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## Looking past the pronoun

### Introduction

It is widely assumed that a pronoun is preferentially interpreted as referring to whatever referent is most salient when the pronoun is encountered. On this view, information that *precedes* the pronoun plays a central role in guiding pronoun interpretation. For example, given the widespread view that subjects are by default more salient than objects (Grosz et al. 1995 and many others), as well as the claim that ‘result’-connectives work against this default subject preference and focus attention on objects (e.g., Stevenson et al. 2000), a subject pronoun is more likely to refer to the subject of the preceding sentence in ex.(1a) than ex.(1b).

- (1a) *Bob tickled Jim and **then** he...*  
(1b) *Bob tickled Jim and **as a result** he...*

Here, we investigate effects of information not available to the processing system until *after* the pronoun has been encountered. It has been observed in previous work (especially in computational linguistics, e.g., Winograd 1972, Grosz et al. 1995, Kehler 2002 and others) that information available after the pronoun (e.g. verb semantics) may influence reference resolution. For example, work by Kehler (2002) and colleagues treats pronoun resolution as a side effect of establishing coherence relations between clauses, which is a process that makes use of both pre-pronominal and post-pronominal information. However, most existing psycholinguistic research on pronoun resolution has traditionally tended to focus on the effects of information available before the pronoun, and there has been relatively little systematic psycholinguistic investigation of what kinds of post-pronominal factors have an impact.

In this talk, we aim to contribute to our understanding of how post-pronominal information impacts reference resolution by testing whether the interpretation of sentence-initial ambiguous pronouns is influenced by the referential properties of the remainder of the sentence (see also Centering-Theoretic research by Grosz et al. 1995 and others). We also investigate how the effect of referential properties interacts with the coherence relation between two clauses (as indicated by the connectives ‘and then’ and ‘and as a result’). This research aims to provide empirical results that can be used to enrich existing theories of reference resolution.

We take as our starting point existing psycholinguistic and cognitive psychology research which has shown that (i) referential processing imposes demands on the resources available to the human sentence processing mechanism (e.g., Warren & Gibson 2002), and that (ii) the human sentence processing mechanism (HSPM) has limited cognitive resources and thus prefers to minimize processing load whenever possible. Building on (i), it seems reasonable to hypothesize that an intransitive sentence (one argument requiring resolution) carries less processing load than a transitive

sentence (two arguments that need to be resolved). Building on (ii), we explore the Processing Cost Hypothesis which predicts that the presence/absence of subsequent referents in the rest of the clause influences whether an ambiguous subject pronoun is interpreted as referring to the preceding clause's subject or object, *with object interpretations being more likely if no further referents are mentioned in the pronoun-containing clause*. The Processing Cost Hypothesis derives this prediction from the claim that HSPM strives to minimize processing cost.

The specific prediction is generated as follows. Let us assume that, upon encountering an ambiguous pronoun, the HSPM activates both the preceding subject and object as possible antecedents, with the default subject preference modulated by the connective as shown in (2) (as predicted by work discourse connectives, e.g. Stevenson et al. 2000 and others):

- (2a) *then*: subject >> object                      (2b) *result*: object > subject

If the Processing Cost Hypothesis is on the right track, encountering another argument later in the pronoun-containing clause increases processing load, and in response to this, to lower processing load, the HSPM gives more consideration to the default ('easy') interpretation, namely *the preceding subject*. The resulting expectation is that ambiguous pronouns (in subject position) in transitive and intransitive clauses (3a,b) will show different degrees of preference for the subject and the object of the preceding clause. Specifically, due to the HSPM striving to minimize processing load, the Processing Cost Hypothesis predicts that there should be more subject interpretations overall in transitives (3b) than intransitives (3a), and more object interpretations overall with intransitives (3a) than transitives (3b). We conducted two experiments to test this prediction.

- (3a) *X verbed Y and {then/as a result} she verbed.*  
 (3b) *Y verbed Y and {then/as a result} she verbed the noun.*

### Experiment 1

In Experiment 1, participants listened to two-clause sequences (ex.(4a-c)) and answered questions about them that probed the interpretation of the subject pronoun. We manipulated the discourse connective (*and then/and as a result*) and verb transitivity (intransitive (4a), transitive with pronominal object (4b), transitive with NP object (4c)). Nonsense words were used in place of verbs and nouns in order to factor out any effects of verb semantics in order to focus on the effects of argument frames. The sentences were spoken with neutral intonation.

- (4a) *Anne tulvered Kate and {as a result/then} she sprelled.*  
 (4b) *Anne tulvered Kate and {as a result/then} she sprelled her.*  
 (4c) *Anne tulvered Kate and {as a result/then} she sprelled the jeg.*

### Results

Participants' responses to the questions show that their interpretation of the subject pronoun is influenced by connective type and by transitivity. As predicted on the basis

of previous work, the subject pronoun is more likely to be interpreted as referring to the preceding object with ‘as a result’ than ‘then’ (‘Result’ conditions: about 35% subject choices on average; ‘Then’ conditions: >80% subject choices on average). Crucially, transitivity also has an effect: Within the ‘then’ and the ‘result’ conditions, there are significantly ( $p's < .05$ ) more subject-interpretations with transitives (4b,c) than intransitives (4a), as shown in (5) below. The two types of transitives (pronominal object, (4b), and NP object, (4c)) show similar choice patterns and do not differ significantly from each other.

(5) Results: Approx. % of *subject* choices:

Result/Intransitive = 23%  
Result /Transitive+noun = 42%  
Result /Transitive+pronoun = 43%

Then/Intransitive = 61%  
Then/Transitive+noun = 94%  
Then/Transitive+pronoun = 89%

However, Exp.1 leaves open the possibility that the transitivity effect stems from the intransitives being interpreted as involving non-agentive subjects (e.g., as unaccusative verbs). Perhaps the increased number of object interpretations with intransitives results from a bias to interpret a non-agentive subject as coreferential with the preceding non-agent (i.e., the object)?

## Experiment 2

Experiment 2 investigated this possibility by using real verbs in the second critical clause, including intransitive verbs with agentive subjects (unergatives, e.g. *sleep*) and intransitive verbs with non-agentive subjects (unaccusatives, e.g., *arrive*). As in Experiment 1, participants heard two-sentence sequences and responded to questions about them. The results show that unaccusatives and unergatives do not differ significantly from each other, indicating that the transitivity effect cannot be attributed to a non-agentive subject interpretation.

## Discussion

Our findings highlight the importance of including the impact of post-pronominal information in theories of reference resolution. The results show that pronoun interpretation is susceptible to the referential properties of the rest of the clause – specifically, object interpretations are more likely in intransitives (i.e., if no further referents are mentioned in the pronoun-containing clause) than in transitives. A possible explanation for our finding that the *presence of subsequent arguments is correlated with an increased likelihood of subject interpretations* comes from the Processing Cost Hypothesis. Further research investigating the incremental processing load induced by sentences such as those in ex.(4) will help assess the validity of this hypothesis.

Could parallelism effects be responsible for the effects that we observed? A sizeable body of existing work (e.g. Smyth 1994) has shown that pronouns in a

particular structural position prefer antecedents realized in the same structural position (parallelism effect) – in other words, subject pronouns prefer subject antecedents and object pronouns prefer object antecedents. However, since all of our critical sentences contained subject pronouns, one possible parallelism-based prediction would be that all conditions should show equal amounts of subject preference. This, however, is not what we found, which argues against a parallelism account. Furthermore, and more crucially, it was observed that both transitive conditions (pronominal object, ex.(4b), and NP object, ex.(4c)) show an increase in subject interpretations relative to the intransitive condition, even though the second clause in the NP-object condition (4c) is not referentially parallel to the first clause. This seems to provide further evidence against a parallelism account (see also Kertz et al. 2006 for recent work suggesting that structural parallelism is not sufficient to explain patterns of reference resolution).

## Conclusions

The finding that post-pronominal information has a significant effect seems to suggest that sentence-initial pronouns do not receive their final interpretation at the point at which the pronoun itself is encountered. Rather, our findings indicate that the referential properties of the remainder of the clause (i.e., whether it is transitive or intransitive) have an effect on the final interpretation assigned to subject position pronouns, possibly due to processing cost considerations. More generally, these results support the idea that psycholinguistic models of pronoun resolution will benefit from incorporating effects of post-pronominal information more fully.

## References

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