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Syntactic priming in comprehension: Parallelism effects with and without coordination

Patrick Sturt [a,*], Frank Keller [b], Amit Dubey [b]

[a] Psychology, University of Edinburgh, 7 George Square, Edinburgh EH8 9JZ, UK
[b] School of Informatics, University of Edinburgh, 10 Crichton Street, Edinburgh EH8 9AB, UK

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ABSTRACT

Although previous research has shown a processing facilitation for conjoined phrases that share the same structure, it is currently not clear whether this parallelism advantage is specific to particular syntactic environments such as coordination, or whether it is an example of more general effect in sentence comprehension. Here, we report three eye-tracking experiments that test for parallelism effects both in coordinated noun phrases and in subordinate clauses. The first experiment replicated previous findings, showing that the second conjunct of a coordinated noun phrase was read more quickly when it had the same structure as the first conjunct, compared with when it did not. Experiment 2 examined parallelism effects in noun phrases that were not linked by coordination. Again, a reading time advantage was found when the second noun phrase had the same structure as the first. Experiment 3 compared parallelism effects in coordinated and non-coordinated syntactic environments. The parallelism effect was replicated for both environments, and was statistically equivalent whether or not coordination was involved. This demonstrated that parallelism effects can be found outside the environment of coordination, suggesting a general syntactic priming mechanism as the underlying explanation.

Introduction

It has been repeatedly observed that the processing of a linguistic unit is facilitated by the recent processing of a linguistic unit with an equivalent syntactic form (see Pickering & Ferreira (2008) for a review). Such *syntactic priming* effects are particularly well-attested in language production, where there is a tendency for speakers (or writers) to re-use syntactic forms that they have recently produced. Priming effects have been found not only in experimental investigations (e.g. Bock, 1986; Pickering & Branigan, 1998; Scheepers, 2003), but also in corpus studies of spontaneous speech (Reitter, Hockenmaier, & Keller, 2006; Reitter, Moore, & Keller, 2006) and written language (Dubey, Keller, & Sturt, 2008; Gries, 2005; Szmrecsanyi, 2005). The probability of producing a particular syntactic form is affected not only by the speaker's own prior production of that form, but also by his or her comprehension of another person's use of that form, as has been shown experimentally by Branigan, Pickering, and Cleland (2000).

In contrast to the considerable evidence for syntactic priming in production, there have been relatively few studies investigating priming effects in comprehension. However, a number of recent studies have shown that the comprehension of a syntactic form is indeed facilitated by the recent exposure to a similar syntactic form, and there are a number of ways in which syntactic priming can affect the comprehension of a subsequent target stimulus. Priming can ease the recovery from syntactic garden paths (Branigan, Pickering, Liversedge, Stewart, & Urbach, 1995; Ledoux, Traxler, & Swaab, 2007; Traxler, 2008); it can also affect the final interpretation of a globally ambiguous sentence (Branigan, Pickering, & McLean, 2005); and it can modulate expectation levels for upcoming constituents, as measured by eye-movements during scene

* Corresponding author. Fax: +44 131 650 3461.
E-mail address: patrick.sturt@ed.ac.uk (P. Sturt).

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viewing (Arai, Gompel, & Scheepers, 2007; Thothathiri & Snedeker, 2008).

In the present paper, we will consider a phenomenon that appears to share many characteristics with syntactic priming, viz., the parallelism preference in the interpretation of coordinated structures. This effect was first reported by Frazier, Taft, Roeper, Clifton, and Ehrlich (1984), and has been confirmed in a series of recent studies (Carlson, 2001; Frazier, Munn, & Clifton, 2000; Knöferle & Crocker, 2009). It is well-known that, with certain exceptions, the coordination of two constituents requires each conjunct to have the same syntactic category (Chomsky, 1957). In addition to this, it can be shown that the processing of the second conjunct is facilitated if it has the same the internal structure as the first conjunct. For example, Frazier et al. (2000) examined sentences like (1) in an eye-tracking study:

(1) a. Hilda noticed a strange man and a tall woman when she entered the house.
b. Hilda noticed a man and a tall woman when she entered the house.
c. Hilda noticed a strange man and a woman with a dog when she entered the house.
d. Hilda noticed a man and a woman with a dog when she entered the house.

They found that on the second conjunct (underlined in (1)) total times were longer in (1-b) than in (1-a), while (1-c) and (1-d) did not differ. This finding was attributed to the fact that the two conjuncts in (1-a) share the same internal structure (determiner, adjective, noun), while those in (1-b) do not. The conditions (1-c) and (1-d) control for the possibility that any difference between (1-a) and (1-b) might be attributable to priming based on the presence or absence of a modifier. Since both conjuncts include a modifier in (1-c) but not in (1-d), such an account would predict a facilitation for (1-c) relative to (1-d). The lack of such an effect led the authors to conclude that the difference between (1-a) and (1-b) was due to the parallelism of syntactic form.

If we view the first conjunct as a prime and the second conjunct as a target, then this *parallelism effect* has obvious similarities with syntactic priming. However, Frazier et al. (2000) argued that the effect is the result of a phenomenon separate from general syntactic priming, as syntactic priming should be observable across the board in different syntactic environments, whereas Frazier et al. (2000) found facilitation for parallel structures only when the structures were coordinated. In a subsequent experiment using segment-by-segment self-paced reading, Frazier et al. (2000) examined sentences such as (2), in which the two critical noun phrases were not in a coordinate context, but instead were the subject and object of a verb.

(2) a. A strange man noticed a tall woman yesterday at Judi's.
b. A man noticed a tall woman yesterday at Judi's.
c. A strange man noticed a woman yesterday at Judi's.
d. A man noticed a woman yesterday at Judi's.

Frazier et al. (2000) found no evidence for parallelism in the reading times for the underlined segment in (2). This led them to conclude that the facilitation that they had previously observed for (1) was not due to general syntactic priming, but was attributable to a specialized parallelism effect that is limited to certain syntactic contexts such as coordination environments.

In this paper, we will address the question of whether the parallelism effect is indeed limited to coordination, or whether it can be found in other syntactic environments as well. In particular, we will present evidence that suggests that parallelism effects for noun phrases related by subordination are similar to those found for coordination, a result that is compatible with an explanation of parallelism as a priming effect. If the priming view is correct, then this would simplify accounts of sentence processing considerably; a priming mechanism is independently motivated, and being able to explain a seemingly distinct effect such as parallelism as priming would lead to a more elegant, more parsimonious theory. The question of whether parallelism is priming is therefore of considerable theoretical importance.

The claim that parallelism effects are a consequence of priming is consistent with a recent model proposed by Dubey et al. (2008), which is based on probabilistic context free grammars (PCFGs). In this model, the probability of a rule is conditioned on whether or not that rule has been used before in a given context (e.g. the whole sentence or the previous sentence). This leads to a higher probability for a rule that has been primed, relative to a rule that is not re-used. This contrasts with standard PCFGs which assume that the probability of a rule in a derivation is independent of all the other rules in that derivation. Dubey et al. (2008) use *surprisal* (Hale, 2001) as a linking hypothesis to map model probabilities onto experimentally obtained reading times. Surprisal predicts that the difficulty of processing a word w is a function of the probability of w given the words that precede w; the lower this probability, the higher the processing cost, and hence the higher the predicted reading time. Dubey et al. (2008) show that a PCFG-based model that is augmented with a priming-based "boost" in its probability model successfully predicts the pattern of processing cost observed in parallelism experiments, including those of Frazier et al. (2000) and Knöferle and Crocker (2006). This type of mechanism is similar in many ways to the activation of *combinatorial nodes* in descriptive accounts of priming in production (e.g. Pickering & Branigan, 1998). Combinatorial nodes can be seen as equivalent to context-free phrase structure rules, and the relative activation (rather than probabilities) of the relevant nodes determines the strength of preference for one structural form over another.

Although Frazier et al. (2000) argued that parallelism effects are distinct from priming, there are reasons why this conclusion might be premature. First, it should be noted that their conclusion is based on a comparison between two experiments using different methods. The parallelism effect was obtained for (1) using eye-tracking, while a null effect was obtained for the stimuli in (2) using self-paced reading, a method which is usually considered