

## The benefits and costs of language prediction: Evidence from ERPs

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**Introduction:** Comprehenders actively anticipate upcoming material based on context, and the facilitation effect of prediction on expected words has been associated with an attenuated N400 [1]. However, it remains unclear what neural signature indexes the processing cost when an expectation is not fulfilled. A number of recent proposals have suggested that post-N400 positivities (PNP) with an anterior-frontal scalp distribution reflecting the cost of integrating an unexpected but still interpretable word [2]. Specifically, unexpected but plausible words have been found to elicit larger frontal PNPs relative to semantically anomalous continuations [3,4]. Moreover, context constraint plays a role in modulating the processing of unexpected plausible words, with highly constrained context eliciting larger frontal PNPs relative to less constrained context [5,6]. The anterior-frontal PNPs therefore have been interpreted as reflecting comprehenders' continuous effort to update from a previously expected semantic representation to a less expected but still interpretable one [6]. While contextual expectation of an event argument is typically used to examine the prediction cost in prior work, the current study makes a parallel comparison between two predictive contexts in Chinese: the verb-noun and the classifier-noun context, with both verbs and classifiers providing predictive cues for the noun phrases. The verb-object relation is based on a set of multidimensional features rooted in rich world knowledge, whereas the classifier-noun relation is often determined by a much narrower semantic dimension (e.g. shape). The current study aims at replicating the basic patterns of PNPs from previous studies, and further shedding light on the functional interpretation of this component.

**Method:** We constructed numeral-classifier-noun and verb-noun phrases in Chinese. Within each structure, there is a strongly and a weakly constraining context for the upcoming noun, with constraint defined as the max cloze probability of the possible continuation nouns, following the basic design in [6]. Under the high-constraint context, there are three levels of cloze probabilities for the upcoming noun, and under the low-constraint context, there are two levels (see Table 1). Cloze probabilities and constraints are matched between the classifier and the verb contexts, based on a separate noun-completion norming study. Twenty native Mandarin Chinese speakers participated in the study. There are 30 items per condition.

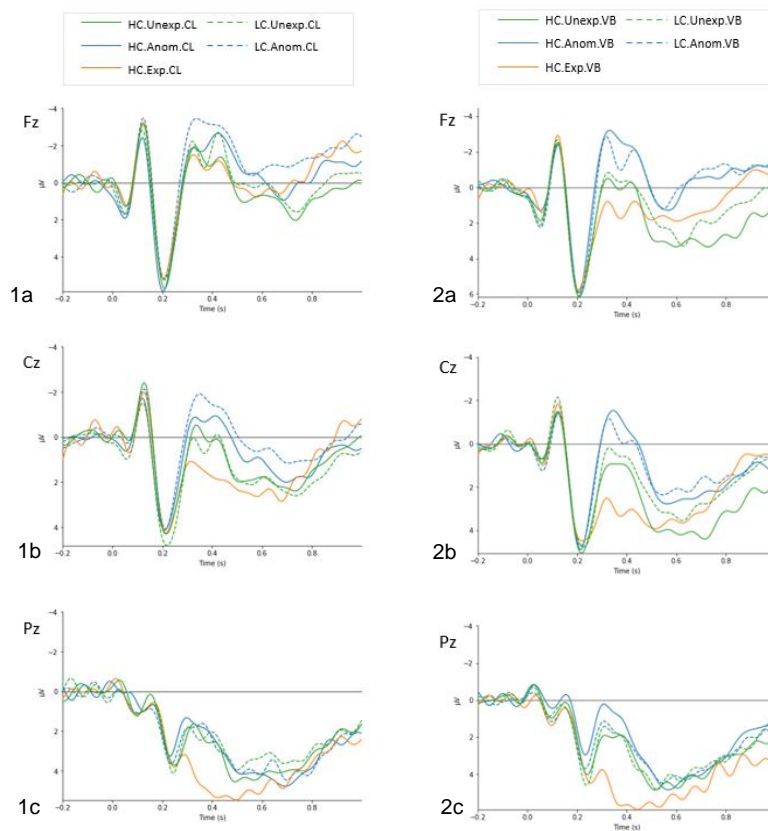
**Result:** Based on previous studies [3 - 6], our analyses focused on two comparisons: (i) a 3-way comparison based on the cloze probability of the noun, i.e. high cloze vs. low cloze vs. anomalous (zero cloze); (ii) and a 2-way comparison between the unexpected (low cloze) nouns in the high constraint context vs. those in the low constraint context. Fig. 1 shows grand-average ERP waveforms at critical electrodes. The current report focuses on the four regions (anterior to parietal, Fig. 2) around the midline electrodes. We analyzed the 300-500ms window from the onset of the critical noun as the N400 window, and the 600-1000ms window as the PNP window, using linear mixed-effects modeling. As expected, the N400 in the mid-frontal and mid-posterior regions is modulated by cloze probability (expectation) in both the classifier and verb conditions, with a larger N400 to the unexpected plausible noun than to the expected noun (CL:  $ps < .05$ ; VB:  $ps < .05$ ), and a larger N400 to the anomalous noun than to the unexpected one (CL:  $ps < .05$ ; VB:  $ps < .05$ ). In the PNP window, in the anterior and mid-frontal regions, a larger PNP effect is elicited by unexpected but plausible nouns than anomalous nouns in both classifier ( $ps < .01$ ) and verb ( $ps < .001$ ) conditions. Moreover, we found a larger PNP to the unexpected nouns in the high constraint context than in the low constraint context in the mid-frontal region. However, this effect is only present for the verb-noun structure ( $p < .05$ ), and not in the classifier-noun structure ( $p = 0.7$ ). These findings suggest that revising unfulfilled predictions in the verb-noun structure is more costly, likely due to the fact that predictions made based on verb information involve a richer set of semantic features, making it more difficult to inhibit the originally predicted representation and successfully shift to an alternative.

**Conclusion:** Examining two different structures in Chinese, we replicated previous findings that the anterior-frontally distributed PNPs index the cost of integrating unexpected but plausible words into context. More importantly, we also showed that the costs of revising unfulfilled predictions is modulated by the type of predictive cues.

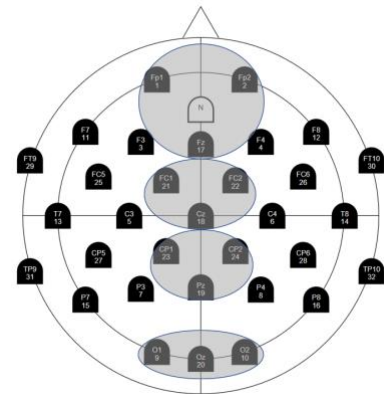
**Table 1.** Experimental stimuli. Numbers in parenthesis indicate cloze probabilities of the corresponding noun. The HC classifier example here signals an object with a flat shape, the LC classifier example signals a more generic shape.

|                   | High Constraint (HC)             |                                |                            | Low Constraint (LC)           |                             |
|-------------------|----------------------------------|--------------------------------|----------------------------|-------------------------------|-----------------------------|
|                   | High Cloze (Exp)                 | Low Cloze (Unexp)              | Anomalous (Anom)           | Low Cloze (Unexp)             | Anomalous (Anom)            |
| Classifier-N (CL) | 一扇门 (.52)<br>one-CL door         | 一扇猪肉 (.02)<br>one-CL pork      | 一扇水果 (.0)<br>one-CL fruit  | 一块蛋糕 (.02)<br>one-CL cake     | 一块水 (.0)<br>one-CL water    |
| Verb-N (VB)       | 激化矛盾 (.51)<br>intensify conflict | 激化能量 (.02)<br>intensify energy | 激化灯 (.0)<br>intensify lamp | 影响贸易 (.01)<br>influence trade | 影响时间 (.0)<br>influence time |

**Fig. 1.** Average ERP waveform from 200ms before to 1000ms after the onset of nouns following classifiers at Fz (1a), Cz (1b) Pz (1c) and verbs at Fz (2a), Cz (2b), Pz (2c).



**Fig. 2.** Midline area channels included in the data analysis, with four regions from front to the back: Anterior, mid-frontal, mid-posterior, parietal.



**Reference**

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