The Problem of Quantifiers in Object Position: Two Processing Studies

1. Introduction: While it is a common place in semantics that quantifiers cannot be analyzed as referring expressions it is a point of disagreement among different semantic frameworks whether this fact is visible to the computational engine of the grammar. Most assume – following Montague (1973) – that the semantic type of a quantifier (hence its combinatorial properties) differ from that of referring expressions. However, this is not a necessary assumption since a satisfactory treatment of the semantics of quantifiers can be had without it using the ε-calculus (cf. Kempson et al. 2001, etc.). This paper presents a series of self-paced reading studies that provide a new type of evidence for the former and against the latter school of thought.

2. Quantifiers in Object Position: Assuming that quantifiers have a different type than referring expression creates a syntax-semantics mismatch when quantifiers appear in internal argument positions. Various solutions to this problem have been proposed (e.g. type-shifting (Montague 1973,etc.), quantifier raising (QR) (May 1977, etc.), continuations (Barker 2001)), all of which maintain that semantic or syntactic composition is more complex for quantifiers in object than in subject position or for referring expressions in subject or object position. Showing that first pass parsing, which reflects processing costs associated with structure building, mimics this differential increase in compositional complexity would constitute therefore a straightforward argument for the assumption that the combinatorial properties of quantifiers are different from those of referring expressions.

3. Resolution of local NP/S ambiguity: Our first experiment compares quantificational with referring DPS that can be either construed as internal arguments or as subjects of embedded clauses ("NP/S ambiguity," Trueswell, et.al. 1993, etc.) with disambiguation occurring on the first word after the quantificational/referential DP, (1).

(1) The nun remembered the/every child (who) was abused and malnourished.

If the semantic complexity incurred by a quantifier in object position affects first pass parsing object disambiguation ('who') should be dispreferred over subject disambiguation ('was') in the case of *every child*. Assuming that definite descriptions can be interpreted as referring expressions (in the default case), no such effect is expected after *the child*. I.e. if the parser "knows" about quantifiers in object position we expect an interaction between determiner type (quantifier/definite determiner) and attachment type (NP/S) in the post disambiguation area.

To control for possible interference of the matrix verb which could create a spurious interaction we chose only S-biased matrix verbs (Trueswell et.al.'93, etc.). Averaging residual reading times over 20 subjects, we obtained two effects: 1. Reading times on the noun immediately following 'the' or 'every' show a main effect of determiner ($p = .036$) such that 'every NP' takes longer than 'the NP'. This shows that the semantic difference between 'the' and 'every' is reflected in real time processing. 2. There is a significant interaction on the first ($p=.045$) word after disambiguation as well as in the region of the word of disambiguation to the third word after that ($p=.01$) between determiner type and attachment type indicating that quantifiers in object position are more difficult for the parser than quantifiers in subject position or definite descriptions in object or subject position.

4. Processing Antecedent Contained Ellipsis (ACE): Experiment 2 extends this research to cases of antecedent contained ellipsis (ACE) and provides real time evidence for QR as being the mechanism to resolve the problem of quantifiers in object position. ACE refers to ellipsis that is properly contained inside the expression that serves as the antecedent for ellipsis resolution, (2).

(2) John talked to every student Mary did.

ACE is puzzling given that ellipsis resolution in general is subject to a parallelism constraint between antecedent and ellipsis site, which seems impossible to satisfy if the ellipsis is properly contained inside the antecedent. A straightforward solution to this paradox is to assume QR of the object DP, thereby undoing antecedent containment, (3) (e.g. Sag 1976, etc.). This view is supported by a rich body of offline data such as the Williams-Sag generalization which fixes the scope of the object DP to be at least as high as the antecedent VP.

(3) [[every student Mary <talked to t>]$_i$ [$_{VP}$ John talked to t$_i$]].

(Assuming reconstruction of the subject)

The goal of Exp. 2 is to determine whether this correlation is reflected in real time processing. Specifically, we compare definite and quantificational DPs in object position across three conditions definable in terms of the size of the gap, (3). In condition A there is no ellipsis at all (the gap is simply a trace) while conditions B and C contain "small" (= intermediate VP antecedent) and "large" (= root VP antecedent) ellipsis sites marked by "did" and "was" respectively, (4).

(4) A. The doctor was reluctant to treat **the/every** patient that the recently hired nurse **admitted** after looking over the test results

B. The doctor was reluctant to treat **the/every** patient that the recently hired nurse **did** after looking over the test results

C. The doctor was reluctant to treat **the/every** patient that the recently hired nurse **was** after looking over the test results

Since definite DPs need to undergo QR only in condition B and C but quantificational DPs undergo QR in all three cases, we expect to find an interaction in the region following the gap. Specifically, we not only predict that reading times (RTs) after the gap for definite DPs in condition B ("the-B") will longer than for "the-A." We also predict that RTs after the gap for "the-B" will be longer than RTs for "every-A" and "every-B" since in the latter cases QR is triggered already when the quantifier is encountered (5 words before the gap). RTs for "the-C" and "every-C," on the other hand, should both show an increase since QR into the root clause cannot be anticipated in either case before the size of the ellipsis is determined.

Averaging residual reading times for 48 subjects we obtained a highly significant interaction (Det.×Size: $F(2,46) = 4.363$; $p = 0.018$) on the second word after the gap. This effect supports the above predictions. Specifically, we observe that RTs for "the-A" are lowest and that RTs for "the-B" are higher than RTs for "every-A" and "every-B." This is consistent with the hypothesis that "the-B" triggers QR at the ellipsis site while "every-A/B" trigger QR already when the quantifier is encountered. Support for this interpretation comes from a main effect of determiner over the two words following "the/every" ($F(1,47)=4.86$; $p=0.032$). Furthermore, we observe an increase of RTs for both "the-C" and "every-C," with the increase for "every-C" being larger than for "the-C." We argue that the steeper increase for "every-C" reflects reanalysis of (by default) local QR of the quantificational DP into non-local QR (QR into the root clause). No reanalysis of this sort is expected for definite DPs because the landing site of QR in these cases is determined at the same time QR is triggered.

5. Summary: It is standardly but not universally assumed that the fact that quantifiers are not referring expressions is visible to the computational engine. Although a wealth of off-line observations (e.g. NPI-licensing, the ellipsis scope generalization, Fox 1998, etc.) support this view, a fair assessment of the significance of these generalizations requires cross-framework comparisons. This paper presents new (and more immediate) evidence in favor of this position by showing real time structure building is sensitive to the quantification/referential status of DPs.