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Embodied or Semantic Processing of Emoji Emotions? Evidence from Four Behavioral Experiments

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Abstract

With the widespread use of emojis in digital communication, questions remain about how emotional information conveyed by emojis is processed. Drawing on embodied cognition and semantic representation perspectives, the present research examined these processes across four studies involving facial feedback, spatial congruency, evaluative priming, and emoji ambiguity. The results showed that: (1) facial feedback manipulations did not significantly affect emoji valence judgments; (2) no significant interaction between emoji valence and spatial position was observed; (3) unmasked priming produced facilitation for valence-congruent targets, whereas masked priming yielded a reversed congruency effect; and (4) responses to emotional faces following emoji primes varied with emoji ambiguity. Overall, the findings did not support the predicted sensorimotor effects, while highlighting the relevance of evaluative and semantic information in emoji-related emotional processing. These findings provide preliminary insights into the cognitive processes underlying emoji emotion processing and suggest that further research is needed to clarify the contributions of embodied and semantic processes.

Keywords: emoji; emoji spatial Stroop task; affective priming; embodied cognition

1. Introduction

Emojis are widely used in text-based online communication (Kralj Novak et al., 2015). As a unique form of nonverbal communication, emojis play a key role in conveying emotional states and social intentions in text-based contexts where facial expressions and tone of voice are absent (Kralj Novak et al., 2015; Bai et al., 2019). However, there is ongoing debate on whether their emotional meanings originate from embodied simulations within the sensorimotor system, or from abstract symbolic associations.

Views on embodied cognition are not always consistent. Perceptual symbol systems theory (Barsalou, 1999) holds that conceptual processing entails modality-specific simulation, with sensorimotor systems involved. Thus, emotional concepts are grounded in facial motor states. Conceptual metaphor theory (Lakoff & Johnson, 1980), by contrast, holds that abstract concepts are structured through metaphorical mappings from bodily experience, with bodily experience as a scaffold. Thus, emotional concepts are grounded in spatial metaphors. In contrast, semantic theory posits that the representation of emoji concepts is independent of the sensorimotor system. These abstract symbols are interconnected through propositional networks, which expand as experience increases and knowledge

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accumulates (Collins & Loftus, 1975). This study begins with this discussion between sensorimotor integration and abstract symbolic linking.

2. Embodied Cognition

In the study of emotions, the idea behind embodied cognition is that your physical state directly shapes what you feel. This perspective suggests that emotional processes are not solely determined by internal representations but are also shaped by sensory and motor states associated with the body. The facial feedback hypothesis represents a classic account within this framework, proposing that facial muscle activation can provide feedback to the brain and subsequently influence emotional experience and the processing of emotional stimuli (Adelmann & Zajonc, 1989). Early empirical support for this hypothesis was provided by a classic study showing that manipulating facial muscle activity through different pen-holding conditions altered participants' evaluations of emotional stimuli (Strack et al., 1988). Subsequent research further indicated that disrupting facial mimicry reduces the speed and accuracy of facial emotion recognition (Oberman et al., 2007), suggesting that bodily feedback may influence emotion-related perceptual processing.

In addition, the spatial Stroop task is widely used to explore how the spatial attributes of stimuli influence processing efficiency (White, 1969). This paradigm reveals the underlying mechanisms of cognitive processing by examining the interference effects between stimulus symbol characteristics and their spatial presentation locations (MacLeod, 1991); the responses obtained are believed to reflect the automatic or implicit levels of processing. In the field of emotion, emotional states are often located within physical space—positive states are associated with the upper space ("I feel elated"), while negative states are associated with the lower space ("I feel down"). Meier and Robinson (2004) validated this association, finding that positive words were processed faster in the upper visual field, while negative words were processed faster in the lower visual field. Subsequent research further revealed that this effect is linked to body posture: positive emotional words are processed more efficiently when combined with an upright posture, and negative emotional words are processed more efficiently when combined with a slumped posture (Dudschig et al., 2015). When it comes to face processing, research tells us that the spatial processing of faces is shaped by emotional expression. A stronger spatial interference effect is created by happy and angry faces than by neutral ones (Jones, 2015). Furthermore, a clear positivity advantage is observed in facial recognition—happy expressions are processed more accurately (D'Argembeau & Van der Linden, 2011).

3. Semantic Cognition

Semantic cognition research suggests that attitudes are represented through associations between objects and their evaluative meanings (Fazio et al., 1986). The perception of an object automatically activates its associated evaluation, which then spreads through interconnected semantic networks. The affective priming paradigm captures this automatic evaluative activation by examining how a preceding stimulus influences responses to subsequent targets. When the emotional valence of the prime and target is congruent, target processing is facilitated; when their valences conflict, processing becomes more difficult (Klauer & Musch, 2003). This effect reflects the automatic activation of emotional concepts by the prime stimulus and the subsequent spread of activation to valence-congruent targets. Extensive research has demonstrated reliable affective priming effects for emotional words (Kazanas & Altarriba, 2015, 2016; Wu et al., 2021) and facial expressions (Aguado et al., 2007), indicating that these stimuli are associated with stable emotional representations. Given that emojis also convey emotional information through visual symbols, an

emerging question is whether they evoke similar patterns of emotional activation during semantic processing.

Emotional meaning is closely linked to conceptual knowledge, which develops through individual experience and language learning (Hoemann et al., 2019). As individuals acquire more differentiated emotion concepts, they become increasingly capable of distinguishing between subtle emotional meanings (Nook et al., 2020). However, processing emotionally ambiguous information may place greater demands on the activation and differentiation of emotional representations. When it comes to emojis, these visual symbols provide affective cues, but their emotional meanings are not always interpreted consistently across individuals and contexts (Fischer & Herbert, 2021). Recent ERP studies further revealed that mismatches between emojis and accompanying words or facial expressions elicit N400 responses, suggesting that emoji processing involves the integration of emotional meaning with contextual information (Yu et al., 2022). Given that ambiguous emojis provide less clearly defined emotional information, it remains an open question whether they interfere with subsequent emotional processing. Specifically, it is important to examine whether emotionally ambiguous emojis prolong adults' reaction times when processing subsequent emotional facial expressions.

When reviewing the existing literature on the cognitive origins of emoji emotion concepts, very few studies have simultaneously examined both the sensorimotor integration and abstract symbolic association pathways within a single framework. In studies examining the cognitive origins of emoji perception, these two pathways have been tested in isolation. On the embodied cognition pathway, Kaye et al. (2022) found evidence that emoji valence was modulated by vertical spatial position in explicit valence ratings, but this effect was not replicated in subsequent reaction time studies (Kaye et al., 2023). On the semantic cognitive pathway, Kaye et al. (2021, 2023) repeatedly found null effects in lexical decision and affective priming tasks. The facial feedback paradigm has not yet been applied to examine the embodied origins of emoji; however, whether facial feedback influences emoji emotion processing, whether emojis elicit affective priming under different presentation conditions, and whether variability in the emotional meanings of emojis influences subsequent emotional processing remain underexplored.

As such, within the four studies reported here, we address these limitations. The present research addressed these questions through four behavioral studies examining whether emoji emotion processing involves sensorimotor and evaluative or semantic processes. Studies 1 and 2 examined two potential sensorimotor influences on emoji emotion processing: facial feedback and spatial-valence congruency. Studies 3 and 4 investigated the role of evaluative and stimulus-related factors through affective priming under masked and unmasked presentation conditions (Study 3) and the effects of emoji ambiguity on subsequent emotional face processing (Study 4). Together, these studies provide complementary behavioral evidence for understanding the cognitive processes involved in emoji emotion processing.

RQ1. *Does emoji valence processing show behavioral evidence consistent with embodied accounts? Specifically, does facial feedback modulate emoji valence judgments, and does vertical spatial position interact with emoji valence during valence processing?*

RQ2. *Does emoji emotion processing show behavioral evidence consistent with symbolic-semantic accounts? Specifically, can emojis produce affective priming effects under different prime presentation conditions, and does emoji ambiguity influence subsequent emotional face processing?*

4. Study 1

Study 1 investigated whether facial feedback influences emoji valence processing. We employed a facial feedback paradigm, which has been widely used to examine the role of facial muscle activity in emotional experience and stimulus evaluation (Adelmann & Zajonc, 1989; Strack et al., 1988).

Drawing upon the previous literature we hypothesize that:

H1a. *Positive emojis will be rated more positively in the smile-facilitating condition than in the smile-inhibiting condition.*

H1b. *Negative emojis will be rated more negatively in the smile-inhibiting condition than in the smile-facilitating condition.*

H2a. *Responses to positive emojis will be faster in the smile-facilitating condition than in the smile-inhibiting condition.*

H2b. *Responses to negative emojis will be faster in the smile-inhibiting condition than in the smile-facilitating condition.*

4.1. Method

4.1.1. Participants

The sample size for this experiment was estimated using G*Power 3.1 software. To detect a moderate effect size ($f = 0.25$) at a significance level of $\alpha = 0.05$ and a power of 0.9 ($1 - \beta$), a minimum of 30 participants was required. A total of 32 participants were recruited through offline recruitment at a university in China. All participants were required to have normal visual acuity or corrected visual acuity, no recent history of severe emotional fluctuations, and be right-handed. Informed consent was obtained from all participants, and they were compensated upon completion of the experiment.

4.1.2. Stimuli

The formal experiment used the 20 emojis evaluated in the preliminary rating study involving 31 participants from a university in China; as shown in Table 1 and Figure A1 in Appendix A, the set consisted of an equal number of positive and negative emojis (as measured by pleasantness).

Table 1. Descriptive Statistics for the Emoji Dimension.

Emoji	Pleasantness	Arousal	Familiarity
😁	5.28	4.97	5.55
😃	5.79	5.38	5.58
😉	5.10	4.72	5.41
😊	5.10	4.72	5.76
😋	5.45	5.14	4.55
😍	6.03	5.86	4.79
😶	2.55	2.41	2.76
😖	1.79	3.41	3.75

Table 1. *Cont.*

Emoji	Pleasantness	Arousal	Familiarity
😱	1.72	4.72	4.10
😬	1.55	5.03	4.68
🤮	1.69	4.31	3.78
😤	1.38	4.55	3.96
😀	1.83	3.93	6.05
😅	4.97	3.62	5.24
😍	5.03	5.41	6.28
☺️	5.45	4.97	5.78
😑	5.00	2.86	3.88
😬	1.79	3.59	4.52
😵	1.69	3.90	3.75
😡	1.62	5.45	5.75

4.1.3. Design/Procedure

We had a 2 (facial manipulation; pen held in teeth, pen held by lips) × 2 (pre-rated emotional valence; positive, negative) within-participants design. The independent variables were facial manipulation and emoji emotion, while the dependent variables were participants' judgments of emoji emotional valence and the reaction time required for these judgments. Before the experiment began, participants were instructed to practice biting a pen under the experimenter's guidance to familiarize themselves with the posture, after which the experiment commenced. The specific methods of biting the pen are shown in Figures 1 and 2 (Wiswede et al., 2009), where Figure 1 depicts the expression produced by biting the pen with the teeth to create a smile-facilitating posture, and Figure 2 depicts the expression produced by holding the pen between the lips to create a smile-inhibiting posture.



Figure 1. Pen held in teeth.



Figure 2. Pen held by lips.

The experimenter began the experiment after explaining the instructions and confirming that the participant understood them. The experiment consisted of two parts: a practice session and a main session. The practice session used two emojis that did not appear in the main session, with the aim of familiarizing participants with the experimental procedure. In the experimental procedure, a red fixation mark "+" was first presented in the center of the screen for 300 ms, followed by an emoji stimulus in the center of the screen. Participants were instructed to respond as quickly as possible within 3000 ms. Participants rated the emotional valence of the emoji by pressing a key (on a 1–7 Likert scale, where 1 is most negative and 7 is most positive; participants were required to use the numeric keypad for all responses). There was a 1000-ms interval between trials. To counteract order effects, half of the participants were instructed to bite the pen with their teeth first, while the other half were instructed to hold the pen between their lips first. The task consisted of two blocks, comprising a total of 20 positive emoji trials and 20 negative emoji trials, with the emojis presented randomly within each block. After completing the first block, participants were asked to solve several simple arithmetic problems before switching their pen-holding posture to begin the second block. The formal experimental procedure is shown in Figure 3.

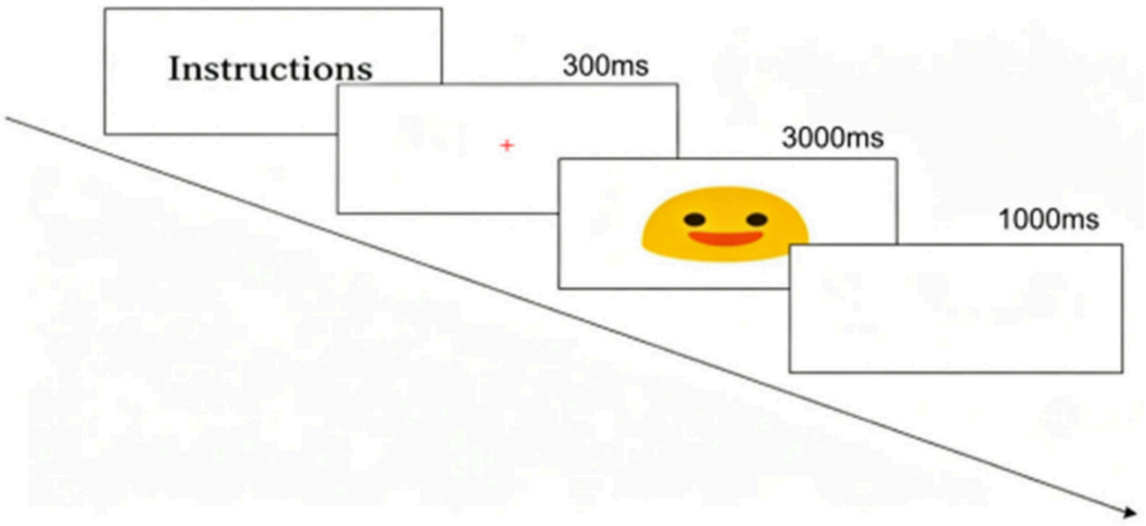


Figure 3. Trial structure for Study 1.

4.1.4. Results and Discussion

Table 2 shows the mean and standard deviations for valence and latency by experimental condition. Data from the 32 participants were included in the repeated-measures analysis of variance, with the results presented in Table 3.

Table 2. Descriptive analysis of study 1.

		Pen Held in Teeth $M(SD)$	Pen Held by Lips $M(SD)$
Positive Emoji	Valence	5.13 ± 0.36	5.07 ± 0.28
	RT (in ms)	2501 ± 189	2501 ± 179
Negative Emoji	Valence	1.87 ± 0.21	1.97 ± 0.46
	RT (in ms)	2389 ± 344	2382 ± 353

Table 3. Analysis of Variance for Valence Judgments and Reaction Times for study 1.

Dependent Variable	Independent Variable	MS	F	p
valence	facial manipulation	0.21	0.37	0.547
	pre-rated emotional valence	324.09	1669.37	<0.001
	facial manipulation*pre-rated emotional valence	0.01	3.53	0.070
reaction time	facial manipulation	428,284.48	0.83	0.369
	pre-rated emotional valence	495.04	2.92	0.097
	facial manipulation*pre-rated emotional valence	379.78	0.42	0.522

The experimental results showed that the main effect of facial manipulation on participants' judgments of emoji valence was not significant, $F(1, 31) = 0.37$, $p > 0.05$; the main effect of pre-rated valence on participants' judgments of emoji valence was significant, $F(1, 31) = 1669.37$, $p < 0.001$, $\eta_p^2 = 0.98$, indicating that the experimental materials were stable and valid, with positive Emojis consistently scoring higher than negative Emojis; the interaction between pre-rated emotional valence and facial manipulation was not significant, $F(1, 31) = 3.53$, $p > 0.05$.

The main effect of facial manipulation on reaction time was not significant, $F(1, 31) = 0.83$, $p > 0.05$; the main effect of pre-rated emotional valence on reaction time was not significant, $F(1, 31) = 2.92$, $p > 0.05$; and the interaction between pre-rated emotional valence and facial manipulation was not significant, $F(1, 31) = 0.42$, $p > 0.05$.

Consequently, neither H1a, H1b, H2a, nor H2b was supported. However, this null finding should be interpreted with caution. Because Study 1 relied on explicit valence judgments, it may not have been sufficiently sensitive to detect subtle or implicit embodied simulations. Thus, the absence of significant effects does not necessarily rule out the involvement of sensorimotor processes in emoji processing. To further examine this possibility using a less explicit task, Study 2 employed the Emoji Spatial Stroop Task to investigate whether emoji valence automatically influences spatial judgments.

5. Study 2

Study 2 investigated whether the vertical spatial position of emojis influences the speed of emotional valence judgments. We employed a spatial Stroop task in which positive and negative emojis were presented in upper, central, or lower positions on the screen. Participants judged whether each emoji conveyed a positive or negative emotion, and their reaction times were recorded. Previous research has shown that positive concepts are

associated with upper spatial positions, whereas negative concepts are associated with lower positions (Meier & Robinson, 2004).

Drawing upon the previous literature we hypothesize that:

H3a. *At the top of the screen, positive emojis will elicit shorter reaction times than negative emojis.*

H3b. *At the bottom of the screen, negative emojis will elicit shorter reaction times than positive emojis.*

5.1. Method

5.1.1. Participants

The sample size for this experiment was estimated using G*Power 3.1 software. To detect a moderate effect size ($f = 0.25$) at a significance level of $\alpha = 0.05$ and a power of 0.9 ($1 - \beta$), a minimum of 24 participants was required. A total of 55 participants were recruited through offline recruitment at a university in China. All participants were required to have normal visual acuity or corrected visual acuity, no recent history of severe emotional fluctuations, and be right-handed. Informed consent was obtained from all participants, and they were compensated upon completion of the experiment.

5.1.2. Stimuli

The same as study 1.

5.1.3. Design/Procedure

We had a 2 (Emoji valence; positive, negative) × 3 (spatial position; top, middle, bottom) within-participants design. The independent variables were emoji valence and vertical spatial position, and the dependent variable was participants' reaction time. We employed the Emoji Spatial Stroop Task (Kaye et al., 2022). A practice session was conducted before the main experiment began; feedback was provided during the practice session, and the main experiment commenced only after participants confirmed their understanding. During the main experiment, a red fixation mark "+" appeared in the center of the screen 300 ms before the stimulus. This was followed by the presentation of an emotional emoji. Participants were instructed to respond as quickly as possible; responses not made within 2000 ms were considered invalid. Participants were required to judge whether the facial expression or emotional word was positive or negative and select their choice by pressing the F or J keys on the keyboard, with reaction times recorded. In trials with a vertical position of "center," the emoji appeared exactly in the center of the screen; in trials with vertical positions of "top" or "bottom," the emoji appeared 2 cm from the top and bottom edges of the screen, respectively. All participants completed the experiment on computers with a resolution of 1920 × 1080, thereby controlling for any potential effects of positional variation. The experiment consisted of a total of 240 trials, evenly distributed across 4 blocks. In the first and third blocks, participants were asked, "Is this emoji happy?" In the second and fourth blocks, they were asked, "Is this emoji sad?" In the formal experiment, each block included 10 positive emotional stimuli × 3 positions (30 trials) and 10 negative emotional stimuli × 3 positions (30 trials), with experimental materials presented randomly within each block. The formal experimental procedure is shown in Figure 4.

5.1.4. Results and Discussion

One participant was excluded because they did not meet the study's participation requirements, resulting in a final sample of 54 participants. All included participants achieved an overall accuracy rate above 95%. Reaction times were analyzed across both correct and incorrect responses to capture overall response latency during the evaluative

task. Similar approaches have been employed in previous studies (Glaser et al., 2013; Negen et al., 2023; O'Shea et al., 2026). Table 4 presents the means and standard deviations of RTs for each experimental condition. Data from all 54 participants were included in the repeated-measures analysis, as shown in Table 5.

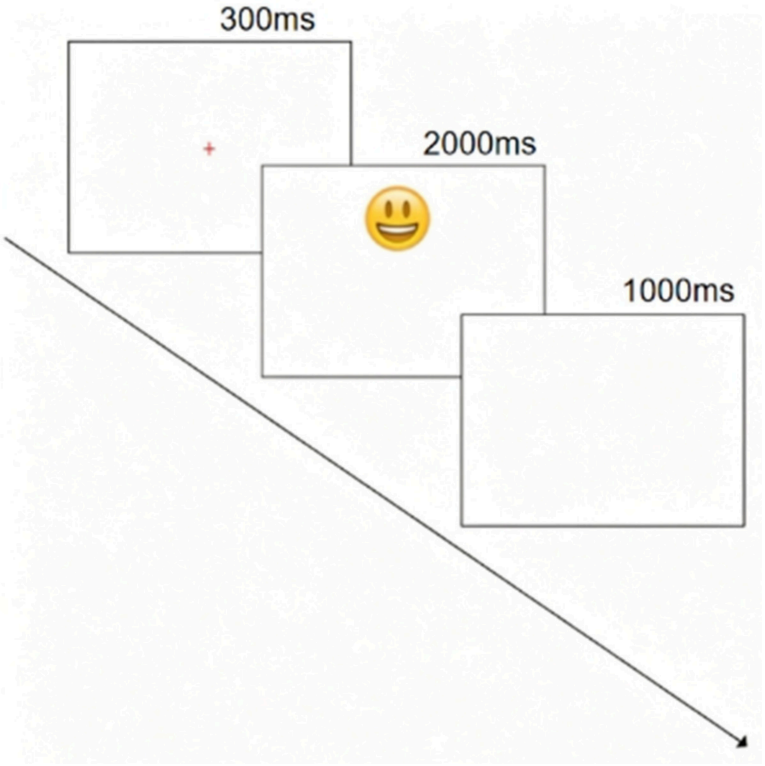


Figure 4. Trial structure for Study 2.

Table 4. Descriptive analysis of study 2.

Emoji Valence	Spatial Position	RT (in ms) *M*	RT (in ms) *SD*
Positive	Top	798	103
	Middle	897	108
	Bottom	1001	110
Negative	Top	809	128
	Middle	928	96
	Bottom	996	106

Table 5. Analysis of Variance for Reaction Times for study 2.

	MS	*F*	*p*
Emoji valence	12,412.46	1.32	0.256
spatial position	1,032,409.45	123.10	<0.001
Emoji valence*spatial position	8961.88	0.85	0.432

The results showed that the main effect of emoji emotional valence was not significant, $F(1, 53) = 1.32$, $p > 0.05$. The main effect of spatial vertical orientation was significant, $F(2, 106) = 123.10$, $p < 0.001$, $\eta_p^2 = 0.70$. Post hoc tests (Bonferroni correction) for the main effect of vertical spatial position revealed that all pairwise comparisons between levels reached the significance level (all $p < 0.001$). Specifically, Responses were faster

for the top position than for the middle position (mean difference = −108.8 ms, 95% CI [−141.2, −76.4]), and faster for the middle position than for the bottom position (mean difference = −86.3 ms 95% CI [−115.7, −56.9]).

The interaction between emoji emotional valence and vertical spatial position was not significant, $F(2, 106) = 0.85$, $p > 0.05$. To further examine the effects of emoji valence at each spatial position, simple main effects analyses were conducted. No significant differences were found between positive and negative emojis at the top (mean difference = −11.20 ms, 95% CI [−50.45, 28.05], $p > 0.05$), middle (mean difference = −31.10 ms, 95% CI [−68.04, 5.84], $p > 0.05$), or bottom position (mean difference = 5.20 ms, 95% CI [−34.98, 45.38], $p > 0.05$).

Consequently, neither H3a nor H3b was supported. This null result should be interpreted with caution, as it may have been partly influenced by a mismatch between the stimulus selection criteria and the task instructions. Specifically, the emojis were selected based on their positive or negative valence, whereas participants were asked to judge whether they were "happy" or "sad." Because negative-valence emojis may convey emotions other than sadness (e.g., anger), this mismatch may have contributed to the absence of the expected spatial congruency effect.

6. Study 3

Study 3 investigated whether emojis activate affective semantic associations under masked and unmasked prime presentation conditions. We employed an affective priming paradigm, in which responses to targets are facilitated when prime and target valence are congruent rather than incongruent (Klauer & Musch, 2003). Previous studies have demonstrated affective priming effects for both words (Kazanas & Altarriba, 2015, 2016) and faces (Aguado et al., 2007). However, whether emojis elicit similar effects and whether these effects depend on awareness of the prime remain unclear. Study 3 therefore examined whether emoji valence congruency facilitates target processing and whether this effect varies across masked and unmasked prime presentation conditions.

Drawing upon the previous literature we hypothesize that:

H4. *Target stimuli will elicit shorter reaction times when preceded by a valence-congruent emoji than by a valence-incongruent emoji under masked presentation conditions.*

H5. *Target stimuli will elicit shorter reaction times when preceded by a valence-congruent emoji than by a valence-incongruent emoji under unmasked presentation conditions.*

6.1. Method

6.1.1. Participants

The sample size for this experiment was estimated using G*Power 3.1 software. To detect a moderate effect size ($f = 0.25$) with a significance level of $\alpha = 0.05$ and a power of 0.9 ($1 - \beta$), a minimum of 24 participants was required. A total of 64 participants were recruited through offline recruitment at a university in China. All participants were required to have normal visual acuity or corrected visual acuity, no recent history of severe emotional fluctuations, and to be right-handed. Informed consent was obtained from all participants, and they were compensated upon completion of the experiment.

6.1.2. Stimuli

Building on Study 1, the selection of emojis was expanded to include a blank emoji. Emotional words were selected from the "Chinese Emotional Word System" database (see Figure A2 in Appendix A), with an equal number of positive and negative terms. All words were standardized in terms of arousal, familiarity, word length, and frequency.

Emotional faces (see Figure A3 in Appendix A) were selected from the Chinese Affective Facial Picture System (CAFPS; Gong et al., 2011), controlling for gender, arousal, dominance, and attractiveness, and ensuring that no individual's face appeared more than three times.

6.1.3. Design/Procedure

We had a 2 (emotional valence congruence: congruent, incongruent) × 2 (target stimulus type: emotional words, emotional facial expressions) × 2 (priming type: masked priming, unmasked priming) within-participants design. The independent variables are emotional valence consistency, target stimulus type, and priming type, while the dependent variable is participants' reaction time. The experiment was programmed and presented using E-Prime 3.0 on a 1920 × 1080 display with a 60-Hz refresh rate. Participants first completed a practice session with feedback to ensure that they understood the task. In masked priming trials, a red fixation cross (+) was presented for 300 ms, followed by an emotional emoji prime programmed to appear for 20 ms. A neutral emoji mask was then presented for 180 ms, followed by a blank screen for 800 ms. In unmasked priming trials, the fixation cross (300 ms) was followed by an emotional emoji prime programmed to appear for 200 ms and a blank screen for 800 ms. The nominal prime–target stimulus onset asynchrony (SOA) was 1000 ms in both conditions. The target stimulus (an emotional face or word) remained on screen until participants responded. Participants judged its valence (positive or negative) by pressing the F or J key. Reaction times and accuracy were recorded. The experiment consisted of eight blocks of 20 trials, with stimuli presented in random order within each block. The procedure is illustrated in Figure 5 (Masked Priming).

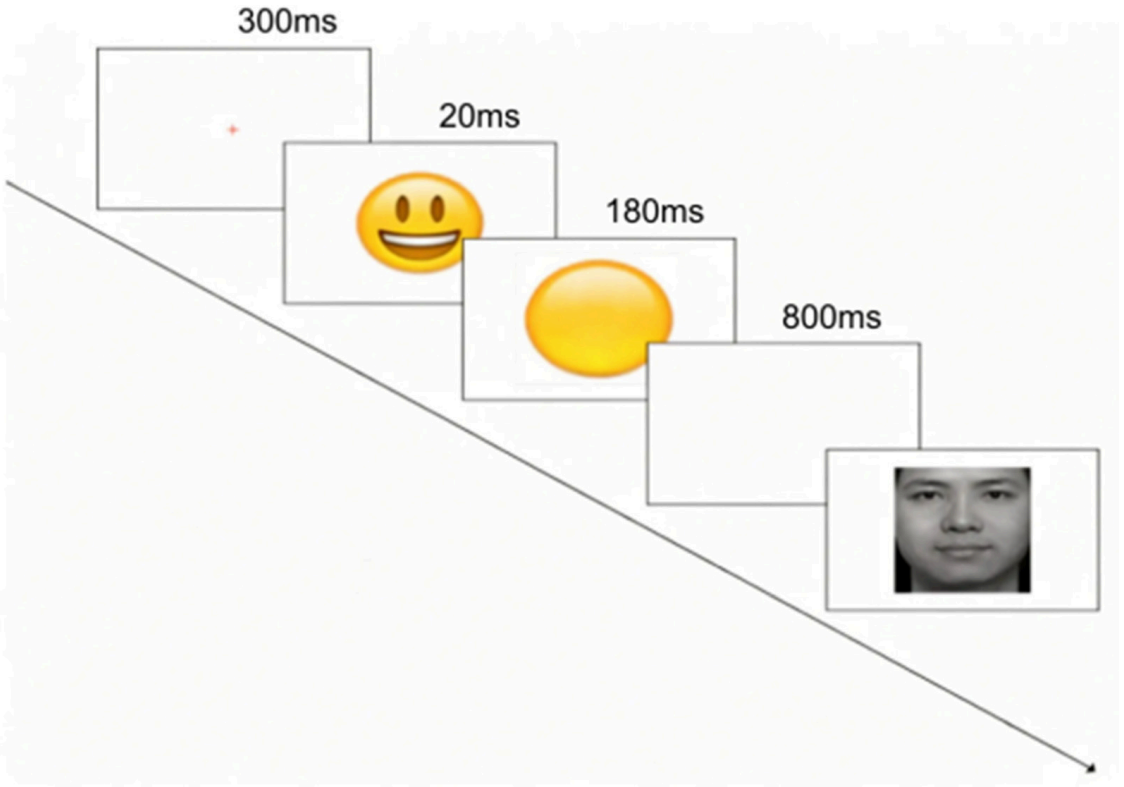


Figure 5. Trial structure for Study 3.

6.1.4. Results and Discussion

No participants were excluded from Study 3, and all participants achieved an overall accuracy rate above 95%. All trials from all participants, including incorrect-response trials, were retained in the RT analyses. Table 6 presents the means and standard deviations of

RTs for each experimental condition. The results of the repeated-measures analysis are presented in Table 7.

Table 6. Descriptive analysis of study 3.

			RT (in ms) *M*	RT (in ms) *SD*
Congruent	Emotional Words	Masked	1030	107
		Unmasked	1135	94
	Emotional Facial Expressions	Masked	1014	107
		Unmasked	1000	99
Incongruent	Emotional Words	Masked	1000	75
		Unmasked	1177	81
	Emotional Facial Expressions	Masked	985	104
		Unmasked	1054	128

Table 7. Analysis of Variance for Reaction Times for study 3.

	MS	*F*	*p*
emotional valence congruent	10,512.500	0.947	0.334
target stimulus type	665,569.531	52.876	<0.001
priming type	909,563.281	84.286	<0.001
emotional valence congruent*target stimulus type	1378.125	0.145	0.704
emotional valence congruent*priming type	196,878.125	21.116	<0.001
target stimulus type*priming type	408,382.031	41.845	<0.001
emotional valence congruent*target stimulus type*priming type	1012.500	0.109	0.742

The results showed that the main effect of emotional valence congruence was not significant, $F(1, 63) = 0.95$, $p > 0.05$. The main effect of target stimulus type was significant, $F(1, 63) = 52.88$, $p < 0.001$, $\eta_p^2 = 0.46$. The main effect of priming type was significant, $F(1, 63) = 84.29$, $p < 0.001$, $\eta_p^2 = 0.57$.

The interaction between emotional valence congruent and target stimulus type was not significant, $F(1, 63) = 0.15$, $p > 0.05$; the interaction between emotional valence congruent and priming type was significant, $F(1, 63) = 21.12$, $p < 0.001$, $\eta_p^2 = 0.25$. Therefore, a simple effects analysis (Bonferroni correction) was conducted. The results showed that under masked priming conditions, participants' reaction times for target stimuli with emotional valence congruent with the priming stimulus were significantly longer than those for emotionally incongruent targets (mean difference = 30 ms, 95% CI [6, 55], $p < 0.05$); under unmasked priming conditions, participants' reaction times for target stimuli with emotional valence congruent with the priming stimulus were significantly lower than when the emotional valence was incongruent (mean difference = −48 ms, 95% CI [−74, −22], $p < 0.001$).

The interaction between target type and priming type was significant, $F(1, 63) = 41.85$, $p < 0.001$, $\eta_p^2 = 0.40$; therefore, a simple effects analysis (Bonferroni correction) was conducted. The results showed that under masked priming conditions, there was no significant difference in reaction times for emotional words and emotional faces (mean difference = 16 ms, 95% CI [−10, 41], $p > 0.05$); under unmasked priming conditions, participants' reaction times for emotional words were significantly longer than those for faces (mean difference = 129 ms, 95% CI [101, 156], $p < 0.001$). The interaction among emotional valence congruence, target stimulus type, and priming type was not significant, $F(1, 63) = 0.11$, $p > 0.05$.

Consequently, H5 was supported, whereas H4 was not supported, as a significant reversed effect was observed under masked conditions. The reversed effect under masked conditions suggests that brief primes may disrupt target processing, whereas clearly visible primes yield standard facilitation. Although prime duration and masking remain potential confounds (and awareness was not assessed), a robust unmasked facilitation effect was still observed.

7. Study 4

Study 4 investigated whether the effects of emoji primes on subsequent emotional face-valence judgments vary as a function of emoji ambiguity. Emotional concepts are shaped by individual experience and language learning, becoming increasingly differentiated through these processes (Hoemann et al., 2019; Nook et al., 2020). However, interpretations of emojis may vary across individuals, particularly for emojis whose emotional meanings are less consistently perceived (Fischer & Herbert, 2021). Such ambiguity may make it more difficult to establish a clear emotional representation, potentially influencing the processing of subsequently presented emotional information. Therefore, emoji ambiguity may affect how quickly adults process positive and negative emotional faces.

Drawing upon the previous literature we hypothesize that:

H6a. *Reaction times will be shorter for positive than negative emotional faces following low-ambiguity emojis.*

H6b. *The difference in reaction times between positive and negative emotional faces was not predicted to be significant following high-ambiguity emojis.*

7.1. Method

7.1.1. Participants

The sample size for this experiment was estimated using G*Power 3.1 software. To detect a moderate effect size ($f = 0.25$) at a significance level of $\alpha = 0.05$ and a power of 0.9 ($1 - \beta$), a minimum of 30 participants was required. Ultimately, the study recruited 36 Chinese university students. All participants were required to have normal visual acuity or corrected visual acuity, no history of significant emotional fluctuations in the recent past, and be right-handed. Informed consent was obtained from all participants, and they were compensated upon completion of the experiment.

7.1.2. Stimuli

The eight emojis used in Study 4 were selected from 15 smiling emojis evaluated in a preliminary rating study involving 31 university students in China (see Table 8). Emoji ambiguity was operationalized as the proportion of participants who rated an emoji as 4 or below on a 7-point valence scale (1 = extremely negative, 7 = extremely positive). The four emojis with the highest proportions were selected as high-ambiguity emojis (see Figure A4 in Appendix A), whereas the four with the lowest proportions were selected as low-ambiguity emojis. The emotional faces were the same as those used in Study 3 and were selected from the Chinese Affective Facial Picture System (CAFPS; Gong et al., 2011).

Table 8. Ambiguity Scores of the 15 Smiling Emojis.

Emoji	Ambiguity Score	Emoji	Ambiguity Score
	0.096		0.612
	0.064		0.354
	0.935		0.483
	0.806		0.387
	0.741		0.354
	0.419		0.193
	0.871		0.548
	0.129		

7.1.3. Design/Procedure

We had a 2 (emoji ambiguity; high, low) × 2 (emotional face valence; positive, negative) within-participants design. The independent variables were emoji ambiguity and emotional face valence, while the dependent variable was participants' reaction time. The experiment consisted of a valence judgment task presented using ePrime 3.0. A practice session was conducted before the main experiment began; feedback was provided during the practice session, and the main experiment commenced only after participants confirmed their understanding. A red fixation mark "+" appeared in the center of the screen 300 ms before the stimulus. This was followed by an emoji presented for 200 ms, then a blank screen for 800 ms, and finally an emotional face. Participants were required to judge whether the facial expression was positive or negative and select their choice by pressing the F or J keys on the keyboard. Reaction times were recorded. There is a 1000-ms interval between trials. The entire experiment is divided into two blocks, each containing 40 trials, with experimental materials presented randomly within each block. After the experiment, participants are asked to rate the emotions expressed by the eight emojis using a scale. During data processing, data from participants who do not meet the experimental requirements are excluded. The flowchart for the formal experiment is shown in Figure 6.

7.1.4. Results and Discussion

Table 9 presents the means and standard deviations of reaction times (RTs) for each experimental condition. After excluding data from six adult participants who failed to complete the experimental task as instructed, data from a total of 30 participants were included in the analyses. All trials, including those with incorrect responses, were retained in the RT analyses. The results of the repeated-measures analysis of variance are presented in Table 10.

The results indicate that the main effect of emoji ambiguity was significant, $F(1, 29) = 198.70$, $p < 0.001$, $\eta_p^2 = 0.87$. Reaction times were longer in the high-ambiguity condition than in the low-ambiguity condition. The main effect of emotional face valence was not significant, $F(1, 29) = 0.97$, $p > 0.05$.

Table 9. Descriptive analysis of study 4.

		RT (in ms) *M*	RT (in ms) *SD*
High ambiguity	Positive face	902	204
	Negative face	850	192
Low ambiguity	Positive face	591	87
	Negative face	692	199

Table 10. Analysis of Variance for Reaction Times for study 4.

	MS	*F*	*p*
emoji ambiguity	1,649,707.500	198.704	<0.001
emotional face valence	18,500.833	0.967	0.333
emoji ambiguity*emotional face valence	175,567.500	17.678	<0.001

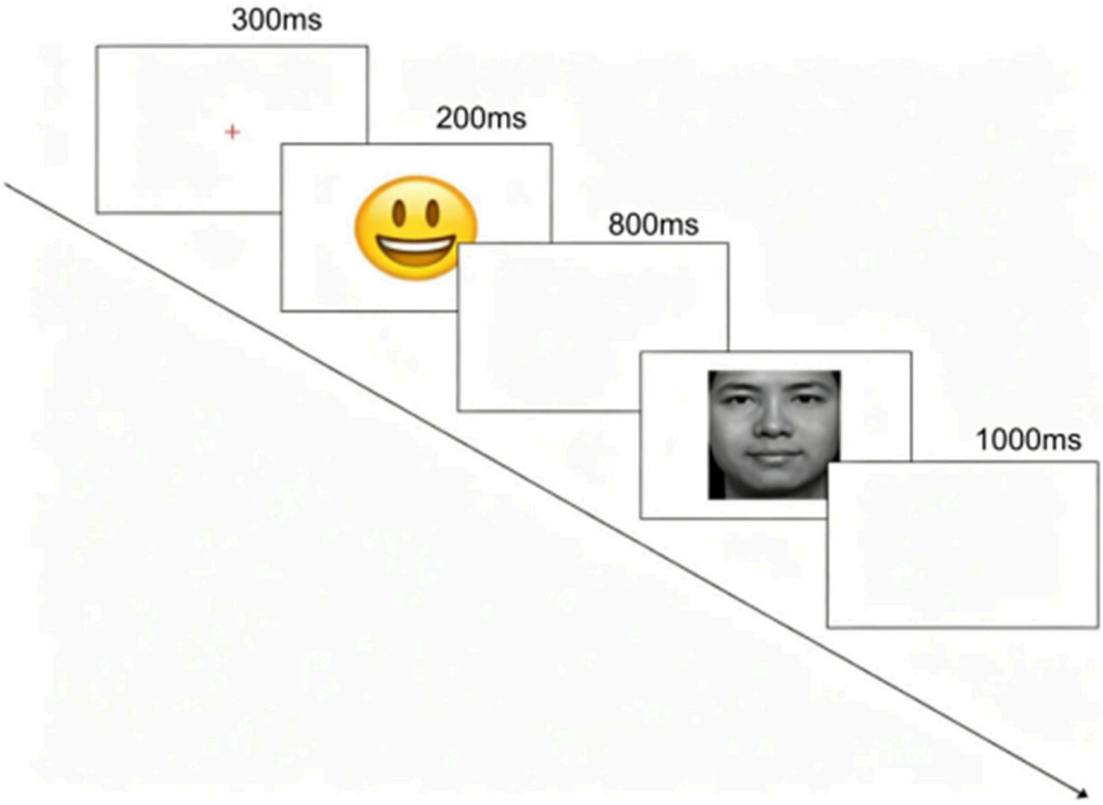


Figure 6. Trial structure for Study 4.

The interaction between emoji ambiguity and the valence of emotional faces was significant, $F(1, 29) = 17.68$, $p < 0.001$, $\eta_p^2 = 0.38$. Simple effects analyses with Bonferroni correction revealed that, under the positive-face condition, reaction times were significantly longer following high-ambiguity emojis than following low-ambiguity emojis (mean difference = 311.00, 95% CI [251.63, 370.37], $p < 0.001$). A similar effect was observed under the negative-face condition (mean difference = 158.00, 95% CI [118.51, 197.49], $p < 0.001$). Furthermore, under the high-ambiguity emoji condition, reaction times did not differ significantly between positive and negative faces (mean difference = 51.67, 95% CI [−11.79, 115.13], $p > 0.05$). However, under the low-ambiguity emoji condition, reaction times were significantly shorter for positive faces than for negative faces (mean difference = −101.30, 95% CI [−165.13, −37.47], $p < 0.05$).

The results supported both H6a and H6b. Specifically, under the low-ambiguity emoji condition, adults responded significantly faster to positive than to negative emotional faces. However, under the high-ambiguity emoji condition, no significant difference in reaction times was observed between positive and negative emotional faces.

8. General Discussion

Emotional meaning is shaped by bodily experiences and/or conceptual knowledge. Embodied cognition theory emphasizes the role of sensorimotor experiences in understanding emotional concepts (Niedenthal, 2007), whereas semantic representation theory highlights abstract representations and associative activation within semantic networks (Collins & Loftus, 1975). These perspectives need not be mutually exclusive. To examine how emotional meaning is processed in emojis, we conducted four studies investigating facial feedback, spatial congruency, evaluative priming, and emoji ambiguity. Overall, the findings provided mixed support for our hypotheses. In Study 1, none of the facial-feedback hypotheses (H1a, H1b, H2a, and H2b) were supported; similarly, neither spatial-congruency hypothesis (H3a or H3b) was supported in Study 2. In Study 3, H4 was not supported, whereas H5 was supported, with reversed and standard congruency effects emerging under masked and unmasked priming, respectively. In Study 4, H6a was supported, whereas H6b was not contradicted by the nonsignificant difference observed between positive and negative faces under high-ambiguity conditions in adults.

Studies 1 and 2 examined whether sensorimotor-related processes contribute to the processing of emotional information conveyed by emojis.

Study 1 employed a traditional facial feedback paradigm, using a pen-in-mouth procedure to manipulate participants' facial postures, with the teeth and lips conditions intended to facilitate and inhibit smiling-related muscle activity, respectively. We found that these manipulations did not significantly affect either reaction times or valence judgments. This null finding warrants careful consideration, as it differs from facial feedback effects previously reported for real faces and other emotional stimuli (Strack et al., 1988; Niedenthal et al., 2001; Oberman et al., 2007). However, the absence of a significant effect should not be interpreted as definitive evidence that facial feedback plays no role in emoji processing. The Many Smiles Collaboration (Coles et al., 2022) reported less conclusive evidence for facial feedback effects when using the unobtrusive pen-in-mouth procedure, highlighting the need for caution when interpreting findings obtained with this manipulation. Moreover, the present study did not include an independent manipulation check or a positive control condition to establish whether the procedure produced the intended changes in facial muscle activity or emotional processing in our sample. Therefore, the null findings may reflect limitations of the manipulation or its sensitivity in the present task, rather than the absence of facial feedback effects. One possible explanation concerns differences in the perceptual characteristics of real faces and emojis. Real faces provide rich facial information, including subtle muscle movements and changes in facial appearance, which may facilitate sensorimotor simulation during emotion processing (Niedenthal et al., 2005). In contrast, emojis are typically simplified and static visual representations. Such differences may influence the extent to which these stimuli engage sensorimotor processes. Nevertheless, because the present study did not directly compare real faces and emojis, this explanation remains speculative. Thus, our findings indicate that facial feedback did not reliably influence emoji judgments under the present experimental conditions, rather than demonstrating that emoji representations are independent of sensorimotor processes.

Study 2 extended this investigation to spatial associations between emotional valence and vertical orientation. Conceptual metaphor theory proposes that abstract concepts are partly structured through concrete bodily experiences, including spatial orientation. In

particular, positive emotions are implicitly associated with "up," whereas negative emotions are associated with "down" (Lakoff & Johnson, 1980; Meier & Robinson, 2004). However, we did not observe a significant valence–spatial congruency effect in reaction times. This finding indicates that spatial congruency did not reliably facilitate emoji processing in the present task. Nevertheless, it does not establish that emotional representations of emojis are independent of spatial or sensorimotor information. Rather, the observed null effect suggests that the association between emotional valence and spatial orientation was not reliably expressed in the behavioral responses measured here.

Studies 3 and 4 examined, from a semantic cognition perspective, whether emoji-based emotional concepts rely on abstract symbolic associations.

Study 3 employed an affective priming paradigm to examine whether emotional information conveyed by emojis influences the processing of subsequent emotional stimuli. By including both masked and unmasked priming conditions, we further investigated whether these effects varied with prime presentation conditions (Klauer & Musch, 2003). The results revealed different patterns across the two conditions. Under masked priming conditions, reaction times were longer for valence-congruent than for incongruent trials, suggesting a reversed congruency effect. This effect may reflect transient interference during the processing of briefly presented emoji primes, although its underlying mechanism remains unclear. In contrast, unmasked priming produced significant facilitation for valence-congruent prime–target pairs. Neither the interaction between valence congruence and target type nor the three-way interaction was significant, suggesting that the congruency effect did not reliably differ between emotional words and facial expressions. Taken together, these findings indicate that the influence of emoji-related emotional information on subsequent processing varied with prime presentation conditions. One possible explanation is that longer, unmasked presentation allows more elaborated processing of emoji-related emotional information, facilitating responses to valence-congruent targets. This interpretation is broadly compatible with the spreading-activation account of semantic networks (Collins & Loftus, 1975). However, evaluative priming effects may involve multiple processes, including associative activation and other forms of evaluative processing (Gawronski & Bodenhausen, 2011). Thus, the findings suggest a role for evaluative and semantic information in emoji-related emotional processing, while leaving the precise underlying mechanisms open for further investigation.

Study 4 further examined how emoji ambiguity influences subsequent emotional face-valence judgments in adults. Adults showed significantly longer reaction times following high-ambiguity emojis than following low-ambiguity emojis, regardless of the valence of the subsequently presented faces. This finding suggests that emotionally ambiguous emojis may increase processing demands during subsequent emotional face processing. One possible explanation is that emojis with less consistently perceived emotional meanings require additional processing to establish a clear emotional representation before individuals evaluate subsequently presented emotional information. Furthermore, the effects of emoji ambiguity varied with face valence. Under the high-ambiguity condition, reaction times did not differ significantly between positive and negative faces, whereas under the low-ambiguity condition, adults responded significantly faster to positive than to negative faces. This pattern suggests that the influence of emoji ambiguity on subsequent emotional face processing may depend on the emotional valence of the target face. Individual differences in emoji familiarity and digital communication experience may also contribute to variation in emoji processing.

Overall, the four studies provide insights into how emotional information conveyed by emojis is processed. Studies 1 and 2 yielded no significant behavioral evidence for the sensorimotor effects examined. Studies 3 and 4, however, demonstrated that emoji-related

responses varied with evaluative and stimulus-related factors, including prime–target valence relationships, presentation conditions, and emoji ambiguity. These findings highlight the relevance of evaluative and semantic information in emoji emotion processing. Nevertheless, the present behavioral results do not uniquely identify the underlying mechanisms or establish that emoji emotion processing is independent of sensorimotor processes.

9. Limitations

This study has several limitations. First, the replicability of facial feedback effects remains debated, and the behavioral measures used may not have been sufficiently sensitive to capture subtle embodied influences. In Study 2, the mismatch between valence-based stimulus selection and emotion-specific instructions ("happy" or "sad") may also have influenced responses, as negative emojis can convey emotions other than sadness. Thus, the null findings in Studies 1 and 2 do not rule out sensorimotor contributions to emoji processing. Future research could use alternative manipulations, complementary measures such as ERP, facial electromyography, and eye-tracking (Yang et al., 2022), and valence-based instructions. Second, Study 3 lacked a neutral baseline, preventing the distinction between facilitation and interference. Moreover, prime duration and masking varied simultaneously, and prime awareness was not objectively assessed. Consequently, the observed effects cannot be attributed specifically to awareness or uniquely interpreted as abstract semantic processing. Future studies should independently manipulate these factors, assess prime awareness, and include a neutral baseline. Third, the interpretation of emoji ambiguity effects in Study 4 warrants caution. Emoji ambiguity was operationalized using the proportion of non-positive ratings in a preliminary study, rather than direct assessments of participants' interpretations during the experiment. Consequently, the operationalized ambiguity levels may not fully reflect how individual participants perceived the emojis. Furthermore, individual differences in emoji familiarity and digital communication experience may have influenced the observed responses. Future research should incorporate direct measures of emoji interpretation and familiarity to better understand how individual differences relate to the processing of ambiguous emojis. Finally, the controlled tasks used in the present studies may not fully capture everyday emoji use, where emotional meaning is shaped by linguistic and social contexts. Future research should examine emoji processing in more ecologically valid communication settings.

10. Conclusions

Across four studies, we examined the processing of emotional information conveyed by emojis from sensorimotor and evaluative or semantic perspectives. We found no reliable behavioral evidence for the facial-feedback or spatial-congruency effects examined under the conditions tested. In contrast, Studies 3 and 4 showed that emoji-related emotional processing varied with prime–target valence relationships, presentation conditions, and emoji ambiguity. Together, these findings suggest that evaluative and semantic factors are relevant to emoji emotion processing, although the underlying mechanisms remain unclear. Importantly, the findings do not establish that embodied and semantic processes are mutually exclusive, nor do they rule out sensorimotor contributions. Further research using complementary methods and more ecologically valid tasks is needed to clarify how these processes contribute to the processing of emotional information conveyed by emojis.

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Validation, Conceptualization. Y.L.: Project administration, Investigation, Data curation. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement: Participants in all studies provided electronic informed consent before participation.

Data Availability Statement: The data sets and codes used for the analyses conducted for our studies are available on OSF: https://osf.io/z4jdf/overview?view_only=3fc63e811d3747aeaa1691daa6fcc35d (accessed on 14 November 2026).

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

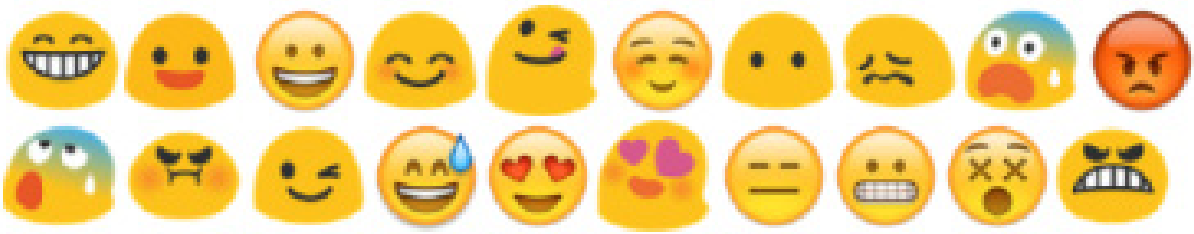


Figure A1. Emojis for study 1, study 2 and study 3.

地狱	奸诈	恶魔	叛徒	车祸	侮辱	凶手
Hell	Treacherous	Demon	Traitor	Car accident	Insult	Murderer
卑劣	残忍	凶狠	爱情	天使	浪漫	高雅
Despicable	Cruel	Fierce	Love	Angel	Romantic	Elegant
优秀	愉快	美食	知己	智慧	自信	
Excellent	Happy	Delicious food	Confidant	Wisdom	Confidence	

Figure A2. Emotional words and definition for study 3.



Figure A3. Emotional faces for study 3 and study 4.



Figure A4. Emojis for study 4.

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