Syntactic Priming in German Sentence Production

Article · July 2000

Source: CiteSeer

CITATIONS
11

READS
135

2 authors:

Christoph Scheepers
University of Glasgow
136 PUBLICATIONS **12,526** CITATIONS
SEE PROFILE

Martin Corley
The University of Edinburgh
82 PUBLICATIONS **2,563** CITATIONS
SEE PROFILE

Syntactic Priming in German Sentence Production

Christoph Scheepers (chsc@coli.uni-sb.de)
Department of Computational Linguistics
Saarland University, 66041 Saarbrücken, Germany

Martin Corley (Martin.Corley@ed.ac.uk)
Department of Psychology and Human Communication Research Centre
University of Edinburgh, Edinburgh EH8 9JZ, UK

Abstract

Current theories of language production tend to differentiate between a (syntactic) *functional* level and a (surface) *positional* level in the generation of sentences, where functional selection precedes and constrains positional processing. In this paper, we present evidence from a syntactic priming study in German, where position, function, and type of constituent are orthogonally specified for monotransitive and ditransitive verbs. In contrast to findings for English (in which these factors are confounded) we show that previous generation of a ditransitive structure can *inhibit* the production of a further ditransitive when the order of potential arguments differs between prime and target. Our results suggest that positional processing must at the least interact with functional processing in production, and point to the importance of cross-linguistic evidence in the formation of models of language processing.

Syntactic Priming is the name given to the tendency that people have to re-use syntactic structure that they have just generated. For example, Bock (1986) demonstrated that, having read aloud a sentence such as *The rock star sold some cocaine to an undercover agent*, participants are more likely to describe a picture with a phrase such as *The girl handed a paintbrush to the man* rather than with the alternative *The girl handed the man a paintbrush*. Current interpretations of these findings tend to emphasise a functional level of sentence production, at which syntactic information (such as subcategorisation properties of verbs) is specified and syntactic roles (such as subject or object) are assigned. The eventual positions of constituents in the utterance are determined by subsequent processes which take as their input the representations built at the functional level (e.g., Bock & Levelt, 1994).

Evidence supporting the existence of a functional level in production has been found in a series of studies by Bock and colleagues (Bock, 1986, 1989; Bock & Loebell, 1990).

(1a) The secretary baked a cake for her boss.

(1b) The wealthy widow drove her Mercedes to the church.

(1c) Susan brought a book to study.

Taking *X primes Y* to mean that utterance *Y* is more likely to be produced by participants who have just produced utterance *X*, it has been demonstrated that *The girl handed a paintbrush to the man* is primed by (1a) (individual lexical items do not affect priming) and by (1b) (the priming of a prepositional phrase is not affected by its thematic role). However, (1c) does not prime *The girl handed a paintbrush to the man* (prosodic similarity does not affect production).

Starting with this evidence, Pickering and Branigan (1998, henceforth P&B) have recently argued for the specification of syntactic verb information within the production lexicon. Using a localised network model of the production lexicon derived from Roelofs (1992, 1993) they argue that lemma nodes for verbs are linked to additional nodes representing syntactic features such as tense and aspect. These nodes in turn link to 'lexeme nodes' on a separate stratum, which represent potential lexical forms of verbs. If the verb lemma <GIVE> and both a past tense node and a perfective aspect node are active, a likely articulation through the lexemic level would be *gave*. The syntactic feature nodes are unique, such that any verb which can be expressed in the past tense is linked to the same past tense node as is <GIVE>. Importantly, P&B also assume that verb lemmas are linked to 'combinatorial' nodes which express the constructions in which a verb can be used. <GIVE> would have links to (at least) two combinatorial nodes, representing 'NP NP' (give the dog a bone) and 'NP PP' (give the bone to a dog) combinations. It is worth noting that (at least) two types of information traditionally described as subcategorisation information are combined by these nodes, since they encode not only the types (syntactic category and case) of arguments used, but also the number of arguments (i.e., the verb's valence).

Using standard assumptions about decaying activation,[1] the priming of *The girl handed the paintbrush to a man* by *The rock star sold some cocaine to an undercover agent* is accounted for by suggesting that the 'NP PP' node retains some activation and thus reaches threshold more easily when making the second utterance. P&B provide support for this model by adopting a novel methodology (see also Branigan, Pickering, Liversedge, Stewart, & Urbach, 1995), in which participants provide written completions for partial sentences. The prime sentences are pragmatically constrained such that the most likely completion is of a given form (e.g., *The racing*

[1] P&B's model deviates from more traditional activation models in that some links, as well as nodes, retain activation over time. However the detail of the model has no bearing on the functional/positional dichotomy to which we address ourselves in this paper.

driver gave the torn overall ___ vs. *The racing driver gave the helpful mechanic* ___) but the target sentences end after the matrix verb (e.g., *The patient showed* ___). In line with P&B's predictions, subjects are more likely to produce target sentences with the same syntactic structures as the primes. Moreover, the priming effect becomes stronger when the verb is repeated between prime and target (when activation from both lemma and combinatorial nodes is assumed to contribute to the effect). Finally, syntactic priming is unaffected by differences between prime and target in the verb's tense, aspect, or number, supporting the idea that syntactic feature information is separate from the representations involved in syntactic priming (i.e. lemmas and combinatorial nodes).

However, P&B's evidence lends itself to alternative interpretations. Firstly, it might be possible to account for their findings in terms of *positional* rather than *functional* processing: in English, the positions of the two arguments of a ditransitive verb such as *give* are confounded with the different syntactic structures that are required to realise each possible sequence ('NP NP' vs. 'NP PP'). The same line of reasoning applies to Bock's research: it might even be argued that the irrelevance of thematic role assignment to PP-priming militates against a view where constituents are stipulated at a lexical (argument structure) level, and for a model in which particular constituents like 'NP' or 'PP' are more likely to be reproduced 'in the same linear position'. Evidence for the view that the order of constituents can be primed (where the underlying syntactic representation remains constant) has been recently demonstrated in Dutch (Hartsuiker, in preparation; Hartsuiker & Kolk, 1998b).

Secondly, P&B's experimental findings might be accounted for if they simply reflected the propensity of the production system to reuse particular types of syntactic constituents (for example, PPs). This hypothesis has the attraction of providing a more natural explanation for the priming of *The girl handed a paintbrush to the man* by sentences including optional arguments or modifiers (Bock & Loebell, 1990).[2] Because the experiments do not contain a baseline condition, it is impossible to tell whether both 'NP NP' and 'NP PP' primes have an effect on the sentence produced, or whether, for example, it is only an 'NP PP' prime which affects the standard distribution of responses (see Hartsuiker & Kolk, 1998a, for a similar argument). If previous findings can be accounted for by a mechanism which is simply more likely to use a particular type of constituent, then people may be equally likely to produce sentences where the verb has a different number of arguments but a particular constituent is reproduced, provided that there are no constraints on the verb produced in the target sentence. To make this concrete, consider a situation in which the prime sentence is *The man gave a toy to the child* (which has an 'NP PP' form). If syntactic priming simply reflects the probability of reusing particular constituents (say, a PP), then in the absence of a constraining verb in the target sentence, people may be as likely to produce *The man sang in the bath* as *The man put the soap in its holder* (since both contain PPs).

German provides an interesting opportunity to explore the issues outlined above more fully. In German, ditransitive verbs such as *geben* (to give) take two case-marked arguments: the object given has accusative case, and the recipient has dative case. Importantly, the order of these arguments is (almost) arbitrary, so that *Ich gab dem Mann das Buch* and *Ich gab das Buch dem Mann* are both translated as "I gave the man the book". Therefore, it is possible to explore priming effects at the positional level (as in studies on Dutch: Hartsuiker, in preparation; Hartsuiker & Kolk, 1998b). A second feature of German is that *mono*transitive verbs (which take a single object) can subcategorise for either accusative or dative case objects, providing an opportunity to test whether certain types of arguments (designated by case rather than syntactic category) are reused over consecutive trials. Taken together, this results in a system where number of arguments (1 or 2), type of arguments (accusative or dative NP), and (for ditransitives) order of arguments are orthogonally specified.

A Completion Experiment on the Internet

The aim of the current study is to exploit these features of German to provide a fuller investigation of syntactic priming, using the sentence completion method pioneered by Branigan et al. (1995) and Pickering and Branigan (1998). In this study, primes consist of ditransitives in each of the possible configurations (which we will refer to as *dat*<*acc* and *acc*<*dat*) as well as monotransitives which subcategorise for single accusative (*acc*) or dative (*dat*) arguments. As well as these four primes, we include a baseline condition (where the prime is unrelated to the type of target that can be generated, given experimental constraints). Finally, because we are interested not only in the order of arguments but also in the numbers and types of arguments generated, participants are left free to choose the verb for the target sentence fragment, in contrast to previous studies.

Participants The experiment was administered via the World Wide Web. Participants were recruited through advertisements in Usenet newsgroups as well as through links from other web pages. Fifty-eight participants from different regions of Germany, Austria, and Switzerland completed the experiment. All of them acquired German as their first language, and most of them (83%) were university graduates or students of different scientific subjects. Participants' average age was 28.5 years, ranging from 18 to 54 years. Thirty-six of them were male, 22 female.

Materials The experiment had a two-factor (5×2) design, using a syntactic priming paradigm in which both primes and targets consisted of sentence fragments for completion. Participants had to complete one of two types of target fragments

[2] P&B provide an alternative account of this finding by suggesting that 'combinatorial' nodes encode syntactic rules (such as VP $\Rightarrow$ NP PP) rather than subcategorisation information.

after having completed one of five types of priming constructions.

The **targets** consisted of pairs of VP-head-final sentence fragments of the forms in (2) below (where ___ represents the missing material that was to be provided by the participant).

(2a) **accusative target** $NP_{[nom]}$ *hat* $NP_{[acc]}$ ___ *wollen*.

(2b) **dative target** $NP_{[nom]}$ *hat* $NP_{[dat]}$ ___ *wollen*.

Each target could be completed in one of two ways. The fragments could be completed using a *monotransitive* verb (i.e., a verb which takes a single object NP in the accusative or dative case for (2a) and (2b) respectively). Alternatively, the completion could consist of a second object NP followed by a *ditransitive* verb. For instance, an accusative target like *Der Mann hat den Freund* ___ *wollen* (The man has the$_{[acc]}$ friend ___ wanted, cf. (2a)) might be completed with *treffen* (to meet) which subcategorises for a single accusative object NP. Alternatively, a phrase like *seinem Kollegen vorstellen* (to introduce to his colleague) might be used, resulting in a ditransitive construction. Likewise, a dative target like *Der Mann hat dem Freund* ___ *wollen* (The man has [to] the$_{[dat]}$ friend ___ wanted, cf. (2b)) could legitimately be completed using *helfen* (to help), which takes a single dative object NP, as well as with a phrase like *seinen Kollegen vorstellen* (to introduce his colleague) as a ditransitive completion. Note that ditransitive completions of examples of the form of (2b) imply a canonical dat<acc ordering of the object NPs. For (2a), on the other hand, ditransitive completions result in less common (though acceptable) acc<dat sequences.

(3a) **acc<dat** $NP_{[nom]}$ *hat* $NP_{[acc]}$ ___ $V_{[ppl;\ <dat,acc>]}$.
or $NP_{[nom]}$ *hat* ___ $NP_{[dat]}$ $V_{[ppl;\ <dat,acc>]}$.

(3b) **dat<acc** $NP_{[nom]}$ *hat* $NP_{[dat]}$ ___ $V_{[ppl;\ <dat,acc>]}$.
or $NP_{[nom]}$ *hat* ___ $NP_{[acc]}$ $V_{[ppl;\ <dat,acc>]}$.

(3c) **acc** $NP_{[nom]}$ *hat* ___ $V_{[ppl;\ <acc>]}$.

(3d) **dat** $NP_{[nom]}$ *hat/ist* ___ $V_{[ppl;\ <dat>]}$.

(3e) **baseline** $NP_{[nom]}$ *war* ___ *als* $NP_{[nom]}$.

The sets of five **priming** materials were constrained such that the most likely completion would be an object NP (in (3a–d)) or a comparative (in (3e)) (the latter, equivalent to the English 'NP1 *was* ___ *than* NP2', served as the baseline condition). Materials modelled on (3a)—where, in an equal proportion of trials, either the dative or the accusative object was missing—were constructed such that the most likely completion would result in a ditransitive construction with (non-canonical) acc<dat argument order. Condition (3b) was similar to (3a), but a canonical dat<acc ditransitive was the most likely outcome. (3c) and (3d) were most likely to be completed as monotransitive constructions with either a single accusative (3c) or a single dative (3d) object NP. A major constraining factor of the priming materials was the verbs, which were selected on the basis of their subcat-specifications from the CELEX German Database: for (3a) and (3b), we selected strictly ditransitive predicates, like *gezeigt* (showed), which subcategorise for both a dative and an accusative object; in (3c), predicates which require a single accusative object, like *untersucht* (examined), were used; and for (3d), we chose predicates taking a single dative object like *begegnet* (came across).[3] The copula-verb baseline condition (3e) implied none of these verb frames.

Thirty different item-sets were generated, each comprising two target fragments (cf. (2)) and ten priming fragments (cf. (3)). There were two sentence fragments per priming condition and one sentence fragment per target condition in each item-set, so that the sentence fragments could be arranged in triplets of two primes of the same condition followed by one target. The sentence fragments used for each of the triplets were semantically unrelated.

All possible combinations of priming and target fragments were used, resulting in ten different triplets per item-set. The resulting 300 triplets were randomly allotted to ten treatments such that each treatment contained an equal number of triplets of each type. Each item-set appeared exactly once per treatment, but in a different condition than in the other treatments. A set of 90 filler fragments was also generated—these included intransitives, passives, or copula-verb constructions similar to (3e). The set of fillers was added to each treatment, resulting in a total of 180 sentence fragments per treatment.

Table 1 shows an example triplet consisting of two priming fragments of type (3a), followed by a target fragment of type (2b).

Table 1: Example material set corresponding to conditions (3a) and (2b).

prime 1	Die Mutter hat das Kind ___ anvertraut.
prime 2	Der Dekan hat ___ dem Professor vorgestellt.
target	Der Junge hat dem Mädchen ___ wollen.

Procedure Materials were presented using the WebExp experimental toolkit (Keller, Corley, Corley, Konieczny, & Todirascu, 1998).[4] Each sentence fragment was presented

[3] Some dative-object verbs in German select a form of *sein* (to be) rather than *haben* (to have) as their perfect tense auxiliary (cf. (3d)). While this kind of restriction can be useful to elicit the intended response in some of the priming constructions, it needs to be eliminated from the targets. Therefore, we used a modal auxiliary like *wollen* at the end of each target fragment, so that any type of infinitival main verb (instead of a participle) could be inserted. Informed by P&B, we considered the resulting syntactic feature differences between prime and target verbs irrelevant for the priming effects of interest.

[4] A demo is available at `http://www.hcrc.ed.ac.uk/web_exp/`

(via a web browser) in a text box, with a series of dashes representing the missing portion: participants were instructed to type one or more words into a second text box such that an *acceptable* sentence was formed from the fragment and the word or phrase that they supplied, where acceptable was defined as grammatically correct and reasonably plausible. There were no further restrictions on how participants completed the sentences, other than their being asked to avoid proper names if possible. Further instructions emphasised that participants should rely on first impressions rather than trying to create witty or original completions.

The WebExp software rotated through the ten sets of materials, so that each new participant saw a different treatment. Within each treatment, the materials were randomised such that each prime-prime-target triple was preceded by three fillers, drawn at random from the ninety available. Completion of an item (by pressing RETURN) resulted in the immediate display of the following item; participants were not able to re-inspect items or responses once they had been recorded. Responses were timed (on the participant's computer) by recording the time taken to make the first keystroke of any response, as well as the time to press RETURN at the end of a response. Completions were required for all 180 items in a given set of materials. At the close of the experiment, participants were thanked for their time and promised a debriefing once the experiment was complete (debriefs were later sent by email).

Two independent judges categorised the responses made to both prime and target fragments, recording the orders and cases of arguments, and the subcategorisation properties of the verbs chosen. The categories were later conflated into *correct* or *incorrect* for primes (reflecting whether the desired response had in fact been elicited) and into *monotrans*, *ditrans* or *other* for targets (reflecting mainly the subcategorisation properties of the verbs chosen). In the few cases where participants had selected a ditransitive verb without including an additional object NP (resulting in an 'implicit argument' construction), target responses were scored as *monotrans*. Grammatically incorrect responses (most of which included wrong case assignments) and responses involving prepositional complements were categorised as *other*.

Analysis Effects were examined by testing hierarchical loglinear models (see Howell, 1997, for an overview), adjusting observed cell counts to factor combinations of prime type (cf. (3)), target type (cf. (2)), completion type (*monotrans* vs. *ditrans* vs. *other*),[5] and either participants or items. The analyses including participants or items as random factors are reported as ${}_{\mathrm{LR}}\chi^2{}_{(\mathrm{subj})}$ and ${}_{\mathrm{LR}}\chi^2{}_{(\mathrm{item})}$ respectively; a further statistic, ${}_{\mathrm{LR}}\chi^2{}_{(\mathrm{marg})}$, refers to an analysis in which the effect itself (i.e., its constituting factor combination) serves as the saturated model, ignoring additional random factors. Technically, the first two statistics represent so-called *partial associations*, whereas the third refers to the *marginal association* of an effect. For main or simple effects only marginal associations (${}_{\mathrm{LR}}\chi^2{}_{(\mathrm{marg})}$) will be reported, as the partial associations are redundant in these cases.

Predictions

Priming Effects Due to the exploratory nature of this experiment, we will skip discussing hypothetical priming effects in favour of a discussion of the theoretical implications of the observed data at the end of this paper. Therefore, we turn our attention to predictions of baseline effects in the following section.

Baselines We assumed that the standard distribution of the target responses would be influenced by (at least) two factors: Firstly, the availability of different subcategorisation frames, and secondly, canonical argument ordering constraints. The former was assumed, as a rough estimation, to be a function of the relative sizes of different verb classes in German, given that participants have to choose from these to generate their responses. According to the CELEX German Database, about 63% of the 'common' verbs in German (i.e. verbs with a lemma frequency of at least 10 per million) are monotransitives requiring a single accusative object NP; 23% are ditransitives, taking both an accusative and a dative object NP; and only 4% are monotransitives subcategorising for a single dative object NP (the remaining 10% are either intransitives or verbs requiring other types of complements). Given this distribution of available verb frames (and because participants may avoid generating non-canonical orderings if possible) we predicted that *monotrans* completions should be predominant for accusative targets like (2a). For dative targets like (2b), however, we expected *ditrans* responses to be most frequent, as the set of verbs which take a single dative object NP is relatively small.

Results

Data from seven participants were excluded from analysis: in five cases, because the proportion of *other* responses was greater than 25% (this may, in some cases, reflect dialectal variations), and in two cases, because median response latencies were extremely slow (at > 20 sec). Target data points from the remaining 51 subjects were excluded if: (a) the immediately preceding prime was categorised as incorrect; (b) the time between the onset of a response to the immediately preceding prime and the onset of the target response lay outwith the participant-specific interquartile range. These criteria resulted in the exclusion of 13% of the trials from analysis. Consequently, the results reported are based on a total of 1334 data points.

The frequency of correct trials varied considerably across priming conditions (acc<dat: 68.5%; dat<acc: 88%; acc: 95%; dat: 90%; baseline: 95%), mainly reflecting the fact that participants were more reluctant to produce the intended completion in the non-canonical (acc<dat) priming condition. For the targets, there were 889 (66.6%) *monotrans*, 341

[5] Note that the 'dependent variable' is treated as a factor (as in a standard χ^2 test).

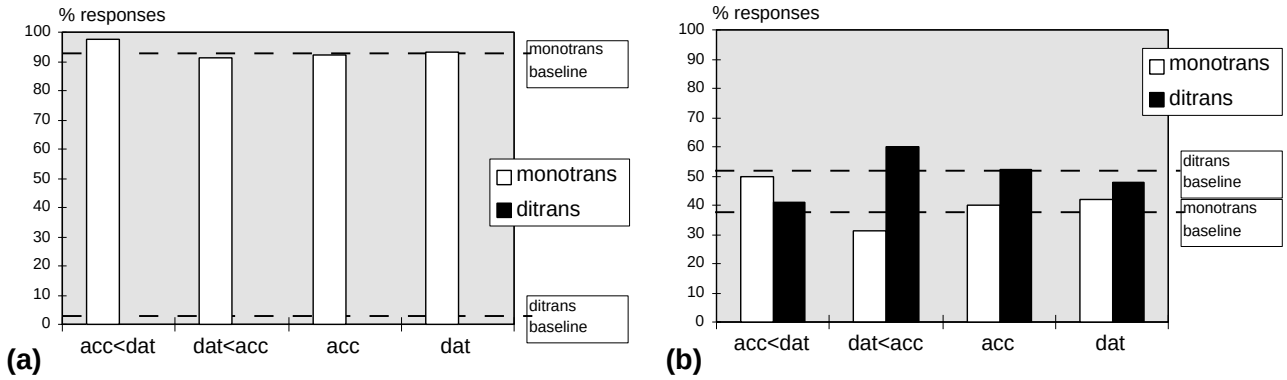

Figure 1: percentages of monotrans and ditrans completions for (a) accusative and (b) dative targets, by type of correctly completed prime.

(25.6%) *ditrans*, and 104 (7.8%) *other* responses in total. Interestingly, participants reused a verb from one of the preceding primes in less than 0.5% of the target completions.

Figure 1 shows the frequencies of *monotrans* and *ditrans* responses (in proportion to the total number of responses per condition) separately for accusative targets (Fig. 1a) and for dative targets (Fig. 1b). Dashed lines indicate baseline response rates. The remaining four prime conditions are represented by data columns.

Baselines In the *baseline* prime condition, the predicted biases were confirmed: for accusative targets, *monotrans* completions were clearly predominant (91%, ditrans = 3%, other = 6%); for dative targets, however, *ditrans* responses were the most frequent (52%, monotrans = 38%, other = 10%). In fact, irrespective of prime type, there was a significant overall interaction between target type and completion type ($_{\text{LR}}\chi^2_{\text{(subj, item, marg)}} > 500$; df = 2; p < .001) which replicates the pattern found in the baseline condition: for accusative targets, *monotrans* completions were the most frequent (93%; ditrans = 0.5%, other = 6.5%: $_{\text{LR}}\chi^2_{\text{(marg)}} > 600$; df = 1; p < .001); for dative targets, *ditrans* completions were the most frequent (51%; monotrans = 40%, other = 9%: $_{\text{LR}}\chi^2_{\text{(marg)}} > 9.950$; df = 1; p < .002).

Priming Effects

The prime type × target type × completion type interaction was significant, at least by tests adjusting for subject and item variation ($_{\text{LR}}\chi^2_{\text{(subj, item)}} > 27.0$; df = 8; p < .001; $_{\text{LR}}\chi^2_{\text{(marg)}} = 15.295$; df = 8; p = .054). Unfortunately, the strong *monotrans* bias in the accusative target condition (there were virtually no *ditrans* responses) rendered any further statistical exploration in this target condition infeasible. Therefore, only the dative target condition was examined in detail. This was done by partitioning the prime type factor into 'monotransitive' and 'ditransitive' primes.[6]

Dative Targets In order to examine the effects of 'monotransitive' primes on the distribution of responses in the dative target condition, a reduced model comprising only the *acc*, *dat*, and *baseline* conditions was generated. Testing this model revealed no significant interaction between prime type and completion type ($_{\text{LR}}\chi^2_{\text{(subj, item, marg)}} < 0.7$; df = 2; p > .70). Testing 'ditransitive' primes via a model including the *acc*<*dat*, the *dat*<*acc*, and the *baseline* condition revealed a reliable impact of prime type on completion type ($_{\text{LR}}\chi^2_{\text{(subj, item, marg)}} > 7.930$; df = 2; p < .02): as can be seen in Figure 1b, the tendency to produce *ditrans* completions was more pronounced after canonical dat<acc primes; the **reverse** tendency, i.e., to produce *monotrans* rather than *ditrans* completions, was found in the non-canonical acc<dat priming condition. Statistically, the proportion of *monotrans* and *ditrans* target completions clearly differed between the two 'ditransitive' priming conditions ($_{\text{LR}}\chi^2_{\text{(subj, item, marg)}} > 6.950$; df = 1; p < .01). Contrasts with the baseline condition were confirmed as statistical trends (acc<dat vs. baseline: $_{\text{LR}}\chi^2_{\text{(subj)}} = 1.903$; df = 1; p < .17; $_{\text{LR}}\chi^2_{\text{(item)}} = 4.758$; df = 1; p < .03; $_{\text{LR}}\chi^2_{\text{(marg)}} = 3.210$; df = 1; p < .08; dat<acc vs. baseline: $_{\text{LR}}\chi^2_{\text{(subj)}} = 3.638$; df = 1; p < .06; $_{\text{LR}}\chi^2_{\text{(item)}} = 2.058$; df = 1; p < .16; $_{\text{LR}}\chi^2_{\text{(marg)}} = 4.100$; df = 1; p < .05).

Discussion

The observed data pattern (at least as established in the dative target condition) bears some interesting implications for the representation of combinatorial information in sentence production (cf. Pickering & Branigan, 1998), and may even challenge some architectural assumptions about the human language production system: it appears that subcategorisation properties of verbs *per se* (in terms of verb valence and case of arguments) are not subject to syntactic priming. This is highlighted by the fact that (a) 'monotransitive' primes (acc and dat) have no significant impact on the distribution of

[6] These analyses considered only the distributions of *monotrans* and *ditrans* completions, as the proportion of *other* responses was totally unaffected by prime type in the dative target condition ($_{\text{LR}}\chi^2_{\text{(subj, item, marg)}} < 1$; df = 4; p > .95).

the (dative) target completions, and (b) 'ditransitive' primes (acc<dat and dat<acc) have *facilitatory* as well as *inhibitory* effects on the relative proportions of *ditrans* to *monotrans* responses, dependent on the sequence of arguments specified in the prime. As the latter indicates, there is clear evidence for the importance of positional information in syntactic priming, comparable to recent results from Dutch (cf. Hartsuiker, in preparation; Hartsuiker & Kolk, 1998b).

With respect to representational aspects of a production model, the results could be interpreted as suggesting that combinatorial nodes in the verb lexicon encode subcategorisation information as well as information about the (canonical/non-canonical) sequencing of arguments, i.e., something similar to what is encoded in traditional context free grammar rules (cf. P&B). Unfortunately, our data remain unclear regarding the precise nature of these representations, since the accusative target condition was uninformative (due to a massive bias towards monotransitive responses in this condition): the observed ordering effects could be due to 'canonical vs. non-canonical' argument ordering (i.e., ditransitive verb-frames become more easily retrievable after canonical primes, but less easily retrievable after non-canonical primes) or to a 'match vs. mismatch' in (implied) argument order between prime and target. At this point, we leave this as a question for future research.

Our data do however greatly constrain the range of plausible architectural assumptions about sentence production. Our findings can be taken as strong evidence against a model which claims that processes at the functional level (i.e., verb retrieval and syntactic function assignment) necessarily precede, and therefore determine, positional processing, but not vice versa (e.g., Bock & Levelt, 1994). It appears that positional processing can, under certain circumstances, determine the outcome of processes at the functional level, in such a way that the ease of retrieving a ditransitive verb (in a target trial) is dependent on the argument order specified in a preceding ditransitive priming construction. Note that the retrievability of the verb (or of its corresponding subcategorisation frame) in the prime cannot account for this evidence, since strictly ditransitive prime verbs had already been presented to participants (unlike the target verbs which participants were free to choose). Thus, it must have been the linear order of the arguments that had to be produced in a correctly completed prime that affected the increased or decreased availability of a ditransitive verb frame in the target trials. This is clearly incompatible with (at least) models which claim that there is no feedback from the positional to the functional level of sentence planning (e.g., Bock & Levelt, 1994).

In general, the results of this and other experiments highlight the importance of cross-linguistic research for refining, and possibly revising, existing theories of human language processing, most of which were developed on the basis of English data. The Internet may provide the ideal medium for this kind of research.

Note The order of the authors is arbitrary. We wish to thank Ulf Reips, Bernad Batinic, Axel Theobald, and John Krantz for kindly providing links to our web experiment from their host pages. We are especially grateful to Frank Keller for his technical support.

References

Bock, J. K. (1986). Syntactic persistence in language production. *Cognitive Psychology*, *18*, 355–387.

Bock, J. K. (1989). Closed-class immanence in sentence production. *Cognition*, *31*, 163–186.

Bock, J. K., & Levelt, W. J. (1994). Language production: Grammatical encoding. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics.* San Diego, CA: Academic Press.

Bock, J. K., & Loebell, H. (1990). Framing sentences. *Cognition*, *35*, 1–39.

Branigan, H. P., Pickering, M. J., Liversedge, S. P., Stewart, A. P., & Urbach, T. P. (1995). Syntactic priming: Investigating the mental representation of language. *Journal of Psycholinguistic Research*, *24*, 489–506.

Hartsuiker, R. J. (in preparation). Determination of word order in written and spoken sentence production.

Hartsuiker, R. J., & Kolk, H. H. J. (1998a). Syntactic facilitation in agrammatic sentence production. *Brain and Language*, *62*, 221–254.

Hartsuiker, R. J., & Kolk, H. H. J. (1998b). Syntactic persistence in Dutch. *Language and Speech*, *41*, 143–184.

Howell, D. C. (1997). *Statistical methods for psychology* (4 ed.). Belmont, CA: Duxbury Press.

Keller, F., Corley, M., Corley, S., Konieczny, L., & Todirascu, A. (1998). *WebExp: A Java toolbox for web-based psychological experiments* (Technical Report No. HCRC/TR-99). Human Communication Research Centre, University of Edinburgh.

Pickering, M. J., & Branigan, H. P. (1998). The representation of verbs: Evidence from syntactic priming in language production. *Journal of Memory and Language*, *39*, 633–651.

Roelofs, A. (1992). A spreading-activation theory of lemma retrieval in speaking. *Cognition*, *42*, 107–142.

Roelofs, A. (1993). Testing a non-decompositional theory of lemma retrieval in speaking: Retrieval of verbs. *Cognition*, *47*, 59–87.