

# Resolving different types of prediction violations during sentence comprehension: Insights from pupillometry and individual differences

Kayla Keyue Chen, Chen Lu, Xinyi Wang, Yuxuan Wu, Wing-Yee Chow

Division of Psychology and Language Sciences, University College London, London, UK  
Contact: Kayla Keyue Chen (keyue.chen.19@ucl.ac.uk)



- Much evidence has shown that contextual information can facilitate retrieval and integration of a predicted word during sentence comprehension [1-2].
- However, prediction can be wrong. Resolving different types of prediction violations may engage distinct cognitive processes [3-5].

Anna went to Starbucks to buy a cup of ...  
a) coffee    b) milk    c) ruler

b) "milk" is unexpected but plausible. Comprehenders may inhibit the expected word "coffee" to integrate "milk" into the context.

c) "ruler" is implausible and cannot be integrated into the context. Comprehenders may attempt to retrieve and reanalyse the preceding context.

- This study investigated the resolution of different types of prediction violations using pupillometry and found that different executive functions predict individuals' pupillary responses to plausible and implausible violations.

## Methods

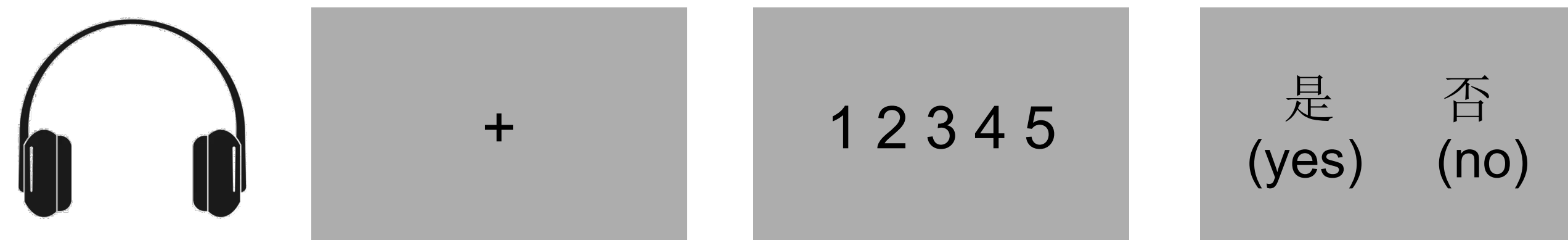
- Participants (n=57) listened to Mandarin Chinese sentences while their pupil sizes were recorded.
- They rated the plausibility of each sentence on a scale from 1 (very implausible) to 5 (very plausible) and answered comprehension questions following a quarter of the sentences.
- Subsequently, they completed five behavioural tasks to evaluate individual differences in cognitive control, working memory, and verbal fluency.

### Language comprehension task

到电影院看电影，换好电影票后，通常还会买\_\_\_\_，一边看电影一边吃。

When going to the movie theatre, after getting the tickets, one usually buys \_\_\_\_\_ to eat during the movie.

- |                           |               |
|---------------------------|---------------|
| a) Expected               | 爆米花 popcorn   |
| b) Unexpected (plausible) | 冰淇淋 ice-cream |
| c) Implausible            | 微波炉 microwave |



### Individual differences tasks

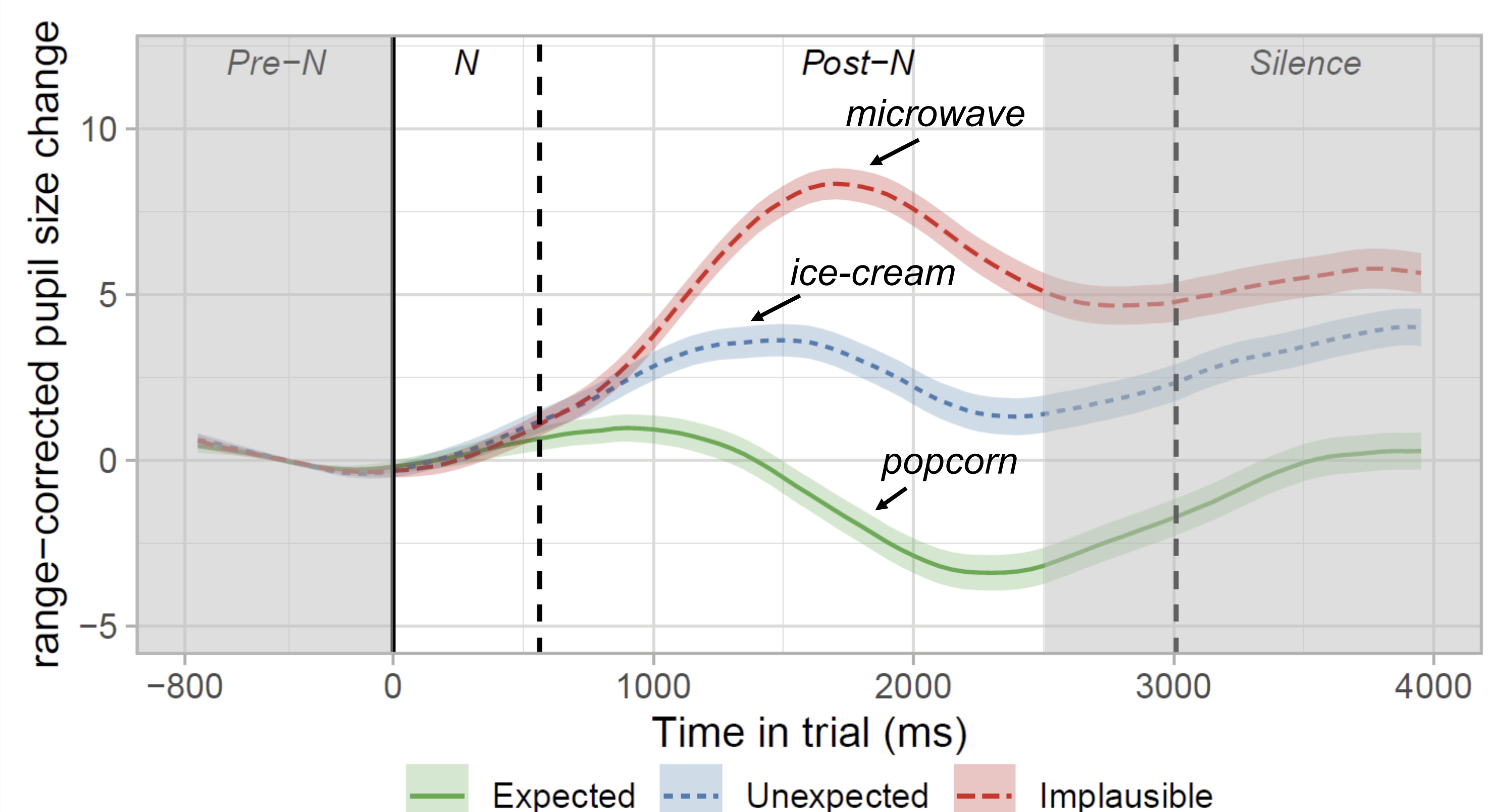
- Cognitive control
  - Chinese colour Stroop: GREEN GREEN
  - AX-CPT: A... X... A... X...
- Working memory
  - Backward-digit span: 4236 → recall: 6324
  - Phonological span: da3li4mei2 → recall: da3li4mei2
- Verbal fluency
  - Semantic category: animal, profession, food, clothing

- Pretest: Pupil size change induced by light intensity. This measured range was used to adjust pupil size measures for individual participants [6].

## Analysis

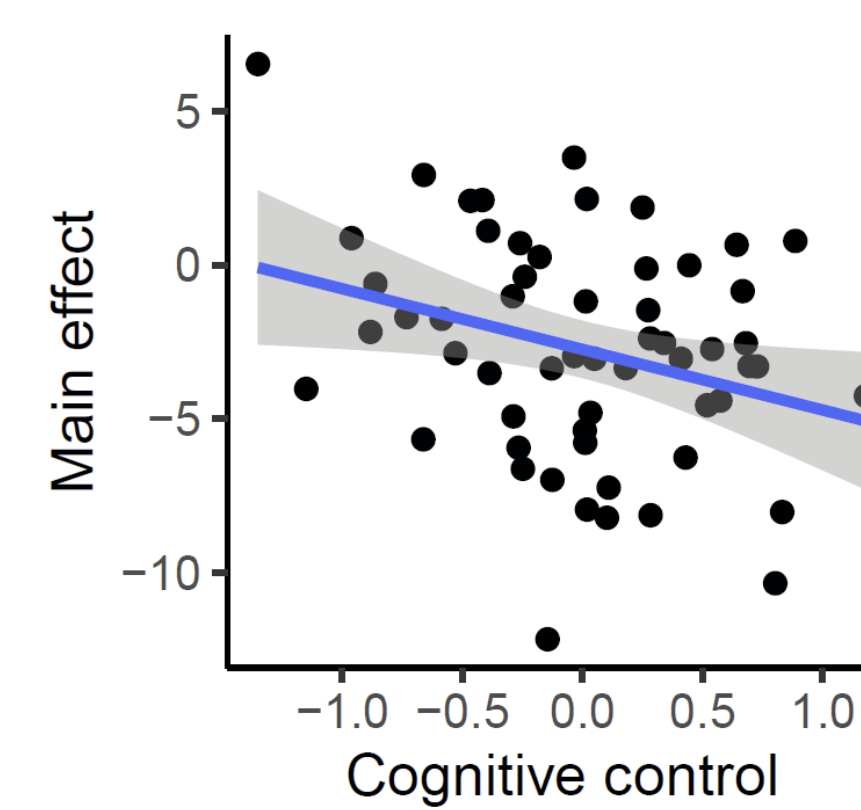
- Pupil size data in the 2500ms following critical noun onset were tested using growth curve analysis including a cubic orthogonal polynomial. Individual differences in the pupil size were retrieved from the estimated random effects of this model.
- Composite scores for cognitive control and working memory were created by first standardising all task scores, then averaging the standardised scores for each subject within each domain. Verbal fluency used standardised scores.

## Results



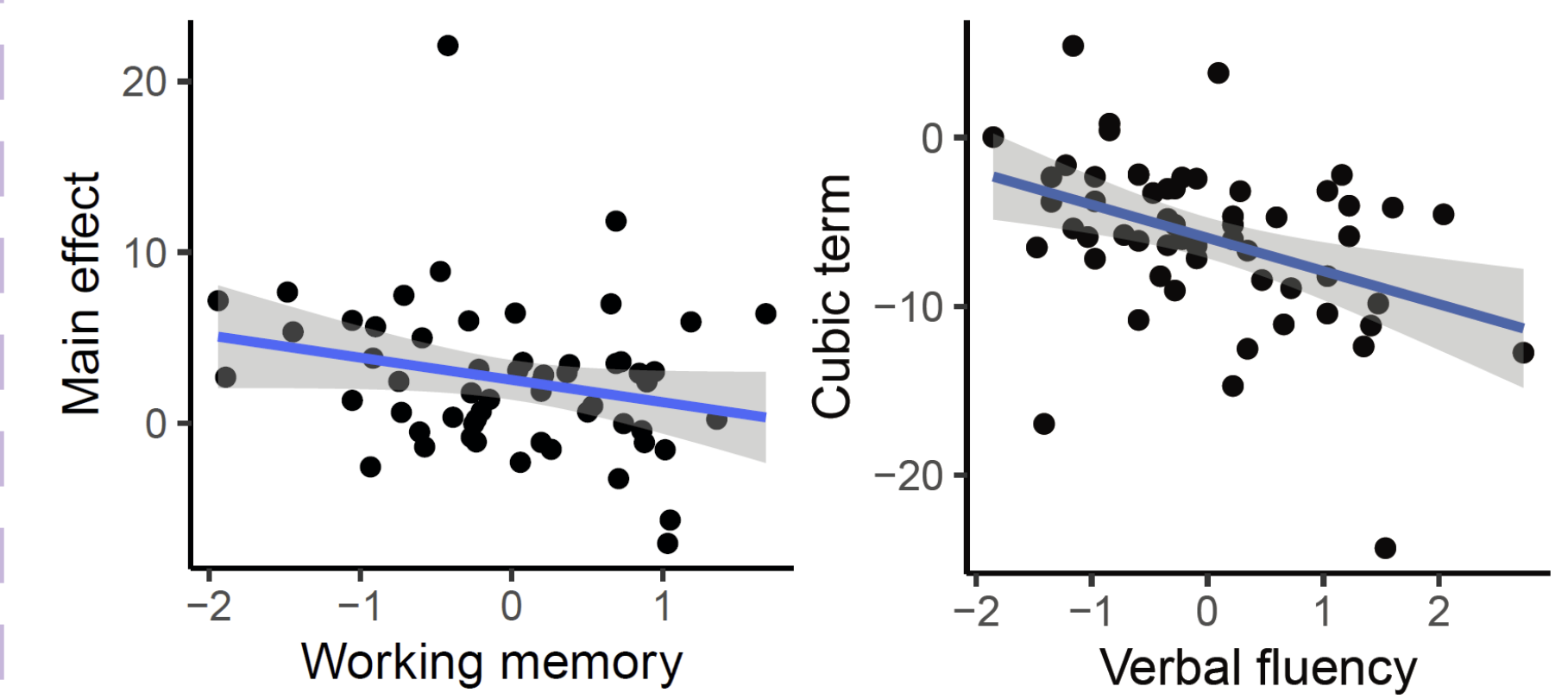
### Effect size ~ Cognitive control + Working memory + Verbal fluency

Effect of Expectancy (Expected vs. Unexpected)



Higher cognitive control ~ Larger difference in pupil size between Expected and Unexpected conditions.

Effect of Plausibility (Implausible vs. Unexpected)



Lower working memory and lower verbal fluency ~ Larger difference in pupil size between Implausible and Unexpected conditions.

## Conclusion

- We found a clear difference in pupil size change: Implausible > Unexpected (plausible) > Expected.
- This indicates that listeners experienced greater difficulty when encountering an unexpected word, and the difficulty was even stronger when the word was implausible within the sentential context.
- Results of individual differences analysis suggest that cognitive control is involved in detecting and resolving both types of prediction violations, but for the implausible one, additional cognitive processes may be required, such as detecting semantic anomalies and rapidly retrieving prior context from working memory.