Early effect of retrieval interference on reflexive binding

The online application of Principle A of the binding theory is claimed to be infallible to memory phenomena like retrieval interference from antecedents that are inaccessible in terms of the binding theory (Phillips, Wagers, & Lau, 2009; Dillon, 2011). Sturt (2003) and Xiang, Dillon, and Phillips (2009) report a set of studies with English reflexives and conclude that if there is any effect of retrieval interference from grammatically inaccessible antecedents, it appears only during later stages of processing. Based on these results, Phillips et al. (2009) and Dillon (2011) propose that reflexive binding is immune to interference during early stages of processing, because the antecedent of a reflexive is retrieved from memory using strictly syntactic information, and that agreement features like gender and number are completely ignored in the antecedent search process.

On the other hand, a large body of work in the domain of dependency resolution in sentence processing has shown that the memory retrieval process utilizes non-syntactic information as well. Van Dyke and colleagues (Van Dyke & Lewis, 2003; Van Dyke & McElree, 2006) have shown that semantic properties of nouns (e.g. animacy feature) and selectional requirements of verbs are utilized in retrievals. Moreover, the process of binding English reflexives inside picture noun phrases (Runner, Sussman, & Tanenhaus, 2006) and Chinese reflexives (Chen, Jäger, & Vasishth, 2011) is shown to be influenced by the agreement features of the grammatically inaccessible antecedent. In fact, recently Cunnings and Felser (2011) have shown that high memory span readers occasionally consider inaccessible antecedents during binding argument reflexives. In the light of these results, the strictly syntactic retrieval account seems to be an exception, which calls for a specialized retrieval mechanism to explain only a limited set of results.

We formulated the question—what type of retrieval cues are used in the reflexive binding process—in terms the cue-based retrieval (CBR) theory (Lewis & Vasishth, 2005). The CBR theory provides a computational architecture for modeling sentence processing phenomena. The theory is based on the memory and processing principles of ACT-R, a cognitive architecture developed for modeling general cognitive processes. We implemented two CBR models of reflexive binding in English—*model-1* that uses strictly syntactic cues and, *model-2* that uses syntactic cues as well as gender marking on the reflexive to identify its antecedent. We also ran an eye tracking study to evaluate the predictions of the two models.

The models' predictions were generated for the four conditions (2x2 design; factors: accessible NP match/mismatch for gender x inaccessible NP match/mismatch for gender) listed in (1). The predictions of the models are in terms of: (i) antecedent retrieval time and (ii) accuracy in retrieving the grammatical antecedent. *Model-1* predicts no interference effect, whereas, *model-2* predicts an interference effect in terms of retrieval times and retrieval accuracies.

(1) a. *Accessible-match/inaccessible-match*: The tough soldier that Fred treated in the military hospital introduced himself to all the nurses.
b. *Accessible-match/inaccessible-mismatch*: The tough soldier that Katie treated in the military hospital introduced himself to all the nurses.
c. *Accessible-mismatch/inaccessible-match*: The tough soldier that Katie treated in the military hospital introduced herself to all the nurses.
d. *Accessible-mismatch/inaccessible-mismatch*: The tough soldier that Fred treated in the military hospital introduced herself to all the nurses.

We ran an eye tracking study (n=40) with the four conditions listed above, to evaluate the predictions of the two models, assuming that early and late effects are distinguishable in the eye tracking measures. As predicted by *model-2*, the study showed an early effect of interference from the inaccessible antecedent in terms of first-pass regression probability; i.e. a gender match between the reflexive and the inaccessible NP (1a and 1c) induced a significantly higher (p=0.038) proportion of first-pass regressions from the reflexive in the sentence. Although other early eye movements measures did not show any significant effect, a regression contingent analysis of first-fixation durations showed a pattern of fixations that was consistent with the interference predictions of *model-2*.

In sum, the eye tracking results are consistent with the predictions of the model that utilizes both syntactic and gender information to identify the antecedent of a reflexive. Moreover, the early interference effect found in the current study is not consistent with the claim that inaccessible antecedents are not considered during earlier stages of processing (Sturt, 2003; Phillips et al., 2009; Dillon, 2011). We conclude that a strictly syntactic search mechanism is overly selective and, hence, unable to account for the data reported here and in other studies like Cunnings and Felser (2011) and Badecker and Straub (2002).

References

Badecker, W., & Straub, K.(2002). The processing role of structural constraints on the interpretation of pronouns and anaphors. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *28*(4), 748–769.

Chen, Z., Jäger, L., & Vasishth, S. (2011). How structure sensitive is the parser? Evidence from Mandarin Chinese. In B. Stolterfoht & S. Featherston (Eds.), *Empirical approaches to linguistic theory: Studies of meaning and structure.* Berlin: Mouton de Gruyter. (in press)

Cunnings, I., & Felser, C. (2011). The role of working memory in the processing of reflexives. *Language and Cognitive Processes.* (in press)

Dillon, B.(2011). *Structured access in sentence comprehension.* Unpublished doctoral dissertation, Maryland.

Lewis, R. L., & Vasishth, S.(2005). An activation-based model of sentence processing as skilled memory retrieval. *Cognitive Science: A Multidisciplinary Journal*, *29*(3), 375–419.

Phillips, C., Wagers, M. W., & Lau, E. F.(2009). Grammatical illusions and selective fallibility in real time language comprehension. *Language and Linguistics Compass.*

Runner, J. T., Sussman, R. S., & Tanenhaus, M. K.(2006). Processing reflexives and pronouns in picture noun phrase. *Cognitive Science*, *30*(2), 193–241.

Sturt, P.(2003). The time-course of the application of binding constraints in reference resolution. *Journal of Memory and Language*, *48*(3), 542–562.

Van Dyke, J. A., & Lewis, R. L.(2003). Distinguishing effects of structure and decay on attachment and repair: A cue-based parsing account of recovery from misanalyzed ambiguities. *Journal of Memory and Language*, *49*, 285–316.

Van Dyke, J. A., & McElree, B.(2006). Retrieval interference in sentence comprehension. *Journal of Memory and Language*, *55*, 157–166.

Xiang, M., Dillon, B., & Phillips, C.(2009). Illusory licensing effects across dependency types: Erp evidence. *Brain and Language*, *108*(1), 40–55.