

An fMRI study of contextual effects on quantifier scope ambiguity resolution in Swedish

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Background: There are aspects of quantifier scope ambiguity (QSA) phenomena that still have not been well-explored experimentally. Consider sentences such as *every child climbed a tree*, which has a singular reading (there is one tree) and a plural reading (every child has their own tree). In the absence of context, the preferred reading is informed by background knowledge. We can alter the preferred reading by providing context which reinforces or conflicts with that background knowledge – providing *we asked the children to line up in front of the oak* would produce a singular reading when ordinarily a plural reading would be selected. A number of languages (e.g., English, Swedish) license QSA in the presence of particular grammatical structures. Potential ambiguities are relatively common in every day language use [2]. Even though there can be multiple interpretations of a given QSA sentence, there will usually be a preferred interpretation that is easily accessed from local context or background knowledge. The existence of QSA phenomena gives us the ability to test the effect of contextual manipulations of expected number. Previous work involving quantifier scope ambiguities in English using the ERP modality found a tendency towards posterior medial activation [1] in plural conditions and fronto-central activations in singular conditions, although this work manipulated the QSA-bearing sentence itself rather than the context. We employ fMRI to obtain a more precise localization relative to contextual effects and background knowledge.

Method: 29 Swedish-language stimuli (14 singular context, 15 plural context, Fig. 1) were taken from a previous online behavioral experiment (in prep.) with a number-biasing context sentence (always involving a group of tourists) and a critical (QSA) sentence. 32 participants (first language Swedish) were recruited to participate in a functional MRI experiment. The stimuli were presented as audio recorded by human voice actors and presented with distractors and in blocks alternated with another experiment. Every stimulus was followed by a text prompt asking for a singular or plural interpretation (e.g., one or more hamsters) to be delivered via button box.

Results: Functional imaging data (Fig. 2) were analyzed in SPM using a general linear model including regressors for the context utterance, QSA utterance, question prompt, response period, and fixation. All events except fixation were modeled separately for singular, plural, and distractor conditions. The contrast comparing singular-prompted relative to plural-prompted QSA utterances revealed a predominantly left lateralized network extending from the anterior temporal lobe into the middle temporal gyrus, superior temporal gyrus, temporo parietal junction (TPJ), and inferior parietal cortex.

Discussion: Left-sided temporal activation matches well-established previous understanding of brain localization in language processing. However, the significant result only pertains during the ambiguous sentence when there is a singular-biasing context. Previous theoretical and behavioural studies in the syntax-semantics interface [3, 4] suggests that singular readings in *every child climbed a tree* should require more cognitive effort than plural readings. In the present study, the biasing context forces that singular reading, leading to the observed activation pattern, at least for speakers of Swedish. Further results include analysis relative to participant response accuracy.

References

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- [3] Eddy G Ruys and Yoad Winter. Quantifier scope in formal linguistics. In *Handbook of Philosophical Logic: Volume 16*, pages 159–225. Springer, 2010.
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Figures and tables

Figure 1: Example of Swedish stimuli with English translation.

Singular context sentence:

"Turisterna passerade väldigt liten bur." (The tourists passed a very small cage.)

Plural context sentence:

"Turisterna passerade den väldigt stora djuraffären." (The tourists passed a very big animal shop.)

QSA sentence:

"Varje turist såg en hamstere." (Every tourist saw a hamster.)

Figure 2: Example view of significant voxels after regression analysis for the singular condition vs. the plural condition during the QSA sentence.

