Task modulates predictive behaviour in constraining context: Eye-tracking evidence from a prediction error study

Yiling Huo[a], Suiping Wang[b], and Wing-Yee Chow[a]

[a]Division of Psychology and Language Sciences, University College London, London, UK;
[b]Philosophy and Social Science Laboratory of Reading and Development in Children and Adolescents (South China Normal University), Ministry of Education, Guangzhou, China

Overview

- Humans use a wide array of information to predict as well as revise / update their predictions [1, 2].
- We set out to investigate whether Mandarin Chinese speakers use tone sandhi knowledge to revise their noun predictions.
- In two visual world eye-tracking experiments, participants listened to **constraining contexts that sometimes identified an unexpected but congruous target** (1/3 of all trials).
- Listeners showed anticipatory looks to the expected object in a listening-while-looking task, but seemed to stop predicting altogether when they needed to select a (sometimes unexpected) picture under time pressure.

Experiment 1

"安妮在星巴克买了一瓶水。"
"At Starbucks, Anne bought a bottle of water."

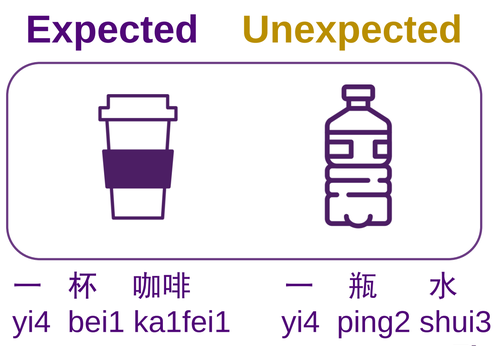

Figure 1. Experiment design.

Methods

• Participants (n=38) saw pairs of objects while listening to highly constraining sentences in Mandarin Chinese (Fig 1).

• **They were asked to select the object mentioned in the sentence ASAP**. Feedback was given per trial (Fig 2).

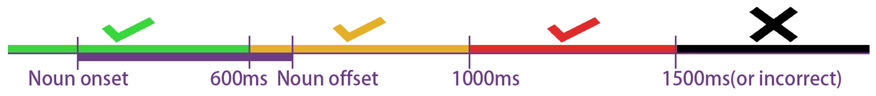

Figure 2. The traffic light feedback system in Experiment 1. RT is judged against the noun onset.

• Target noun always appeared in a numeral-classifier-noun phrase (critical NP). It identified:

  - **The expected object** (e.g., "coffee") **in 2/3 of all trials.**
  - **An unexpected but congruous object** (e.g., "water") **in 1/3 of all trials** (including all 40 experimental items).

• The experimental materials were designed to investigate whether listeners can use tone sandhi patterns to revise their noun predictions:

• We manipulated the numeral in the critical NP and the informativeness of the numeral's tone:

  - Half of the experimental items had the numeral *yi*/one (the *yi* sandhi; see Box 1 below) while the other half had the numeral *liang*/two (the T3 sandhi);
  - The tone of the numeral was informative about the target noun in the Different Tones condition but uninformative in the Same Tones condition.

> ➢ **The T3 sandhi**: in Mandarin Chinese, a T3 (dipping tone) syllable becomes T2 (rising tone) when followed by another T3 syllable.
> ➢ **The *yi* sandhi**: the morpheme *yi* 'one' is realised in T4 (falling tone) when followed by a syllable in T1, T2, or T3, but it is realised in T2 (rising tone) when followed by a T4 syllable.

Box 1. Tone sandhi in Mandarin Chinese.

Results

• Window analysis with mixed-effects logistic regression (intercept-only models) showed **no more looks to the competitor (expected) object** than the target in the pre-NP (-250-0ms), numeral, and classifier windows (Fig 3). Suggesting **no prediction of the expected noun prior to target onset**.

• Divergence point analysis using bootstrapping methods [3] did not reveal a significant difference in the onset of looks to the unexpected target between the two conditions (Fig 3).

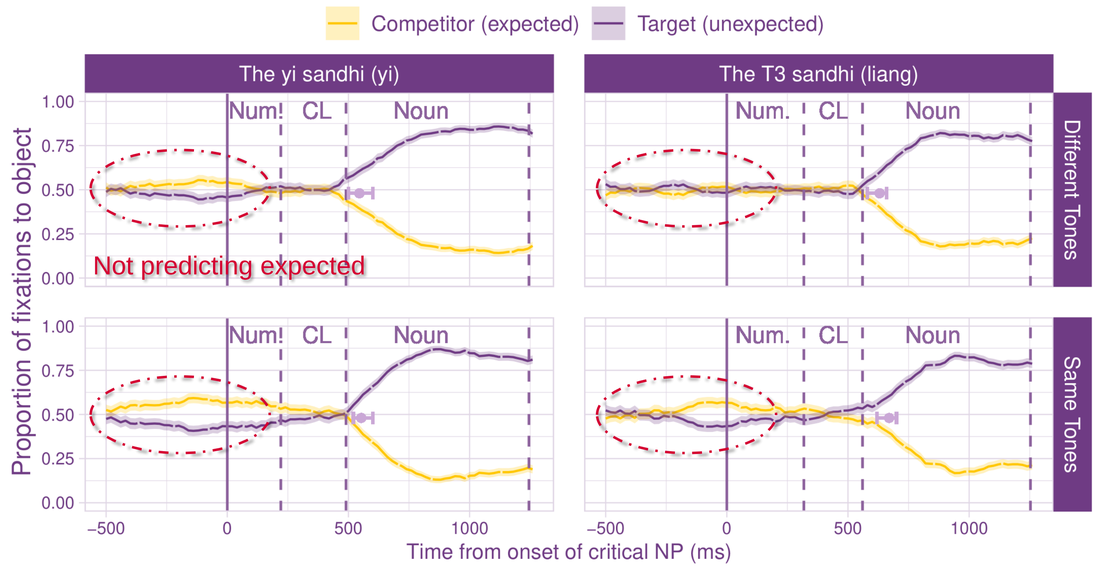

Figure 3. Proportion of fixations to each object**, Experiment 1, with picture selection task**. Light purple dots and horizontal error bars indicate the mean onset of looks to the target object and 95% credible intervals.

Experiment 2

Methods

• Stimuli are the same as Experiment 1.

• Participants (n=39) were asked to listen for comprehension, and **answer a simple Yes/No comprehension question** after 1/3 of the trials (50 fillers). Participants were not asked to select pictures.

• Feedback on accuracy was given every 25 trials.

Results

• Window analysis showed significantly more looks to the competitor (expected) object in the pre-NP (-250-0ms), numeral, and classifier windows (Fig 4), suggesting **prediction of the expected noun prior to target onset**.

• No effects of revising predictions based on tone sandhi (Fig 4).

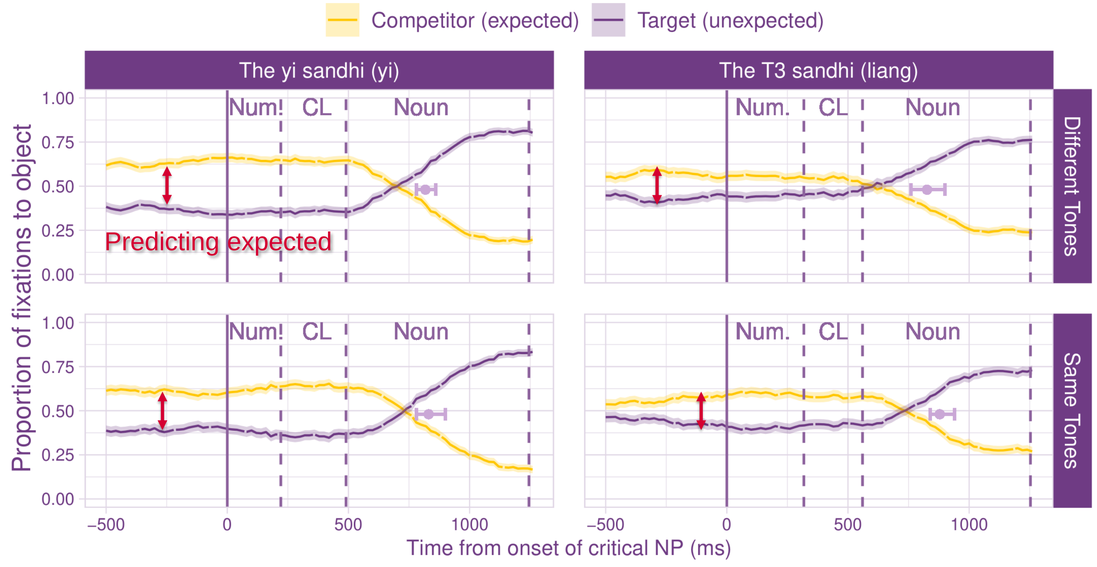

Figure 4. Proportion of fixations on each object, **Experiment 2, with passive listening (comprehension question) task**. Light purple dots and horizontal error bars indicate the mean onset of looks to the target object and 95% credible intervals.

Discussion

On task modulation of prediction:

- In the present study, the sentences were highly constraining but they ended with an unexpected noun 1/3 of the time.
- Listeners showed anticipatory looks to the expected object in a passive listening task (Exp 2), but not when they had to select the target object under time pressure (Exp 1).
- Listeners may have stopped predicting in Exp 1 because the cost of making a prediction error may be too high (having to switch from the expected to the unexpected object may cost them the "best" feedback).
- High costs of prediction errors could lead listeners to opt for a different comprehension strategy (to wait for bottom-up input).

On revising predictions:

- We found no evidence that Mandarin Chinese listeners could use tone sandhi to revise an existing prediction.

References: [1] Kamide, Y., Altmann, G. T., & Haywood, S. L. (2003). The time-course of prediction in incremental sentence processing: Evidence from anticipatory eye movements. *Journal of Memory and language*, 49(1), 133-156. [2] Chow, W. Y., & Chen, D. (2020). Predicting (in) correctly: listeners rapidly use unexpected information to revise their predictions. *Language, cognition and neuroscience*, 35(9), 1149-1161. [3] Stone, K., Lago, S., & Schad, D. J. (2021). Divergence point analyses of visual world data: Applications to bilingual research. *Bilingualism: Language and Cognition*, 24(5), 833-841.