

Every quantifier scope ambiguity is enabled by a context

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1 Introduction

The sentence "every road leads to a town" entails a *quantifier scope ambiguity* (QSA; Kurtzman and MacDonald, 1993; Dotlačil and Brasoveanu, 2015), i.e., there is either one town (singular) or different towns (plural). A pilot study shows 16 of 20 Swedish speakers make a plural interpretation of this sentence.

This study concerns the competitive effects of syntactic factors and the larger pragmatic context on QSA resolution in Swedish. Most previous work is in English¹. Experimental studies can shed light on the real-time mechanisms involved in QSA resolution.

Ambiguities are common in every day language use (Koller et al., 2010). The role of context in ambiguity resolution is more or less a linguistic truism (Mey, 2003); a language user uses contextual factors to interpret ambiguous sentences. Much of the previous work has focused on manipulations of the order of the quantifiers (Kurtzman and MacDonald, 1993). Less attention has been given to the effect of a previously described scenario serving as a context for the experiment participant to interpret the ambiguous target sentence; that is, whether prior context can overcome biases².

QSA resolution can be sensitive to syntactic variation (Sayeed et al., 2019). The syntactic factor explored in this study is grammatical gender. The final word of the QSA sentence (*every road leads to a town*) is marked for indefiniteness. The Swedish indefiniteness markers are the articles *en* or *ett*, which correspond to the two grammatical genders UTRUM and NEUTRUM. Both articles are also the number words for *one* (1). The neutrum form *ett* has stronger numerical qualities.

The QSA that is investigated in this study stems from the quantifier *varje* (*every*, in English). A previous study examining the neurological foundations of quantifier interpretation has found that quantifiers activate areas of the brain associated with numeracy (McMillan et al., 2005). This finding suggests a cognitive basis for the interpretation of quantifiers that could extend to grammatical markers.

¹Exceptions exist, such as Sayeed et al. (2019) and Radó and Bott (2018) for German or Scontras et al. (2014) for Chinese.

²One exception is Villalta (2003), who manipulated the order of information presentation in a larger contextual scenario before testing the interpretation of *how many* questions with scope ambiguities. Her manipulation was not focused on the lexical-pragmatic aspects of the scenario as in our study.

We pose the following two questions: (1) can the interpretation of QSA be controlled by non-determinative contextual information, and if so, to what degree?, and (2) is the interpretation of QSA in Swedish affected by the grammatical gender of the indefinite noun?

We expect that plural contexts will prompt more plural readings of a QSA sentence and vice versa. We also expect that plural contexts with the NEUTRUM gender will show a greater number of singular readings, compared to plural contexts with the UTRUM gender, due to the additional role of the NEUTRUM marker as the cardinal number one.

2 Method

A total of 28 Swedish speaking participants took part in the experiment. All had Swedish as their first language and were above the age of 18.

2.1 Stimuli

The experiment was a forced choice judgement task (20 critical trials and 10 distractors) via the online platform Pavlovia. Participants were asked to imagine that the following two sentences were spoken by a friend. First there was a contextual sentence, establishing connotations to either a singular or plural reading of the critical sentence, and then a critical sentence with the structure: *varje turist såg en X (=every tourist saw an X)*. Each critical sentence had two versions, with either UTRUM or NEUTRUM gender. A final question followed the critical sentence: *What do you assume your friend means, did every tourist see the same X?*

2.2 Data analysis

We conducted a multilevel logistic regression analysis, with random intercepts for participants, using the *glmer* function of the *lme4* package (version 1.1-35.3) in R. The analysis follows the equation:

$$\text{logit}(P(y_{ij} = 1)) = \gamma_{00} + \beta_1 \text{SIN}_{ij} + \beta_2 \text{UTR}_{ij} + u_{0j}$$

γ_{00} is the fixed intercept (overall average intercept). β_1 is the fixed effect (slope) for the context predictor (SIN). β_2 is the fixed effect (slope) for the gender predictor (UTR). u_{0j} is the random intercept for participant j , representing the participant-specific deviation from the overall intercept.

In the analysis, every trial is analyzed as an individual observation (N=560). The binary dependent variable is the QSA reading (plural = 0, singular = 1) and the predictors are the two conditions contextual sentences and grammatical gender. The results are presented as odds ratios (OR; Szumilas, 2010).

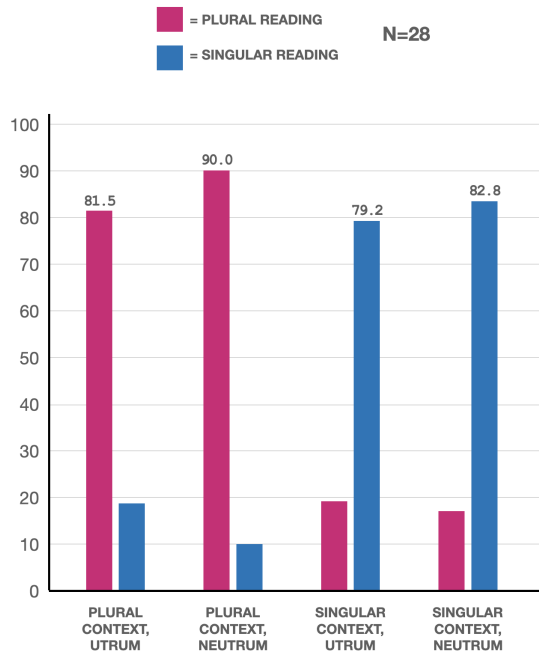


Figure 1: Percentages of QSA interpretations for each combination of conditions. Contextual condition provides substantial effects on QSA interpretations.

3 Results

The results show that every critical sentence was subject to both singular and plural readings. Results are shown in Figure 2. The multilevel logistic regression analysis showed an effect of context condition, but not of grammatical gender (Table 1).

The singular readings per participant had a mean of 9.40 and a SD of 3.58. 9 participants had 10 singular readings during the experiment, which is equal to the total amount of singular contexts. 2 participants had 2 singular readings during the experiment. 1 participant had 19 singular readings during the experiment.

4 Discussion

The results show a substantial effect of contextual information on participants' interpretations, affirming our hypothesis. The multilevel logistic regressions analysis show significant between-participant variability in the baseline log-odds of singular readings, as indicated by the variance of the random intercepts (.73). We see variation in the data. Among the 20 critical trials, two participants made 18 plural readings, while another participant made 19 singular readings. Given the relatively

ODDS RATIOS FOR SINGULAR READINGS

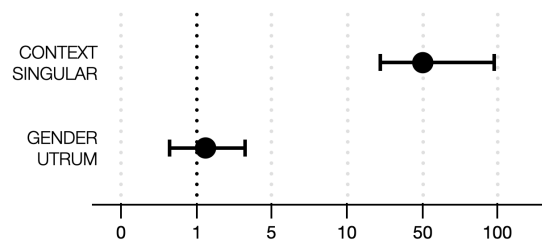


Figure 2: The Odds Ratios result for singular readings of QSA sentences show a sizable effect of contextual sentences, OR = 50.20, 95%CI[24.32, 103.65]. The results show no reliable effect for grammatical gender, OR = 1.26, 95%CI[.69, 2.31].

	Est.	St.Er	z	p
Intercept	-2.19	.36	-6.05	<.001
contextSIN	3.91	.36	10.58	<.001
genderUTR	.23	.30	.76	.43

Table 1: The results from the multilevel logistics regression analysis. Binary predictors and the results list effects of singular conditions for contextual information (contextSIN) utrum conditions for grammatical gender (genderUTR).

modest sample size of the current study, there is reason to speculate that some individuals might consistently favor one type of reading across all trials.

These results provide an insight into the intricate nature of ambiguity resolution; it shows that language users that exhibit strong preferences for QSA interpretations still deviates from their preference given certain contexts.

The grammatical gender conditions did not show a reliable effect in the logistic regression analysis. A detectable trend goes in the opposite direction of the hypothesis. One potential explanation for this trend could be the additional cognitive load created by this potential indecision about whether to introduce a new discourse referent instead prompts the processor to rely more on contextual cues, favoring the plural interpretation. This would be in line with previous findings Dwivedi (2013).

One direction for future experimental research is to focus on how QSA interpretation relates to e.g. lexical ambiguity, while simultaneously taking measures to increase the ecological validity of the experimental tasks.

The implication of this work for research into computational representations of language interaction is that there is a fine-grained connection between the "nitty-gritty" of the syntax-semantic interface, lexical-pragmatic knowledge, and the immediate context.

References

- Jakub Dotlačil and Adrian Brasoveanu. 2015. The manner and time course of updating quantifier scope representations in discourse. *Language, Cognition and Neuroscience*, 30(3):305–323.
- Veena D Dwivedi. 2013. Interpreting quantifier scope ambiguity: Evidence of heuristic first, algorithmic second processing. *PloS one*, 8(11):e81461.
- Alexander Koller, Stefan Thater, and Manfred Pinkal. 2010. Scope underspecification with tree descriptions: Theory and practice. *Resource-Adaptive Cognitive Processes*, pages 337–364.
- Howard S Kurtzman and Maryellen C MacDonald. 1993. Resolution of quantifier scope ambiguities. *Cognition*, 48(3):243–279.
- Corey T McMillan, Robin Clark, Peachie Moore, Christian Devita, and Murray Grossman. 2005. Neural basis for generalized quantifier comprehension. *Neuropsychologia*, 43(12):1729–1737.
- Jacob L Mey. 2003. Context and (dis) ambiguity: a pragmatic view. *Journal of Pragmatics*, 35(3):331–347.
- Janina Radó and Oliver Bott. 2018. What do speaker judgments tell us about theories of quantifier scope in German? *Glossa: a journal of general linguistics*, 3(1).
- Asad Sayeed, Matthias Lindemann, and Vera Demberg. 2019. Verb-second effect on quantifier scope interpretation. In *Proceedings of the Workshop on Cognitive Modeling and Computational Linguistics*, pages 134–139.
- G. Scontras, M. Polinsky, E. C.-Y. Tsai, and K. Mai. 2014. Chinese scope: an experimental investigation. In *Proceedings of Sinn und Bedeutung 18*, Vitoria-Gasteiz, Spain.
- Magdalena Szumilas. 2010. Explaining odds ratios. *Journal of the Canadian academy of child and adolescent psychiatry*, 19(3):227.
- Elisabeth Villalta. 2003. The role of context in the resolution of quantifier scope ambiguities. *Journal of Semantics*, 20(2):115–162.