Are emoji a poor substitute for words? Sentence processing with emoji substitutions

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Abstract

With the integration of emoji into digital keyboards, people are increasingly using multimodal interactions between text and image in real-time interactions. One technique of using emoji is to substitute them into sentences. We here investigate the online processing of these interactions, by modulating either the grammatical category of those substitutions (Experiment 1: nouns vs. verbs) or the type and location of substitutions (Experiment 2: emoji vs. logos, within sentences vs. at their end). We found a processing cost for self-paced reading times of images compared to words, which indeed extended past the emoji itself, but no difference in comprehensibility ratings between word and congruent-image substitutions. Overall, these results suggest that, despite costs of switching modalities, text and images can be integrated into holistic multimodal expressions.

Keywords: multimodality; sentence processing; emoji; visual language

General Introduction

Human communication is naturally multimodal, exemplified in face-to-face interaction by the convergence of speech and gesture (McNeill, 2000). However, digital text-based communication renders such bodily features unavailable to speakers. In their place, emoji have become a prevalent non-verbal indicator of emotional and pragmatic information. Emoji are pictographic expressions integrated as a semi-standardized inventory with messaging applications and computer operating systems (Danesi, 2016). They typically fall in two distributions relative to sentences: either following a sentence or substituted into it (Cramer, de Juan, & Tetreault, 2016):

John loves eating 🍕 *every Friday.*
John loves eating pizza every Friday. 🍕

Here, we examine this relationship between emoji and sentence structure.

The substitution of one modality into another is a possible feature of nearly all multimodal interactions (Cohn, 2016): Gestures can replace words in speech (McNeill, 2000), images can replace written words in sentences, and words can substitute for images in the structure of a visual narrative sequence (Cohn, 2016). In all of these cases, the structure of one modality (syntax, narrative) is retained while a unit from another modality substitutes for a unit in that dominant sequence. For emoji, such substitutions are now increasingly facilitated by messaging programs (Apple Messenger, WhatsApp) which suggest emoji to replace for words while a user is typing, as in Figure 1.

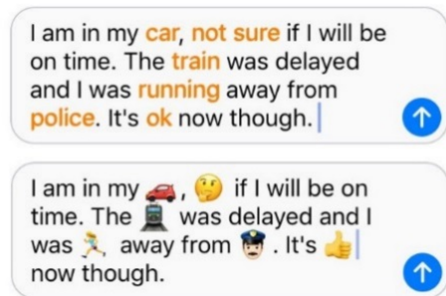

Figure 1: Suggestions of emoji for words in Apple iOS

Only some research has examined these types of substitutive relationships between images and words. Potter et al. (1986) presented participants with sentences at a rapid presentation rate where images were either congruous or incongruous with their substituted nouns. Comprehension and recall of substituted images were only marginally more strained than regular words, and this effect was maintained regardless of the substitutions' ordinal position in the sentence (middle vs. end) or the number of words which were replaced. Additional work has also suggested that participants can accurately interpret sentences whether nouns or verbs are substituted for images (Mihalcea & Leong, 2008). Nevertheless, these effects were greater for sentences which are shorter and less syntactically complex, and with high frequency words.

Additional research has examined the time it takes to read images or emoji substituted into sentences. In general, substituting emoji for words in a message requires a reader to take more time to read than a message of only text (Gustafsson, 2017). Other work has suggested that the time it takes to view an image replacing a word can be modulated by the sentence context. For example, verb aspect can modulate a replaced-image depending on whether it depicts a state congruous with the type of event described, i.e., ongoing vs. completed actions (Madden & Therriault, 2009).

Further studies measuring event-related brain potentials has implicated that a common semantic system underlies the processing of both modalities. When images have been substituted for sentence-final words, incongruous images elicit neural responses indicating more strained semantic processing (N400) than substitutions by congruous images, and these waveforms are similar to those to incongruous or unexpected words (Federmeier & Kutas, 2001; Ganis, Kutas, & Sereno, 1996; Nigam, Hoffman, & Simons, 1992). These results imply that sentence contexts modulate the semantic processing of images similar to their modulation by words, despite the modality-switch. In addition, the inverse effect has been observed for the substitution of words for images in visual narrative sequences of comics (such as *Pow!* replacing a climactic punch)—words incongruous to the narrative sequence elicit a larger N400 than congruous words (Manfredi, Cohn, & Kutas, 2017). Altogether, this work implies that a common semantic system can be expressed by multiple modalities, while negotiating the grammatical structure of one of them (Cohn, 2016).

In this paper, we investigate further aspects of multimodal text-image interactions in sentences by going beyond semantic manipulations alone. We used a self-paced reading paradigm (e.g., Aaronson & Scarborough, 1976) to investigate the online processing of sentences while modulating either the grammatical categories of those substitutions (Experiment 1: nouns vs. verbs) or the type of image substitutions (Experiment 2: emoji vs. logos).

Experiment 1: Grammatical categories

Prior studies have primarily investigated the semantics of images substituted for words in sentences, and the comprehension of those sentences. However, most of these studies have only substituted images for nouns in sentences. Nevertheless, perhaps the most well-known image substitution replaces a verb: *I* ❤ *NY*. We thus asked whether substitutions differ depending on their grammatical category.

A difference in processing noun and verb substitutions by emoji may be expected, given that objects (typical of nouns) are easier to depict in a straightforward pictorial representation than events (typical of verbs). Indeed, the argument structure of verbs (e.g., Gruber, 1965) means that a pictorial depiction would collapse across both the verb (e.g., *run*) and its arguments (e.g., *a person*), thus conveying more information in one unit (e.g., 🏃). If an emoji were to replace a verb in this fashion, the arguments may thus be repeated, and the relationships between the verb and nouns weakened by the absence of a lexicalized verb. Such a prediction was made by Potter et al. (1986) in their study of image substitutions for nouns.

We therefore first asked whether substitutions for verbs differ in online processing from verbs, and further, whether emoji more typical of one grammatical category would be anomalous if perceived in a different syntactic position (such as emoji replaceable for nouns moved to verb position). In addition, because previous substitutions have appeared at the sentence-final position, it did not allow for assessing any downstream effects of substitutions on sentence processing. We therefore presented participants with sentences replacing emoji for nouns and verbs, or reversing their positions, in a self-paced reading task where we measured how long participants viewed each word in a sentence. Our analysis focused on both the critical position, and downstream effects up to two subsequent positions after the critical word.

Methods

Stimuli We created 32 unique base sentences which described a variety of actions and events. These "no-emoji" sentences were manipulated further by creating "normal substitutions" which replaced an emoji either for a noun (the grammatical object) or for a verb. "Switched substitutions" were created by then reversing the positions of the "normal" noun and verb emoji. For example, as in Table 1 a normal sentence substitutes a pizza emoji for the noun *pizza*, and a heart for the verb *loves*. In the switched versions, a pizza replaces *loves* and a heart replaces *pizza*. Experimental conditions were interleaved with additional sentences (see Experiment 2) which together were counterbalanced across 8 lists in a Latin Square design such that no list repeated a sentence.

Following Mihalcea and Leong (2008), all sentences were designed to be simple and easy to read, with no difficult words. All sentences used the present simple tense and were based on the available emoji vocabulary set from Apple iOS. Canonical meanings of emoji were used, as outlined by Emojipedia.org.

Table 1: Example sentences used in Experiment 1

	Noun	**Verb**
No emoji	John loves eating ***pizza*** every Friday.	John ***loves*** eating pizza every Friday.
Normal	John loves eating 🍕 every Friday.	John ❤ eating pizza every Friday.
Switched	John 🍕 eating pizza every Friday.	John loves eating ❤ every Friday.

Participants We recruited 72 participants (31 female; mean age: 26.8, range: 17-62) in the online study. Using a 1 (low) to 7 (high) scale, participants reported having a fluent level of English proficiency (M=5.5, SD=1.32) though most participants were Dutch and spoke English as a second language. They also reported high levels of frequency of using texting applications (M = 6.44, SD=.9), using emoji (M = 4.97, SD = 1.2), and emoji familiarity (M = 5.78, SD = 1.1).

Procedure Participants were presented with an online experiment via Qualtrics, and we used the *jspsych* javascript plugin for the self-paced reading experiment. After consenting to their participation, participants were given instructions for the experiment where they were told to read sentences by pressing a button for each subsequent word. Trials began with a screen reading "Ready" followed by each sentence word-by-word, centered on the screen, which advanced with a button press. After each sentence, participants rated the sentence for its comprehensibility (*How much did this sentence make sense?*) and enjoyability (*How enjoyable was this sentence?*) using 7-point Likert scales. If there was a substitution, they were then asked to fill in which word they thought the emoji replaced in the sentence.

Data Analysis Reading times were analyzed using a subjects analysis which collapsed across items. Outlier removal was performed on reading times which omitted all datapoints greater than 2.5 standard deviations above the mean, and all below a threshold of 300 milliseconds. We first used a 2

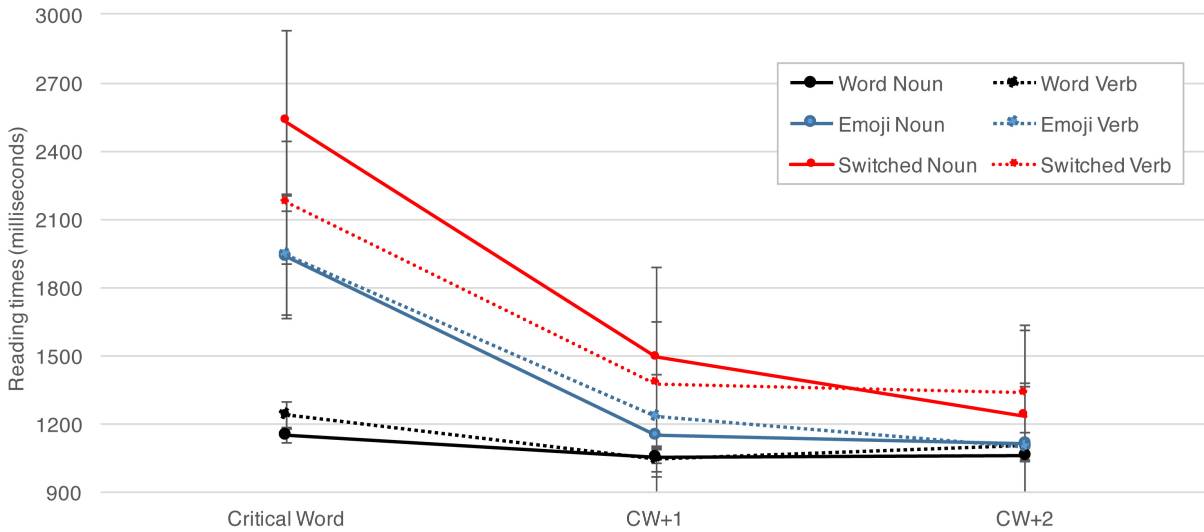

Figure 2: Self-paced reading times from Experiment 1 across sequence positions. Error bars depict standard error.

(Category: Noun, Verb) x 3 (Type: No emoji, Normal, Switched) x 3 (Critical Position: Critical Word, CW+1, CW+2) repeated measures ANOVA to analyze reading times. Additional follow up ANOVAs at each critical position were used to further analyze the relations between sentence types, and we used post-hoc tests with a Bonferroni correction.

Because both No Emoji conditions (noun and verb) came from the same sentences, our analysis of comprehension scores could not use a factorial ANOVA. We therefore measured ratings using a one-way repeated-measures ANOVA across all five sentence types. Finally, participants' accuracy for recognizing which words were replaced by emoji was assessed with a 2 (Category: Noun, Verb) x 2 (Type: Normal, Switched) repeated-measures ANOVA.

Results

Our omnibus analysis found main effects of Type and Critical Position (all *F*s>82.1, all *p*s<.001), but not Category (*p*=.233). This arose because, on average, viewing times for Switched emoji were longer than Normal emoji, which in turn were longer than normal words. In addition, reading times at the critical word were longer than those at subsequent words. Additional interactions appeared between Type, Position, and/or Category (all *F*s>31, all *p*s>.05).

Analyses at each critical position clarified these findings. At the critical word, we found a main effect of Type, $F(2,144)=82.8$, $p<.001$, and Category, $F(1,72)=4.6$, $p<.05$, and an interaction between them, $F(2,144)=6.3$, $p<.005$. These results arose because, as depicted in Figure 2, Normal emoji substitutions were read longer than normal words, and Switched emoji were even longer than Normal emoji ($p<.005$), but only in the Noun position. Normal and Switched emoji did not differ in the Verb position ($p=.44$).

At the panel after the critical word, we again found a main effect of Type, $F(2,144)=34.6$, $p<.001$, but not Category ($p=.716$), and an interaction between them, $F(2,144)=3.1$, $p<.05$. This arose because again, words after Switched emoji were read longer than after Normal noun emoji ($p<.05$), but not after normal verb emoji ($p=.05$). Words after normal noun emoji were also slower than those after normal words ($p<.001$).

Finally, two positions after the critical word, we found a main effect of Type, $F(2,144)=9.04$, $p<.001$, but not of Category ($p=.258$), nor an interaction between them ($p=.164$). This arose because words two positions after Switched emoji were still read slower than after both Normal emoji and words (p<.001), though words after Normal emoji and words did not differ ($p=1.0$). No differences were observed for those following nouns versus verbs ($p=.258$).

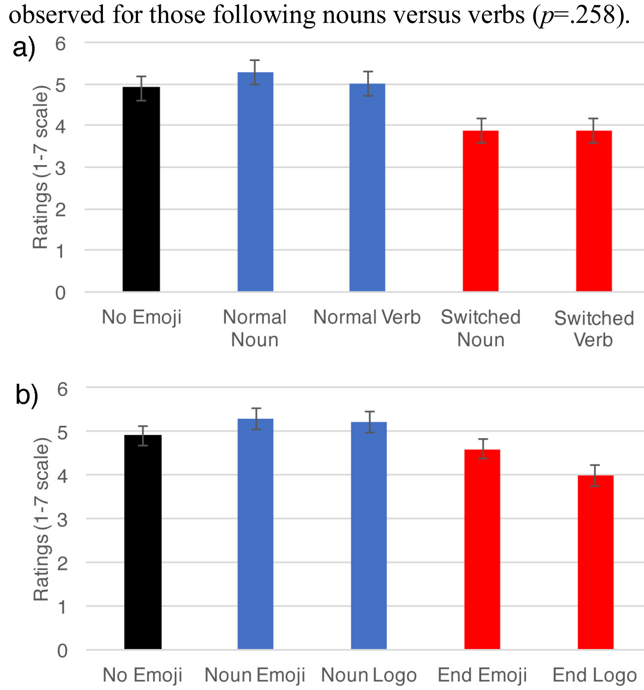

Figure 3: Ratings for comprehensibility of sentences (1=hard to 7=easy to understand) in a) Experiment 1, and b) Experiment 2. Error bars depict standard error.

A one-way ANOVA across all conditions found that comprehension scores differed across sentence types, $F(4,288)=37.1$, $p<.001$. As depicted in Figure 3a, sentences with no emoji did not differ in ratings from those with Normal Nouns or Verbs (all *p*s>.07), but these were all rated as more comprehensible than Switched emoji (all *p*s<.001). Switched Nouns and Verbs did not differ ($p=1.0$).

Finally, in our analysis of participants' accuracy we observed main effects of substitution Type, $F(1,71)=104.14$, $p<.001$, and of Category, $F(1,71)=4.90$, $p<.05$, but not an interaction between them, $F(1,71)=.33$, $p=.57$. This arose because the words substituted by emoji for Normal Nouns (96%) and Verbs (90%) were correctly recognized more accurately than Switched Nouns (56%) and Verbs (60%).

Discussion

We examined the self-paced reading times to emoji substituted with nouns or verbs in sentences, or reversed, compared to those in regular, all-textual sentences. We found that reading times were slower on the whole for emoji than for words. These findings are consistent with previous observations that overall messages were read slower if words were replaced by emoji (Gustafsson, 2017). However, reading times did not differ between normal nouns and verbs. This implies that the lexical differences between nouns and verbs do not motivate a difference in emoji comprehension. Overall, these results show that there is a cost for the online processing of images substituted into sentences.

Nevertheless, "verb" emoji switched into noun position were even slower than normal emoji. Such slowing did not occur significantly for the reverse substitutions, of "noun" emoji in verb position. One reason for this may be the aforementioned collapsing of argument and verb when using an emoji as an event/verb. Because an "emoji verb" by necessity collapses an object with an event, emoji of objects (here used as nouns) may more readily be construed in a verb role, while the reverse is less true. That is, a pizza emoji can imply eating or cooking, because those actions are done to pizza, but a cooking or heart emoji cannot imply pizza.

While we would not characterize this difference between nouns and verbs as evidence that emoji play grammatical roles, they do indicate that there are preferred positions for image-substitutions in sentences based on their semantic congruity with the words they are replacing. This is further supported by the greater accuracy for emoji substituted in positions with semantic alignment versus those in switched positions. This aligns at least somewhat with previous work finding greater processing costs for substituted images that were incongruous with their sentence context (Federmeier & Kutas, 2001; Ganis et al., 1996; Nigam et al., 1992).

In addition, these processing costs appeared to be sustained at positions after the critical word. Both types of substitutions led to slower reading times at the position after the critical word, and this maintained at still an additional word for switched emoji. This suggests that substitutions in general may have downstream effects on processing sentences. However, the attenuated reading times for words following normal emoji substitutions suggests a more rapid integration into the meaning of the sentence, while the incongruities from switched emoji persisted.

Despite these costs, ratings suggest that the overall comprehension of sentences did not suffer from normal substitutions. These findings are consistent with Potter et al.'s (1986) observation that reported comprehension does not differ largely between sentences with or without substituted images. This finding is further supported by high accuracy (>90%) for recognizing which words were substituted for normal emoji. Nevertheless, we did find that comprehension scores and word-recognition accuracy were lower for those with emoji of switched positions.

Overall, these results support that images with certain semantic content have preferential positions in sentences, while others do not.

Experiment 2: Emoji and Logos

Our second question asked whether the type of image interacting with sentence structure mattered for processing. In particular, emoji have become a well-established visual vocabulary set used in communication, but what about other highly systematic and conventionalized images that may not typically appear in a communicative context? For this, we therefore compared emoji with brand logos from established companies. Corporate logos are a distinct visual signature for companies that concisely convey that product (Foroudi, Melewar, & Gupta, 2014). This makes logos an effective comparison for emoji, in that they are both single unit pictograms with fairly entrenched lexicalized associations. Thus far, no research has compared the processing of emoji and logos in linguistic contexts. However, emoji have been looked at for their marketing potential, and companies like Burger King[1] and IKEA[2] have created emoji to promote and market their products.

In addition to manipulating the type of images, we also examined a different placement than Experiment 1. Here, emoji/logos were either substituted for words within the syntax of the sentence, or placed at the end of the sentence, after the final word. Placement of emoji at the end of sentences is more frequent than those within sentences, often with repeated meaning as in a sentence (Cramer et al., 2016; Kelly & Watts, 2015; Markman & Oshima, 2017; Zhou, Hentschel, & Kumar, 2017). Varying these positions thus allowed us to compare the processing of emoji when directly interacting with the syntactic structure (substitution) compared to being an external congruent message.

Methods

Stimuli For Experiment 2, we used the 32 base sentences from Experiment 1, including the no-emoji and normal-noun

[1]Burger King: http://shortyawards.com/8th/burger-king-chicken-fries-emoji-campaign

[2] IKEA: http://www.ikea.com/nl/nl/campagne/emoticons.html

conditions. To these, we added conditions which moved the "noun emoji" to the end of the sentence, and also used a brand logo, which appeared either as a replacement for a noun or at the end of the sentence (Table 2). Brand logos were well known in the Netherlands, and included Burger King, Apple, Starbucks, KLM, and Shell Gas, among others. These logos were balanced with emoji of a burger, a computer (resembling an iMac), coffee, an airplane and a gas pump, respectively. These stimuli were counterbalanced into 8 lists with those from Experiment 1 using a Latin Square design such that no sentence appeared twice to a participant.

Table 2: Example sentences used in Experiment 2

	Within-sentence	**End of sentence**
No emoji	John loves eating ***pizza*** every Friday.	John loves eating pizza every ***Friday***.
Emoji	John loves eating every Friday.	John loves eating pizza every Friday.
Logo	John loves eating every Friday.	John loves eating pizza every Friday.

Participants The same participants took part in Experiment 2 as Experiment 1.

Procedure The same procedures were used in Experiment 2 as Experiment 1. At the end of the experiment participants viewed a list of 44 logos including those that appeared in the experiment along with filler logos. They were asked to identify which logos they viewed in the experiment.

Data Analysis The same analysis methods were used in Experiment 2 as Experiment 1.

Results

A 2 (Position: Noun, End) x 3 (Type: No-emoji, Emoji, Logo) repeated measures ANOVA was used to analyze reading times of words and images in sentences. For the no-emoji condition at the "end of sentence" position, we analyzed reading times to the final word of the sentence.

We found main effects for both Position, $F(1,71)=17.13$, $p<0.001$, and Type, $F(2,142)=104.07$, $p<0.001$, along with an interaction between them, $F(1,128)=8.73$, $p<0.001$. As in Figure 4, these results arose because images at the end of the sentence were viewed slightly longer than those within a sentence, but both image conditions were viewed longer than the no-emoji words, but did not differ from each other.

Though comprehension ratings on the whole were very high for all sentence types (all above 4 on a 7 point scale; see Figure 3b), they did differ overall, $F(4,288)=11.2$, $p<.001$. The comprehensibility of sentences with no emoji did not differ with any other sentence types (all $ps>.316$), except for those with logos at the end ($p<.001$). Emoji and logos substituted in noun position also did not differ ($p=1.0$). However, emoji and logos substituted within sentences were rated as more comprehensible than those at the end of the sentences ($p<.001$), and emoji at the end were in turn higher than logos at the end ($p<.001$).

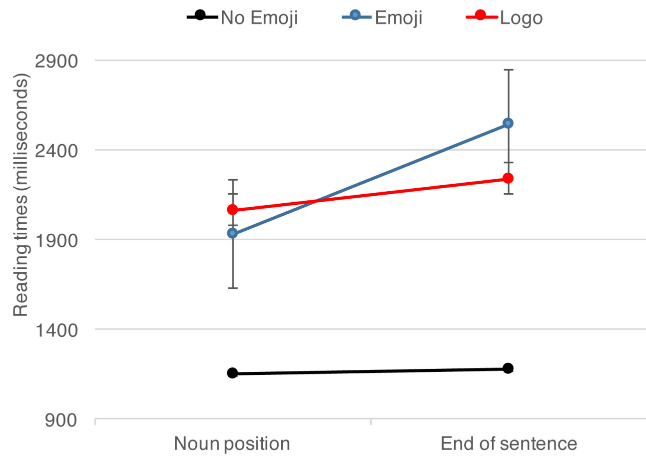

Figure 4: Reading times to critical positions in Experiment 2. Error bars depict standard error.

Finally, we examined participants' recall for which logos appeared within or at the end of sentences. Participants recalled logos that were substituted into sentences ($M=0.93$, $SD=0.16$) almost twice as accurately as logos which were placed at the end sentences ($M=0.48$, $SD=0.01$), $t(71)=-20.60$, $p<0.001$.

Discussion

This experiment compared the reading times of words in sentences with emoji and logos substituted for nouns, and with those placed at the end of sentences. Though we found that both emoji and logos were viewed longer than words, consistent with Experiment 1, we found no difference between the viewing times of emoji and logos. This implies that both emoji and logos are semantically integrated into a sentence in comparable ways, despite one being integrated into messaging systems (emoji) and the other being tied to specific branded items (logos).

Brand logos may be considered as categorically more specific than the basic level categories conveyed by emoji (e.g., Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976), and yet do not differ in reading times integrated into a sentence. It would be interesting to explore whether such specificity would create an increased incongruity compared to emoji when switched into non-noun positions (as in switched verb position in Experiment 1).

We also found that images at the final position were read significantly longer than those substituting for words. This is interesting, because emoji are commonly placed at the end of sentences in online communication (Cramer et al., 2016; Kelly & Watts, 2015; Markman & Oshima, 2017; Zhou et al., 2017). One possible reason for the slower emoji at the end of a sentence could be that they are involved in a sentence wrap-up effect (Rayner, Kambe, & Duffy, 2000). However, no such slowing was found in the final word of sentences, implying that a wrap-up alone is not at work. Rather, sentence-final images may trigger a reanalysis of the sentence relative to that image, seeking to form connections between the emoji or logo with the prior meaning in the sentence, rather than integrating it into a grammatical context, like the final word of the sentence.

General Discussion

This experiment examined the word-by-word processing of sentences involved in multimodal interactions with images like emoji or logos. On the whole, we found that there was a processing cost evident in the moment-to-moment reading times of images substituted into sentences, which was greater for those that were switched from semantically congruent positions. This is consistent with research on sentence-final substitutions of images for words (Federmeier & Kutas, 2001; Ganis et al., 1996; Nigam et al., 1992), though here we show also that substitutions had downstream costs on subsequent words in the sentence. However, these online costs for "normal" substitutions of images replacing words did not appear to negatively affect perceived comprehensibility of sentences, also in line with previous research (Potter et al., 1986). Here, we show that such comprehensibility maintains in different substituted positions (noun, verb) and with different types of images (emoji, logos). Such results suggest overall that switches between modalities may incur costs, but combined text-image interactions allow for multimodal messages perceived as a singular semantic expression.

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