Scope ambiguity in Broca’s aphasia: A comparative approach

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Summary: The current study provides novel empirical data concerning the interpretation of scope ambiguity in Broca’s aphasia. We tested a group of individuals diagnosed with Broca’s aphasia (BAs) on scopally ambiguous sentences involving negation and every, and compared their performance to that of a group of typical adults and a group of 4-6 year old children. Our results reveal overall worse performance from BAs, compared to children and typical adults (TAs). Moreover, BAs and children (but not TAs) performed significantly worse on inverse scope (IS) than on surface scope (SS). Finally, unlike children, BAs displayed difficulty despite the presence of an explicit Question Under Discussion (QUD) (Gualmini et al. 2008). Their observed difficulty on the IS condition suggests that the impairment in BA affects operations at the syntax-semantics interface. Additionally, this study provides novel comparative evidence that the linguistic performance of BAs and children may be driven by different underlying factors, at least in the domain of scope ambiguity.

Background: It is a well-known finding that BAs exhibit impaired comprehension performance on constructions involving specific grammatical operations. Most research to date has focused on constructions involving overt movement (cf. Grodzinsky 2000; Grillo 2005; Santi & Grodzinsky 2012). Despite the apparent centrality of movement to the impairment observed in BA, still little is known about how these individuals perform with respect to covert movement operations such as those involved in deriving different scope readings. Crucially, scope ambiguity phenomena provide us with a unique opportunity to test the status of the grammar in BAs; they involve a single surface structure that can be associated with more than one meaning, with the only difference being that one interpretation (the IS reading) involves an additional grammatical operation, e.g., reconstruction (e.g., Reinhart 1997, 2006). A further motivation for this study comes from the long-standing observation that linguistic phenomena that arise late in child language seem to be most vulnerable to impairment in BA (e.g., Caramazza & Zurif 1976; Grodzinsky 1990; Avrutin 2000). The source of these apparent parallels remains unclear with explanations for the linguistic performance of these populations commonly attributed to different underlying causes. Despite the large and growing body of literature on children’s interpretation of scopally ambiguous sentences (e.g., Musolino 1998; Musolino & Lidz 2003, 2006; Moscati et al. 2014), however, work in this domain involving BAs has been limited (Saddy 1995; Varkanitsa et al. 2012). Applying a comparative approach, i.e. across populations, to the investigation of scope ambiguity can help us to further explore the apparent impairment in grammatical operations in BA, and additionally, allow us to better understand the linguistic/processing similarities and differences in language acquisition and aphasia.

Experiment: We used a Truth Value Judgment Task (Crain & Thornton 1998) to test the comprehension of scopally ambiguous sentences containing universal every and negation, e.g., Every doctor didn’t drink coffee. We compared performance across a group of BAs (n=9), a group of TAs (n=22), and a group of 4-6-year-old children (n=12). Participants were tested on two within-subject conditions: (i) an IS condition, in which the context was consistent only with the IS interpretation; and (ii) an SS condition, in which the context was also consistent with the SS interpretation. The target sentences were uttered as responses to an explicit QUD, e.g., Did every doctor drink coffee? Crucially, both readings of the ambiguous target sentences constituted good answers to the QUD, which has been shown to be an important factor influencing the interpretation of scopally ambiguous sentences. Moreover, evidence suggests that 4- and 5-year-old children’s apparent difficulty with IS readings disappears once the ‘correct’ QUD is provided explicitly (Gualmini et
al. 2008; Moscati et al. 2014). The QUD also provides us with a precise model for controlling the discourse context.

**Materials & Procedure:** Participants watched a series of short stories, told through images presented on a laptop computer. The context stories began with four individuals considering two possible activities to undertake. The end of the story differed across conditions: in the IS condition (Fig. 1), two of the four individuals decided to carry out the activity mentioned in the target sentence. In the SS condition (Fig. 2), none of the four individuals decided to do so.

At the end of each story, the researcher explicitly asked a question (the QUD) about the story, e.g., *Did every elephant collect coconuts?* and a recorded individual then responded with the target sentence e.g. *every elephant didn’t collect coconuts*, which was crucially both true in the context and a good answer to the QUD. Target sentences were produced with neutral intonation to avoid a potential bias for either scope reading. The participant’s task was to judge whether or not the sentence was a true description of the story. Each participant received 20 test trials, consisting of 10 stories compatible with the IS interpretation and 10 stories (also) compatible with the SS interpretation.

**Results & Discussion:** Fig. 3 displays the proportion of yes-responses across conditions. We ran a mixed-effect logistic regression analysis with maximal random structures and with the IS condition in BAs as the reference level. The model revealed: (i) BAs differed from both TAs and children in the IS condition (both $p < .001$); (ii) BAs’ performance in the IS condition differed from that in the SS condition ($p < .001$); (iii) there was no interaction between group and condition. Simple effects analysis also revealed a significant difference between the IS and SS conditions for children, and only a marginally significant difference for the TAs. The results indicate that BAs and children performed worse on the IS than the SS condition; children, however, perform better overall and access the IS interpretation more than the BAs. The results from the children are consistent with the findings of Gualmini et al. (2008), which reveal that when explicitly provided with an appropriate QUD, children can successfully access IS readings. The presence of an explicit QUD, however, does not appear to be a facilitating factor affecting the performance of BAs. In sum, the findings of the current study contribute novel evidence from scope ambiguity resolution that the grammatical impairment in BA extends to covert grammatical operations at the syntax-semantics interface. The study additionally provides novel comparative evidence that the linguistic performance of BAs and children may be driven by different underlying factors, at least in the domain of scope ambiguity.