features of a picture, leading to increased engagement and higher emotional response. Further, Lieberman et al. (2011) pointed out that affect labeling should not always be considered as a down-regulatory technique, since in some situations labeling may trigger rumination (i.e. repeatedly thinking about personally distressing events), which could amplify distress. Indeed, Herbert, Sfärlea, et al. (2013) found that sometimes rehearsing intentional and self-related labels while processing emotional stimuli led participants to experience emotions more intensely. Together, more research is needed to elucidate how and why affect labeling decreases or increases emotions under different conditions (Lieberman et al., 2011).

4.2 The Foreign Language Effect

In the current study, L2 use reduced both subjective negative emotions and ERP amplitudes compared to L1 use. This supports the Foreign Language Effect (FLE), such that processing emotions in L2 creates a larger emotional distance than in L1, resulting in dampened emotional experience. The FLE for emotion regulation is consistent with Morawetz et al.'s (2017) finding that *content labeling* in L2 (e.g. label a snake picture as "animal") regulated negative emotions better than in L1. It's important to note that, Morawetz et al. (2017) only found a FLE for *content labeling*, but not for *emotion labeling*. At first glance, this seems to contradict my results, since the task in the current experiment was called "affect labeling". However, the *emotion labeling* condition used in Morawetz et al. (2017) required participants to label internal feelings (e.g. label the feeling triggered by a snake picture as "fear"), whereas the current study asked participants to label the emotional contents of the facial stimuli (e.g. label a fearful face as "afraid"), so it could be considered as *content labeling* of the emotional face.

My findings are also in line with Dylman & Bjärtå (2019) that demonstrated reduced distress after switching from L1 to L2 to process negative texts. Nevertheless, unlike in Dylman & Bjärtå (2019), the L2-related regulation effect in the current study was observed in a consistent L2 setting (i.e. no language switching within a block). This implies that the FLE is not necessarily confined to situations that require constant language switching, consistent with the finding of Morawetz et al. (2017).

To sum up, labeling the emotional content in L2 helped distance the participants from the emotional source more effectively compared to labeling in L1. This enhanced distancing effect likely resulted from increased distraction and abstraction (symbolic representation) in

L2. First, using L2 labels seemed to reduce attentional resources (N170 and EPN) allocated for emotion face processing compared to using L1 labels, possibly due to the higher cognitive load or cognitive control during L2 use (Dylman & Bjärtå, 2019). Further, since L1 and L2 usually differ in their initial context of acquisition (emotional versus academic), it's been suggested that L1 relates to more concrete emotional processes whereas L2 relates to more abstract cognitive processes (Caldwell-Harris, 2014; Shin & Kim, 2017). Thus, it's likely that converting the emotional faces into the more abstract L2 created a larger distance between the labeler and the raw emotion. As discussed in Torre & Lieberman (2017), "once the prefrontal regions of the brain have the emotional information in symbolic format, there is no additional utility in having the alarm (e.g., amygdala) continue to signal for attention". If this is true, then it'd be interesting to see whether using more abstract emotion words in L1 could regulate emotions more effectively. For instance, the current study only included basic Chinese emotion words such as *shēngqì* ("angry"), so future studies should consider using words with more abstract meanings such as dàfāléitíng ("behaving furiously like a thunderstorm") to test their effectiveness in emotional distancing.

The reduced emotionality in L2 has real-life implications for bilingual therapies. On the one hand, using a non-dominant L2 in therapy could create an emotional distance for clients to discuss highly negative events objectively without being overwhelmed (Santiago-Rivera & Altarriba, 2002). On the other hand, due to the detachment experienced in L2, clients might feel less engaged in therapy or struggle to find the accurate emotion words to describe their feelings (Rolland, Dewaele, & Costa, 2017). Santiago-Rivera & Altarriba (2002) suggested that therapists could conduct the initial sessions in the client's dominant L1 to build rapport and trust, and during later stages of treatment, they could switch to the less emotional L2 for clients to describe detailed emotional events. Thus, considering the positives and negatives of the FLE in emotion regulation, therapists should strategically decide the language of use depending on the need of the client and the progression of the therapy for the purpose of emotional disengagement or engagement. Finally, the client's personal history and relationship with their L2 (e.g. frequency of L2 usage, discussed in the section below) should be considered as well.

4.3 Theoretical Implications for the L2 Emotionality Effects

The current study found that, among all the language history variables (L2 proficiency, frequency of usage of L1 and L2), frequency of L2 usage was the only significant predictor of the LPP amplitude when comparing the L2 label condition with passive viewing and with the L1 label condition. First, the positive correlation between L2 frequency usage and L2-viewing LPP indicates that, as bilinguals use their L2 more frequently, the *L2 advantage* (i.e. decreased emotional reactivity to negative stimuli in L2) disappears, leading to less effective regulatory effect (i.e. a larger LPP in L2). Next, the positive correlation between L2 frequency usage and L2-L1 LPP indicates that the FLE also decreases (i.e. similar LPP amplitudes in L1 and L2) as the frequency of L2 usage increases. Finally, none of the language history variables predicted the amplitude of N170 and EPN, implying that the early emotional regulatory processes are largely implicit and automatic, and thus are not modulated by individual differences in bilinguals' language background.

Considering the theories and models discussed in Chapter 1, the study supports the *episodic trace theory of language emotionality*, which proposes that the L2 emotionality effect depends on the frequency of language usage in L1 versus L2 contexts (Puntoni et al., 2009). That is, using L2 more frequently would increase the number of relevant episodic traces stored in memory, thereby inducing a strong echo of emotions experienced in L2. Similarly, the results also support the *emotional contexts of use* theory, which proposes that L2 can become emotional if it is acquired or used frequently in an emotional context (Harris et al., 2016). Despite the theory's emphasis on the emotional "context" as a causal factor for language emotionality, it is not very different from the episodic trace theory, since frequent usage very likely entails emotional use, given the highly emotional nature of interpersonal interactions (Caldwell-Harris, 2014).

However, different from the prediction of the *Revised Hierarchical Model* (RHM), L2 proficiency was not a significant predictor. It is possible that proficiency is only a byproduct of the higher frequency of usage (in emotional contexts), but not a casual factor that accounts for the L1-L2 emotionality difference. However, it should also be noted that all participants in the current study are studying in their L2-speaking country (i.e. USA), so their

L2 proficiency levels might be relatively homogeneous. Future studies should increase the sample size and include participants with more diverse L2 proficiency levels.

Finally, the study also provided evidence for the *theory of L2 disembodiment*, which distinguishes between interpretive and automatic emotion processing in L1 and L2 (Pavlenko, 2012). At a higher interpretative level, the participants in my study rated L1 and L2 labels as the same in valence and intensity, but they showed different neural responses across languages at a lower automatic level. The theory of L2 disembodiment tentatively discussed the role of frequency of L2 usage in facilitating the automatic emotion processing in L2, but it did not specifically predict if, how, and when the frequency of L2 usage influences somatovisceral or neurophysiological activity (Pavlenko, 2012). In the current study, we showed that frequent L2 usage increased the electrophysiological responses at the later stages (LPP) of emotion regulation via L2 labeling, but not at the early stages (N170, EPN).

4.4 Strengths, Limitations, and Future Directions

Very few studies have examined the effectiveness of emotion regulation in bilinguals' two languages. The current study is the first one to use the ERP technique to investigate the L1-L2 difference for emotion regulation at a neural level. Further, the study isolated the effect of proficiency and frequency of usage on the L1-L2 emotion processing while controlling for other language history variables (e.g. language dominance, initial context of L2 acquisition, age of L2 acquisition). In general, the current study adds evidence to the affect labeling research by elucidating the impact of labeling on neural activity at different temporal stages.

Nevertheless, the present study also has several limitations. First, the facial expressions might not have been unpleasant enough to trigger strong negative emotional responses. Anecdotally, a few participants reported that they did not feel particularly negative about the faces. Thus, to induce emotions more effectively, future studies could consider using more naturalistic and distress-causing pictures, such as those from the International Affective Picture System (IAPS).

Further, the bilinguals in my study are currently living in their L2-speaking country (i.e. USA), so the facilitated regulatory effect in L2 may not be generalizable to bilinguals who live in their L1-speaking country (e.g. Chinese-English bilinguals in China). It's likely that, when bilinguals are immersed in a new culture, they tend to show a "positivity bias" in L2 that makes them especially immune to negative information in L2 (Conrad, Recio, & Jacobs, 2011). Additionally, cross-cultural differences in emotion regulation should be considered. For instance, Davis et al. (2012) found that college students from China and USA used different strategies for spontaneous emotion regulation (when no explicit regulation instruction was given). In particular, Chinese students reported more usage of emotional disengagement (e.g. distraction) whereas American students used more emotional engagement strategies (e.g. cognitive reappraisal). Therefore, cross-cultural effectiveness of affect labeling needs to be validated, given the lack of uniformity in ERP studies.

Finally, future studies should examine the impact of other personal characteristics of bilinguals on the outcome of emotion regulation using more naturalistic tasks (e.g. face-to-face conversation). For instance, Quiñones-Camacho et al. (2019) found that Spanish-English bilinguals who used fewer engagement strategies (e.g. cognitive reappraisal) for emotion regulation showed reduced physiological arousal when talking about negative events, but only for those who were more physiologically aroused at rest and only when they were speaking English. Therefore, researchers should create models that account for the individual differences (e.g. resting arousal and emotion regulation strategy use) to better predict bilinguals' emotion regulation outcome in their L1 and L2.

4.5 Conclusion

The current study confirms the Foreign Language Effect (FLE) in emotion regulation via affect labeling, such that bilinguals consistently showed reduced emotionality in L2 than in L1 at both a subjective and a neural level. However, the study only partially supports the down-regulatory effect of affect labeling, given that labeling in L1 increased LPP for angry emotions. Additionally, L2 becomes more emotional as the frequency of L2 usage increases, as reflected by the weaker L2 detachment effect for emotion regulation at the later stage (LPP).

Appendix

Table 3: Valence and intensity ratings for Chinese and English labels

Word	Valence	Intensity
afraid	3.28	4.83
angry	3.00	6.06
depressed	2.50	5.44
fearful	3.00	5.50
frightened	2.72	6.06
furious	2.22	7.11
heartbroken	2.28	6.44
infuriated	2.50	6.89
irritated	3.22	5.39
melancholy	3.39	4.06
outraged	2.06	7.44
sad	3.33	4.50
scared	2.94	5.56
sorrowful	3.06	4.44
terrified	2.11	6.83
害怕	2.83	5.11
心碎	2.17	6.83
忧郁	3.17	4.33
恐惧	2.61	6.11
恐慌	2.44	6.28
恼怒	2.94	5.72
悲伤	2.83	4.61
悲哀	2.94	4.56
惊恐	2.61	6.39
愤怒	2.83	6.44
愤懑	2.89	5.83
暴怒	2.17	7.89
沮丧	3.33	4.83
生气	3.11	5.39
畏惧	3.00	5.39

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