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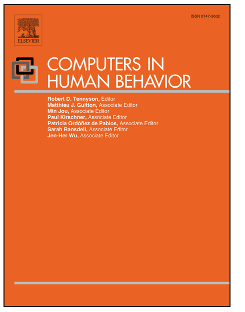

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Do all facial emojis communicate emotion? The impact of facial emojis on perceived sender emotion and text processing

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Declaration of Interest

The authors have no conflict of interest to declare.

Abstract

Facial emojis can express a variety of positive and negative emotions, and are commonly used in digital, written communication. However, little is known about how emojis impact text processing and how different emoji-text combinations give rise to a sender's mental state. In this study, we investigated how facial emojis with positive valence (= happy emojis) and facial emojis with negative valence (= upset emojis) embedded in emotionally ambiguous/neutral text affect the perceived mental state of the sender using ratings (Experiment 1) and the processing of the text messages using Event-Related Potentials (Experiment 2). We predicted that (1) the same text message with happy and upset emojis would convey different sender mental states, and (2) emoji valence would affect the processing of subsequent text in valence-specific ways. Our Experiment 1 results showed that while texts with upset emojis convey specific sender mental states, texts with happy emojis convey positive emotion more generally, with no further differentiation between emojis. In ERPs (Experiment 2), we found that emojis affect subsequent text processing at N400, and emoji valence affects processing downstream at the second word. We concluded that all facial-emojis impact text processing, but happy and upset emojis carry differential social-emotional salience and impact text processing differently when content becomes available.

Keywords: emojis, emotion, language, ERP, Late Positive Component

1. Introduction

Facial emojis[1] are a frequently used, non-verbal tool in computer mediated communication (CMC). What information is conveyed by facial emojis and how does such information affect the processing of the text they accompany? According to a recent review by Bai et al. (2019), emojis can act as visual symbols, or be read as non-verbal cues that fulfill semantic or emotional functions. Specifically, emojis can represent content (e.g., flags or foods), more transitive meaning (e.g., behaviors or activities) or emotions (e.g., positive, or negative). Furthermore, the 'tears of joy' emoji was named *word of the year* by the Oxford dictionary in 2015, suggesting that the emoji alone carries meaning comparable to the meaning conveyed in a word. Here our primary focus is not about perception of emojis, but rather, the effects of emojis on word processing.

Research investigating emoji-text interaction is still in its infancy. However, we will synthesize ideas and results from different approaches, such as corpus-based studies, behavioral experiments and computational modelling below. Despite still being an emerging field, research on the perception, processing, and interpretation of emojis and emoji-text combinations is important, due to the pervasiveness of emoji use in CMC.

Previous research has found that adding emojis to text can alter the text's meaning. For example, a wink emoji at the end of a text message can render the text message from literal to ironic meaning (Howman & Filik, 2020; Weissman & Tanner. 2018). In addition, the

[1] We use the term emoji to refer to heterochromatic, horizontally oriented icons used in computer mediated communication (CMC). Some of these emojis can be realized in Unicode. We will use the term emoticon to refer to monochromatic and/or vertically oriented icons used in CMC, which are considered more typographic in nature. Most of them can be realized using keyboard characters. Similar distinctions between emojis and emoticons have been used in previous literature, for example in the Lisbon Emoji and Emoticon Database (LEED, Rodrigues et al., 2018), in Bai et al. (2019)'s review of emojis, and Aldunate & González-Ibáñez (2017)'s review of emoticons, though not all studies reported here have used the same standards. This is likely because the field of emoji and emoticon research is young and especially earlier works lacked clear terminology due to some forms not being developed yet. If needed, we will describe and adjust authors' terminology according to these metrics.

information conveyed in emojis can enrich the meaning of a text message. There are several ways in which emojis can impact how readers perceive the meaning of a text message. We have summarized and briefly outlined them as hypotheses below. The first hypothesis is that all emojis make their accompanying texts appear more positive, regardless of text valence. For example, a negative text message paired with a negative emoji would be rated as less negative compared to the same negative text message without an emoji. Novak et al. (2015) found that tweets with emojis were rated more positive than those without. In addition, Thompson et al. (2016) found that the tongue-emoticon (:p) elicited an increase in smiling activity and a decrease in frowning in facial EMG, even though the emoticon's expression was not smiling. Moreover, Riordan (2017) paired non-face emojis with either positive (e.g. *party time* [party popper emoji]) or negative text messages (e.g. *lost my keys* [key emoji]). Participants selected which specific emotions from a list of 8 were present in a text message and rated how much of that emotion was present. Results showed that text-emoji pairs communicated a higher level of positive emotion, specifically joy, compared to text alone, regardless of the message's valence. While these studies provide support for the hypothesis that emojis (both facial and non-facial emojis) increase enjoyment overall, some limitations apply. Firstly, potential difference might exist between facial and non-facial emojis. Riordan (2017) only used non-facial emojis. Secondly, congruency between emoji valence and text valence might mediate these findings, such that when emoji valence and text valence are incongruent, the recipient might interpret a statement as ironic. However, oftentimes, irony is not conveyed by an emoji of the opposite valence, as would be analogous to verbal irony, but by the wink emoji (e.g. Howman & Filik, 2020; Weissman & Tanner, 2018).

A second hypothesis is that emojis impact their accompanying texts in valence-specific ways. Positive emojis make a message more positive, while negative emojis make it more negative. In other words, emojis add emotional information. In Lo (2008), participants read and rated text messages with coherent emoticons (e.g. *John said: the sun is shining bright today :-)*), opposite-meaning emoticons (e.g. *John said: the sun is shining bright today :-(*), and without emoticons, on -4 to 4 point scales of emotion (*very sad* to *very happy*), attitude (*dislike* to *like*) and attention (*indifference* to *attention*). Text messages without emoticons were rated around 0 on all three scales, text messages with coherent emoticons were rated higher (happy, like, attention), and text messages with an incoherent emoticon were rated lower (sad, dislike, indifference). These results suggest that emojis affect text valence in valence-specific ways, intensifying the emotional valence conveyed by a message. In addition, Derks et al. (2007) found that contextual valence affects emoji frequency. In social-emotional context (finding a present for a friend) rendered negative, more emojis were used than in task-oriented context (solving a homework problem) rendered negative. But when these same contexts were rendered positive, no difference in the number of emojis used emerged, suggesting valence-specific usage patterns.

Third, slightly different from the above-mentioned function of adding positive and negative emotion to text meaning, it is possible that emojis are used to facilitate the recognition of pre-existing text emotion without adding new emotional information. In other words, emoji simply echo previous emotional information. Supportive of this, the study on tweets by Novak et al. (2015) also reported that the presence of an emoji increased the accuracy with which a rater self-agreed on the emotional meaning of a tweet, suggesting that emojis indeed facilitate emotion recognition. Similarly, when considering the valence of the emojis used, Derks et al. (2007) reported that emoji valence matched the valence of the context they appeared in, which suggests that the emojis reflect context valence, therefore possibly function to clarify, or reinforce emotional information.

Fourth, emojis may draw emphasis on specific words, which help the recipients process word semantics more in-depth or disambiguate information. Research using computational modeling supports that emojis enrich meaning in language (Huang et al., 2008), and that emojis are especially important to communicate abstract concepts (Rotaru & Vigliocco, 2020). Huang et al. (2008) developed a structural equation model to assess why facial emojis[2] are used in CMC. Participants (*N*=216) filled in a questionnaire covering five sections: emoticon use, information richness, enjoyment, personal interaction (=closeness with friends while using CMC), and usefulness. It was found that emoji-use positively affected enjoyment, which subsequently affected personal interaction. An indirect positive correlation was also found between emoji use and information richness, which indicates that the use of emojis in CMC improved the communicative efficiency and effectiveness. As Huang et al. (2008) put it, emojis allow users to convey more meaning in less time. More recently, in investigating unimodal and multi-modal models, Rotaru & Vigliocco (2020) combined linguistic, visual, and emotional (emoji) computational models and showed that when representing abstract concepts, such as emotion, the additional use of emoji improved model performance, suggesting that emojis enrich emotional meaning in language.

Experimentally, Kaye et al. (2020) tested the emoji-text interface using a lexical decision paradigm (LDT). Positive, negative, or neutral words were presented side by side with positive, negative, or neutral emojis, which output congruent, incongruent and neutral conditions. Each

[2] Huang et al. (2008) used the term *emoticon* to refer to graphical emoticons used in Yahoo! Messenger at the time of the study. These graphical emoticons are strongly reminiscent of emojis (yellow faces in horizontal orientation that display facial expressions and will therefore be referred to as emojis throughout this paper.

emoji appeared to the right of the target word. Results showed that emoji valence, regardless of congruency, did not affect word processing as measured in RT. However, this conclusion is limited to the processing of the words that appear before/simultaneously with emojis, not after. In an eyetracking study, Robus et al. (2020) paired neutral sentences, such as *Charlotte returned to her private study and started working on her essay*, with a smiling or a frowning emoji that was placed in a sentence-initial, sentence-middle, or sentence-final position. Emojis, regardless of valence, in sentence-final position received longer and more frequent fixations compared to emojis in other positions, with similar overall reading times across all conditions. These studies informed us that either adding local emphasis is not a function of emojis, or emphasis effects of emojis requires a finer-grained measure than Reaction Time (RTs) and eye tracking. Another idea here is that emojis do not cause readers to deploy attention to specific words, but towards the overall message globally. One study reviewed above also provided support for this global attention possibility. In Lo (2008), text messages with coherent emoticons received higher attention ratings than those with incoherent emoticons. While this measure was self-report and subjective, it still points towards the idea that coherent emojis reinforce the emotional meaning of a text message and possibly increase the attention towards the meaning of that message.

Fifth and finally, emojis help maintain a connection between the sender and the receiver during texting. Kelly & Watts (2015) analyzed the communicative roles of emojis in CMC in structured interviews. They found that, rather than conveying content information, emojis can be used to maintain a conversational connection, where the recipient simply acknowledges that they have received a message. This suggests that emojis may act as embellishments to text. In a similar vein, Boutet et al. (2021) used eyetracking and ratings to study how message-emoji congruity affects the perception of the sender's mental state. Results showed that negative emojis, regardless of congruity, shifted the perceived mental state to negative, whereas positive emojis increased positivity in a congruent message, but did not affect mental state ratings when paired with a negative message. However, key evidence for the significance of emojis comes from their ratings of the sender's emotional warmth, where positive emojis showed increased emotional warmth, regardless of the message's congruity. Thus, increased emotional warmth supports the idea that emojis act to maintain conversation connection.

In sum, it appears that emojis and emoticons can significantly affect the emotional meaning of a text message (Lo, 2008), possibly by clarifying or through repetition (Novak et al., 2015). In addition, emojis may carry out social functions, such as maintaining an emotional connection and adding warmth to communication (Kelly & Watts, 2015; Boutet et al., 2021). From previous literature, it remains unclear if the emotional meaning is intensified (Derks et al., 2007) or mildened (Novak et al., 2015, Thompson et al., 2016, Riordan, 2017) and what role emoji valence plays for these functions. While it appears that positive emojis may communicate emotional warmth (Boutet et al., 2021), both RTs (Kaye et al., 2020) and eyetracking (Robus et al., 2020) suggest that emoji valence does not significantly affect cognition on a behavioral level. However, the mixed past results may be due to the diversity in techniques (e.g., behavioral measures, corpus analysis), small item-numbers, and use of both emojis and emoticons. Thus, a more fine-grained method of investigation could potentially help disambiguate and further inform previous accounts.

Event-related potentials (ERPs) provide a finer-grained and neural measure to investigate the incremental computations that underlie behavioral responses. ERPs reflect changes in the electrical current on the scalp surface during a specific cognitive event (e.g., reading). The measure is continuous with the temporal resolution at the scale of milliseconds. ERPs are positive or negative deflections compared to baseline activity and naming conventions reflect this polarity together with the average peak timing from stimulus presentation (e.g. N400 described a negative-going waveform peaking around 400 ms after stimulus onset). There are many ERP components, and each is thought to reflect a/some underlying cognitive process(es). A common ERP component of language processing is the N400. The N400 is a negative waveform peaking around 400 ms post stimulus with a centro-parietal distribution and it is typically associated with various levels of semantic processing (Kutas & Federmeier, 2011, Brown & Hagoort, 1993, Lau et al., 2008), where less expected items elicit larger N400 amplitudes. In addition, extra-linguistic context such as value systems also affect the N400 amplitude (Van Berkum et al., 2009). For example, voices that are incongruent with a sentence meaning (a man's voice saying *I am pregnant*) elicited a larger N400 than congruent voices (van den Brink et al., 2012), which suggests that listeners rapidly integrate social information, such as speaker identity. Similar results have been obtained for investigations on the effects of mood states on text processing (Egidi & Nusbaum, 2012). In this study, participants were put in a positive, neutral, or negative mood using videos. When participants read context stories that ended in either positive or negative ways (e.g. *He eventually passed/failed the exam*), a mood-congruency effect was found, with larger N400 for sentence endings incongruent with a participant's mood.

Emotion conveyed in language impacts the ERP late positive component (LPC). Prior research has established that valenced stimuli reliably elicit an increased LPC with centro-parietal distribution (Citron, 2012; Hinojosa, Moreno, & Ferré, 2019). While some argue that the LPC is typically enhanced for negatively-valenced stimuli (Delaney-Busch et al., 2016), others found the LPC to be sensitive to positive valence (Kissler et al., 2009) or both positively and negatively valenced stimuli (Bayer et al., 2010). This is true for words in isolation, as well as words in sentential context (e.g. Holt et al., 2009). In addition to valence affecting the LPC, research on language and mood has discovered that a negative mood can lead to a reduced LPC amplitude (Vissers et al., 2010, Verhees et al., 2015).

We identified only two studies that used ERPs to look at emoji-language combinations. One study paired positive and negative facial and non-facial emojis with positive and negative words in congruent and incongruent pairings and measured ERP responses at the word (Yang et al., 2021). In addition, they used a non-affective condition, in which a yellow emoji without facial features replaced the emoji. Participants saw the emoji, followed by the word, and ERPs were measured to the onset of the word. They were no differences in word RTs, but in word ERPs, they found an increased N100 for emoji-word combinations compared to the non-affective condition. which the authors concluded that emojis increased attentional resources allocated to word processing, as indexed by N100. At N400, they found an increased N400 for incongruent pairs compared to congruent pairs and the non-affective condition, as well as an increased N400 for congruent emoji-word pairs compared to the non-affective condition. Thus, they concluded that emojis are integrated as multimodal content and establish an emotional tone, and when emoji valence is incongruent with word valence, integration of emoji and word semantics is more difficult at the neural level (N400), but not on a behavioral level (RT).

Another study looked at emoji-text combinations and a speaker's communicative intent beyond the single word level with ERPs. Weissman & Tanner (2018) used positive or negative statements, such as *The cake she made was terrible,* and combined them with a valence congruent emoji (frowning), a valence incongruent emoji (smiling), or a wink emoji after the statements. Measuring ERPs at the sentence-final emoji, not any word, they found that the wink emoji elicited a larger P200 and a larger P600 than both, congruent and incongruent emojis. While the P200 was associated with increased attention, the P600 has been associated with irony (e.g. Pfeifer & Lai, 2021), so Weissman & Tanner (2018) concluded that the wink emoji can alter the perceived meaning of text from sincere to ironic, demonstrating that sentence-final emojis can indeed affect sentence meaning. While the abovementioned two studies provided much needed data on the neural processing of language combination, they did not investigate the scenario where emoji is available prior to or simultaneous with the text. Weisssman & Tanner (2018) timelocked ERPs to the emoji itself, and therefore could not speak to how emojis may affect the processing of subsequent text. Yang et al. (2021) used single words that do not reflect naturalistic use of emoji-text combinations in CMC. In addition, Yang et al. (2021) used only 10 emotionally valenced words per condition, which does not allow to assess how emojis affect emotionally neutral words or larger linguistic units.

The current study investigated how emojis affect the perception of a sender on a behavioral level (Experiment 1) and text processing on a neural level (Experiment 2). To avoid any terminology confusion with emoji valence (positive, negative) and ERP polarity (positive, negative), we will refer to the positive emojis as happy condition, and the negative emojis as upset condition. Our research has two aims: determining (1) whether emoji valence differentially affects text processing, and (2) whether emojis carry unique, significant (emotional) meaning or act as embellishments or syntactic markers for text messages.

In Experiment 1, we hypothesized that emojis affect perceived sender emotion. Specifically, we predicted that adding an emoji to a text message would significantly affect perceived sender emotion compared to comma, such that a happy emoji made senders appear more positive, while a upset emoji made senders appear more negative (c.f. Lo, 2008). We furthermore predicted that all happy emojis increase sender emotion ratings in similar ways, indexing the maintenance of a conversational connection (c.f. Kelly & Watts, 2015).

2. Experiment 1

2. 1. Methods

Participants. Seventy-one native speakers of English (mean age = 19.03, SD = 2.28 years) participated for course credit. All of them indicated that they used Emojis in text messages or social media. None of them reported any color-vision impairments. All research activities were approved by the local Institutional Review Board.

Materials and design. The study used a within-participants design with 3 conditions: text preceded by a happy emoji, an upset emoji, and no emoji (comma). One hundred and seven texts were initially created. Each text message began with an interjection (greeting or exclamation, e.g., *Hey*), followed by either an emoji or a comma and then the rest of the text message (e.g., *please call me*). A norming survey conducted online verified that the texts were indeed emotionally ambiguous. Ninety undergraduates (age M = 19.12, SD = 2.46) who did not participate in any part of the experiment participated in the norming for course credits. Twelve participants were excluded due to not listing English as their primary language. Participants either rated sentences with text-initial punctuation marks (commas) or text-final punctuation marks (exclamation or question marks), on a 7-point Likert-type scale (0 = very negative, 6 = very positive). Five texts were excluded because they were rated as too emotional (very negative, valence < 1.5 or very positive, valence > 4.5). The remaining 102 texts had a mean valence of 3.07 (SD = 0.74). The mean text length number of words after the emoji was 3.31 words (SD = 1.02, Range = 2 - 7 words).

Twenty iOS emojis, including 10 happy[3] and 10 upset ones, were selected initially from the Lisbon Emoji and Emoticon Database (LEED) (Rodrigues, Prada, Gaspar, Garrido, & Lopes, 2018). Emojitracker (emojitracker.com) was used to determine the most frequently used facial emojis by real Twitter users. After the initial norming survey of text messages, participants were asked to rate the emojis. Participants were presented with each emoji individually and instructed to rate its valence and arousal on 7-point Likert-type scales (valence: 0 = very negative, 6 = very positive; arousal: 0 = very low arousal, 6 = very high arousal). Five happy and five upset emojis were excluded after this norming for not having an extreme enough valence or having excessive non-yellow elements. The remaining 5 happy emojis had a mean valence of 5.10 (*SD* = 0.21) and mean arousal of 3.35 (*SD* = 0.38) and the remaining 5 upset emojis had a mean valence of 1.15 (*SD* = 0.45) and mean arousal of 3.86 (*SD* = 0.63). Paired t-tests revealed a significant difference in valence ($t(8)=-16.066$, $p<.001$) but no difference in arousal ($p=.21$). Emojis are shown in Figure 1.

Figure 1

Emojis Used in the Present Study.

[3] We decided to use 'happy' and 'upset' as category labels to avoid confusing with 'positive' and 'negative' ERP waveforms.

The final set of 102 text messages in 3 conditions, so 306 items total, were rotated via Latin Square and separated into 3 lists, such that each list only had one version (happy emoji, upset emoji or no emoji) of each item. The full list of materials is available as supplementary materials (Appendix B). List number was counterbalanced with subject number. Participants saw text messages with either happy emojis, upset emojis or punctuation marks. Each participant only saw each text message once.

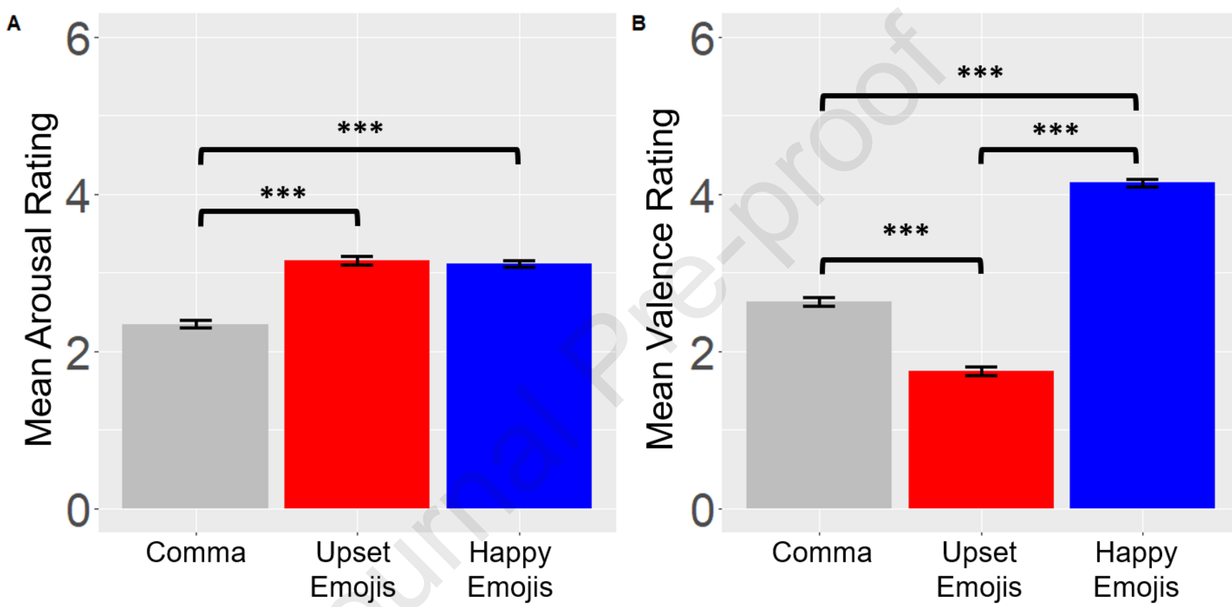
Procedure. Participants consented to participate in the web-based study. They were introduced to the concepts of valence and arousal with examples and were then instructed to treat each stimulus as a text message. Next, they rated the mental state of the sender using a 0-6 Likert scale for valence ("How does the sender feel?" 0 = very negative, 6 = very positive) and a 0-6 Likert scale for arousal ("How intense does the sender feel?" 0 = very low arousal, 6 = very high arousal). Attention checks were implemented to ensure active participation. The total experimental session lasted about 25-30 minutes.

2. 2. Results

Mean valence and arousal ratings of text messages in combination with emojis are summarized in Figure 2. Data were entered into a single-factor Repeated-Measures (RM) ANOVA, which revealed a significant main effect of condition for valence ($F(2,300) = 142.1$, $p < .001$, $\eta^2 = .49$) and arousal ($F(2,300) = 19.97$, $p < .001$, $\eta^2 = .12$). Follow-up paired t-tests showed significant differences in arousal between comma and happy ($t(202) = 12.108$, $p < .001$, $d = 1.7$), and between comma and upset ($t(202) = 10.817$, $p < .001$, $d = 1.51$), with both emoji conditions signaling a more aroused mental state, but not between happy and upset ($p = .58$). For valence, differences between all three conditions were significant (comma vs upset: $t(202) = 11.726$, $p < .001$, $d = 1.64$; comma vs. happy: $t(202) = 21.562$, $p < .001$, $d = 3.02$; happy vs upset: $t(202) = 34.456$, $p < .001$, $d = 4.82$). The same message conveyed a more positive mental state when combined with a happy emoji, compared to comma, and similarly, the same message conveyed a more negative mental state when combined with an upset emoji.

Figure 2

Mean Arousal and Valence Rating Results from Experiment 1

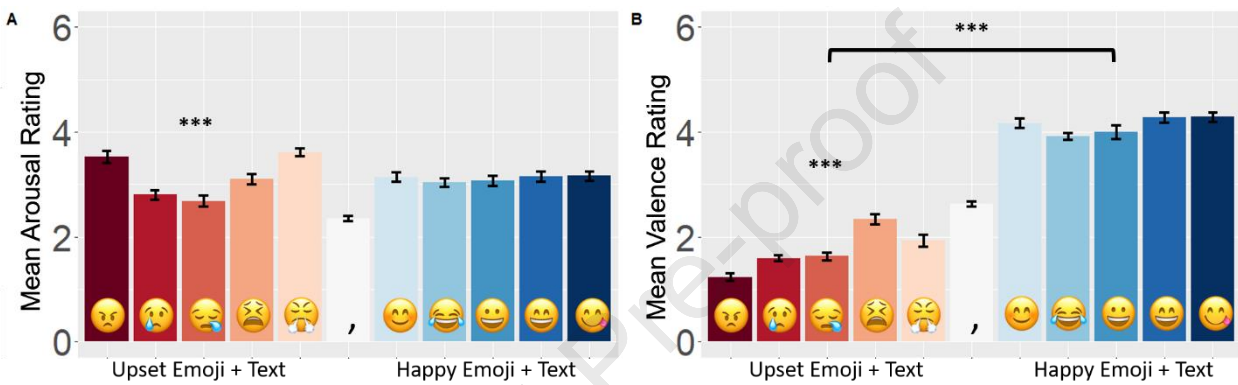


Mean ratings for the same text messages paired with either comma (grey), upset emojis (red), or happy emojis (blue) on arousal (left, 6 = very high arousal) and valence (right, 6 = very positive) in Experiment 1. Error bars reflect SE.

Emoji-specific analysis: To test if specific emojis elicit different responses, we calculated mean valence and arousal ratings based on each of the emojis. Results are visualized in Figure 3. A RM-ANOVA of emoji within happy emojis did not reveal any significant differences in arousal ($p = .15$) or valence ($p = .93$). By contrast, a RM-ANOVA of emoji within the upset emojis did reveal significant differences in arousal ($F(4, 92) = 7.275$, $p < .001$, $\eta^2 = .24$) and valence ($F(4,92) = 4.912$, $p = .001$, $\eta^2 = .18$). Follow-up pairwise comparisons within the upset emojis are displayed in table 1 for arousal and for valence in table 2. All p-values were Bonferroni-corrected.

Figure 3

Mean Arousal and Valence Rating Results in Experiment 1 per Emoji



Mean arousal (left/red) and valence (right/blue) ratings of sender's mental state from text messages when combined with each of the emojis in Experiment 1. White bar (middle/white) represents the condition where text messages appear with the comma. Error bars are SE.

Table 1

Pairwise Comparisons for Arousal Ratings of Perceived Sender Emotion per Individual Emoji

Arousal	Angry 😠	Cry 😢	Sleepy 😪	Tired 😫	Triumph 😤
Angry 😠					
Cry 😢	$t(40)=4.866$, $p<.001$, $d = 1.5$				

Sleepy 😪	*t*(37)=5.248, *p*<.001, *d* = 1.69	-			
Tired 😫	-	-	-		
Triumph 😤	-	*t*(40)=6.8, *p*<.001, *d* = 2.1	*t*(37)=7.212, *p*<.001, *d* = 2.32	*t*(40)=4.199, *p*=.001, *d* = 1.3	

All *p*-values are Bonferroni corrected. Effect sizes denoted in Cohen's *d*.

Table 2

Pairwise Comparisons for Valence Ratings of Perceived Sender Emotion per Individual Emoji

Valence	Angry 😠	Cry 😢	Sleepy 😪	Tired 😫	Triumph 😤
Angry 😠		*t*(40)=3.598, *p*=.008, *d* = 1.11	*t*(40)=3.659, *p*=.007, *d* = 1.18	*t*(40)=9.236, *p*<.001, *d* = 2.85	*t*(40)=5.123, *p*=.001, *d* = 1.58
Cry 😢			-	*t*(40=6.59, *p*<.001, *d* = 2.03	-
Sleepy 😪				*t*(37)=5.791, *p*<.001, *d* = 1.86	-
Tired 😫					-
Triumph 😤					

All *p*-values are Bonferroni corrected. Effect sizes denoted in Cohen's *d*.

2. 3. Discussion

Experiment 1 showed that facial emojis affect how we perceive a sender's mental state from their text message, suggesting that emojis do enrich text-messages beyond embellishment. This was evident because we used the same text messages in all three conditions, yet the perceived mental state from the text messages differed both, from comma and between valence conditions. Furthermore, we found that upset emojis in text messages conveyed a more fine-grained picture of the emotional state of a sender than happy emojis did. In fact, as shown in pairwise comparisons, all text messages with upset emojis carried a unique signature of valence and arousal levels of a sender's mental state, whereas the same text messages combined with happy emojis could not be used to differentiated a specific mental state, but merely overall positivity. Our results are in line with Boutet et al. (2021), who found differential effects of positive and negative emojis on the perceived mental state of the sender. While their negative/upset emojis impacted the perceived mental state of the sender regardless of message incongruity, positive/happy emojis made only congruent messages more positive. This suggests that a text message with an upset emoji carries a different amount of significance for the recipient, possibly because adding an emoji to the text message is voluntary, or because upset emojis are more frequently used in negative, social context (Derks et al., 2007). In addition, it is possible that the upset emojis are preferentially used to communicate negative affect, because they do so more efficiently than words alone (c.f. Huang et al. 2008, Rotaru & Vigliocco, 2020). For the text messages containing happy emojis, our results showed no difference between the specific emojis used, suggesting that rather than communicating a specific emotional state, happy emojis in text messages add positive sentiment to text more generally. This is in line with previous findings from Boutet et al. (2021), who found that happy emojis overall communicate sender's emotional warmth, and with Riordan (2017), who found that emojis communicated more joy overall. Thus, it is plausible that happy emojis in text messages appeal to the sender-recipient relationship, rather than conveying additional mental state information, and act as signals of maintaining a conversational or relational connection (Kelly & Watts, 2015). Upset emojis in text carry emotional content information beyond the text message alone, demonstrating social significance, and ultimately resulting in more detailed representations of the sender's mental state.

3. Experiment 2

Experiment 1 provided evidence that emojis in text messages are interpreted as additional mental-state signals by the recipient compared to no emoji. However, previous literature beyond the rating level has not compared the effects of different emojis on processing the same text. While Yang et al. (2021) did explore emoji-word combinations, these (1) were limited to single, valenced words and (2) are not reflecting naturalistic parings of emojis and text as used in CMC. In addition, Yang et al. (2021) used facial and non-facials emojis, such as a heart of thumbs up. Therefore, our Experiment 2 aims at investigating the effects of facial emojis on longer and more naturalistic text messages with ERPs. In addition, we aimed at expanding the results from Experiment 1 by gaining a more granular picture of text processing using neural measures.

We investigated ERPs at the first word and the second word post emoji, but not the remaining words, due to the differing length of the text messages used and high number of trials required for ERP studies. We made two predictions: (1) Mirroring results from Experiment 1, we predicted that both types of emojis would impact text-processing compared to a comma, which does not carry any extralinguistic information. This impact would be indexed by increases in the N400 amplitudes of the following word (Yang et al., 2021). Following results from Experiment 1, we furthermore hypothesized that happy emojis act to maintain a conversational connection (Kelly & Watts, 2015), while upset emojis are meaningful signals of the sender's emotional state. Thus, (2) we predicted that upset and happy emojis would differentially impact word processing, as reflected in differences in ERP components. Due to the lack of previous ERP research and mixed results about LPC (c.f. Introduction), we did not make specific predictions about how ERP components might be impacted, but we predicted that effects would likely manifest at LPC, typical for emotion manipulations (Citron, 2012).

3. 1. Methods

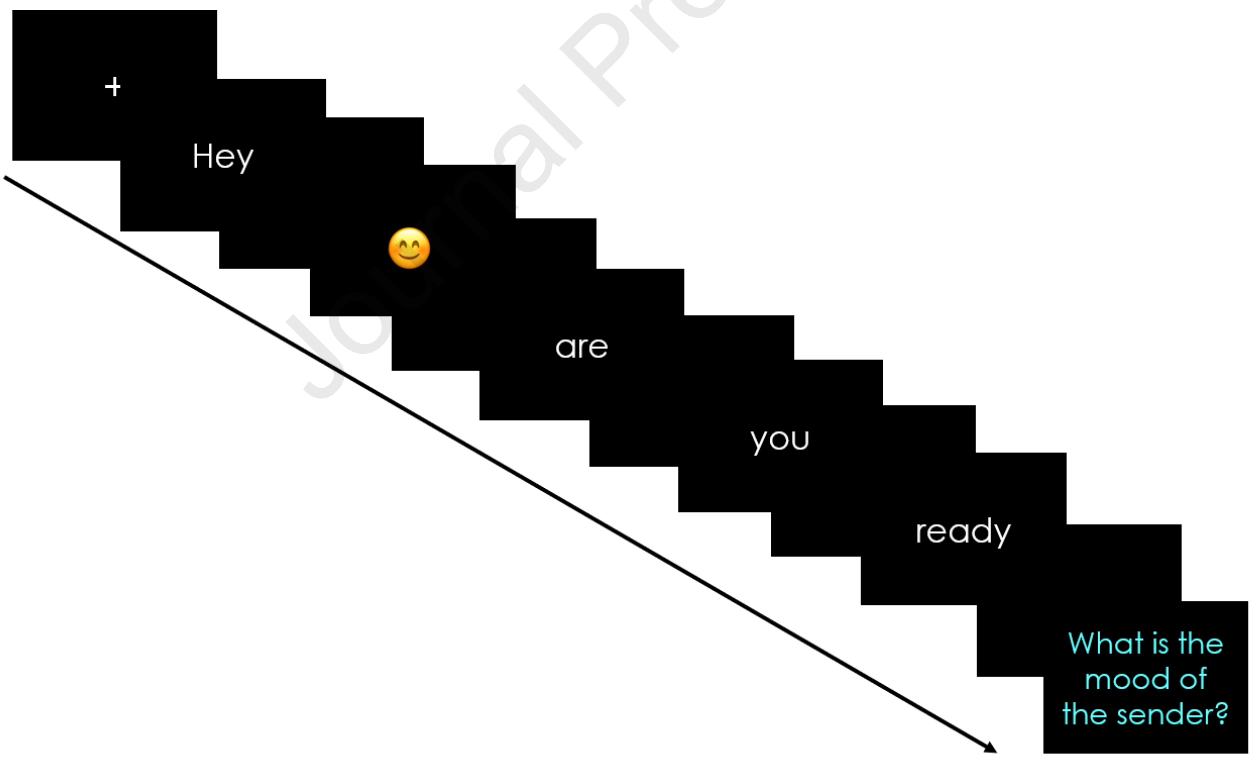
Participants. Forty-nine college students gave written consent to participate in the experiment for course credit. All were right-handed, native speakers of English with no known neurological or developmental abnormalities. All reported normal or corrected to normal vision. All reported to use emojis in interpersonal communication. Thirty-six of these (16 males, mean age M = 19.28 years, SD = 1.19) were in the final analysis. Thirteen participants had to be excluded due to excessive noise in their data, with less than 10 segments kept in all three conditions (> 65% average trial loss). The study was approved by the local Institutional Review Board.

Materials and Design. Same as Experiment 1.

Procedure. Participants gave written consent and were fitted the electrode cap. Then, they were seated in a sound attenuated booth, approximately 80 cm away from a 22-inch LCD screen. The keyboard for written answers was placed on the desk in front of participants, so that they could comfortably type during the experiment. Participants were verbally instructed to read stimuli as if they were text-messages. Stimuli were presented using E-Prime 3.0 (Psychology software tools, Pittsburg, PA, USA) in light grey font (Century Gothic, size 20) on black background. Instructions were displayed in light blue-green font (teal) to visually separate them from the stimuli. Each trial started with a fixation cross (500 ms) at the center of the screen. Then, each word/emoji item was presented word-by-word item-by-item for 300 ms (+/-10 ms jittered), followed by a 500 ms (+/-10ms jittered) blank screen. After each trial, a screen appeared that said: “What was the mood of the sender?” and participants were required to type their answer using the keyboard. The purpose of the task is two-fold: We wanted to verify that the participants did read the text and that they considered the sender’s mood explicitly. A schematic overview of a trial is presented in Figure 4. Participants were instructed to keep their answers short and that they could repeat previously given answers if needed. After the text entry was completed, participants hit enter and a screen appeared that said “Blink, or continue”, so that participants could rest before the next trial. Trials were randomized for each participant within their list. The total session lasted about 60-70 min.

Figure 4

Trial Structure of Experiment 2



Font size increased for visibility. ERPs were time locked to the onset of the first two words after the emoji.

EEG data acquisition and pre-processing. EEG was recorded continuously from 64 Ag/AgCl active electrodes (ActiCap and actiCHamp, Brain Vision) without filtering at a sample rate of 500 Hz. Electrodes were placed using a 10-20 system, with Cz as the online reference. All electrode impedances were kept below 10 kΩ.

Data was analyzed offline using Brain Vision Analyzer 2.0. Data were band-pass filtered continuously with Zero phase shift Butterworth filters at 0.01 Hz and 30 Hz, order 4, with a notch filter at 60 Hz. Data were re-referenced to the average of the left and right mastoids. Ocular movements were corrected with an Independent Component Analysis algorithm Infomax.into 2 epochs: (1) First word epoch: from 200 ms before the onset of the first word – 850 ms after, and (2) second word epoch: from 200 ms before the onset of the second word – 850 ms after. Artifact rejection was conducted automatically and segments with artifacts exceeding a total Max-Min difference of 100 µV were removed. All segments were normalized to a 200 ms pre-stimulus baseline, and averaged ERPs time-locked to the onset of the first/second word in each condition were computed.

EEG Analyses. The selection of the time windows and electrodes was based on collapsed localizers (Luck & Gaspelin, 2017). For this, waveforms of all three conditions (comma, happy emoji, upset emoji) were averaged and used to determine the temporal and spatial parameters for the non-collapsed data analyses. After visually inspecting the collapsed data, we determined our two time windows of interest, an early, N400-like timewindow (300-500 ms) and a late, LPC-like timewindow (650-850 ms), and a single scalp location where effects were the most pronounced. This location contained electrodes CP1, CP2, CPz, P1, P2, Pz. Amplitudes per channel were exported per condition and average values entered into a single factor Repeated

Measures ANOVA of 3 emoji (happy, upset, comma). Greenhouse-Geisser correction was applied to account for the violated assumption of sphericity.

Behavioral analyses. Behavioral responses were exported and checked for whether participants were reading each text and whether the mood they typed matched the experimenter-defined mood/condition of a given trial. For this, a human rater read each emoji-text combination and rated the written response as either 1 = match/plausible, 0.5 partial match, or 0 = no match/implausible. Ratings were then summarized both per participant, and per text message, the latter indexed by average score per condition.

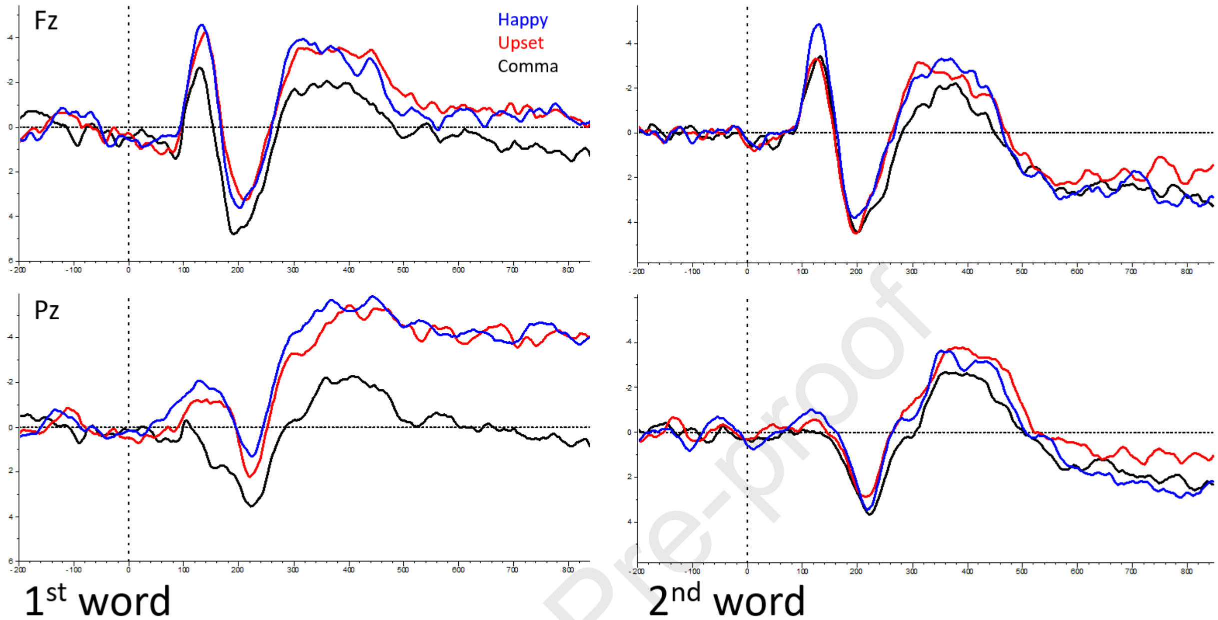
3. 2. Results

Behavioral results. On average, participants provided plausible/matching responses for 96% (SD = 0.35%) of the trials. Thus, it seems that participants actively engaged in the task and paid attention to the text messages. Most answers were single word responses, as encouraged by instructions. Mood plausibility ratings were significantly higher in the comma condition (M = 99.5%, SD = 0.02%) than in both, the happy condition (M = 94.7%, SD = 0.09%) and in the upset condition (M = 93%, SD = 0.09%), both $p < .001$. However, happy and upset conditions did not differ in the amount of plausibility ($p = .18$) provided in the answers.

ERP results. The averaged segment counts (out of 34 segments per condition) were as follows: First word segment: 29.08 for words following happy emoji, 28.72 for words following upset emoji and 28.47 for words following no emoji/comma. Second word segment: 28.58 for happy emoji, 29.81 for upset emoji and 28.83 for no emoji/comma. Averaged waveforms are displayed for channels Fz and Pz in Figure 5 and analyzed timewindows and pooled channels are displayed in Figure 6.

Figure 5

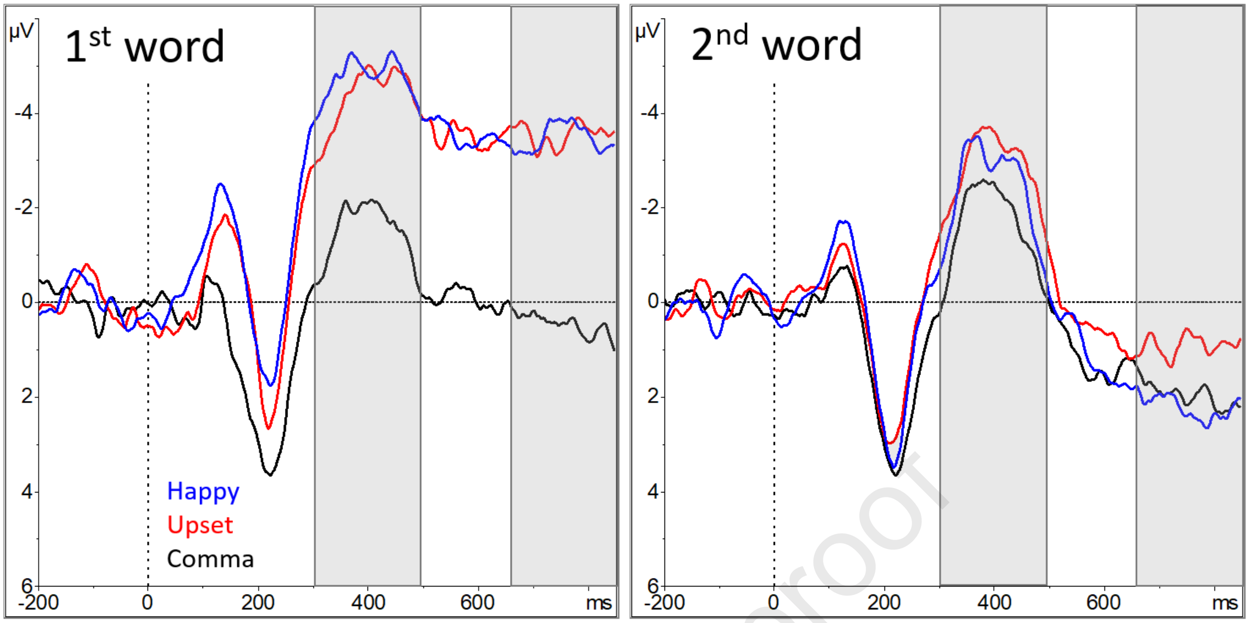
Grand Averaged ERP Waveforms for First and Second Words at Fz and Pz



Words following happy emojis are in blue, words following upset emojis are in red. Black line represents comma condition.

Figure 6

Pooled Grand Averaged ERP Waveforms for the First and Second Words



Pooled parietal channels (Cp1, Cp2, Cpz, P1, P2, Pz). Grey areas show analyzed timewindows. Words following happy emojis are in blue, words following upset emojis are in red. Black line represents comma condition.

First word post emoji.

Early timewindow (N400, 300-500ms). At the first word post emoji, we found a significant main effect of emoji ($F(2,34) = 20.459$, $p < .001$, $\eta^2 = .369$). While words preceded by happy and upset emojis did not differ ($F > 1$), words preceded by commas were significantly different from the happy condition ($F(1,35) = 22.254$, $p < .001$, $\eta^2 = .389$) and the upset condition ($F(1,35) = 27.380$, $p < .001$, $\eta^2 = .439$).

Late timewindow (650 to 850 ms). At the first word post emoji, we found a significant main effect of emoji ($F(2,34) = 25.343$, $p < .001$, $\eta^2 = .42$). While words preceded by happy and upset emojis did not differ ($F > 1$), words preceded by commas were significantly different from the happy condition ($F(1,35) = 26.738$, $p < .001$, $\eta^2 = .433$) and the upset condition ($F(1,35) = 34.854$, $p < .001$, $\eta^2 = .499$

Second word post emoji.

Early timewindow (300-500ms). At the second word post emoji, we found a main effect of emoji ($F(2,34) = 4.272$, $p = .019$, $\eta^2 = .109$). Words preceded by happy emojis did not differ from words preceded by upset emojis ($F = 1.09$), words preceded by comma differed from the happy condition ($F(1,35) = 4.116$, $p = .05$, $\eta^2 = .105$) and the upset condition ($F(1,35) = 6.876$, $p = .013$, $\eta^2 = .164$).

Late timewindow (650-850ms). At the second word post emoji, we found a main effect of emoji ($F(2,34) = 3.690$, $p = .034$, $\eta^2 = .095$). Words preceded by upset emojis differed from words preceded by happy emojis ($F(1,35) = 5.137$, $p = .03$, $\eta^2 = .128$) and commas ($F(1,35) = 4.396$, $p = .043$, $\eta^2 = .112$). Words preceded by happy emojis did not differ from the comma condition ($F < 1$).

4. Discussion

The purpose of this Experiment 2 was to see if extralinguistic information conveyed in emojis, particularly emotional valence, affects text processing, and if so, in which way. We tested two hypotheses in this study. First, emojis impact text processing compared to commas, manifested as increased N400 amplitudes. Second, emoji valence differentially impacts text processing, manifested at LPC. We found that words, both in first and second position, elicited larger N400 amplitudes if they were preceded by emojis compared to words preceded by commas. At the first word, this negativity was sustained, and emoji valence did not affect the N400 amplitude for words. At the second word however, we found words preceded by upset emojis showed a reduced late positivity amplitude (LPC), but no difference between words preceded by comma or happy emojis.

Behavioral results. Mood descriptions in the comma condition were rated as more plausible than in either emoji condition. However, given the high overall scores per participant (96%), we think that the differences in plausibility ratings between comma condition (99%), upset emoji condition (94.7%) and happy condition (93%), while statistically significant, are ceiling effects and have low real-world impact. They show that participants paid attention throughout the experiment and completed the task in a meaningful way. Alternatively, it is possible that raters found a wider range of answers plausible in the comma condition, as text messages alone were neutral and therefore allowed for more mood interpretations. By contrast, in the happy and upset conditions, the number of plausible moods was more constrained. Speculatively, the minute differences between both emoji conditions (happy and upset) and the comma condition could also be attributed to differences in arousal. In Experiment 1, arousal within the happy and the upset conditions did not significantly differ from each other but was significantly larger than in the comma condition. Thus, it is possible that verbalizing a more aroused mental state is more difficult. Lastly, it is possible that participants considered all messages during the experiment as coming from a single sender, which would impact the plausibility of happy and upset conditions most.

ERP results. Words following emojis elicit larger N400 amplitudes compared to words following commas, showing that words following emojis are processed differently. This increased N400 occurs for both, words immediately following the emoji/comma and the second words. This N400 is an index of semantic processing difficulty and have several possible interpretations that we will outline below.

First, following traditional accounts of language processing (e.g. Kutas & Federmeier, 2011, Brown & Hagoort, 1993), words following emojis require more semantic integration than those following commas. Emojis provide a rich context in which word semantics need to be integrated to create a coherent representation. Thus, an increased N400 for words following emojis suggests that the emoji context allows for a broader search for meaning.

Second, the increased N400 could index multimodal integration, that is, visual information from the emoji and linguistic information from the word. Research looking at co-speech gestures has found that integration of speech and gestures often impacts early ERP components. However, congruency of gesture and language can impact the N400 amplitude. Kelly et al. (2004) found that incongruent gestures elicit larger N400 than congruent gestures when presented simultaneously. However, in the case of co-speech gesture, both modalities are presented at the same time, whereas in the present study, emojis and words are presented consecutively and not simultaneously. Still, it is possible that the emoji contains additional or different information from what is linguistically conveyed, thus eliciting increased N400 amplitudes as soon as linguistic input arrives. In other words, emojis enrich language.

A third account for the N400 results is the extra-linguistic context provided by the emoji. The emoji may act as setting the emotional tone for the message (c.f. Yang et al., 2021), which in itself leads to an increase in N400 amplitudes, with no difference for happy and upset emojis, because emoji meaning is used to disambiguate the incoming linguistic input. This interpretation of the N400 as an index of emotional tone/mood would also be in line with Egidi & Nusbaum (2012)'s findings on mood and language. Thus, our word-N400 effects, present on both words following emoji, might be an emoji-related N400 effect that previous research without a no-emoji baseline was unable to detect (c.f. Yang et al., 2021).

At the second word after the emoji, we observed two effects, a replication of the previously discussed N400 and a reduced LPC for the second words preceded by upset emojis compared to happy emojis and commas. We suggested that this LPC reflects emotional processing (c.f. Citron, 2012). In our data, we see words following happy emojis eliciting a larger positivity than those following upset emojis. Because in prior literature, it is unclear if positive valence (Kissler et al., 2009), negative valence (Delaney-Busch et al., 2016), or valence in general (Bayer et al., 2010) elicits larger LPC amplitudes, we can use the comma condition as a baseline here. Crucially, we see no difference between words following happy emojis and those following commas, which suggests that happy emojis follow this baseline way of language processing. Words following upset emojis, however, show a reduced LPC, meaning that they differ from the comma-induced baseline language processing. We believe that this is because their negative valence needs to be integrated with the linguistic information at hand and results in different cognitive processes compared to both, happy and comma conditions. This is further in line with the idea that a negative mood can lead to reduced LPC amplitudes (Vissers et al., 2010; Verhees et al., 2015). Vissers et al. (2010) found a reduction of P600 effects when a negative mood was induced compared to positive mood. In addition, they found that the reduction in P600 correlated with the change in the emotional state of the participant. Thus, the upset emoji may have induced a more negative emotional tone (c.f. Yang et al., 2021) or emotional framing of the message compared to a happy emoji or a comma.

The fact that is effect is only present at the second word post emoji has several reasons. First, a glance at the averaged ERP waveforms in Figure 5 clearly illustrates that the effects of the emoji on the subsequent word are strong. Thus, any more subtle effect, such as those of emoji valence, might be cancelled out by other, more global processing differences. Second, the first word post emoji contains very little semantic information (see full list of stimuli in supplementary materials). About half of the items contain pronouns (e.g. I, you), other deictic elements (e.g. that) or question words (e.g. what, how), which are traditionally viewed as function words that require further content enrichment. Thus, it seems plausible that only at the second word, where enough content is present, effects of emoji valence play out.

In line with our interpretation of the LPC as indexing a reduced LPC for words following upset emojis is the idea that happy emojis merely embellish language and maintain a social connection, without carrying much additional information or operation, while upset emojis add additional information to language processing and provide a more negative emotional tone or framing of the message. In other words, happy emojis impact language processing similar to syntactic markers, such as commas, and upset emojis function as semantic markers, and are integrated with the context.

5. General Discussion

Based on results from Experiment 1 and 2 combined, we found that (1) sending an upset emoji carries specific mental state information, i.e., each emoji conveys a different mental state. Sending happy emojis conveys overall a positive mental state or excitement, without any variation between the different happy emojis. In the ERPs to the subsequent text message (not emojis), we see both emoji general and valence specific results. Emojis add information to a text message beyond those of a comma, as reflected by behavioral ratings and ERPs. We think this addition is most likely of emotional nature, but we cannot exclude other types of information without further studies.

For emoji valence, our study suggests that happy and upset emojis differentially impact text. Behaviorally, the same text message indexes a very different sender mental state, depending on which emoji is used. In ratings, happy emojis all convey a general positive sender emotion, while upset emojis convey more specific mental state information. Neurally, upset emojis elicit more in-depth processing of subsequent words, likely due to their social-emotional salience, whereas happy emojis do not impact the subsequent text processing in the same manner.

To refresh the reader's memory, here are the five hypotheses we outlined based on previous findings in the introduction about how emojis might impact text:

(1) all emojis make their accompanying texts appear more positive, regardless of text valence
(2) emojis impact their accompanying texts in valence-specific ways
(3) emojis are used to facilitate the recognition of pre-existing text emotion without adding new emotional information
(4) emojis may draw emphasis on specific words, which help recipients process word semantics more in-depth or disambiguate information
(5) emojis help maintain a connection between the sender and the receiver during texting

With regards to these hypotheses, our experiment supports the idea that emojis impact text in valence-specific ways (support for hypothesis two, reject hypothesis one), and they clearly add new information, rather than just repeating it (reject hypotheses three). Whether this added information is due to emphasis that prompts more in-depth semantic processing (hypothesis four) or emotional framing is unclear.

In addition, our work corroborates the idea that emojis help maintain a social connection between sender and recipient (Kelly & Watts, 2015), but only if they are of positive valence (partially accept hypothesis five). Thus, our work expands previous accounts in the following way: It corroborates previous results for happy emojis, wherein they signalize a warm sender-recipient relationship (c.f. Boutet et al., 2021) and express positive emotion overall (c.f. Riordan, 2017), ultimately acting more to maintain the social connection between sender and recipient, and contrasts that upset emojis are treated as meaningful social-emotional cues that affect the recipient and amplify negative emotion conveyed in the emoji. Moreover, our data suggests that information from upset emojis is integrated as content, thus acting as tools of the sender to express their mental state in a more indirect fashion. Happy emojis, on the other hand, reflect upon the sender-recipient relationship, rather than their mental state. Our results support the idea that emojis are used to communicate emotion, but more specifically, we show that upset emojis convey explicit sender information, while happy emojis merely reinforce a warm and positive sender-recipient relationship.

Limitations. Our work has several limitations. First, we selected our emojis based on frequency of use and valence, which may hold an important confound. While all happy emojis were smiling and could be characterized as happy, the upset emojis show a variety of emotional expressions, such as anger, sadness and agitation. We would like to raise two points about this. (1) There may be less variance in the expression of positive emotion compared to negative emotion in general. It is easier to find distinct negative facial expressions than it is to find distinct positive facial expressions. For example, Ekman & Friesen (1971) found 6 'basic facial expressions', which are sadness, fear, disgust, anger, surprise and happiness. While the idea of reading emotions from facial expressions has been challenged (e.g. Barrett et al., 2019), it remains true that these facial expressions show discriminable features for negative emotions like sadness, anger, fear and disgust, but only one instance of a clearly positive emotion, happiness. It is a chicken-and-egg question of whether we are better at recognizing negative emotions in facial expressions or whether we reflect our negative emotions more distinctly in our facial expression that we cannot answer based on the current study.

(2) Relating to the current study, while there might be more variation in the upset group, there also is variation in the happy group. For example, our emojis contain ‘blushing’ and ‘laughing so hard that one’s eyes start to tear’. These are both positive emotions with very different levels of arousal and different mental states, despite our emoji ratings not different in arousal between happy and upset. Similarly, the yum emoji reflects that something is tasty, which again is a unique sentiment, distinct from laughing hard or blushing. Thus, there also is variation within the positive emojis, we may just have less clear emotion concepts and facial expression for this, or the exact emotion may not matter to the same degree it does for negative emotion, where the consequences might be quite different. Given the low number of trials per emoji, we were unable to further dissociate the emojis to explore if they affected text processing differently. Future work could explore these differences to gain a more fine-grained picture.

Secondly, we chose to use a comma as a baseline for our study. While this seemed to make sense based on prior behavioral results (Lo, 2008) and considering we were interested in word ERPs, our ERPs drew a very different picture. We saw striking differences in ERPs both at the emoji position (before the first word - which we expected) as well as after the emoji/comma manipulation (at the first word - which we did not expect). Thus, the comparison between our emoji conditions to our comma baseline is potentially flawed, especially at the first word, where we might see a sustained negative shift for both emoji conditions due to a previous positive shift at emoji position compared to comma. However, it seems clear that the baselining of our data most strongly affects both emoji conditions, and seems to affect them both in similar ways, which leads us to believe that differences at the second word between upset emojis and happy emojis are real effects and not caused by baselining. In addition, our analysis was done on words following emojis and commas, not at the emoji/comma onset and therefore excluding the comma condition based on visual differences could be biased. To avoid the problem altogether, we think future studies should contrast differences between emoji conditions. Other studies have addressed this problem by using "neutral" facial emojis (e.g. Yang et al.,2021; Gantiva et al., 2019; Boutet et al., 2021). However, these do not resemble real-life expressions and no emoji is truly neutral – they are associated with a slightly negative expression (Emojipedia).

Lastly, our text messages had different lengths. While this does not weaken the robustness of our results because we were comparing the same text messages in happy and upset emoji conditions, this does hinder our ability to look at linguistic processing after the second word post emoji. However, we decided to use these messages to convey more naturalistic texting behavior. Future research could consider using longer or same-length text messages. To conclude the limitations, we would like to remind the reader that the interpretations we offer are exactly that, an offer. More research is needed to interpret findings more clearly.

In conclusion, our work is the first to provide evidence that emojis impact the emotional significance of a text message (Exp. 1) and subsequent text processing (Exp. 2) and can carry different qualities of emotional information. While happy emojis maintain resources for subsequent text processing and act indistinguishable from commas downstream of processing, upset emojis index continued emotional processing, even two words after their appearance.

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Highlights

- We investigated how facial emojis impact text comprehension using behavioral ratings and EEG
- In ratings, negative emojis communicate specific mental states, while positive emojis communicate general positive emotion
- In ERPs, the first words preceded by emojis elicited a larger N400 compared to the first words preceded by commas
- In ERPs, the second words after emojis showed valence-specific word processing, as reflected by LPCs
- Positive emojis maintain conversation flow, negative emojis impact text processing by providing emotional frame for text