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Authors

Stevenson, Rosemary J.

Nelson, Alexander W . R .

Stenning, Keith

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Strategies in pronoun comprehension

Rosemary J. Stevenson
Human Communication
Research Centre
Psychology Department
University of Durham
Science Laboratories
South Road
Durham DH1 3LE
United Kingdom

rosemary.stevenson@durham.ac.uk

Alexander W. R. Nelson
Human Communication
Research Centre
University of Edinburgh
2 Buccleuch Place
Edinburgh EH8 9LW
United Kingdom
sandy@cogsci.ed.ac.uk

Keith Stenning
Human Communication
Research Centre
University of Edinburgh
2 Buccleuch Place
Edinburgh EH8 9LW
United Kingdom
keith@cogsci.ed.ac.uk

Abstract

The aim of this study was to distinguish between three heuristic strategies proposed to account for the assignment of ambiguous pronouns: a subject assignment strategy, a parallel function strategy and a parallel order-of-mention strategy. According to the subject assignment strategy a pronoun is assigned to a preceding subject noun phrase. A parallel function strategy predicts that a pronoun will be assigned to a noun phrase with a parallel grammatical function whereas a parallel order strategy predicts that a pronoun will be assigned to a noun phrase in a parallel position in a previous clause. These strategies were tested by examining the interpretation of ambiguous subject and non-subject pronouns. The results showed a bias to assign a pronoun to a preceding subject, suggesting the operation of a subject assignment strategy. However, this bias was reversed for non-subject pronouns. These pronouns showed a bias to preceding non-subjects with parallel grammatical roles, thus supporting a parallel function hypothesis. Finally, the subject assignment bias was reduced when a non-subject pronoun had a different grammatical role from the non-subject antecedent, thus supporting a parallel order-of-mention strategy. We conclude that all three strategies may constrain the assignment of ambiguous pronouns.

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Introduction

The comprehension of pronouns is made up of many processes operating at many different levels (syntactic, semantic and nonlinguistic). One such set of processes involves heuristic strategies: mechanical rules of thumb operating over a particular level of representation. Three strategies for pronoun comprehension concern us here: subject assignment, parallel function and parallel order. The subject assignment strategy (e.g., Broadbent, 1973; Clancy, 1980) proposes that ambiguous pronouns will be assigned to antecedents which function as subjects and the parallel function assignment strategy (Sheldon, 1974) proposes that pronouns will be assigned to antecedents with parallel (identical) grammatical functions.

Sheldon (1974) proposed that parallel function was used in pronoun resolution and noted that (1a) is easier than (1b).

- (1) a. Mary hugged John and Betty kissed him.
b. Mary hugged John and he kissed Betty.

A parallel order strategy (Nelson, Stevenson & Stenning, 1992) is similar to a parallel function strategy except that a pronoun might be assigned to an antecedent with a parallel position in a clause. Consider an example from Nelson *et al.*, shown in (2). The structure of the two clauses means that there is no parallel antecedent with the same grammatical function as the non-subject pronoun but a parallel order strategy would assign *him* to *Hector* because both noun phrases come second in their respective clauses.

- (2) Terry took Hector to the pavilion and Brenda waved to him.

Several investigators have studied parallel function in pronoun comprehension and various factors which interact with it (e.g., Caramazza and Gupta,

1979; Cowan, 1980). The general conclusion of such studies is that parallel function does influence the comprehension of ambiguous pronouns. However, Crawley, Stevenson and Kleinman (1990) observed that very few studies of parallel function have used non-subject pronouns and so the results cannot distinguish between a parallel function strategy and a subject assignment strategy because both strategies predict that ambiguous pronouns will be assigned to the subject antecedent. By contrast, the two strategies predict different outcomes when non-subject pronouns are used; the subject assignment strategy predicting subject assignment and the parallel function strategy predicting non-subject assignment. Using three sentence texts, Crawley, Stevenson and Kleinman (1990) found a clear subject assignment bias with non-subject pronouns, from which they concluded that parallel function was not being used.

Unfortunately they only used non-subject pronouns which will only distinguish between subject assignment and parallel function if either strategy is used in isolation. However, it is possible that both strategies are involved in comprehension, so that subject pronouns may show a more marked subject assignment bias than do non-subject pronouns. That is, the subject assignment bias observed by Crawley, Stevenson and Kleinman (1990) for non-subject pronouns might have been attenuated by a concurrent but conflicting parallel function strategy. Nelson, Stevenson and Stenning (1992) followed Crawley *et al.*'s design but used non-subject pronouns. They found that there is indeed a parallel function and subject assignment strategy. They observed a subject assignment bias for both subject and non-subject pronouns but crucially the bias was significantly reduced for non-subject pronouns.

Nelson *et al.* also found in a *post hoc* analysis that there was an order-of-mention effect. There were cases where the grammatical function of the potential antecedents and the pronoun were not the same so grammatical function could not operate. Yet there was an assignment bias very similar to parallel function although smaller in magnitude, which they attributed to parallelism over order-of-mention. Stenning (1991) has also found effects of order-of-mention in text processing. However, Cowan (1980) has investigated order-of-mention effects in pronoun assignment and concluded that there are no effects.

Given the conflicting evidence we pursued the strategy of parallelism over order-of-mention in this experiment. Nelson *et al.* (1992) had used three sentence texts and a single sentence condition. The single sentence condition showed the strongest effects of parallelism hence we used a similar single sentence condition in the present study. Our materials were therefore very similar to those used by Nelson *et al.*, except that we distinguished between

parallel grammatical function (which also involved parallel order) and parallel order-of-mention in the absence of grammatical parallelism.

In summary, this experiment investigated the use of a parallel order-of-mention strategy in comparison with a parallel function strategy in single sentences.

Experiment

Subjects

The subjects were 96 volunteer students from Durham University.

Materials and Design

Each subject read 24 sentences which described three individuals. Each sentence was made up of two conjoined clauses: the first mentioned two of the participants and the second mentioned the third participant and a pronoun which referred to one of the two individuals mentioned in the first clause.

The design factors were Pronoun position (subject *vs.* non-subject), and Parallelism (grammatical *vs.* order-of-mention). Pronoun was a within-subjects factor and Parallelism was a between-subjects factors.

Table 1 shows a set of example sentences.

Two lists of 24 sentences were constructed (available from the authors on request). Each list corresponded to one of the levels of the Parallelism factor. These lists were used to make four lists of materials, two in each level of the between-subjects conditions. Both levels of the Pronoun factor were contained in each pair of lists. Across the four lists each sentence occurred with a subject and a non-subject pronoun.

Each sentence was followed by a question derived from the crucial part of the second clause in the target sentence by repeating the second clause with the pronoun replaced by one of the potential antecedents (*e.g.*, Sammy kicked Ellen? or John kicked Ellen?). The question was used to determine the assignment of the pronoun in the preceding sentence. The number of times each potential antecedent was substituted was balanced across materials.

Procedure

The task was a self-paced reading task, followed by a question about the target sentence. Each sentence was presented clause by clause. Subjects were asked to press the space bar as soon as they had read and understood the clause. Once the final clause had been read, the screen cleared and then the question appeared. After answering the question by pressing one of two keys marked *true* and *false*, subjects were prompted to start the next trial.

The time taken to read the last clause of each sentence was measured in milliseconds and the answer to each question was recorded.

Table 1: Examples illustrating the Parallelism and Pronoun factors.

Grammatically Parallel	
John	punched Sammy on the nose and he kicked Ellen in the back.
John	punched Sammy on the nose and Ellen kicked him in the back.
Parallel Order	
Mary	helped Priscilla change the wheel and she talked to Graham without interest.
Mary	helped Priscilla change the wheel and Graham talked to her without interest.

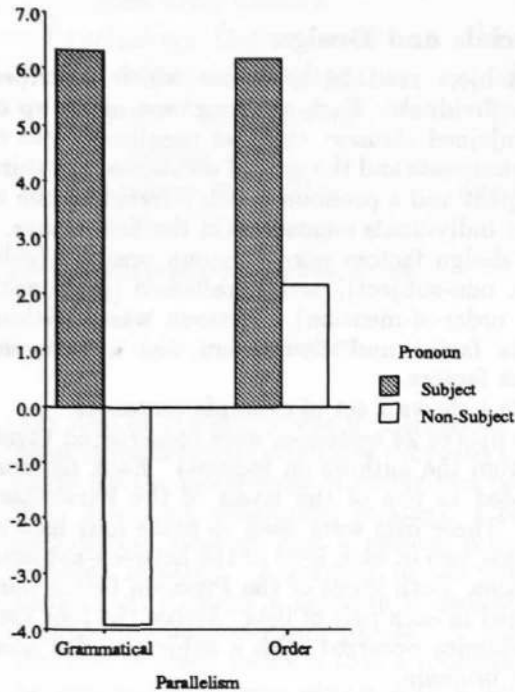


Figure 1: Mean assignment biases by Pronoun and Parallelism.

Results

Assignment data For each sentence, subjects' assignments for the pronoun were inferred from the answer to the question. These assignment data were then prepared for analysis of variance by subtracting the number of non-subject assignments from the number of subject assignments by condition by subject. This meant that each subject had a score for each condition that ranged from +12 to -12. The score represented the assignment bias: a positive number indicated a subject assignment bias and a negative number a non-subject assignment bias.

Figure 1 shows assignment bias by Pronoun and Parallelism.

Analysis of variance shows that the interaction between Parallelism and Pronoun is significant ($\min F'(1, 91) = 8.46, p < 0.01$). The main effect

of Parallelism is also significant ($\min F'(1, 89) = 7.25, p < 0.01$) as is the main effect of Pronoun ($\min F'(1, 91) = 43.97, p < 0.01$). The data shows that the assignment bias for Subject pronouns is unchanged by the Parallelism factor. However the Parallelism factor has a large effect on the Non-subject pronouns. In Grammatically parallel sentences non-subject pronouns shows an assignment bias to non-subject antecedents and in Order parallel sentences they show an assignment bias to subject antecedents.

Reading Times Reading times over 10000ms (0.08%) and under 350ms (0.3%) were replaced. A maximum likelihood analysis was carried out on the data with Pronoun, Assignment and Parallelism as fixed factors. There were no significant effects. Figure 2 shows the mean reading times by all three factors. There is a suggestion that there is a parallelism effect for the Grammatical sentences and a straightforward subject assignment effect for Order sentences.

Assignment Times Question answering times over 10000ms (0.1%) and under 350ms (0.1%) were replaced. A maximum likelihood analysis was carried out on the data with Pronoun, Assignment and Parallelism as fixed factors. The interaction between Pronoun and Assignment was the only significant effect, $F_1(1, 2288) = 8.26, p < 0.005$. Figure 3 shows the mean reading times by Parallelism and Figure 4 shows the means for the interaction. Assignments are made faster for subject pronouns when the assignment is to a subject antecedent than to a non-subject antecedent. The situation is reversed for non-subject pronouns where assignments to non-subject pronouns are made faster than assignments to subject pronouns.

Discussion

The assignment data clearly show two parallelism effects. In grammatically parallel sentences the assignment bias is affected by pronoun position in the predicted way. Subject pronouns are more likely to be assigned to subject antecedents than to non-subject antecedents. Non-subject prono-

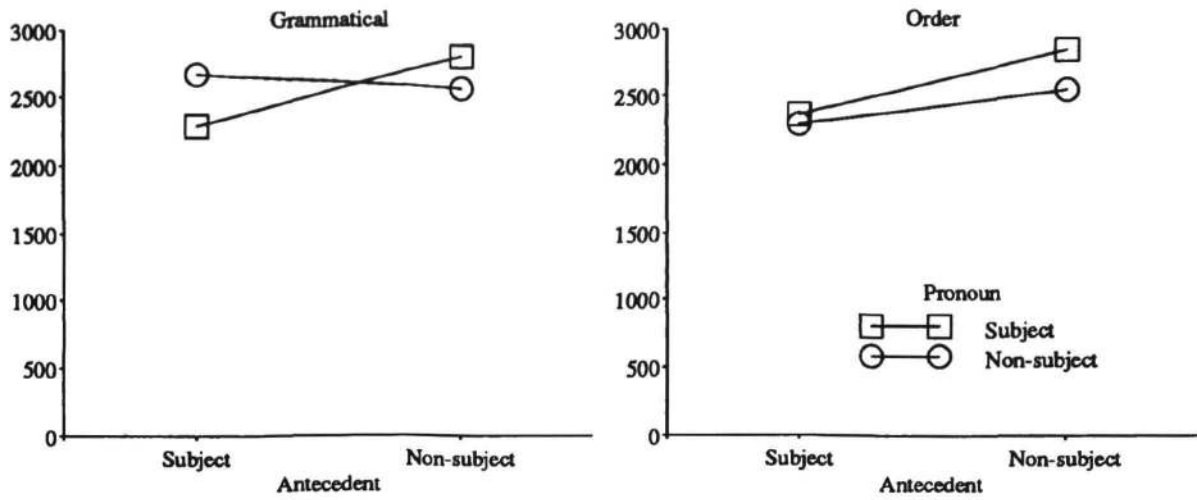


Figure 2: Mean reading times by Pronoun and Assignment by Parallelism (Grammatical and Order). Note the Ns vary across conditions.

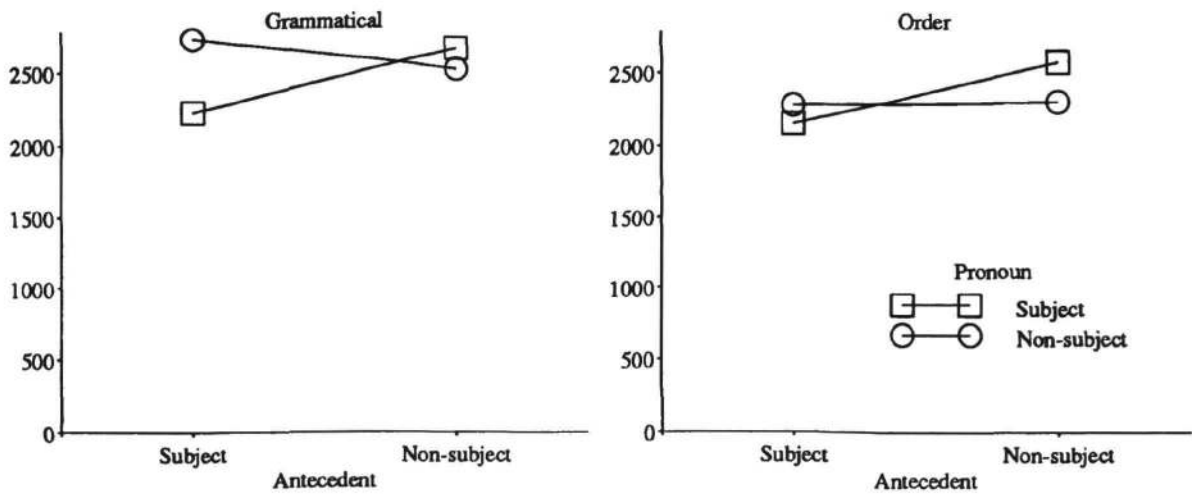


Figure 3: Mean question answering times by Pronoun and Assignment by Parallelism (Grammatical and Order). Note the Ns vary across conditions.

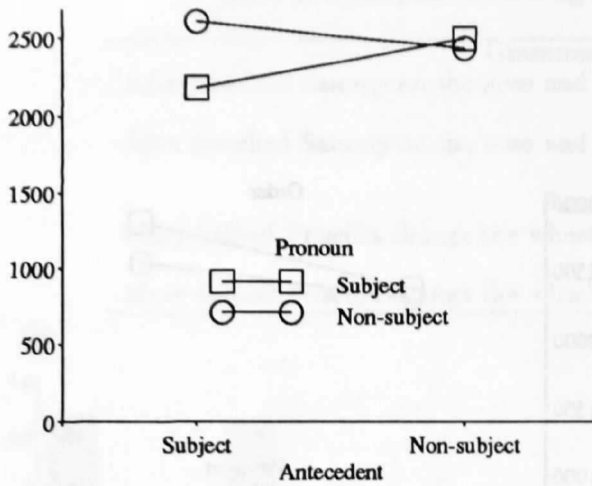


Figure 4: Mean question answering times by Pronoun and Assignment. Note the Ns vary across conditions.

uns are more likely to be assigned to non-subject antecedents. Such an effect of pronoun position supports a parallel function hypothesis. A similar pattern of results arises for Order parallel sentences where grammatical function cannot operate for non-subject pronouns. Relative to the assignment bias for subject pronouns the assignment bias for non-subject pronouns is reduced: that is, there is a decreased likelihood of assigning a non-subject pronoun to a subject antecedent. However, the subject assignment bias for non-subject pronouns in Order sentences is greater than the subject assignment bias for non-subject pronouns in Grammatical sentences.

We interpret these results as supporting the view that in grammatically parallel sentences two parallelism strategies can operate: grammatical parallelism and order parallelism. However, where grammatical parallelism cannot be used with non-subject pronouns, the size of the parallelism effect overall is reduced because only order parallelism is available. Thus, performance reflects the number of strategies that support a single interpretation. For subject pronouns, the subject in the preceding clause is chosen as the antecedent most often because three strategies support such an assignment: subject assignment, grammatical parallel function, and order parallel function. For non-subject pronouns, parallel effects are most marked when the pronoun occupies the same grammatical role as the non-subject antecedent. In this case, the reader benefits from both grammatical and order parallelism. However, parallel effects are reduced (though still present) when the non-subject pronoun and the non-subject antecedent occupy different grammatical roles. In this case only order parallelism can be used. These results confirm the *post hoc* ana-

lysis presented in Nelson, Stevenson and Stenning (1992). However, they contradict Cowan's (1980) result that ordering of potential noun phrase antecedents has no effect. The reason for this apparent disagreement is that Cowan assigned both potential antecedents the same grammatical function (by making them conjoined subjects) which meant that many of his subjects found his sentences anomalous. Such a situation does not arise with our materials.

Our data on reading times and assignment times suggest that pronoun assignments may not be completed immediately. The reading time data for the last clause shows no significant effects of any of the design factors, although the pattern of results is consistent with the use of the three strategies as outlined above. However, there is an effect of parallelism in the assignment times: when a pronoun is assigned to an antecedent with a parallel function the time is faster than when the pronoun is assigned to a non-parallel antecedent. This clear effect of parallelism in the assignment times suggests that subjects did not complete an assignment until they answered the question following the sentence.

Such a suggestion is compatible with Greene, McKoon and Ratcliff's (1992) view that pronoun assignment may have to be encouraged by motivating subjects with a question. They suggest that when subjects are forced to make assignments which they might not normally make the processes are strategic rather than automatic. However, the comparison is not straightforward because there is a crucial difference between our materials and theirs. The pronouns we used were ambiguous whereas theirs were unambiguous.

Our results also relate directly to the work by Gernsbacher and colleagues (Gernsbacher & Hargreaves, 1988; Gernsbacher, Hargreaves & Beeman, 1989) on first mention *vs.* recency effects. They have found that in a priming task items mentioned first in a sentence are easily accessible compared to items mentioned later. However, within a clause there is also a recency effect which is attenuated outside the clause. Since our pronouns and antecedents were in separate clauses, these effects would suggest that we should have observed a consistent assignment bias to the first mentioned antecedent in our test materials. However, pronoun position and pronoun function clearly have an effect.

The three strategies that we have chosen to investigate are only part of a larger range of strategies used in pronoun resolution. Apart from the implications they have in themselves we believe that their interaction illustrates a crucial aspect of the human sentence processing mechanism. We believe that the three strategies operate together and each produce a candidate antecedent. A competition mechanism then selects one choice which the subject becomes aware of as the ante-

cedent. A similar mechanism has been described by Bates and MacWhinney (MacWhinney, Bates and Kliegl, 1984) for resolving conflicting form-to-function mappings in their Competition Model. The result is a choice which satisfies as many of the constraints on the selection of an antecedent. This mechanism explains the additive nature of the strategies.

In English, word order is closely attended to because it provides so many cues for interpretation. However, in other languages such as German much more variety is permitted and more cues are derived from morphology rather than word order. It remains to be seen whether or not parallel strategies of grammatical function and order could also be found in German.

Overall, our results support the existence of parallelism over function and parallelism over order of mention as well as a subject assignment strategy. We interpret these effects as strategic ones rather than automatic ones because of the delay in observing the parallelism effects. We also view these strategies as exerting constraints on interpretation, constraints that must be satisfied before a unique assignment can be made.

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