Minimizing prediction errors: Comprehenders rapidly adapt to morphosyntactic violations but not to semantic violations

Yano, M. (Kyushu University) Suwazono, S. (Okinawa Hospital) Arao, H. (Taisho University) Yasunaga, D. (Kanazawa University) & Oishi, H. (Ritsumeikan University)
masayano@kyudai.jp

Introduction: Recent studies of sentence comprehension have demonstrated behavioural and physiological evidence for predictive processing at various linguistic levels. Furthermore, several studies reported that comprehenders rapidly adjust their expectation to probabilistic statistics in the experiment. For example, Fine et al. (2013) found that a garden-path (GP) effect was lessened as their participants were repeatedly presented with GP sentences during a self-paced reading experiment. Nevertheless, it remains controversial whether the adaptation depends on types of prediction errors. More concretely, it is unclear whether people adjust their expectation only to *a priori* less frequent disambiguation patterns of grammatical sentences or even to ungrammatical sentences when they are repeatedly exposed to them.

Experiment: To address this issue, the present study conducted two event-related potential (ERP) experiments that examined whether people adapt to morphosyntactically anomalous sentences (Experiment 1) and semantically anomalous sentences (Experiment 2). We manipulated the probability of morphosyntactically/semantically grammatical and ungrammatical sentence occurrences through experiments. For the low probability block, morphosyntactically or semantically anomalous sentences were presented less frequently than neutral sentences (the ratio of 1 to 4), while they were presented as frequently as neutral sentences in the equal probability block. The ratio of the syntactically/semantically neutral and unnatural sentences was manipulated by intermixing filler sentences to balance the number of trials of the target sentences. The sentences given in (1) and (2) show a sample set of target sentences used in Experiments 1 and 2. The sentence in (1a) is grammatical (i.e., control condition), whereas the sentence in (1b) involves a morphosyntactic violation because intransitive verbs must mark a single argument with a nominative case ("-*ga*"), not with an accusative case ("-*o*") in Japanese. The sentence (2a) is semantically neutral, whereas the sentence in (2b) is semantically anomalous because the verb "*naita*" (cried) takes an inanimate noun as its subject (i.e., animacy violation). At the end of each trial, participants were asked to judge whether a sentence is acceptable. Forty native Japanese speakers were recruited and randomly assigned to either Experiment 1 or Experiment 2 (20 participants for each experiment). If the participants adapt to ungrammatical sentences, ERP differences between ungrammatical and grammatical sentences should decrease during the equal probability block, in which they were repeatedly exposed to ungrammatical sentences.

Results & Discussion: Experiment 1 showed a smaller P600 effect for the ungrammatical sentences in the equal probability block than the low probability block, in consistent with Coulson et al. (1998) and Hahne and Friederici (1999) (Figure 1, left). The linear mixed-effects models that included trial order as a fixed factor revealed that this smaller P600 effect resulted from an amplitude's decrease in the ungrammatical sentences and an increase in the grammatical sentences as the experiment went along (Figure 2, right). The former result is interpreted as evidence for rapid adaptation to morphosyntactic violation. As evidenced by the P600 increase in the grammatical sentences, such an adaptation, in turn, leads to a processing difficulty in the grammatical sentences. In the low probability block, on the other hand, the P600 increased during the experiment (Figure 2, left). Since the pre-verbal phrase provided useful information as to a syntactic structure of the sentence in this block, the participants incorporated this information into the predictive computation. Consequently, the processing was facilitated at the verb, attenuating the P600 amplitude of the grammatical sentences. However, such predictive processing led to a severe prediction error in the ungrammatical sentences, eliciting a robust P600. In Experiment 2, the semantically anomalous sentences elicited a larger N400 effect than the semantically neutral counterparts, regardless of the probability manipulation (Figure 1, right). Importantly, the trial order analyses did not reveal any evidence of adaptation to semantic anomalies. These results suggest that people take into consideration not only the probability of violations but also types of prediction errors (i.e., how likely a type of error might occur) in determining whether to adapt to deviant linguistic input (cf. Hanulíková et al., 2012).

(1) Experiment 1: morphosyntactic violation

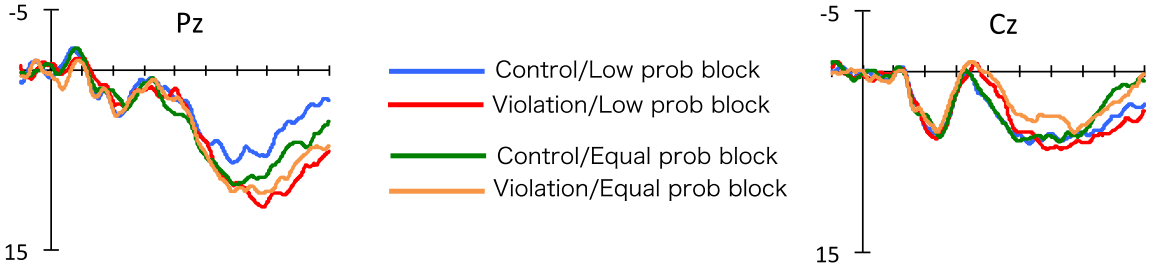
(a) bara-ga kare-ta.
rose-NOM wither-PAST
"The rose withered."

(b) * bara-o kare-ta.
rose-ACC wither-PAST
Lit. "* withered the rose."

(2) Experiment 2: semantic violation

(a) shinseizi-ga nai-ta.
Baby-NOM cry-PAST
"The newborn baby cried."

(b) shikibo-ga nai-ta.
baton-NOM cry-PAST
Lit. "??The baton cried."



Exp1: morphosyntactic violation

Exp2: semantic violation

Figure 1. Grand average ERPs of the verb in Experiments 1 (left) and 2 (right).
The x-axis represents the time duration and each hash mark represents 100 ms. The Y-axis represents the voltage. Negativity is plotted upward.

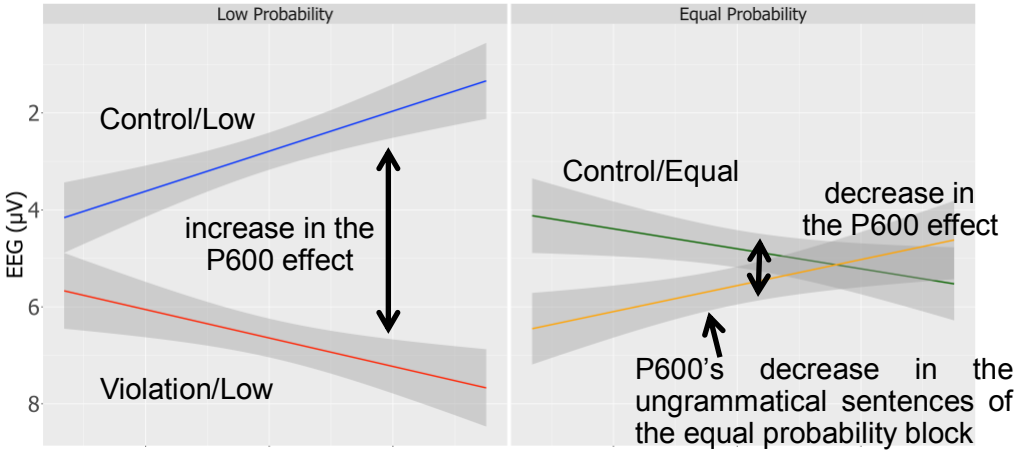


Figure 2. The P600 change during Experiment 1 (morphosyntactic violation).
The x-axis represents item order (z-scored) and the y-axis represents the amplitude of the P600 in the time-window of 700–900 ms. Negativity is plotted upward

Reference:
Fine et al. (2013) PLoS ONE, 8. doi:10.1371/journal.pone.0077661. Coulson et al. (1998) Lang Cognitive Proc, 13, 21–58. Hahne & Friederici (1999) J Cognitive Neurosci, 11, 194–205. Hanulíková et al. (2012) J Cognitive Neurosci, 24, 878–87.