Multimodal prediction in text + emoji sentences: an ERP study

Benjamin Weissman (UIUC), Neil Cohn (Tilburg University), and Darren Tanner (UIUC)
bpweiss2@illinois.edu

Recent findings demonstrating that emojis can alter the on-line processing of a sentence (Weissman and Tanner, 2018) and interact with grammar (Cohn et al., 2018) suggest that these multimodal text-image interactions belong to an integrated system, as opposed to two separate ones. In this study, we address this issue by examining an important aspect of language processing: prediction. By examining how sentence context modulates the predictability of emojis, we explore how such interactions point towards an integrated multimodal communicative system and what aspects of emojis are anticipated during sentence processing.

A set of ERP studies (e.g., DeLong et al., 2014, Brothers et al., 2015) have examined the neural mechanisms underlying prediction by comparing expected to unexpected yet plausible completions in high constraint sentences ("The chef carved the turkey with the *knife/scissors*"). This type of completion, which makes sense in the sentence but is nonetheless unexpected, elicits a classic N400 effect and an additional late (600-900ms) frontal positivity (LFP), compared to the expected completion. Anomalous, implausible completions in low-constraint sentences ("Her favorite animal is the *monkey/avocado*"), in which prediction is less reliable and useful, elicit the N400 but not the frontal positivity.

This study consisted of two ERP experiments using stimuli in the conditions described above (and see Table 1). Experiment 1 (n=20) substituted an emoji for the sentence-final word; Experiment 2 (n=20) presented the word.

In high constraint sentences, participants demonstrated the same mis-prediction effects (N400, LFP; see Fig. 1, red) to emojis as to words, suggesting that they were predicting the upcoming emoji. This indicates that participants not only predicted upcoming lexical content (regardless of modality) but also were able to rapidly access that lexical content and update their discourse model (see e.g., Brothers et al., 2015). There was a significant correlation between N400 amplitude and cloze probability but not between N400 and visual similarity (between expected and actual emoji) nor between N400 and conceptual similarity, suggesting participants are rapidly accessing the form-meaning mappings and anticipating the lexical content of emojis.

In low constraint sentences (Fig. 1, blue), words elicited the more classically-posterior N400 effect but anomalous emojis in low constraint sentences elicited an anterior negativity more alike that found in studies that substituted line drawings for words (e.g., Ganis et al., 1996). We hypothesize that predictive/preparatory mechanisms active in high constraint sentences (e.g., Rommers et al., 2017; Wang et al., 2018) may be helping to facilitate the lexical access of emojis in high constraint, and that lessened activity of these mechanisms in low constraint may be reflected in the low-constraint differences.

The results of these experiments constitute evidence that lexical content is anticipated cross-modally and prediction is modulated by contextual effects like sentential constraint. This work contributes both to the nascent program of research on the language processing of emojis and to continuing research on prediction processes during language comprehension.

High	The chef carved the turkey with the 🔪	The chef carved the turkey with the ✂️
Low	Her favorite animal is the 🐵	Her favorite animal is the 🥑

Table 1 – Example stimuli from Experiment 1 (completions in Experiment 2 were words)
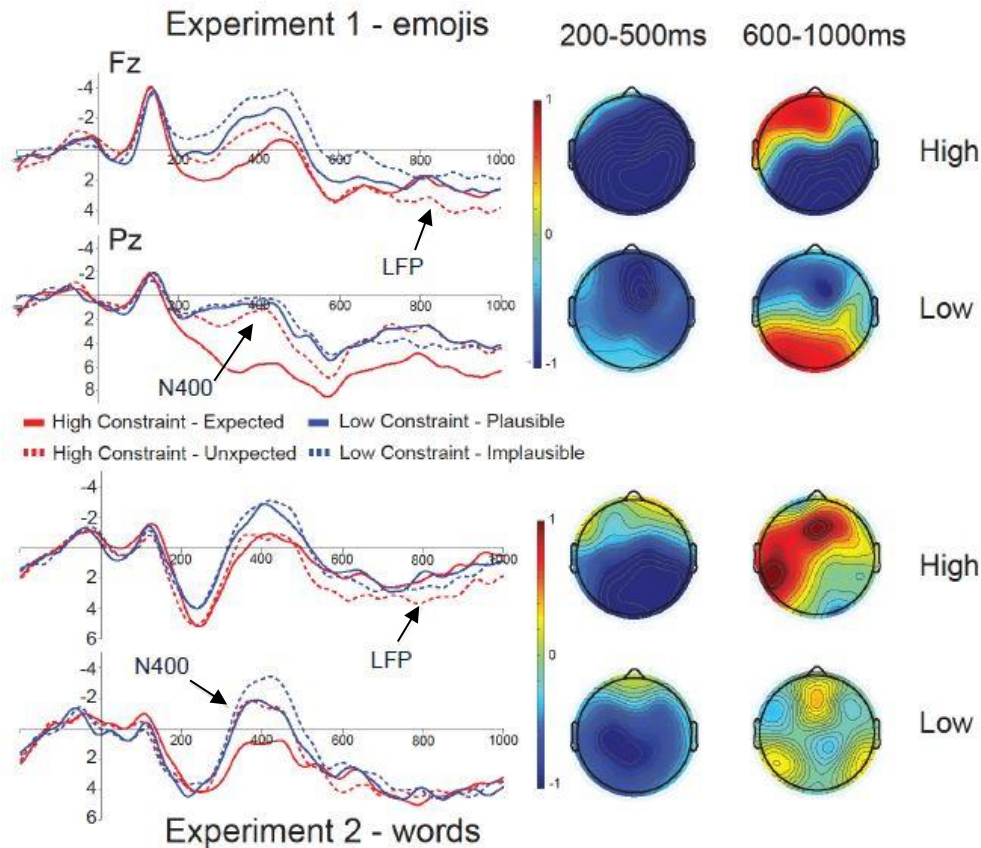

Fig. 1 – Grand mean ERP waveforms from Fz and Pz in Ex. 1 (top) and Ex. 2 (bottom) with scalp topographies in two relevant time windows on the right. Negative is plotted up.

References

Brothers, T., Swaab, T., Traxler, M., 2015. Effects of prediction and contextual support on lexical processing: Prediction takes precedence. *Cognition* 136, 135–149.

Cohn, N., Roijackers, T., Schaap, R., Engelen, J., 2018. Are emoji a poor substitute for words? Sentence processing with emoji substitutions. *Proc. 40th Cogn Sci Soc,* 1524-29.

DeLong, K.A., Quante, L., Kutas, M., 2014. Predictability, plausibility, and two late ERP positivities during written sentence comprehension. *Neuropsychologia* 61, 150-62.

Ganis, G., Kutas, M., & Sereno, M. I. (1996). The search for "common sense": An electrophysiological study of the comprehension of words and pictures in reading. *J Cogn Neurosci* 8(2), 89-106.

Rommers, J., Dickson, D.S., Norton, J.J.S., Wlotko, E.W., Federmeier, K.D., 2017. Alpha and theta band dynamics related to sentential constraint and word expectancy. *Lang Cogn Neurosci* 32, 576-89

Wang, L., Hagoort, P., Jensen, O., 2018. Language prediction Is reflected by coupling between frontal gamma and posterior alpha oscillations. *J Cogn Neurosci* 30, 432-47.

Weissman, B., Tanner, D., 2018. A strong wink between verbal and emoji-based irony: How the brain processes ironic emojis during language comprehension. *PLoS One* 13.