Symmetrical Or Not?: A New Method To Probe Real-Time Semantic Categorization

Uğurcan Vurgun[1], Heesu Yun[1], Barbara Landau[2], John Trueswell[1]

Introduction: Symmetry, a fundamental concept in cognition and the natural world, poses an interpretative challenge due to the disparity between its formal definition and linguistic expression. The logical definition (e.g., "if A is related to B, then B is related to A") is often distorted when expressed linguistically, such that e.g., 'North Korea is similar to Red China' is interpreted differently from 'Red China is similar to North Korea' despite their logical equivalence (Tversky, 1977). Gleitman et al. (1996) offer evidence that this interpretive asymmetry stems from the syntactic positions of arguments, such that symmetry is restored when both arguments are on equal syntactic footing (e.g., a Conjoined NP Intransitive, “North Korea and China are similar”). Here a novel eye-tracking method tested how syntax and lexical semantics contribute to the symmetry interpretation. Syntax had rapid effects, modulated by lexical semantics.

Experiment: Forty-one undergraduates, all native speakers of English, participated. During the Training Phase (Fig1), participants were introduced to a sorting task designed to highlight the concept of symmetry. Participants were trained to place videos depicting symmetrical activities into a folder marked with a symmetrical image, and videos of non-symmetrical activities into a folder marked with a non-symmetrical image, via mouse clicks. Then during a Test Phase, participants sorted spoken auditory sentences into the folders via clicking without feedback. Eye movements were recorded with a Tobii X300. Target sentences (N=24) were either Transitive or Intransitive and contained either a Symmetrical or Non-Symmetrical verb (Fig2). All analyses used generalized linear mixed-effects models with random effects for subjects and items.

Findings. *Folder choice:* The participant’s selection of the Symmetric folder was influenced by a combination of lexical semantics and sentence structure (Fig3A). Transitive sentences led to less symmetrical choices overall ($z=14.864$, $p<0.001$), with this effect of Syntax interacting with Verb Symmetry ($z=2.332$, $p=0.0197$), such that Transitive sentences showed more symmetrical choices when the verb was Symmetrical as opposed to Non-Symmetrical. *RT*: Processing difficulty was observed for Transitive Sentences containing a Symmetrical verb as compared to other sentences (Fig3B) resulting in a reliable interaction between Syntax and Verb Symmetry ($p<0.001$); this suggests conflicting support for symmetry in this condition. *Eye gaze*: Looks to the symmetrical folder were plotted from sentence onset (Fig4) and analyzed for regions of reliable effects and interactions using cluster-based permutation tests. For Syntax, a significant cluster was found from 1250 to 4450 ms ($p=0.001$), indicating a strong syntactic influence on eye gaze during this interval. Verb Symmetry and Syntax interaction was significant from 1800 to 4450 ms ($p=0.001$). These results reveal a striking interplay between syntax and semantics, demonstrating that while syntax primarily guides initial interpretations of symmetry, lexical semantics also plays a significant role, particularly in transitive constructions.

Conclusion: While symmetrical terms (e.g., "meet", “agree”) contain symmetrical semantics, syntax can introduce asymmetries in meaning (Gleitman et al., 1996). Using a novel measure of real-time commitment to this abstract notion of (non-)symmetry, we find contributions of syntax and lexical semantics. Commitments to symmetry based on syntactic evidence emerge as soon as the parsing mechanism can extract such evidence. A limitation is that our results may also reflect broader judgments (“joint vs. single-actor activities”), not just symmetry. Follow-up work

[1] University of Pennsylvania
[2] Johns Hopkins University

will clarify this. Still, our method of combining action training with auditory testing offers a promising new approach to examining real-time interpretations of symmetry and other semantic categories (e.g., causality) even for sentences conveying abstract, non-imageable meanings.

Figure 1: Experimental Method

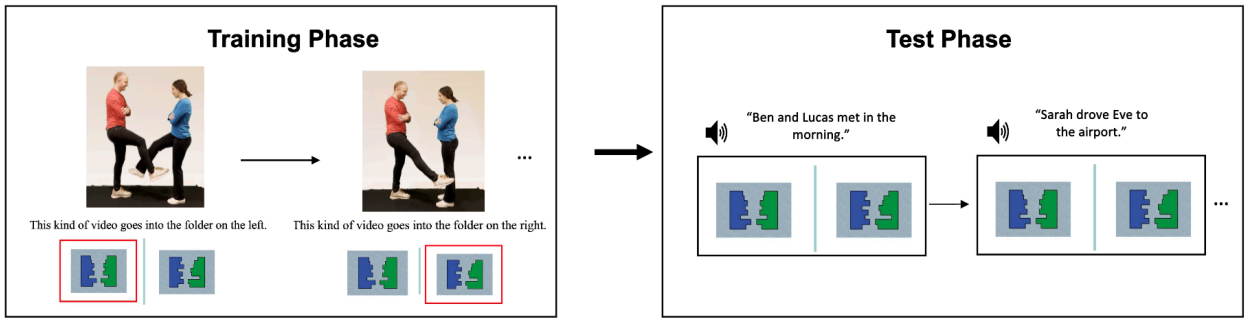


Figure 2: Example Target Sentences

a. Ben and Lucas met in the morning. (Intransitive Syntax, Symmetrical Verb)
b. Sarah and Eve drove to the airport. (Intransitive Syntax, NonSymmetrical Verb)
c. Ben met Lucas in the morning. (Transitive Syntax, Symmetrical Verb)
d. Sarah drove Eve to the airport. (Transitive Syntax, NonSymmetrical Verb)

Figure 3: A.) Mean Proportion of Symmetrical Choices; B.) Mean Reaction Time

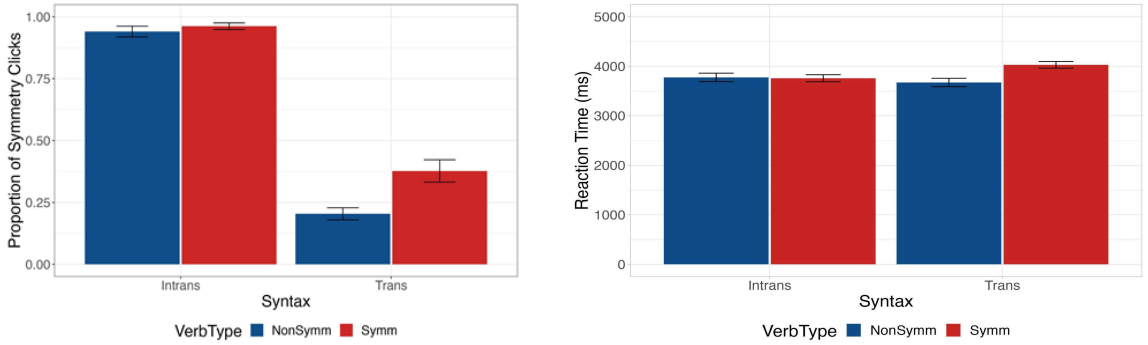
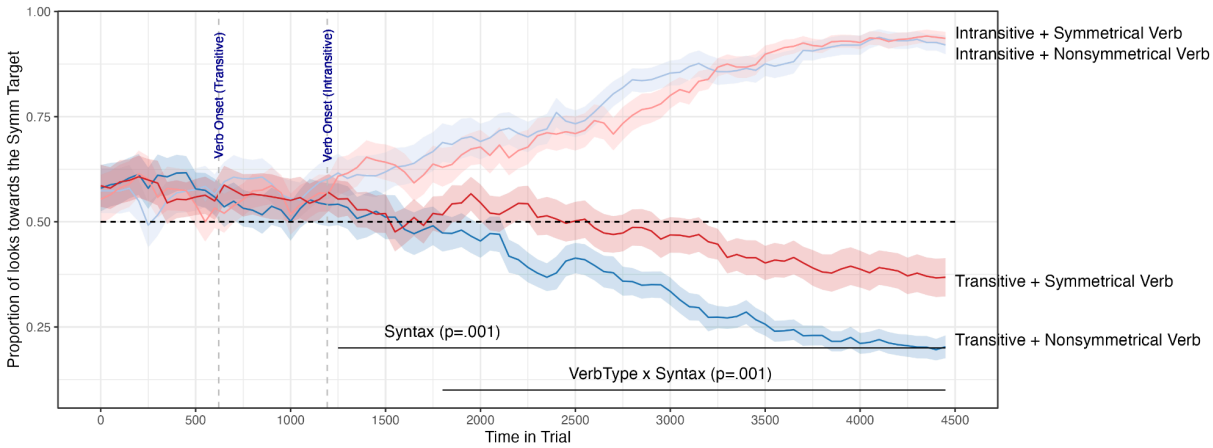


Figure 4: Proportion of looks to Symmetrical Folder over time from Sentence Onset



References Gleitman, L. R., Gleitman, H., Miller, C., & Ostrin, R. (1996). Similar, and similar concepts. *Cognition, 58(3),* 321-376. Tversky, A. (1977). Features of similarity. *Psychological Review, 84(4),* 327-350.