Mandarin classifier informativity gates prediction updating in Maze Reading

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While comprehenders are thought to continuously make predictions during sentence processing, their predictions may sometimes be incorrect. Recent research has suggested that comprehenders rapidly update their predictions in the face of prediction failures [2], but how they can do so remains unclear, with conflicting results in the current literature. One EEG study found that Italian speakers failed to use local adjectives to update their predictions after encountering prediction-inconsistent gender markers [1], while another EEG study found that Mandarin speakers can use local cues encoded in specific classifiers (CL) or adjectives to update their predictions after encountering a prediction-inconsistent CL [3]. A possible explanation for these different results is that specific CLs are more informative than gender markers, allowing Mandarin speakers to rapidly converge on a small set of candidate nouns that predictive adjectives can then usefully update over. However, the more informative the CL is, the smaller the set of candidate nouns will be, ultimately reducing the predictive value of any following adjective. To investigate this possibility, we conducted an A-maze reading study manipulating the informativeness of CLs in prediction (in)congruent contexts, followed by a neutral or predictive adjective. If CL informativity drives rapid prediction updating, we expect the benefit of predictive adjectives on target nouns be inversely related to CL informativity, with higher informative CLs reducing the usefulness of predictive adjectives.

Method. Forty native Chinese speakers participated in a word-by-word Maze reading task involving 32 experimental items and 64 fillers, where distractors were automatically generated using [4]. We manipulated global Context {congruent, incongruent} to change the congruency of the CL with the initial context-based prediction of an upcoming noun, and manipulated the local Adjective {predictive, neutral} by changing the informativeness of local semantic cues (Table 1). The informativeness of CLs was calculated using a fill-mask procedure with a pretrained RoBERTa model for Chinese [5], where a higher probability of the CL–target noun pair (CL-N Prob) indicates a more informative CL (Table 2).

Results. RTs were analyzed using linear mixed-effects models, with Context, Adjective and CL-N Prob (log-transformed) as fixed factors. On adjectives, we found main effects of Context (Est = 219.97, p = .027) and CL-N Prob (Est = -94.47, p = .012), an interaction between them (Est = 101.66, p = .005), and a marginal three-way interaction (Est = 123.98, p = .081). On target nouns, we found main effect of CL-N Prob (Est = -44.99, p = .009), interactions between Context and CL-N Prob (Est =50.75, p=.033), and between Adjective and CL-N Prob (Est =49.57, p=.018), and a marginal three-way interaction (Est=-71.15, p = .087). Post-hoc analyses on adjectives and target nouns revealed that the interaction effects on both regions were driven by incongruent contexts: For adjectives, predictive adjectives were read significantly slower than neutral adjectives at lower CL-N Prob levels (Figure 1); for target nouns, neutral adjectives elicited significantly higher RTs than predictive adjectives at lower CL-N Prob levels (Figure 2).

Discussion. The results align with previous studies on rapidly prediction updates driven by Mandarin CLs [2-3] while providing new insights into the role that CL informativity plays in this process. In incongruent contexts we found that higher informative CLs reduced the processing costs of subsequent predictive adjectives and also reduced the facilitation effects of predictive adjectives on target nouns. We proposed that highly informative CLs rapidly narrow down the set of candidate nouns when comprehenders' initial predictions are incorrect, with subsequent cues becoming less useful in updating predictions. The lack of facilitation effects for predictive adjectives in cases of very highly informative CLs [this study] and very low informative gender markers [1] may be related to theories of Uniform Information Density [6]. There may be a goldilocks zone of informativity in which local predictability is most usefully applied to smoothly update sentence contexts.

Context	Adjective	Sentences
Congruent	Predictive	Xiaoming | walked into | a beverage shop, | bought | -le | one | CL_bei | **freshly-squeezed** | de | **juice** | to | quench his thirst.
Congruent	Neutral	Xiaoming | walked into | a beverage shop, | bought | -le | one | CL_bei | **discounted** | de | **juice** | to | quench his thirst.
Incongruent	Predictive	Xiaoming | walked into | a bakery shop, | bought | -le | one | CL_bei | **freshly-squeezed** | de | **juice** | to | quench his thirst.
Incongruent	Neutral	Xiaoming | walked into | a bakery shop, | bought | -le | one | CL_bei | **discounted** | de | **juice** | to | quench his thirst.

Table 1: English translations of a sample item, with vertical bars representing word cuttings. Adjectives and target nouns are bolded.

Input	Target Word	Prob (CL-N Prob)	Log Prob (CL-N Prob)
One CL_ba [MASK].	Key	0.12	-0.93
One CL_chuang [MASK]	Cotton quilt	0.007	-2.13
One CL_zuo [MASK].	Mountain	0.002	-2.74
One CL_kuai [MASK].	Cake	0.0006	-3.26
One CL_pian [MASK].	Cloud	0.00004	-4.35

Table 2: English translations of sample inputs and outputs from the fill-mask procedure. The output represents the probability when MASK is the Target word.

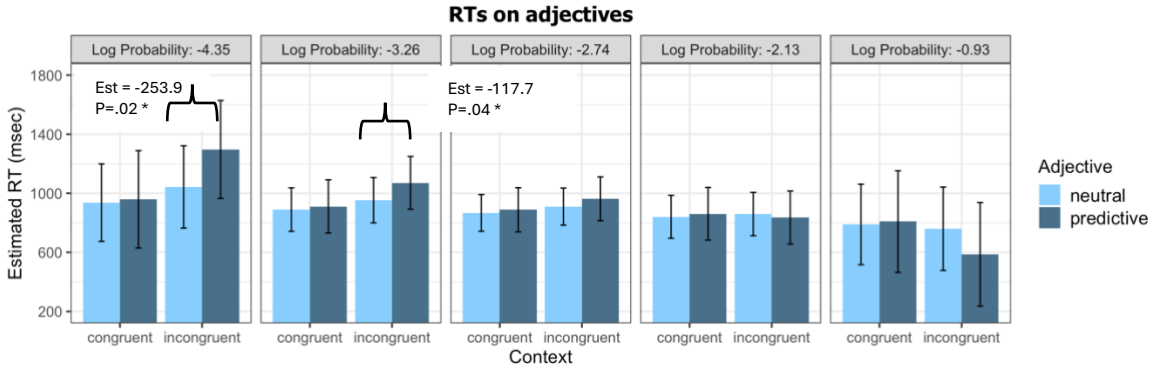

Figure 1: The effect of Informativity (CL-N Prob) and Adjective Predictability on adjectives on RTs, by Context. Figures are drawn informativity quartile (0%, 25%, 50%, 75%, 100%) and ordered from lower to higher informativity.

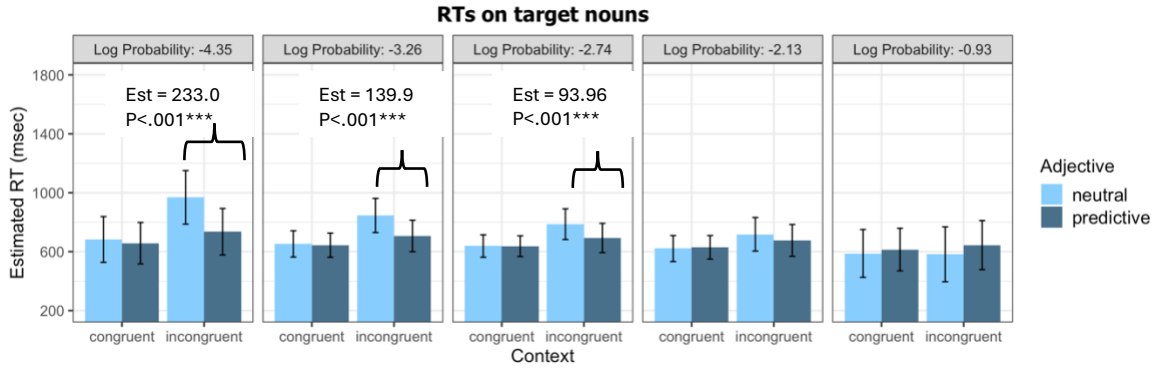

Figure 2: The effect of Informativity (CL-N Prob) and Adjective Predictability on target nouns on RTs, by Context. Figures are drawn informativity quartile (0%, 25%, 50%, 75%, 100%) and ordered from lower to higher informativity.

Reference

[1] Husband, E. M., & Bovolenta, G. (2020). *Language, Cognition and Neuroscience*, 35(3), 273-291. [2] Chow, W. Y., & Chen, D. (2020). *Language, cognition and neuroscience*, 35(9), 1149-1161. [3] Chen, K., Xia, F., Wang, S., Chow, W. Y. (2024). HSP 2024. [4] Levinson, L., Tang, Y., Chiang, L. Y.-C., Zhou, W.-J., & Chung, S. (2023). HSP 2023. [5] Zhao, Z., Chen, H., Zhang, J., Zhao, X., Liu, T., Lu, W., ... & Du, X. (2019). arXiv:1909.05658. [6] Levy, R. (2018). *CogSci*.