Lexical processing differences between words and emoji: Evidence from neural oscillations

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Prior work on processing emoji in sentence contexts has indicated that people are generally able to integrate semantic and pragmatic information from emoji in real time; ERP studies have demonstrated that emoji in sentence contexts can elicit the same types of neural responses as corresponding words [1,2]. Other sentence processing experiments, however, have found differences between the processing of emoji and words [3,4,5]. In non-emoji research, Time frequency analysis of neural oscillations in EEG has found differences in the lexical processing of words and pictures in sentence contexts, despite qualitative similarities in N400 effects [6]. This is interpreted as evidence for modality-specific meaning processing that exists alongside a more general processing mechanism. The present study examines this idea further by systematically manipulating the constraint of the sentential context leading up to a target noun; by analyzing neural oscillations in the EEG signal, nuances undetected by ERP analysis may emerge [7]. Exploring both the similarities and differences of the lexical processing of emoji and words will elucidate the extent to which lexical processing mechanisms are modality-specific, part of a larger, modality-independent lexical representational system, or both.

Participants (N=40) read English sentences (N=160) one word at a time in RSVP. For half of the participants, the entire sentence was delivered in word form; for the other half of participants, the sentence-final noun was replaced by a corresponding emoji (Fig 1). Half of the sentences were high-constraint sentences with a Cloze task-confirmed high-expectancy sentence-final noun; half of these ended in that highly expected noun, and half of these ended in an unexpected but plausible noun. The other half were low-constraint sentences with no specifically-predicted sentence-final noun; of these, half ended in a plausible noun and half ended in an implausible noun. ERP analysis of this data [2] indicated N400 and Late Frontal Positivity effects for unexpected words and emoji in high constraint as well as an N400 effect for implausible words and emoji in low constraint. The present analysis examines neural oscillatory patterns in the same EEG data.

As we are less interested in the low-level perceptual differences between encountering words and emoji, we exclusively analyze differences of differences, comparing the word expected-unexpected difference to the emoji expected-unexpected difference. In highly constraining sentences, cluster-based permutation tests with independent t-tests indicate a significant interaction (p = 0.03), reflecting increased power in alpha/theta bands for unexpected words or, alternatively, decreased power in alpha/theta bands for words (Fig. 2); this finding emerges for words only, not emoji. No significant difference between words and emoji emerged for the plausible-implausible difference in low constraint sentences.

These findings emphasize the idea that while there are general meaning-making mechanisms that exist independent of the content's modality, there may, too, be modality-specific mechanisms at play. That the emoji-word difference (a) is itself present in the analysis of expected-unexpected differences and (b) is present in highly but not lowly constraining sentences, this difference can be clearly attributed to lexical processing rather than lower-level stimulus intake and thus indicates that lexical integration across modalities interacts with

sentential context. Theories specifying a “dual code” (i.e., both verbal and visuospatial processing) for emoji [8] or, more broadly, a multimodal cognitive architecture for language itself [9] are well-positioned to account for these word-emoji differences alongside the already-demonstrated similarities.

High Constraint Expected	The chef carved the turkey with the knife The chef carved the turkey with the 🔪	Low Constraint Plausible	Her favorite animal is the monkey Her favorite animal is the 🐒
High Constraint Unexpected	The chef carved the turkey with the scissors The chef carved the turkey with the ✂️	Low Constraint Implausible	Her favorite animal is the avocado Her favorite animal is the 🥑

Figure 1 – Example sentences illustrating the constraint conditions & sentence-final noun variations from the experiment.

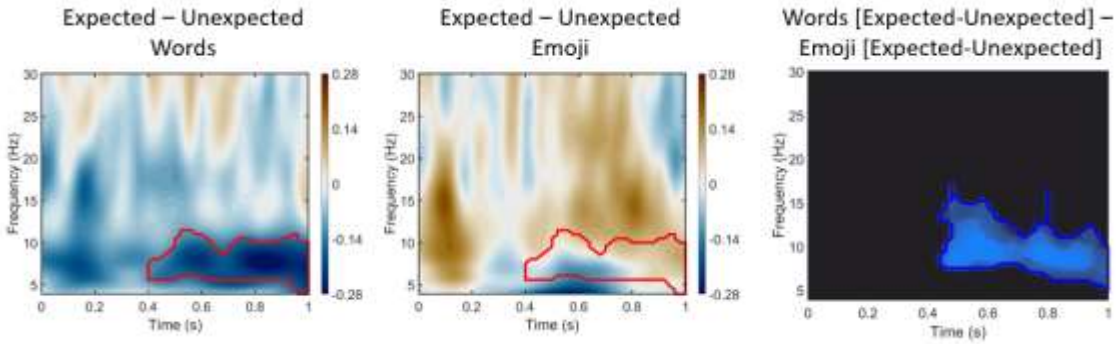

Figure 2 – Visualizations of time-frequency analyses time-locked to sentence-final noun in high constraint sentences only. Left and middle depict activity to Expected minus Unexpected nouns for words and emoji, respectively; right depicts the difference of that difference between words and emoji.

References

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