The Interpretation of Concealed Questions: MEG and Eye-tracking Data

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Introduction

This study investigated constructions where a question-selecting verb grammatically combines with an entity-denoting NP, which can be paraphrased as a covert question (e.g. *John knew the name ~ John knew what the name was*). We examined the hypothesized processing cost of this semantic mismatch with eye-tracking and magnetoencephalography (MEG). Complement coercion (*the author began the book*) has been hypothesized to involve similar semantic repair mechanisms to concealed questions and has been shown to (a) be behaviorally costly and (b) engage increased amplitudes in an Anterior Midline Field in MEG. Our study addressed whether concealed questions are also behaviorally costly and affect AMF amplitudes.

Materials and Methods

Question-selecting verbs were contrasted with non-question-selecting verbs in passive sentences. Critical verbs were matched for lexical level factors as well as in their similarity to the preceding contexts (LSA measures).

CQ: The name of the furry animal was **learned** by the young students

Control: The name of the furry animal was **spelled** by the young students

Eye-tracking

Subjects: 40 native English speakers. ***Stimuli:*** 28 items. ***Eye-tracker:*** Eyelink I headmounted eye-tracker, 250 Hz sampling rate ***Regions for analysis:*** Verb region & Spill-over region (= next two words) e.g., The name of the furry animal was **/ learned/ by the/** young students.

MEG

Subjects: 16 native English speakers. ***Stimulus presentation:*** Word by word, 300ms on, 300ms off. ***Task:*** Off-line sensicality judgment. ***MEG recording:*** 148-channel neuromagnetometer (4-D Neuroimaging, Magnes WH 2500). Sampling rate: 678 Hz. Recording band: .1- 200Hz. ***Data analysis:*** A multiple-source model, BESA (Brain Electric Source Analysis), was applied to all MEG activity elicited at -100 to 800 ms from stimulus onset.

Lexical decision control experiment

In order to assess whether any observed effect of question concealment could be due to lexical-level differences between the two different verb types, the critical verbs were also presented to the subjects in isolation in a lexical decision task.

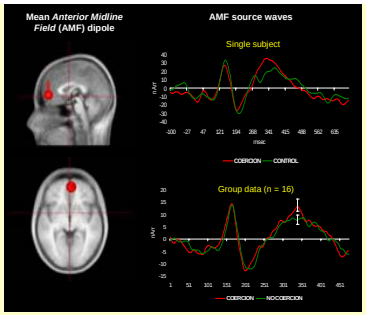
MEG background: AMF Effect of Complement Coercion

In an earlier MEG study, Pylkkänen, Llinas & McElree (CUNY 2005, submitted) investigated the neural bases of complement coercion, which involves a semantic mismatch between an event-selecting verb and a non-event denoting argument.

Coerced: ***The professor began the book before his evening tea.***

Control: ***The professor read the book before his evening tea.***

Complement coercion was found to elicit increased amplitudes in the ***Anterior Midline Field (AMF)***, generated in ventromedial prefrontal cortex and hypothesized to reflect nontransparent semantic composition.

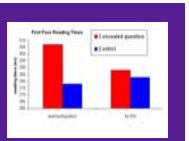


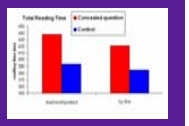
➢ ***Representationally, concealed questions and complement coercion have both been hypothesized to involve type-shifting. If the mechanisms of interpreting concealed questions are indeed similar to those of complement coercion, concealed questions should also elicit increased AMF amplitudes.***

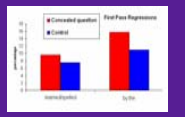
Eye-tracking Results

Question-selecting verbs incurred early processing costs over controls on the verb region.

- ➢ Reliable effect of question concealment in verb region (t1 = 3.14, p=.003; t2 = 2.67, p = .01) for first-pass duration.
- ➢ Reliable effect of question concealment in verb region (t1 = 2.19, p =.03; t2 = 1.89, p = .07) for total reading time.
- ➢ *No* reliable effect for first-pass regressions.
- ➢ *No* reliable effect for spill-over regions.



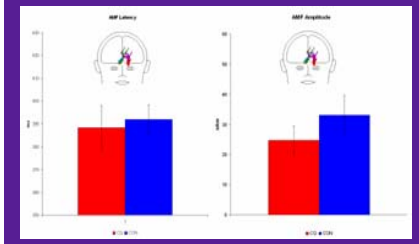




MEG Results: Concealed Question Composition Distinct from Coercion

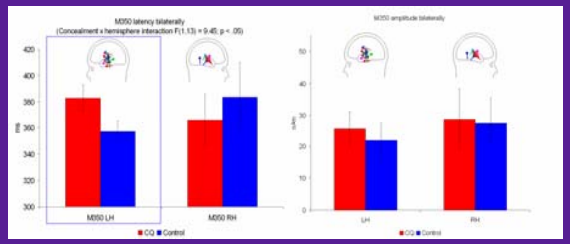
The off-line sensicality judgments collected during the MEG measurement showed no effect of question concealment (M = 770.94, SD = 292.90) over controls (M = 800.54, SD = 328.61) , p=.49, suggesting that the two types of sentences did not differ in sensicality. Accuracy was identical (84%) for each condition.

No AMF effect



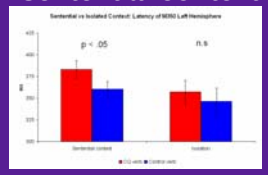
➢ In contrast to complement coercion, question concealment did not modulate AMF amplitudes.

Left-lateral M350 effect



➢ CQ verbs displayed a latency delay for the M350 left hemisphere source, an area associated with lexical access (Embick *et al.*, 2001, Pylkkänen and Marantz, 2003), over controls. There was also a trend towards increased left hemisphere M350 amplitudes for CQ verbs.

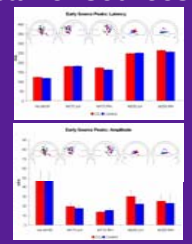
M350 effect limited to sentential context



Lexical Decision Control

➢ Critical verbs did *not* exhibit a latency effect in isolation, suggesting that the M350 effect depends on a semantic mismatch between the object and verb.

No effect in earlier sources



➢ Critical verbs did *not* show either amplitude or latency differences over controls.

Conclusion

Like complement coercion, concealed questions were found to be behaviorally costly. However, they elicited a distinct MEG effect from the AMF effect reported for complement coercion. Our results are consistent with the hypothesis that concealed question interpretation involves a lexical-level operation triggered by semantic mismatch, qualitatively distinct from the type invoked for complement coercion. Our localization of the cost for the semantic resolution of concealed questions left laterally is broadly compatible with a previous coercion study involving aphasic patients (Piñango and Zurif, 2001) and suggests that multiple regions may be active in semantic composition and repair.