## Quantifier Spreading in School Aged Children

Comprehension of sentences containing universal quantifiers develops late, with children prone to making so-called quantifier spreading errors when asked to judge whether a sentence such as *Every apple is in a bowl* matches a picture with extra empty bowls (see Fig 1). Previous studies of quantifier comprehension in school age children suggest that errors decrease at around 9 years of age (e.g., Brooks & Braine, 1996; Brooks & Sekerina, 2005/2006); other studies indicate that the errors persist in adults with low academic attainment (e.g., Street & Dąbrowska, 2010), who might fall back on good-enough representations in which the scope of the quantifier is underspecified (Ferreira et al., 2002). Recent research (Minai et al 2011) has suggested that the development of cognitive control is crucial to successful interpretation of sentences with universal quantifiers. Minai and colleagues used eye tracking to gauge preschool children's attention, and found comprehension errors to co-occur with greater numbers of looks to the extra objects. Interestingly, these increased fixations to the irrelevant extra objects were observed in a two-second period prior to the onset of the sentence, and were not evident during sentence processing. Note, however, that the majority of the preschool children tested made quantifier-spreading errors, which limited the ability of the authors to compare the attentional patterns of children with good versus poor comprehension skills.

Our study re-examines the relationship between attention patterns and language comprehension by testing school-age children who are transitional in their understanding of sentences with universal quantifiers. Forty children, ages 5;8 to 12;1 (mean = 8;8, sd = 1;11) completed a sentence-picture verification task. They were asked whether each picture in a series matched a corresponding sentence spoken aloud. Three quantifier conditions were used: (1) pictures with objects and containers in 1-to-1 correspondence (depicting unrelated objects as distractors); (2) pictures with objects and containers in partial 1-to-1 correspondence, requiring a "no" response, and (3) pictures with objects and containers in partial 1-to- 1 correspondence, requiring a "yes" response. (Children also heard reversible active and passive sentences to ensure compliance with task instructions: they averaged 96% correct on active sentences, and 89% correct on passives.) Children completed the Peabody Picture Vocabulary Test (PPVT) and the Test of Nonverbal Intelligence (TONI), with standardized mean scores of 108 (sd=15) for the PPVT, and 109 (sd=12) for the TONI. As shown in Table 1 children performed accurately (above chance) on all sentence conditions, except for the partial 1-to-1 condition, requiring a "yes" response. Accuracy on this condition was unrelated to standardized PPVT and TONI scores, and only weakly related to age ($r$ = .22).

Eye-movement analyses were conducted for the "partial 1-to-1_ yes" condition, to compare children with good versus poor comprehension. We measured eye-movements from the onset of the sentence (frame 0) through to the child's response ("yes" or "no"). As shown in Fig 2, incorrect responses were accompanied by more frequent looks to the extra objects or containers than correct responses. This pattern was especially pronounced for the Container sentences, and persisted from the offset of the sentence (at approximately frame 42) to the end of the trial. These results confirm the findings of Minai and colleagues that errors in sentence comprehension may be indicative of poor attentional control, and identify a link between executive functioning and sentence processing to be pursued in future research.

References

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*Table 1: Mean Percentage of Correct Picture Choices by Quantifier Position (N=40).* $^{*}p < 0.001$

| Condition *(Example)* | Object Sentence *Every apple is in a bowl* | Container Sentence *Every bowl has an apple in it* |
|---|---|---|
| 1 to 1_yes | 80.0% (30.1)* | 81.9% (31.5)* |
| Partial 1 to 1_no | 89.4% (21.8)* | 90.0% (23.9)* |
| Partial 1 to 1_yes | 53.1% (35.9) | 53.8% (36.0) |

*Figure 1*: *Examples of Pictures for "1 to 1_yes" and "Partial 1 to 1_yes" Conditions, paired with Object and Container Sentences. Note: for the "Partial 1 to 1_no" Condition, pictures paired with Object and Container sentences were swapped.*

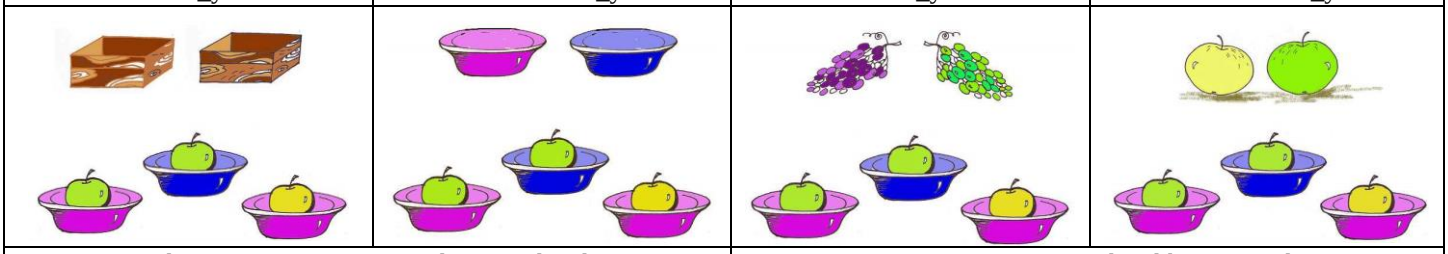


*Figure 2*: *Proportions of looks to extra objects (EO) or containers (EC) versus pairs (PR) as a function of frame, for sentences presented with Partial 1 to 1 pictures ("yes" condition). Each frame is 33 ms; sentences terminated on average after 42 frames.*