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Second Language Shapes Emotional Facial Expression Perception, but Only When Words are Unmasked: Evidence from Masked and Unmasked Affective Priming Paradigms

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The present study explored the influence of second language (L2) emotion words on the perception of emotional facial expressions. Our study encompassed two types of L2 emotion words: emotion-label words (Experiments 1a, 2a, 3) and emotion-laden words (Experiments 1b, 2b, 4). Five cohorts of Chinese-English bilingual individuals (with a total of *N* = 144 for all experiments) were assigned the task of evaluating the valence of faces that were presented subsequent to being preceded by either masked or unmasked second language (L2) emotion words serving as primes. The affective priming effects were scrutinized across both masked and unmasked conditions between emotion-label words and emotion-laden words in L2. Surprisingly, despite an increase in L2 proficiency, neither the emotion-label words nor the emotion-laden words were able to impact emotional facial expression perception in the masked priming paradigm. However, in the unmasked priming condition, both types of emotion words demonstrated a priming effect on emotional facial expression perception. These findings are in agreement with the disembodied account, which posits that L2 emotion words are not processed affectively. They highlight the significance of utilizing diverse emotional stimuli to investigate the intricate interplay between emotion and bilingualism.

Key words: emotion-label words, emotion-laden words, emotional facial expression, valence, second language

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The interplay between bilingualism and emotion has been a theme of investigation for several decades, as evidenced by notable studies (Altarriba, 2014; Altarriba & Basnight-Brown, 2011; Altarriba, 2003; Anooshian & Hertel, 1994; Pavlenko, 2012; Rosselli et al., 2017; Sutton et al., 2007). The field of bilingualism has greatly benefited from the extensive research conducted within affective neuroscience, psycholinguistics, applied linguistics, and neurolinguistics, shedding light on various aspects of bilingualism and emotion (Comanaru & Dewaele, 2015). However, little attention has been given to exploring how bilingualism specifically influences emotion perception.

An Interactive Perspective on Emotion and Bilingualism

The impact of emotion activation and its amplitude in both the first language (L1) and second language (L2) has been widely explored in bilingual research (Anooshian & Hertel, 1994; Eilola & Havelka, 2011; Eilola et al., 2007; Ferré et al., 2018; Ferré et al., 2010; Jończyk et al., 2016; Ponari et al., 2015; Sheikh & Titone, 2016; Wu & Thierry, 2012). While research in L1 emotion has confirmed the bidirectional relationship between emotion and language, where emotion and language mutually influence each other at various levels, little attention has been given to how bilingualism influences emotion perception.

Recent investigations on the impact of language on emotion perception have shown that language impairment is connected with deficits in emotion perception (Lindquist et al., 2014). Additionally, the temporary loss of semantic access to emotion words interfered with the perception of facial expressions (Gendron et al., 2012; Lindquist et al., 2006). However, these investigations were conducted in an L1 context, leaving a gap in our understanding of whether L2 emotion words can also influence emotion perception. Building upon the expanded knowledge of L2 emotion activation (Rosselli et al., 2017), this study aims to further explore whether emotional facial expression perception can be shaped by L2 emotion words. Examining the effect of L2 in emotion perception can significantly enhance our understanding of how language impacts emotion from a bilingual perspective.

Recent research trends in both L1 and L2 emotion words have highlighted the importance of emotion word type in constraining emotion word processing (Kazanas & Altarriba, 2015; Kazanas & Altarriba, 2016a, 2016b; Wu et al., 2020; Wu & Zhang, 2019b, 2020; Wu et al., 2021a, 2021b, 2022; Zhang et al., 2018; Zhang et al., 2017, 2024; Zhang, et al., 2020; Zhang et al., 2019). The notion of emotion word type suggests that emotion words can be classified into two categories: emotion-label words and emotion-laden words (Wu & Zhang, 2020). Emotion-label words (e.g., happiness, worry) straightforwardly describe specific affective states, while emotion-laden words (e.g., marriage, divorce) can also elicit emotions but with connotations. Here, the term “induce” refers to the idea that reading emotion words can simulate certain emotions. Numerous previous studies have consistently shown that emotion-label words induce more significant emotion activation compared to emotion-laden words in various languages, such as Chinese (Wang et al., 2019) and English (El-Dakhs & Altarriba, 2019). For example, there was evidence demonstrating that emotion-label words elicited enhanced early event-related potentials (ERPs) compared to emotion-laden words in a flanker task (Zhang et al., 2018).

In a recent ERP study that focused on L1 (Chinese), the impact of the two types of words on shaping emotional facial expression perception was examined (Li et al., 2022). Us-

ing an unmasked priming paradigm, Li et al. (2022) discovered that disgusted facial expressions, when preceded by positive emotion labels (in the inconsistent condition), elicited a significantly larger N400 amplitude (more negative) compared to disgust faces preceded by negative emotion labels (in the consistent condition). However, this effect was not observed when emotion-laden words were used as primes. These results confirmed the distinction between emotion-label words and emotion-laden words, as well as the modulation of L1 words on emotional facial expression perception. Li et al. (2022) did not explore the influence of L2 on emotion perception and focused solely on emotions related to happiness and disgust. Although Li et al. (2022) revealed a pronounced difference between happy and disgusted faces, with happy faces showing less susceptibility to the influence of emotion words than disgusted faces – likely owing to the greater ease in discerning happy expressions – other emotional expressions, such as anger and sadness, also merit further investigation (Zhang et al., 2025). The current study expands beyond these limitations by examining the impact of L2 emotion words on emotional facial expression perception, encompassing a broader range of emotions.

The Present Study

The objective of the present study was to examine how second language (L2) influences emotion perception, specifically emotional facial expression perception. The current investigation involved the use of emotion-laden words and emotion-label words in the L2 context.

To achieve this goal, six experiments were conducted utilizing both the masked and unmasked priming paradigms. The masked priming paradigm has been extensively employed in psycholinguistic research, particularly for visual word perception (Kinoshita & Lupker, 2004). In this paradigm, primes (e.g., words) are briefly displayed (e.g., 50ms) after a forward mask and are then masked by targets or a backward mask. Since the primes are presented momentarily and masked, participants are usually unaware of their existence. However, even without conscious processing of the primes, they can still facilitate the processing of target words if they are related to the targets, such as semantically associated (e.g., doctor-nurse) or translation equivalents (e.g., doctor-医生). Consequently, this paradigm has been a powerful tool for examining how lexical factors (e.g., orthography, phonology) and semantic factors influence word perception, while effectively ruling out strategic influences (Kinoshita & Lupker, 2004). The masked priming paradigm has also been extensively adopted in bilingual visual word perception. The previous studies have shown that L2 words as primes in the masked priming paradigm have difficulty producing translation priming effects on L1 words (e.g., using doctor primes for 医生, a Chinese translation equivalent of doctor), but L1 primes words could easily produce translation priming effect on L2 target words. These results suggest that, unlike L1 words, it is challenging for L2 words to automatically generate semantic activation within such a short duration as 50ms (Nakayama et al., 2013; Nakayama et al., 2014; Zhang, Wu, Zhou, et al., 2019). This characteristic enables us to explore whether L2 emotion-label words and emotion-laden words can automatically induce an emotion effect that shapes emotion perception. In contrast, the unmasked priming paradigm involves primes that are not masked and are visible to the participants, allowing for explicit processing of the primes, including their orthography, phonology, and semantics. As a result, it was discovered that primes in both L1 and L2 were capable of generating a sig-

Table 1 The theoretical underpinnings and hypotheses

Previous studies	Masked translation priming	Unmasked translation priming	Theoretical implications
L1(prime)-L2(target)	Yes	Yes	Automatic and implicit semantic activation for L1 words
L2(prime)-L1(target)	No	Yes	Elaborate and explicit semantic activation for L2 words
The present study	Masked affective priming	Unmasked affective priming	Hypotheses from different accounts
L2(prime)-facial expression(target)	No	Yes	Disembodied account L2 words could activate semantics in the unmasked priming condition rather than in the masked priming condition, and L2 affective priming depends on the semantic rather than automatic affective activation.
	Yes	Yes	Embodied account L2 words could activate semantics in both the unmasked priming condition and masked priming condition, and L2 affective priming depends on the automatic affective activation rather than semantic activation.

nificant priming effect (Basnight-Brown & Altarriba, 2007). Therefore, it was predicted that both L2 emotion-laden words and emotion-label words would generate a priming effect in this paradigm. This prediction is examined in Experiment 3 (emotion-label words) and Experiment 4 (emotion-laden words).

If L2 emotion words, including emotion-label words and emotion-laden words, are capable of subliminally inducing an emotion effect, it is expected that the modulation of L2 emotion words on emotion perception will be observed for both emotion-label words (Experiment 1a, 2a, 3) and emotion-laden words (Experiment 1b, 2b, 4). However, according to the disembodied account (Pavlenko, 2012), emotion activation in L2 is primarily semantic rather than affective. In other words, for late bilinguals who acquired their second language after puberty, prior emotional experiences are deeply rooted in L1 contexts, allowing for automatic affective responses to L1 words. In contrast, L2 learning, often confined to classroom environments, provides limited exposure to emotionally rich experiences, making it challenging for L2 words to automatically activate affective information. As a result, L2 words typically require explicit semantic processing to trigger an affective priming effect. Consequently, it is expected that neither emotion-label nor emotion-laden words will effectively prime emotional facial expression perception in the masked priming paradigm. This is because in the masked priming paradigm, L2 primes may not activate semantics. However, it can be expected that

both L2 emotion-label words (Experiment 3) and emotion-label words (Experiment 4) will prime emotional facial expression perception in the unmasked priming paradigm. To test these hypotheses, the present study utilized an affective masked priming paradigm (Wu et al., 2021a, 2021b), in which a masked prime word (an emotion-label word or an emotion-laden word) was briefly presented before a target face that could either be in the same valence as the prime word (related condition) or in the opposite valence (unrelated condition). For the unmasked priming paradigm, primes were not masked and were presented for a relatively longer duration, allowing participants to explicitly process the primes. In previous studies, the affective priming effect was observed as faster perception of faces in the related condition compared to the unrelated condition. In contrast, according to the embodied theory of L2 emotions, it is anticipated that L2 emotion words can elicit an affective priming effect in both masked and unmasked priming paradigms. This is because L2 emotion words are capable of automatically activating affective information, with minimal dependence on explicit semantic processing. Therefore, in the current experiments, the affective priming effect of emotion-label words and emotion-laden words on facial expression perception was compared across the six experiments (see Table 1 for more details).

Experiment 1a

Experiment 1a aimed to investigate the impact of L2 emotion-label words on emotional facial expression perception using a masked priming paradigm. In this experiment, participants were presented with masked L2 emotion-label words as primes, followed by target faces, and were asked to evaluate the emotional valence of the faces. According to the disembodied account, second language (L2) emotion-label words are incapable of generating an affective priming effect within the masked priming paradigm.

Method

Participants

Twenty-three Chinese-English bilinguals (mean age: 26.75 ± 3.73, six males) participated in the current experiment. The sample size is calculated by G*power (Faul et al., 2007), meaning that when the effect size is medium (i.e., partial $\eta^2 = .1$) for repeated-measures and power is 0.8, at least 20 participants are required, namely $F(1, 19) = 4.38$, $p = .05$, also in line with previous similar studies (Wu & Zhang, 2019; Zhang et al., 2018). The English lexical knowledge was measured by LexTALE (Lemhöfer & Broersma, 2012), and the mean LexTALE score was 52.68, suggesting that the participants were low proficient English speakers. LexTALE is a quick and valid English proficiency test that has been widely utilized. The participants (Chinese native speakers) started to learn Chinese at around 1.7 years old and English at 7.7 years old. Therefore, they were late bilinguals. In addition, all participants were right-handed and had no neurological or psychiatric disorders. They also had normal or corrected-to-normal vision. The participants voluntarily completed these experiments in exchange for extra credit or monetary compensation. They were recruited from the class WeChat group and made appointments with the experimenter. Owing to the unbalanced gender ratio within the university, a significant majority of the participants were female students.

Materials

In order to compare the findings between the experiments, we also initially matched

the emotion-label words and emotion-laden words. Therefore, in this section, we describe the characteristics of both types of words (Experiment 1a, 2a, and 3: emotion-label words; Experiment 1b, 2b, and 4: emotion-laden words). The emotion words (as primes) consisted of 40 English positive emotion-label words, 40 English positive emotion-laden words, 40 English negative emotion-label words, and 40 English negative emotion-laden words (Warriner et al., 2013). The four types of emotion words did not differ in word frequency (Brysbaert & New, 2009), F (3, 156) = 1.950, p = 0.124, arousal (Warriner et al., 2013), F (3, 156) = 1.155, p = 0.329, familiarity, F (3, 156) = 1.572, p = 0.198, and word length, F (3, 156) = 0.251, p = 0.860. It is important to note that in the current experiment, only emotion-label words were included (see the word list in the supplementary table). Another 160 emotional faces (80 negative faces and 80 positive faces) were obtained from the Chinese Affective Face Picture System (Gong et al., 2011). Negative faces and positive faces were also equally distributed into two categories that were primed by emotion-label words and emotion-laden words. Therefore, there were 160 faces collapsed into four sections that were matched on arousal, F (3, 156) = 0.322, p = 0.809. Positive faces were more positive than negative faces, F (3, 156) = 223.717, p < 0.001, while no difference was found for faces that were primed by the emotion-label words and emotion-laden words respectively, ps > 0.1 (see Tables 2 and 3 for details for words and faces). The pairing between words and faces was random, indicating that emotion words were not semantically associated with the emotional facial expressions.

Table 2 *Mean and standard deviation (SD) in brackets for word characteristics for English emotion-label words and emotion-laden words as primes*

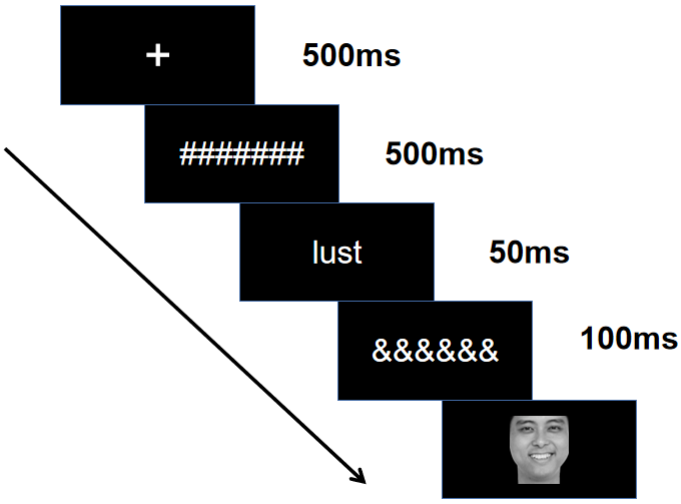
	Emotion-label words		Emotion-laden words	
	Negative	Positive	Negative	Positive
Sample	horror	lust	ghost	gift
Word frequency	2.38 (0.54)	2.61 (0.94)	2.60 (0.48)	2.70 (0.35)
Word length	7.53 (2.25)	7.63 (2.64)	7.40 (1.93)	7.23 (1.78)
Arousal	4.86 (0.96)	4.57 (1.11)	4.84 (0.73)	4.60 (0.76)
Valence	2.97 (0.65)	6.86 (0.95)	2.96 (0.71)	6.53 (0.81)
Familiarity	5.79 (0.56)	5.89 (0.74)	5.61 (0.74)	5.62 (0.70)

Table 3 *Mean and standard deviation (SD) in brackets for emotional facial expressions characteristics*

	Negative		Positive	
	Related	Unrelated	Related	Unrelated
Valence	3.05 (0.54)	3.10 (0.65)	5.92 (0.75)	5.81 (0.76)
Arousal	5.56 (0.71)	5.61 (0.61)	5.48 (0.45)	5.56 (0.51)
Attractiveness	4.03 (0.42)	4.13 (0.38)	5.16 (0.67)	5.10 (0.67)

Procedure

Participants provided their informed consent before commencing the experiment. Prior to the main task, they underwent an assessment using LexTALE to measure their English lexical knowledge. Subsequently, participants engaged in an emotional facial expression perception task, where they were required to judge whether presented faces were negative or positive by pressing the corresponding buttons. Each trial started with a fixation point displayed for 500ms, followed by a forward mask for 500ms. The primes, consisting of English emotion-label words, were then briefly presented (50ms) immediately after the forward mask, and subsequently masked by a backward mask for 100ms, ensuring that participants remained unaware of the primes (Wu et al., 2021a, 2021b). The targets, which were emotional facial expressions, were presented after the backward mask and remained on the screen until participants responded (refer to Figure 1). To familiarize participants with the task, 16 practice trials were administered using different materials from the formal trials. The main experiment comprised 160 trials (80 related trials and 80 unrelated trials), distributed across 40 trials within each



Note. Alt = "Each trial begins with the display of a fixation point, maintained for a duration of 500 milliseconds to ensure participant focus. Subsequently, a forward mask is introduced and held for 500 milliseconds. Following the forward mask, a prime word swiftly follows, exposed to the viewer for a brief 50-millisecond interval. This prime word is then veiled by a backward mask, which shrouds it for a controlled duration of 100 milliseconds. After this masked priming phase, a target face is presented to the participants. Their task is to swiftly evaluate the emotional valence of the presented face, discerning whether it conveys a negative or positive emotional expression."

Figure 1 Trial scheme for Experiment 1a.

block. The order of trials within each block, as well as the order of the blocks themselves, was randomized. It is important to note that two lists were used. In one list a positive face was primed by a positive emotion-label word (related condition), while in the other list the same positive face was primed by a negative emotion-label word (unrelated condition). The assignment of participants to the two lists was counterbalanced. Importantly, none of the participants reported awareness of the primes during the experiment.

Results

Trials that exceeded 2.5 SD ± Mean were discarded, thereby 1.77% of the data was deleted. A 2 (valence: negative and positive) × 2 (relatedness: related and unrelated) repeated-measure ANOVA was performed for both accuracy rate and reaction time analysis.

For accuracy rate, there was no main effect or interaction, *p*s > .0.5. However, for reaction

Table 4 *Mean reaction time (ms) and accuracy rate (%) in brackets of emotion-label words (Experiment 1a) and emotion-laden words (Experiment 1b) as a function of relatedness and valence on emotional facial expression perception*

	Negative		Positive	
	Related	Unrelated	Related	Unrelated
Emotion-label	737 (90.9)	754 (91.6)	683 (91.8)	670 (91.4)
Emotion-laden	747 (90.6)	759 (90.6)	667 (92.8)	679 (92.0)

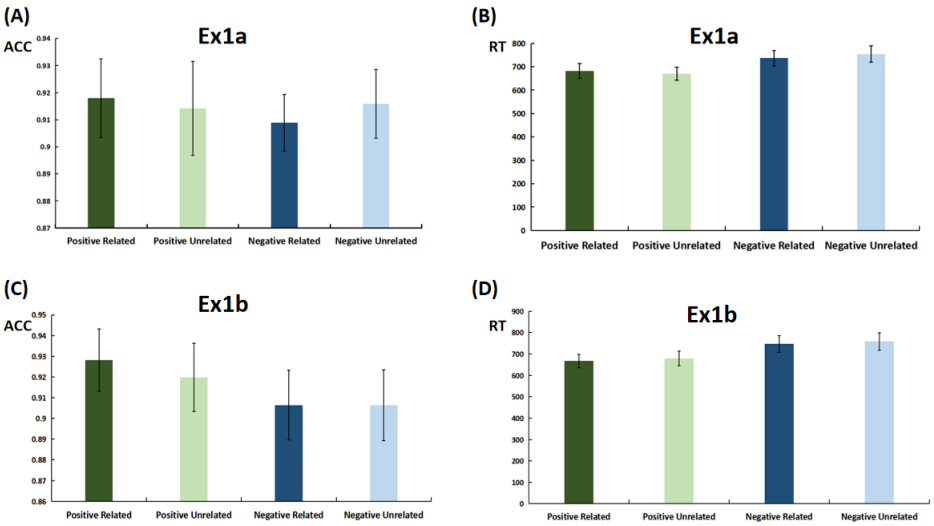


Figure 2 The accuracy rates (ACC) and reaction times (RT) to different conditions in Experiments 1a and 1b.

time, positive faces (677ms) were recognized faster than negative faces (746ms), F (1, 22) = 15.324, $p < 0.001$, partial $\eta^2 = 0.411$. In addition, there was an interaction between valence and relatedness, F (1, 22) = 5.593, $p < 0.05$, partial $\eta^2 = 0.346$. However, post hoc comparisons showed no priming effect of emotion-label words on facial expression perception, t (22) = 1.389, $p > 0.1$ for positive words, t (22) = 1.787, $p > 0.08$, for negative words (see Table 4, Figure 2 for more details).

Discussion

Experiment 1a successfully replicated previous findings that positive stimuli are processed more rapidly than negative stimuli, consistent with the density hypothesis, which suggests that positive emotions are more densely clustered than negative emotions. This clustering of positive emotions likely confers a processing advantage for positive stimuli, particularly in valence evaluation (Unkelbach et al., 2008; Zhang et al., 2019).

However, contrary to the predictions of the embodied account, which posits that L2 emotion words are embodied, the results of Experiment 1a revealed that L2 emotion-label words in the masked priming paradigm did not prime facial expression perception. This finding challenges the notion that emotion-label words, even in L2, can automatically and rapidly induce emotions (Zhang et al., 2020; Zhang et al., 2019). It is possible that the low English proficiency level of the participants in the current experiment hindered the automatic activation of emotions triggered by the emotion-label words. To explore this possibility further, Experiment 2a will further delve into the influence of L2 emotion-label words. Moving forward, Experiment 1b concentrates on investigating the impact of L2 emotion-laden words on emotional facial expression perception within the same group of bilingual participants.

Experiment 1b

Experiment 1b aimed to further examine how L2 emotion-laden words influence emotional facial expression perception when the words are subliminal. If emotion-laden words in L2 cannot produce an emotion effect quickly and automatically, it is predicted that masked L2 emotion-laden words would not produce a priming effect.

Method

Participants

Twenty-two Chinese-English bilinguals (mean age: 27.05 ± 3.56 years old, five males) participated in the present experiment. Sixteen of them also participated in Experiment 1a, and the interval between the two experiments was at least two weeks. The order of the two experiments was also counterbalanced among the participants. Because of the substantial overlap in the sample between the two experiments, it was natural to find that the participants from the two experiments did not differ in English proficiency as indexed by LexTALE, $F < 1$.

Materials

The stimuli of facial expressions were identical with Experiment 1a, except that L2 emotion-laden words were chosen as primes in the experiment.

Procedure

The procedure was identical to that of Experiment 1a.

Results

Trials (3.41% data) that exceeded the range of *M* ± 2.5 *SD* were deleted. There was no main effect or interaction in accuracy rate analysis, all *p*s > 0.3. For reaction time, the main effect of valence was observed, F (1, 21) = 20.384, $p < .001$, partial $\eta^2 = .493$. Shorter reaction times to positive faces (673ms) than to negative faces (753ms) were found. No other main effect or interaction was identified, *p*s > .05 (see Table 4, Figure 2 for more details).

Discussion

Experiment 1b replicated the processing advantage for positive faces, similar to the findings of Experiment 1a. We did not observe any modulation of L2 emotion-laden words on emotional facial expression perception when these words were subliminally presented to the participants. It is important to note that the null effect of the primes on target face perception in Experiment 1b could potentially be attributed to the use of interchangeable samples between Experiments 1a and 1b. To address these concerns and strengthen the validity of the findings, two separate groups of Chinese-English bilingual participants were recruited for Experiment 2a (L2 emotion-label words) and Experiment 2b (L2 emotion-laden words), respectively. By recruiting distinct participant groups for each experiment, we aim to overcome the limitations associated with the sample interchangeability observed in the previous experiments.

Furthermore, in Experiment 2a and 2b, we will also explore the role of higher L2 proficiency. Both groups of Chinese-English bilingual participants in Experiment 2a and 2b had higher L2 proficiency compared to the participants in Experiment 1a and 1b. More details regarding the methodology for each experiment can be found in the respective method sections.

By addressing these methodological concerns and investigating the impact of L2 emotion-label words and emotion-laden words on emotional facial expression perception, we aim to provide a more comprehensive understanding of how L2 proficiency and different types of L2 emotion words influence the perception of emotional facial expressions in bilingual individuals.

Experiment 2a

Experiment 2a had two purposes. The first purpose was to replicate the findings of Experiment 1a by recruiting another group of Chinese-English bilinguals. The second goal was to explore whether an increase in English proficiency can alter the findings of Experiment 1a.

Method

Participants

Thirty-two Chinese-English bilinguals (4 males, mean age: 20.97 ± 0.59 years) participated in the present experiment. Their LexTale score (72.37) was higher than the score of the participants in Experiment 1a, F (1, 50) = 50.689, $p < 0.001$. The main L2 learning onset was at around 8 years old. None of the participants were involved in Experiments 1a and 1b.

Stimuli and Procedure

The stimuli and procedure were identical with the Experiment 1a.

Results

Trials that exceeded the *M* ± 2.5 *SD* were deleted from further analysis (3.59% data).

Table 5 *Mean reaction time (ms) and accuracy rate (%) in brackets of emotion-label words (Experiment 2a) and emotion-laden words (Experiment 2b) as a function of relatedness and valence on emotional facial expression perception*

	Negative		Positive	
	Related	Unrelated	Related	Unrelated
Emotion-label	915 (91.9)	928 (91.0)	879 (88.5)	893 (87.9)
Emotion-laden	948 (89.8)	961 (89.4)	900 (90.4)	902 (91.6)

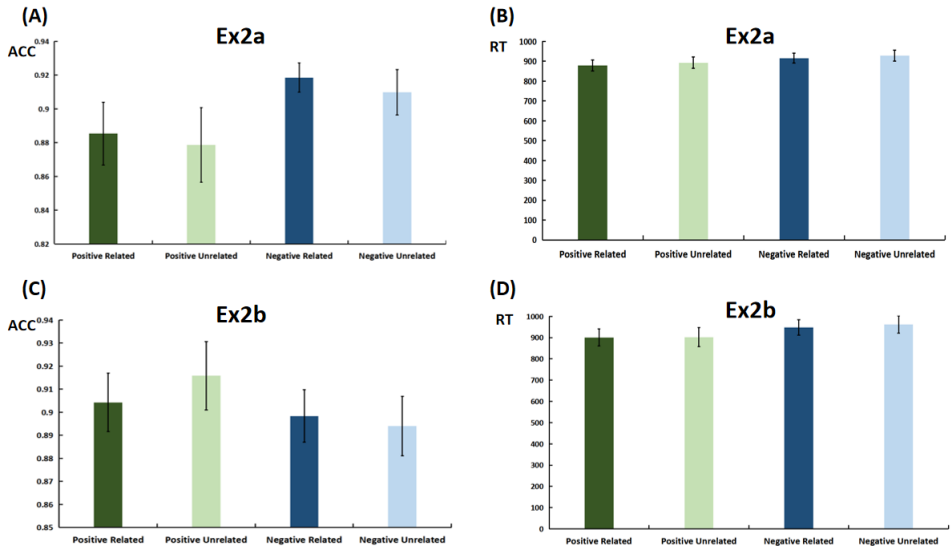


Figure 3 The accuracy rates (ACC) and reaction times (RT) to different conditions in Experiments 2a and 2b.

There was no main effect or interactions in accuracy rate, all *p*s > 0.1. As for reaction time, positive faces were evaluated marginally faster than negative faces, F (1, 31) = 3.319, p = 0.078, partial η^2 = .097. The main effect of relatedness and the interaction between the two factors were not significant, both *p*s > 0.1 (see Table 5, Figure 3 for more details).

Discussion

Experiment 2a replicated the processing advantage of positive faces over negative faces, consistent with the findings of previous experiments. However, there was no observed priming effect for the emotion-label words, regardless of their valence. This finding, in conjunction with the results from Experiment 1a, provides support for the disembodied account, suggesting that L2 emotion words are primarily processed semantically rather than affectively.

Specifically, the participants in Experiment 2a were classified as late bilinguals, as they began learning English (L2) around the age of 8. Previous research has indicated that late

bilinguals exhibit a reduction in emotion activation for L2 words. Given this reduced emotion activation in L2, it becomes challenging for the L2 prime words to influence emotional facial expressions in the masked priming paradigm.

Experiment 2b

The objective of this experiment was to replicate the findings of Experiment 1b using a different group of bilingual participants with higher proficiency in their second language (L2). The main hypothesis was that language proficiency would influence the priming effect of emotion-laden words on emotional facial expressions. Specifically, it was predicted that Chinese-English bilinguals with enhanced English proficiency would exhibit automatic activation of emotion when presented with L2 emotion-laden words. As a result, the L2 emotion-laden words would facilitate subsequent perception of facial expressions. This would suggest that their increased language skills enable them to automatically activate emotions upon reading L2 emotion-laden words, consequently influencing their perception of facial expressions. On the other hand, if language proficiency does not impact the priming effect, no significant facilitation of primes on facial expression perception would be expected. In this case, the participants' level of language proficiency would not play a significant role in the automatic activation of emotions triggered by L2 emotion-laden words.

Method

Participants

Thirty-six Chinese-English bilinguals participated in the current experiment (8 males, mean age: 21.75 ± 1.00 years). This group of bilinguals also had a higher lexTALE score (64.43) than the participants from Experiment 1b, F (1, 54) = 10.135, $p < 0.01$. However, it is important to note that the participants in the present experiment were lower in English proficiency than those in Experiment 2a, F (1, 66) = 9.119, $p < 0.01$. The participants did not take part in the previous three experiments.

Stimuli and Procedure

The stimuli and procedure were identical to Experiment 1b.

Results

Trials that exceeded the M ± 2.5 SD (3.07% data) were removed from the following analysis. As for accuracy rate, no main effect or other interactions were found, all ps > 0.1. Compatible with the findings of prior experiments, positive faces (901ms) were processed faster than negative faces (954ms), F (1, 35) = 8.577, $p < 0.01$, partial $\eta^2 = .197$. The main effect of relatedness was not significant and the valence and relatedness did not interact, both Fs < 1, ps > 0.1 (see Table 5, Figure 3 for more details).

Discussion

The results of the present experiment were consistent with those of Experiment 1b. The main effect of valence replicated the finding of a processing advantage for positive faces over negative faces. However, similar to Experiment 1b, no priming effect for emotion-laden words was observed. This indicates that, within the context of the masked priming paradigm, it was challenging to identify any influence of subliminal L2 emotion-laden words on emotional facial expression perception. The absence of a priming effect suggests

that the subliminal presentation of L2 emotion-laden words did not significantly impact participants' perception of emotional facial expressions. Despite the presence of valence effects, the subliminal primes did not elicit the expected modulation of emotional processing.

Experiment 3

The present experiment aimed to explore the affective priming effect of L2 emotion-label words on facial expression perception in an unmasked priming paradigm. Since the L2 words were not masked in the experiment, affective priming effect was expected to be present.

Method

Participants

Twenty-seven Chinese-English bilinguals (3 males, mean age: 20.48 years) participated in the experiment. None of them participated in the other experiments. They started to learn English as an L2 at round 7 years old. The mean of LexTale for the participants was 59.54, indicating the participants were late and medium-level English L2 speakers. Two participants were deleted due to their overall accuracy rate being lower than 70%.

Stimuli and Procedure

The stimuli were identical to Experiment 1a. The procedure was analogous to that in Experiment 1a. There were two differences between the current experiment and Experiment 1a. The first difference was that the prime was not masked, so there was no forward and backward mask. The second one was the primes were displayed on the monitor for 250ms, allowing a relatively long duration for participants to process the L2 primes.

Results

The trials that exceeded the $M \pm 2.5\ SD$ (2698ms) were deleted from further analysis, thereby 3.61% trials were trimmed. As for accuracy rate, the main effect of relatedness was observed, F (1, 24) = 13.673, $p < 0.01$, partial $\eta^2 = .363$, with higher accuracy rate in related condition (89.3%) than in unrelated condition (84.4%). However, the main effect of valence and the interaction between valence and relatedness were not found, F (1, 24) = 1.455, $p > 0.05$, partial $\eta^2 = .057$ for valence, and F (1, 24) = 0.315, $p > 0.05$, partial $\eta^2 = .013$ for the interaction. As for reaction time, the main effect of valence was not significant, F (1, 24) = 1.641, $p > 0.05$, partial $\eta^2 = .043$. However, the main effect of relatedness was found, F (1, 24) = 4.588, $p < 0.05$, partial $\eta^2 = .160$, with shorter reaction times to related trials (979ms) than to unrelated trials (999ms). Moreover, there was also an interaction between valence and relatedness, F (1, 24) = 4.635, $p < 0.05$, partial $\eta^2 = .162$. Post hoc comparisons showed a priming effect in the positive condition (t = -3.035, $p_{bonf} < 0.05$) rather than in the negative condition (t = 0.11, $p_{bonf} > 0.05$) (See Table 6, Figure 4 for details).

Discussion

Experiment 3 revealed a significant priming effect of L2 emotion-label words on facial expression perception, indicating that L2 words can influence the perception of emotions. This effect was observed within the context of the unmasked priming paradigm, where participants were able to explicitly process the primes. The ability to consciously process the primes allowed for the facilitation of facial

Table 6 *Mean reaction time (ms) and accuracy rate (%) in brackets of emotion-label words (Experiment 3) and emotion-laden words (Experiment 4) as a function of relatedness and valence on emotional facial expression perception*

	Negative		Positive	
	Related	Unrelated	Related	Unrelated
Emotion-label	1003 (91.0)	1002 (86.7)	955 (87.5)	996 (82.2)
Emotion-laden	975 (91.6)	1006 (88.4)	923 (90.0)	957 (83.0)

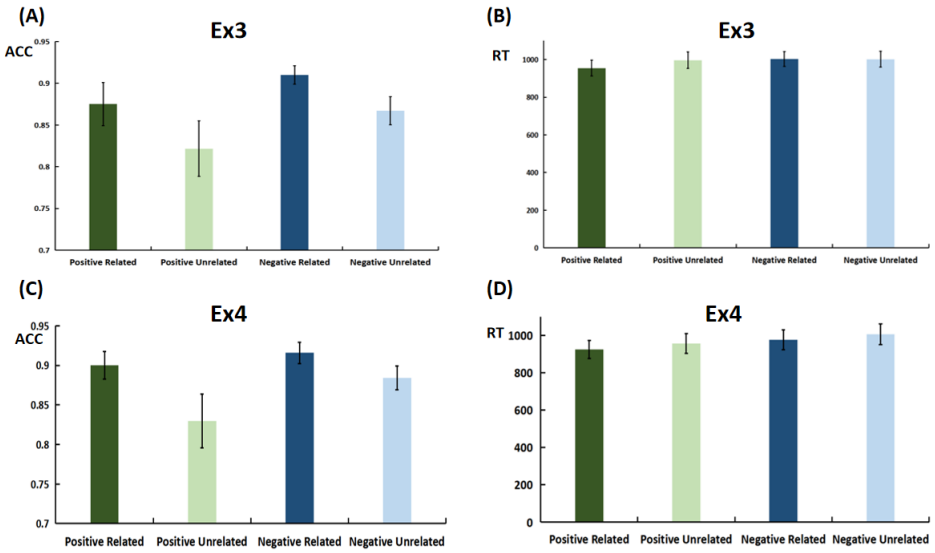


Figure 4 The accuracy rates (ACC) and reaction times (RT) to different conditions in Experiments 3 and 4.

expression perception when primed by L2-related words.

However, the reaction time results demonstrated that the priming effect was limited to positive words. This finding aligns with the density hypothesis, which posits that positive emotions tend to be more clustered, while negative emotions are more dispersed (Unkelbach et al., 2008). It suggests that positive emotion words, due to their clustering, may have a greater impact on the perception of facial expressions compared to negative emotion words.

An interesting distinction between the present experiment and Experiments 1a and 2a is the absence of a valence effect in the current findings. One possible explanation for this discrepancy is that the unmasked L2 primes influenced participants' perception of the target facial expressions, thereby reducing the strength of the valence effect exhibited by the faces. The influence of the L2 primes may have attenuated the impact of the inherent valence of the facial expressions, resulting in a diminished valence effect.

Experiment 4

Experiment 4 further explores how emotional facial expressions perception is shaped by L2 emotion-laden words. It was expected that in the unmasked priming paradigm, L2 emotion-laden words would facilitate facial expression perception when the valence of primes and targets was identical.

Method

Participants

Twenty-seven Chinese-English bilinguals (2 males, mean age: 20.93 ± 1.41 years) participated in the current experiment, and none of them participated in the previous experiments. Their L2 learning onset was at around 7.6 years, and their LexTALE mean score was 59.25, suggesting that their English proficiency was at medium level. The participants from Experiments 3 and 4 were not different in LexTALE scores, $t < 1$, $p > 0.1$. Almost all participants were right-handed (one left-hand speaker) and none of them suffered from mental or neurological disorders. One participant was excluded due to the low accuracy rate (less than 70%).

Stimuli and Procedure

The stimuli were the same as those in Experiment 1b. The procedure was identical to Experiment 3.

Results

Trials that exceeded the $M \pm 2.5$ *SD* (3065ms, 2.73% data) were deleted from further analysis. For accuracy rate, the valence effect was not significant, F (1, 25) = 1.538, $p > 0.05$, partial $\eta^2 = .058$. However, the relatedness effect was confirmed (unrelated: 85.7%, related: 90.8%), F (1, 25) = 8.768, $p < 0.05$, partial $\eta^2 = .26$. There was no interaction between valence and relatedness, F (1, 25) = 1.797, $p > 0.05$, partial $\eta^2 = .067$. The reaction time results were very similar to those in accuracy rate. Only relatedness effect was observed (unrelated: 981ms, related: 949ms), F (1, 25) = 6.392, $p < 0.05$, partial $\eta^2 = .204$; and valence and the interaction between the two factors were not significant, F (1, 25) = 2.586, $p > 0.05$, partial $\eta^2 = .094$ for valence, F (1, 25) = 0.008, $p > 0.05$, partial $\eta^2 = .000$ for the interaction (See Table 6, Figure 4 for details).

Discussion

Experiment 4 successfully replicated the main findings of Experiment 3, providing further evidence that both emotion-laden words and emotion-label words in L2 have the ability to influence emotional facial expression perception within the unmasked priming paradigm. Specifically, participants exhibited shorter reaction times and higher accuracy rates when responding to related trials compared to unrelated trials. These findings support the notion that L2 emotion words, regardless of their specific type, can facilitate the perception of emotional facial expressions.

Similar to Experiment 3, the absence of a main effect of valence in Experiment 4 suggests that, within the context of the unmasked priming paradigm, there was no significant difference in facial expression perception between positive and negative conditions. This finding shows that the influence of L2 emotion words on facial expression perception superseded any inherent valence effects exhibited by the facial expressions themselves.

General Discussion

The primary objective of this investigation was to examine the influence of L2 emotion words

on emotion perception, specifically focusing on emotional facial expression perception, within a masked and an unmasked priming paradigm. The results from six experiments consistently demonstrated that subliminal L2 emotion words, irrespective of their type, failed to impact emotional facial expression perception. However, in the unmasked priming condition, both L2 emotion-laden words and emotion-label words produced priming effects on emotional facial expression perception.

The use of the masked priming paradigm was chosen for this study as it allows for the exploration of the potential impact of subliminal emotion words on emotion perception. Previous research has consistently shown that L2 words as primes have limited ability to generate semantic activation in a masked priming paradigm (Jiang & Forster, 2001; Nakayama et al., 2013). Consequently, if L2 emotion words were able to automatically elicit emotional effects (Sheikh & Titone, 2016), one would expect them to influence emotion perception. Conversely, if the induction of emotion by L2 words relies on semantic activation (Winskel, 2013), no modulation of L2 words on emotion perception would be anticipated. The unmasked priming paradigm served as a baseline to confirm the presence of priming effects elicited by L2 emotion words. Additionally, the present study examined the differential impact of emotion-label words and emotion-laden words, comparing how these two types of words shaped the role of L2 in emotion perception across the six experiments.

A consistent and robust finding across the initial four experiments was the processing advantage observed for positive faces in valence evaluation. This finding aligns with previous research demonstrating that positive emotions are easier to identify than negative ones in various contexts, including words (Kazanas & Altarriba, 2015, 2016a, 2016b), faces (Leppänen & Hietanen, 2004), and pictures (Kwon et al., 2009). The density hypothesis offers an explanation for the difference in processing speed between negative and positive signals, suggesting that negative signals are more discrete while positive signals tend to be clustered (Alves et al., 2017a, 2017b). For instance, within the negative category, there can be fear faces, sad faces, or angry faces, resulting in greater variance and difficulty in assigning a single valence. This indicates that negative emotions have a more discrete configuration, particularly within the negative domain (Izard, 2007; Lench et al., 2013; Lench et al., 2011). In contrast, positive emotions, characterized by smiling faces, share a common visual expression. Consequently, the perception of positive faces is comparatively easier and faster, as perceiving a smile reliably signals positive emotion.

However, no modulation of subliminal L2 emotion words on emotional facial expression perception was observed in the four masked priming experiments. According to the mediated account, emotion-laden words are a unique type of emotion concept that relies on the mediation of emotion-label words to induce emotional effects (Altarriba & Basnight-Brown, 2011; Wu et al., 2021a). Therefore, it is expected that emotion-laden words would not elicit a priming effect on emotional facial expression perception within the masked priming paradigm. Additionally, it has been found that late bilinguals have limited capacity to explicitly process L2 prime words in the masked priming paradigm (Nakayama et al., 2013). This may explain the lack of influence observed for emotion-label words in L2 on emotion perception in Experiments 1a and 2a. It is possible that the low English proficiency of the bilingual participants in Experiments 1a and 1b constrained the emotional activation triggered by L2 emotion-label words.

However, even with an increase in English proficiency, no impact of emotion-label words in L2 on emotion perception was observed in Experiment 2a, suggesting that the emotion activation within emotion-label words may be unaffected by language proficiency.

An alternative explanation could be that the English proficiency of the Chinese-English bilingual participants in Experiments 2a and 2b was not sufficiently high to elicit automatic emotion activation. However, this speculation is not supported by a recent study that demonstrated the influence of emotion word type on affective picture processing in L2 (Wu et al., 2019). Specifically, affective pictures preceded by L2 emotion-label words were processed faster and elicited decreased electrophysiological activation compared to those preceded by emotion-laden words. These findings clearly indicate that the processing of affective pictures was modulated by the type of L2 emotion words. However, the current study did not find a similar effect of emotion word type. One potential explanation for this discrepancy lies in the nature of the emotional stimuli used. While the present study focused on emotional facial expressions, the previous study examined affective pictures. Affective pictures can evoke multiple and diverse emotions, such as fear, anxiety, and shock, whereas emotional facial expressions in the present study were based on basic emotions, including fear, sadness, anger, surprise, and happiness (Izard, 2007). Consequently, the emotional content conveyed by facial expressions may be clearer and more distinct compared to affective pictures, making them less susceptible to the influence of both emotion-label words and emotion-laden words. However, further investigation is warranted to directly compare emotional facial expressions and affective pictures in order to explore this explanation. Additionally, future studies could explore emotional facial expressions captured by the constructionist account (Gendron et al., 2018) to gain further insights into the interplay between language and emotion. It has been contended that the process of deriving meaning from facial expressions can exhibit significant diversity among individuals and in different situations (Gendron et al., 2018). For instance, future research endeavors might explore how individuals possessing diverse emotional language capabilities perceive emotional facial expressions.

In the final two experiments, conducted within the unmasked priming paradigm, it was found that both L2 emotion-laden words and emotion-label words produced a priming effect on emotional facial expression perception. Specifically, emotional facial expressions preceded by L2 words of the same valence were recognized faster than those preceded by L2 words of a different valence, replicating findings from previous studies demonstrating such affective priming effects (Lu et al., 2011; Yao et al., 2019). These results are in line with the previous four experiments, which collectively indicate that L2 emotion words are processed semantically rather than affectively. It was observed that explicit semantic processing of L2 primes is required to generate an affective priming effect, whereas in the masked priming paradigm, late L2 speakers did not engage in implicit and affective processing of the L2 primes (Zhang et al., 2019). However, a certain degree of contradiction exists between the present study and the research conducted by Li et al. in 2022. Firstly, Li et al. (2022) discovered that positive faces, specifically happy faces, exhibited greater sensitivity to the influence of emotion-label words compared to negative faces, namely disgust faces. In contrast, the current study demonstrated that the affective priming effect of emotion-label words was solely observed for positive ones, suggesting that positive faces are more prone to being impacted by emotion-label words in L2. Secondly, there was no

priming effect for emotion-laden words as no disparity was found between consistent and inconsistent conditions for the emotion-laden word group in terms of N400. Conversely, the present study revealed that regardless of positive or negative faces, L2 emotion-laden words demonstrated significant affective priming. These inconsistent results could be attributed to several factors. The first reason is that multiple types of negative faces, including fear, sad, and angry faces, were combined in the negative face condition. This amalgamation of distinct emotions would lead to discrepancies in negative faces, making it difficult for negative emotion-label words to generate a priming effect. However, in the case of positive faces, according to the density hypothesis posited by Unkelbach et al. (2008), which suggests that positive emotions are more alike and are represented in a denser manner compared to negative emotions that exhibit greater variability, positive emotions are integrated in their representation. Consequently, it is feasible for positive emotion-label words to initiate an affective priming effect. As for emotion-laden words, the mapping between emotional concepts derived from emotion-laden words and emotional facial expressions is arbitrary. Nevertheless, the valence conveyed by emotion-laden words and facial expressions is extremely clear. Under unmasked priming conditions, participants can explicitly process L2 emotion-laden words, and related valence information is activated, which can generate a strong and valid priming effect on emotional facial expression recognition. In contrast, in the study by Li et al. (2022), since the negative faces were only disgust faces, although disgust-related emotion-laden words can activate disgust-associated emotions, it is plausible that other negative emotions such as fear could be activated, thus reducing the priming effect of negative emotion-laden words.

Several limitations of the present study merit further elaboration. Firstly, our sample is predominantly female, and it has been found that gender may have an impact on emotional processing (Lausen & Schacht, 2018). Consequently, future studies could recruit a more gender-balanced set of participants. Secondly, different types of negative faces were lumped into one category. However, some evidence has indicated that negative emotions are distinct entities (Lench et al., 2011). Thus, it is advisable for future studies to follow the study of Li et al. (2022) to further explore how other negative faces, such as fear and anger, are modulated by emotion-label words and emotion-laden words in L2 separately. Finally, it is noteworthy that we separated emotion-label words and emotion-laden words in distinct experiments. Combining these two types of words in a single experiment would significantly enhance the internal validity. This is because it enables a direct comparison of the priming effects of the two types of words and reduces the variance among participants. However, facial expressions derived from the existing database are limited in number after controlling for related variables. Thus, it is suggested that future studies enlarge the number of facial expressions in the database, thereby permitting a more sophisticated and complex experimental design, comparing L1 and L2 directly.

In conclusion, the six experiments utilizing both the masked and unmasked priming paradigms aimed to investigate the influence of L2 emotion-label words and emotion-laden words on the processing of emotional facial expressions. The findings confirmed the processing advantage of positive faces over negative faces. However, no modulation of L2 emotion words, including both emotion-label words and emotion-laden words, was observed in the masked priming condition. Interestingly, an increase in L2 proficiency did

not change this null effect. Conversely, a modulation of emotion perception by L2 emotion words was found in the unmasked priming paradigm. The current study provides support for the L2 disembodied account proposed by Pavlenko (2012).

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