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EEG correlates of covert dependency formation in Mandarin wh-questions



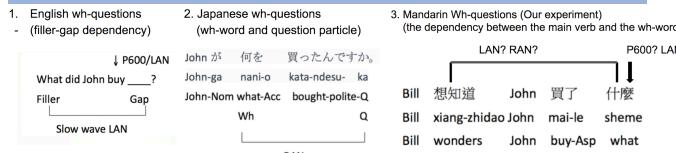
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Introduction

- Event-related potential (ERP) components like the **P600** and **LAN** are sensitive to the processes underlying how questions are understood.
- However, prior data from English and Japanese are consistent with several different functional interpretations of these components.
- P600** ERP component begins \sim 600 ms post-stimulus on the posterior scalp [2], [3]. Linked to "syntactic integration" with debate about specific functional role:
 - reactivation of the *wh*-filler?
 - thematic role assignment?
 - semantic integration between the verb and the *wh*-filler?
- LAN/RAN** ERP component is an increased negative voltage in 300-500 ms post-stimulus over the left or right anterior scalp. Associated with both storage and retention of information in working memory. [1], [4]

We use *in situ* Mandarin wh-questions to narrow down these different functional interpretations



P600 Predictions

- If it reflects integration between verb and filler, expect it at wh-word in Mandarin direct questions (IQs)
- But, if it reflects re-activation of wh-filler, do not expect it with *in situ* Mandarin questions

Sustained LAN/RAN Predictions

- Expect to see if the question-selecting main verb served as a cue and needs to be stored
- Do not expect if question-selecting verb imposes low demands on working memory

EEG Methods

Participant: N=37 native speakers of Mandarin Chinese read Chinese questions and declarative sentences word-by-word during EEG recording.

Procedure: Word-by-word reading task: yes/no comprehension question, breaks (Sessions lasted about 2 hrs)

Recording & Statistics: EEG data were recorded at 500 Hz from 61 active electrodes. Epochs around word onset were re-referenced to linked-mastoids, cleaned of artifacts with visual inspection and ICA, band-pass filtered from 0.1-30 Hz, and baseline-corrected. A non-parametric statistical analysis was conducted across all electrodes time-locked to (i) the *wh*-word, or (ii) the interval between the main verb and the *wh*-word

Stimuli

Stimuli come from four conditions: (1) **indirect questions** (2) **direct questions** (3) **declarative sentences** (4) **yes/no embedded questions**. Each condition includes both short and long versions.

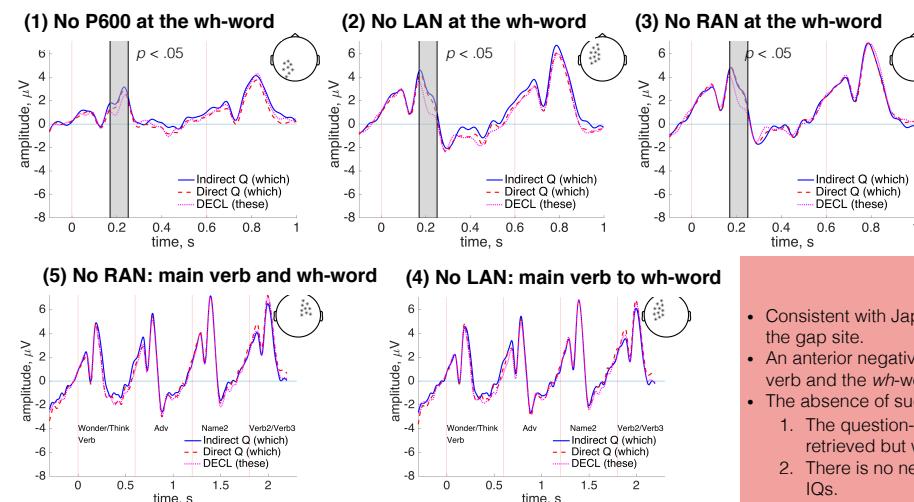
Indirect questions include a question-selecting main verb (e.g. wonder) that provides a cue for a subsequent wh-word, in contrast to **direct questions**, which include a non question-selecting main verb (e.g. think). **Declarative sentences** and **yes/no embedded questions** serve as controls.

Norming

- The main verbs were matched based on the strokes of the word, the word frequency, and the frequency of the first and the second characters.
- 64 target sentence sets were selected based on the result of an acceptability judgement norming test.

8 Lists were created (48 sentences per condition plus 120 fillers).

EEG Results



- (a) Short indirect question:**
張偉 詢問 前幾天 詠晴 開了 那些 先例
Zhangwei ask few-days-ago Yongcheng create which precedent
'Zhangwei asked which precedents that Yongcheng created a few days ago.'
- (b) Long indirect question:**
張偉 詢問 前幾天 詠晴 逼迫 錦華 開了 哪些 先例
Zhangwei ask few-days-ago Yongcheng force Chinghua create which precedent
'Zhangwei asked which precedents that Yongcheng forced Chinghua to create a few days ago.'
- (c) Short direct question:**
張偉 調查 前幾天 詠晴 開了 那些 先例
Zhangwei investigate few-days-ago Yongcheng create which precedent
'Which precedents did Zhangwei investigate Yongcheng forced Chinghua to create a few days ago.'
- (d) Long direct question:**
張偉 調查 前幾天 詠晴 逼迫 錦華 開了 哪些 先例
Zhangwei investigate few-days-ago Yongcheng force Chinghua create which precedent
'Which precedents did Zhangwei investigate Yongcheng forced Chinghua to create a few days ago.'
- (e) Short declarative sentence:**
張偉 調查 前幾天 詠晴 開了 這些 先例
Zhangwei investigate few-days-ago Yongcheng create these precedent
'Zhangwei investigated that Yongcheng created these precedents a few days ago.'
- (f) Long declarative sentence:**
張偉 調查 前幾天 詠晴 逼迫 錦華 開了 這些 先例
Zhangwei investigate few-days-ago Yongcheng force Chinghua create these precedent
'Zhangwei investigated that Yongcheng forced Chinghua to create these precedents a few days ago.'
- (g) Short embedded yes/no question:**
張偉 詢問 前幾天 詠晴 有沒有 開了 先例
Zhangwei ask few-days-ago Yongcheng have-not-have create precedent
'Zhangwei asked if Yongcheng created precedents a few days ago.'
- (h) Long embedded yes/no question:**
張偉 詢問 前幾天 詠晴 有沒有 逼迫 錦華 開了 先例
Zhangwei ask few-days-ago Yongcheng have-not-have force Chinghua create precedent
'Zhangwei asked if Yongcheng forced Chinghua to create precedents a few days ago.'

References [1] Kluender, R., M. Kutas. 1993. Bridging the gap: evidence from ERPs on the processing of unbound dependencies. *Dependencies. J. Cogn. Neurosci.* 5, 196-214. [2] Kaan, E. et al. 2000. The P600 as an index of syntactic integration difficulty. *Lang. Cogn. Processes* 15, 159-201. [3] Phillips, C. et al. 2005. ERP effects of the processing of syntactic long-distance dependencies. *Cogn. Brain Res.* 22, 407-428. [4] Ueno, M., R. Kluender. 2009. On the processing of Japanese wh-questions: an ERP study. *Brain Res.* 1290, 63-90.

Conclusions

- Consistent with Japanese covert dependencies, no P600 was found at the gap site.
- An anterior negativity was also not found between the cue "wonder" verb and the *wh*-word in IQs.
- The absence of such a negativity suggests two possibilities:
 - The question-selecting main verb is needed to be stored and retrieved but with lower processing cost.
 - There is no need to store the *wh*-filler in memory when processing IQs.

In Progress: Simulations to check for sensitivity



Questions:

- What should the topography and variance look like?
- What should the shape and variance of the latency be?
- What should the variance of the effect estimate be?