Syntactic priming in language production

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People have a tendency to repeat the types of sentences they use during language production. Recent experimental work has shown that this phenomenon is at least partly due to ‘syntactic priming’, whereby the act of processing an utterance with a particular form facilitates processing a subsequent utterance with the same or a related form. In this review, we first provide an overview of the evidence for syntactic priming. The review will then explore the implications of this research for three different areas of language theory: the possible functional significance of syntactic priming in coordinating speakers during dialogue, the mechanisms underlying sentence production, and the nature of linguistic representation.

Both observational and experimental evidence indicate that people are more likely to use a particular syntactic structure at certain points in the interview; whilst both the corpus studies and experimental studies might actually be showing the well-known facilitatory effects of repeating particular words. However, experimental demonstrations of syntactic priming convincingly rule out most alternative explanations.

In all of these studies, participants are exposed to one or other prime sentence, and its impact on production of a target sentence is measured. The first clear experimental evidence for syntactic priming in production was provided by Bock, who found that speakers tended to repeat syntactic form when producing sentences that were not related in meaning and did not form a connected discourse (see Box 1 and Fig. 1). These studies suggest that syntactic priming cannot be explained by lexical, thematic or metrical correspondences between prime and target. In other words, this form of priming appears to be due specifically to the structure of sentences, not the repetition of words, types of event or sound patterns; the syntactic structure of a sentence appears to prime the syntactic structure of a subsequent sentence. Other studies have demonstrated syntactic priming using sentence completion (see Fig. 2) and sentence recall. Two reports indicate that it occurs in Dutch, so the phenomenon is not limited to English. It is also found in both spoken and written language production. We therefore conclude that syntactic priming does occur. Furthermore, beside being an interesting observation in itself, what it is able to tell us about the way that language is represented and used?

Syntactic priming and coordination in dialogue

Syntactic priming might occur purely as a by-product of syntactic processing, but an alternative is that it serves a functional role. One attractive possibility is that syntactic priming facilitates the use of dialogue. Speakers are faced with the highly complex problem of communicating an idea in a well-formed and fluent utterance, and therefore have to integrate a number of very different kinds of information. Thus, any means of reducing the computational load would be beneficial. Syntactic priming could be a means of reducing the load associated with syntactic processing, by...
facilitating production of particular syntactic structures. Listeners, on the other hand, are faced with interpreting syntactically ambiguous utterances. If listeners are sensitive to speakers’ tendency towards syntactic priming, then they have a better chance of resolving such ambiguities correctly. Clearly, then, both speakers and listeners would benefit from syntactic priming effects in dialogue, with speakers being primed by the utterances they produce and those produced by other participants in the dialogue. These effects would result in local syntactic consistency in dialogue: a tendency for participants in a dialogue to produce the same or similar structures. In other words, participants should tend to coordinate the syntactic structures of their contributions.

Research on the establishment of conventions predicts that speakers in a dialogue will coordinate their language\(^3\). In keeping with this, there is good evidence for coordination at many levels in dialogue. In describing abstract mazes, participants tended to converge on particular types of description (e.g., descriptions based on paths between positions, or in terms of figures such as T-shapes or promontory-like shapes) and to use the same words as each other, in the same way\(^4,5\). This is a form of semantic coordination in terms of the mental models employed by the participants. Work on the coordination of referring expressions suggests that participants form a ‘conceptual pact’ or temporary agreement about how to refer to an object\(^6,7\). This conceptual pact may gradually develop through a dialogue.

**Box 1. Evidence for syntactic priming from picture description**

Bock used the gains of a memory test to investigate syntactic priming effects in individual speakers (Ref. 2). In her experiments, speakers alternately read prime sentences and described semantically unrelated target pictures. Bock manipulated the syntactic forms of the sentences that speakers read. For example, the prime sentence might be an active in one condition (e.g., ‘One of the fans pushed the referee’) and a passive in the other condition (e.g., ‘The referee was pushed by one of the fans’). Alternatively, it might employ the propositional-object form of an alternating dative verb in one condition (e.g., ‘A rock star sold some cocaine to an undercover agent’) and the double-object form in the other condition (e.g., ‘A rock star sold some cocaine to a new location’). The target pictures were designed so that they could be described using either form. Participants showed an increased tendency to produce an active target picture description after an active prime, a passive target picture description after a passive prime, and so on.

Other studies extended these original results. For instance, the production of propositional-object sentences like ‘The secretary took a cake to her boss’ was more effective as an active sentence than a passive sentence (Ref. 3). In similar studies, Bock and colleagues demonstrated that the tendency for sentence production to be repeated within sections of a dialogue or text is a consequence of syntactic priming effects (Ref. 4). In keeping with this, there is good evidence for coordination at many levels in dialogue. In describing abstract mazes, participants tended to converge on particular types of description (e.g., descriptions based on paths between positions, or in terms of figures such as T-shapes or promontory-like shapes) and to use the same words as each other, in the same way (Ref. 5). This is a form of semantic coordination in terms of the mental models employed by the participants. Work on the coordination of referring expressions suggests that participants form a ‘conceptual pact’ or temporary agreement about how to refer to an object (Ref. 6). This conceptual pact may gradually develop through a dialogue.

<table>
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<th>Glossary</th>
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<tr>
<td><strong>Active</strong>: a sentence such as ‘The girl saw the boy’, where the grammatical subject (the girl) is typically the initiator of the action denoted by the verb.</td>
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<td><strong>Adjunct</strong>: adjoins express information that is not an inherent part of the meaning of the action denoted by a verb. For example, information about location is not inherent to the meaning of ‘run’ (e.g., ‘Bob runs in the bath’).</td>
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<td><strong>Argument</strong>: argument adjoins express information that is not an inherent part of the meaning of the action denoted by a verb. For example, the meaning of ‘put’ is altered when the object is moved away from the subject (e.g., ‘Put the rubber duck in the bath’ is an argument of the verb).</td>
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<td><strong>Dative verb</strong>: a verb, such as ‘give’, that is associated with three arguments: the entity that performs the action, the entity that is acted upon, and the entity that is the beneficiary of the action. ‘Alternating’ dative verbs can appear in two syntactic realizations, one in which the entity that is acted upon precedes the beneficiary of the action (e.g., ‘give the book to the girl’) and one in which the beneficiary of the action precedes the entity that is acted upon (e.g., ‘give the girl the book’). In this way, we call the former the ‘propositional-object form’ and the latter the ‘double-object form’.</td>
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<td><strong>Grammatical function</strong>: relating to meaning.</td>
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<td><strong>Grammatical role</strong>: relating to the grammatical structure of language.</td>
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<td><strong>Lexical</strong>: relating to words.</td>
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<td><strong>Local syntactic consistency</strong>: the tendency for syntactic structures to be repeated within sections of a dialogue or text.</td>
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<td><strong>Metrical</strong>: relating to the rhythmic structure and stress pattern of words.</td>
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<td><strong>Morphological</strong>: relating to the structure of forms of words.</td>
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<td><strong>Semantic</strong>: relating to meaning.</td>
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<td><strong>Thematically</strong>: relating to the role that an entity plays in an event (e.g., beneficiary of an action).</td>
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**References**

Syntactic priming in language production

Clear there are good theoretical grounds for predicting syntactic priming effects between speakers in dialogue, but is there empirical evidence to support this? The corpus evidence reviewed earlier includes demonstrations of local syntactic consistency between speakers in dialogue, but, of course, such studies can be explained without appeals to syntactic priming. There is also some evidence from memory recall experiments that priming for the production of particular syntactic forms can occur as a result of comprehension alone, but these findings relate to individual speakers outside a dialogue11. Recent work suggests strongly that syntactic priming does occur between speakers in dialogue when other explanations can be excluded (H. Branigan, M. Pickering and A. Cleland, unpublished data). Pain of speakers took it in turns to describe pictures to each other that could be described using two forms. One speaker was a confederate of the experimenter who was scripted to produce one or other form as the prime. When the verb remained the same between prime and target, the experimental subject used the same form as the confederate on 77.5% of trials (chance would be 50%); when the verb differed, the percentage was 69%. While preliminary findings, these effects were extremely large, in comparison with data from studies of isolated sentences.

The mechanisms underlying sentence production

Bock and colleagues11,26 argued that producing a sentence involves the activation of procedures associated with producing a particular syntactic form. Thus, there might be a particular procedure associated with producing sentences like ‘The teacher gave the book to the boy’ (the prepositional- object form) and another associated with producing sentences like ‘The teacher gave the boy the book’ (the double-object form). The activation of a procedure does not disappear immediately, and so subsequent use of that procedure is facilitated. They argued against an alternative explanation of priming, whereby priming is due to an episodic trace or phonological memory of a particular sentence2. One obvious problem with this alternative is that the actual prime and target sentences can be very different (e.g. priming occurs when prime and target differ in words and fine-grained syntactic structure5).

But the procedural account is problematic if priming occurs from comprehension to production. The procedure associated with comprehending a particular syntactic form must be different from the procedure associated with producing it, because the operation involved is reversed. However, there is another explanation of syntactic priming. The relevant information about syntactic form is the same in both comprehension and production (assuming that there is a rough correspondence between the sentences that people will produce and the sentences that they regard as acceptable sentences of their language). It would therefore be least redundant to represent this information once only, and to draw upon this same body of information in both comprehension and production. (This position may appear natural, but representational assumptions made by theories of language comprehension and theories of language production do not always correspond.) We argue that syntactic priming arises as a result of residual activation of aspects of this representation12. Below, we consider the nature of this representation in more detail; but first, we consider the way in which this representation might relate to the rest of the language production system.

We adopt a recent model of lexical representation in language production due to Levelt and colleagues10. They assumed a model of language production that comprises stages of ‘conceptualization’ (generating a message to express), ‘formulation’ (encoding the message in linguistic form) and ‘articulation’ (realising the linguistic expression as a series of sounds). Under their account, lexical entries are represented at three levels: ‘concrete stratum’, encoding semantic information, a ‘lemma’ stratum, encoding syntactic information, and a ‘form’ stratum, encoding morphological and phonological information. Levelt10,11.
The idea that syntactic priming taps into knowledge of language, and as such can inform theories of syntactic representation, is clearly anomalous to those linguists who believe that the domain of linguistics is not that of mental representations (Ref. 6). In their view, linguistics seeks to produce theories of the structural properties of language defined as a collection of sentences, and the sentences of the language themselves constitute the only relevant data. In such accounts, the truth of a linguistic rule cannot be affected by anything that is represented in the mind. Even if this is a reasonable interpretation of one type of linguistics, these findings suggest that the sentences by the bee’, they access the knowledge of language, and as such can inform theories of syntactic representation, is clearly anomalous to those linguists who believe that the domain of linguistics is not that of mental representations (Ref. 6). In their view, linguistics seeks to produce theories of the structural properties of language defined as a collection of sentences, and the sentences of the language themselves constitute the only relevant data. In such accounts, the truth of a linguistic rule cannot be affected by anything that is represented in the mind. Even if this is a reasonable interpretation of one type of linguistics, these findings suggest that the sentences by the bee’, they access the knowledge of language, and as such can inform theories of syntactic representation, is clearly anomalous to those linguists who believe that the domain of linguistics is not that of mental representations (Ref. 6). In their view, linguistics seeks to produce theories of the structural properties of language defined as a collection of sentences, and the sentences of the language themselves constitute the only relevant data. In such accounts, the truth of a linguistic rule cannot be affected by anything that is represented in the mind. Even if this is a reasonable interpretation of one type of linguistics, these findings suggest that the sentences by the bee’, they access the knowledge of language, and as such can inform theories of syntactic representation, is clearly anomalous to those linguists who believe that the domain of linguistics is not that of mental representations (Ref. 6). In their view, linguistics seeks to produce theories of the structural properties of language defined as a collection of sentences, and the sentences of the language themselves constitute the only relevant data. In such accounts, the truth of a linguistic rule cannot be affected by anything that is represented in the mind. Even if this is a reasonable interpretation of one type of linguistics, these findings suggest that the sentences by the bee’, they access the knowledge of language, and as such can inform theories of syntactic representation, is clearly anomalous to those linguists who believe that the domain of linguistics is not that of mental representations (Ref. 6). In their view, linguistics seeks to produce theories of the structural properties of language defined as a collection of sentences, and the sentences of the language themselves constitute the only relevant data. In such accounts, the truth of a linguistic rule cannot be affected by anything that is represented in the mind. Even if this is a reasonable interpretation of one type of linguistics, these findings suggest that the
Box 3. Evidence from syntactic priming against grammatical transformations

Bock, Lushb and Money (Ref. 6) examined syntactic priming for active and passive sentences using the running recognition memory test paradigm (see Box 1). They primed the production of active or passive target descriptions of pictures (e.g., an alarm clock waking a boy) with an active or a passive prime containing either an animate or an inanimate subject. They found syntactic priming effects: participants produced more active after an active prime and more passive after a passive prime. But they also found an independent priming effect for grammatical function assignment, which was based on animacy: after producing a sentence with an animate subject, participants were more likely to produce another sentence with an animate subject. For example, an animate subject in an active sentence primed an animate subject in a passive sentence. The interesting linguistic point in these cases is that the binding that was primed was the binding between the property of animacy and the subject of the sentence that was actually produced. In other words, words or concepts categorized together the subject of an active sentence and the subject of a passive sentence. These findings argue against the ‘relations-changing’ theories of linguistics, in which the subject of a passive sentence is treated in the same way as the object of an active sentence (Refs 4–6). Instead, they provide evidence for theories of grammar in which the role of transformations is reduced (Ref. 6) or eliminated (Refs f,g).

References


Experiments, the two alternative syntactic forms involved the same phrases combined in different orders. For example, participants might say ‘The ball is on the table’, ‘On the table is the ball’, ‘The cat is under the table’, ‘Under the table is the cat’, ‘The grass is on the ground’, ‘On the ground is the grass’, ‘The tomato is on the plant’, ‘On the plant is the tomato’, ‘The toy is on the shelf’, ‘On the shelf is the toy’. The evidence for plural priming in dialogue suggests further that the combinatorial nodes are shared between production and comprehension. As such, it provides good evidence for Levelt and colleagues’ proposal that the lemma stratum is common to both comprehension and production. This claim is striking, because theories of language comprehension do not normally incorporate a lemma stratum. Syntactic priming and knowledge of language

We have argued that syntactic priming is informative about a lemma stratum that is common to both comprehension and production, and that priming works by activating knowledge that is stored at this level. We therefore claim that syntactic priming taps into knowledge of language itself, and as such can inform linguistic theories that are concerned with accounting for knowledge of language (see Box 2).

Chomsky argues that evidence from language processing is not informative about knowledge of language, essentially because any pattern of processing data (e.g. reaction times) is compatible with one grammar combined with one set of processing assumptions, or a different grammar combined with a different set of processing assumptions. Instead he favours the use of ‘linguistic’ evidence, most notably grammaticality judgements. The problem with his argument is that grammaticality judgements are themselves the product of language processing. We argue that syntactic priming is less affected by Chomsky’s criticisms than grammaticality judgements. First, participants are generally unaware of the priming manipulation or the purpose of the investigation and therefore the task provides evidence about mental representation without engaging explicit or conscious strategies. Conscious strategies, as employed in making grammaticality judgements, are obviously prone to bias. More fundamentally, however, grammaticality judgements provide direct evidence only about whether a sentence forms part of a language. They cannot provide direct evidence of which grammatical relationships between two sentences. Thus syntactic priming is directly informative about syntactic categorization. Furthermore, because it is purely dependent on categorization, the inference from syntactic priming to theory of syntax is independent of particular assumptions about processing. Explicit judgements of similarity, in contrast, may reflect non-syntactic similarities.

We therefore claim that results from experiments about syntactic priming allow us to draw inferences about knowledge of language. For example, the finding that prepositional-object sentences prime other prepositional-object sentences, whereas double-object sentences prime other double-object sentences, with other sources of the priming being excluded (Refs f,g), suggests that people’s knowledge of language represents a distinction between these two types of sentence and that the finding that syntactic priming occurs

Outstanding questions

• What is the precise nature of the linguistic representations that can be primed? Do they correspond to the representations assumed by a particular approach to syntax?

• In what sense is syntactic priming a kind of implicit learning?

• To what extent is priming affected by the nature of the communicative situation? Is it an automatic process that occurs irrespective of the situation, or is it more strategic, with producers being primed more if the previous utterances are in some sense more relevant to them?

• Can priming be informative about the stages that the processor goes through in the production of utterances?

• Which, if any, other levels of linguistic representation can be primed? Are there, for example, abstract levels of semantic representation that may be primed?

• Can priming be informative about the representations employed by diverse groups of language users, such as children, second-language learners, and various kinds of aphasic patients?
between sentences describing different types of events\(^3\) suggests that people's mental grammars contain a syntactic component that is unencumbered with information about the type of event described. Future studies may be able to determine precisely what primes what, thereby specifying the nature of syntactic knowledge in more detail.

One experiment that illustrates this potential was conducted by Bock and colleagues\(^4\). Using the running recognition paradigm shown in Fig. 1, they found evidence that speakers treat the subjects of active and passive sentences alike (see Box 3). This finding supports linguistic theories which provide the same account of subjects in active and passive sentences and which do not treat passive sentences as "transformed" versions of active sentences\(^5\)–\(^9\).

Conclusions

Syntactic priming is clearly of considerable interest in its own right. However, we believe that it can be employed as a method that will allow us to appreciate the intricacies of syntactic representation and processing, just as, for example, semantic priming has allowed researchers to understand much about lexical-semantic representation\(^10\). In contrast to work on semantic priming, however, there have only been a handful of studies on syntactic priming. The area is ready for a great deal of further exploration.

For example, there has been very little attempt to apply syntactic priming to the study of any population apart from normal adults. One recent study has looked at syntactic priming in Broca's aphasics\(^9\), and found, perhaps surprisingly, strong priming even when other aspects of language production were severely impaired. This suggests that such patients often retain knowledge of language, though they are not always able to use it appropriately. It also lends support to the claim that syntactic priming is largely an automatic, implicit process. A similar claim has been made about semantic and lexical coordination in young children's dialogue\(^11\). Priming might therefore be very effective in young children and those less practiced in language use. If so, skilled language-users might be less susceptible to syntactic priming, because they have more computational resources available and hence are much more active about developing their communicative goals in syntactic detail. However, this is a question for further research.

This review has explored the importance of research on syntactic priming for theories of dialogue, accounts of the mechanisms underlying language production, and the nature of linguistic representation. It should be apparent that it has much to offer to all of these areas.

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References