RUNNING HEAD: Syntax in Speaking

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Building Syntactic Structure in Speaking

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Abstract

We investigated how people produce simple and complex phrases in speaking using a newly developed immediate recall task. People read and tried to memorize a target sentence, then read a prime sentence, and then did a distractor task involving the prime sentence. Despite the delay and activity between memory and recall, people could still recall the target sentence although the syntactic form of the recalled sentence was influenced by the syntactic form of the prime sentence. This result replicates the syntactic priming effect found with other experimental paradigms. Using this task, we tested how people used abstract syntactic plans to produce simple and complex noun phrases. We found syntactic priming both when targets and prime sentences matched in complexity and when they did not match, suggesting that simple and complex noun phrases are built by the same syntactic routines during speech production.

Building Syntactic Structure in Speaking

Knowledge of syntactic rules is important for both speaking and understanding. In talking, people combine words into grammatically well-formed structures, and in listening they break down other people's utterances into grammatical units. But how these rules work is still somewhat of a mystery. In this paper we present a method for probing into the structure and use of abstract syntactic plans and apply this method to the investigation of the syntactic rules used to create simple and complex noun phrases in speaking.

The method we use takes as its base the phenomenon of <u>syntactic priming</u>, where the use of a syntactic structure in a sentence increases the likelihood of the use of that same structure in a new sentence. This phenomenon has been used before to investigate the generation of syntax in spontaneous speech (Bock, 1986, 1989; Bock & Loebell, 1990; Levelt & Kelter, 1982). But spontaneous speech production does not lend itself to the control necessary to test some predictions about syntactic plans. To gain control, we developed a recall task that uses whole sentence primes. With this task, we replicate some well-known syntactic priming effects, and make some new discoveries about building syntactic structure in speaking.

<u>Syntactic Priming in Spontaneous Production.</u> Bock (1986) was one of the first people to systematically investigate the role of syntax in production. She investigated whether repeating a sentence with a particular structure influenced the description of a subsequent picture. People repeated aloud sentences containing either double-object (NP-NP) constructions as in (1), or prepositional-object (NP-PP) constructions as in (2):

(1) The waiter brought the customers a tray of drinks.

(2) The waiter brought a tray of drinks to the customers.

After repeating, they described a picture containing an agent, a recipient, and an action, such as a picture of a man reading a book to a child. People were more likely to describe the picture with a double-object construction after repeating a double-object sentence than after repeating a prepositional-object sentence, and vice versa. Similarly, more pictures were constructed in passive voice after a passive sentence than after an active sentence. These results show that using a particular structure in speaking encourages the renewed use of that structure in upcoming speech.

But syntax is not the only contribution to picture descriptions; some semantic factors also play a role. People were far less likely to use the passive voice in the description of a picture with a human agent, such as the book was read by the man, than in a picture with a nonhuman agent, such as the church is being struck by lightning (Bock, 1986). Nonetheless, above and beyond the agency effect, there is still an effect of syntactic priming, with passive being used more frequently after passive primes than active primes.

In fact, syntactic priming supersedes at least three other kinds of similarities between primes and targets. First, lexical similarities between prepositions have no effect on syntactic priming. People were just as likely to describe a picture as The waiter will bring a tray of drinks to the customers after a priming sentence using the same preposition, The secretary took a cake to her boss, as after a sentence using a different preposition, The secretary baked a cake for her boss (Bock, 1989).

Second, thematic similarities between primes and targets have no effect on syntactic priming. People were just as likely to describe a picture as The girl is handing a paintbrush to the boy after the syntactically similar and conceptually similar prime The wealthy widow gave her Mercedes to the church as after the syntactically similar but conceptually dissimilar prime The wealthy widow drove her Mercedes to the church (Bock & Loebell, 1990). People were also equally likely to describe a picture in passive voice after a full passive The construction worker was hit by the bulldozer as after a prepositional locative The construction worker was digging by the bulldozer (Bock & Loebell, 1990).

Third, metrical or phonological similarities between primes and targets have no effect on syntactic priming. Sentences that look like true NP-PP syntactic primes because of their metrical and phonological structure, such as Susan brought a book to study, do not have the same effect as genuine syntactic primes, such as Susan brought a book to Stella (Bock & Loebell, 1990).

Only genuine primes will produce the syntactic priming effect. In sum, syntactic priming cannot be explained by recourse to lexical, thematic, metrical, or phonological similarities. There must be an abstract representation of syntax that is being tapped into when people repeat utterances.

The Activation Metaphor. Priming effects in production are typically described with models that use an activation metaphor (e.g., Dell, 1986, 1988; Kempen & Vosse, 1989; Levelt, 1989; Meijer, 1994; Roelofs, 1992). In these models knowledge is represented as abstract units that are activated when they are involved in the generation of an utterance. Syntactic rules are one kind of knowledge unit, with each abstract syntactic structure represented by a different unit. When a unit has been expressed verbally and its mental representation is no longer necessary, its activation decays to a resting value, with some residual activation remaining. Priming is the consequence of this residual activation. The activation increases the likelihood of that unit's selection into a new utterance.

With this metaphor, syntactic facilitation is a direct result of the processing dynamics of syntax generation. The recent use of a syntactic routine might leave some residual activation on that

routine. Because activation levels determine which routine will be selected, a routine that starts out with more activation will require less additional activation to get selected. So the more activation a

routine has, the more likely it will be that that routine will be selected.

The syntactic priming effect is not only well-modelled by the activation metaphor, it is essential to the activation metaphor's success. Were syntactic priming never found, activation and decay could not be the sole mechanism of speech production. An activation-only model would have to be enhanced by either a monitoring process that corrected for the repeated use of syntactic routines, or a dampening device that actively inhibited reactivation of recently activated syntactic routines. Neither of these solutions would be elegant in light of the fact that priming for knowledge units is such a robust phenomenon. People's productions of words are influenced by the meaning and sounds of primes despite people's being told to ignore the primes and despite the primes' being presented in a different modality form the words (Meyer & Schriefers, 1991; Schriefers, Meyer, & Levelt, 1990). People's productions of words are even influenced by subtle similarities between primes and targets, such as sharing consonant-vowel structure (e.g., Meijer, 1996). Were there no such thing as syntactic priming, syntactic routines would have had to have been treated as special kinds of knowledge units requiring monitoring or dampening where other units did not.

Syntax as a Function of a Sentence's Verb. Given that there are many different syntactic constructions possible, how do particular syntactic routines get activated in combining words? One influential idea is that words themselves store information about which syntactic routines they can be a part of (Bresnan, 1982; Kempen & Hoenkamp, 1987; Kempen & Vosse, 1989; see Levelt, 1989, for an extensive overview). The essence of this lemma-driven approach is that when words are chosen for an utterance, their syntactic properties are also retrieved, and these properties guide the construction of the syntactic trees of the phrases or sentences containing those words. That is, a word specifies which syntactic category it belongs to, such as noun or verb, and also what other grammatical information needs to be present in order for the word to be used, such as a transitive object. As an example, the verb give requires a subject, a direct object, and an indirect object. When give is chosen for an utterance, syntactic routines are activated that arrange the utterance according to a grammatical template that has positions for each of the required noun phrases.

Potter and Lombardi (1990; Lombardi & Potter, 1992) used a recall task to take a closer look at this lemma-driven syntax production process. First they demonstrated that a recall task could be used to investigate priming in production. They had people read a sentence, do a distraction task, and then try to accurately recall the sentence. In the distraction task they saw a list of five words followed by a probe word and had to say whether the probe was part of the list. People were very accurate at recalling the sentences, but their recall could be influenced by the words in the list. For example, if they were trying to remember The knight rode around the palace searching for a place to enter and they saw the word castle in the list, they would sometimes replace palace with castle.

Potter and Lombardi (1990) concluded that recall of sentences was not done through verbatim memory of the words in the sentence. Instead people remembered the gist of the sentence and then used recently activated words that fit the sentence's meaning to reconstruct the sentence. Intrusions occurred because the intruding words were recently activated by the presentation in the list and because they fit the meaning of the sentence, being nearly synonymous with the words they replaced.

Lombardi and Potter (1992) then went on to use the recall task to study the role of verbs in activating syntactic routines. People first memorized sentences as in (3) and (4) and then did the same distraction task as before. The interfering list of words contained a verb closely related to the one in the recall sentence, in this example donate:

(3) The rich widow is going to give a million dollars to the university.

(4) The rich widow is going to give the university a million dollars.

Although give and donate are almost synonymous, they have different syntactic properties. Give can have a direct and indirect object in either an NP-NP construction or an NP-PP construction, but donate can only have a direct and indirect object in an NP-PP construction. If the surface structure affects recall of the words in the sentence, then donate, when it intrudes, should only intrude in (3) and not in (4). But it turned out that the surface structure did not prevent intrusions. Instead, when a verb intruded into an incompatible sentence, the sentence was altered to preserve grammaticality. When donate was incorrectly recalled as part of The rich widow is going to give the university a million dollars, people reproduced the target sentence as The rich widow is going to donate a million dollars to the university.

The surface structure did affect recall when the syntactically more flexible verb intruded in a target sentence containing the less flexible verb, such as when give intruded in The rich widow is going to donate a million dollars to the university. Unlike intrusions of less flexible verbs that restrict syntactic possibilities, when a more flexible verb intrudes, the speaker is free to choose either an NP-NP or an NP-PP construction. Lombardi and Potter (1992) found that in the majority of sentences recalled with flexible intrusions, the same syntax was used as in the target sentence. This result can be interpreted as an example of syntactic priming (Bock, 1986, 1989; Bock & Loebell, 1990). That is, because it was recently used, the syntax of the target sentence was more active, and because the flexible verb does not restrict the syntax, the correct syntactic routine was selected in reproducing the target sentence.

Alternatively, the observed recycling of syntax might also be explained by people's memorization of the order of words in the sentence. They might remember they saw the agent, recipient, and the object in that order in the original sentence, without having any memory for the actual syntax. This explanation seems unlikely given that Potter and Lombardi (1990) found that there is no verbatim memory for the words in the utterance. It would also not explain why the order would be misrecalled when a less flexible verb intruded.

Potter and Lombardi's (1990; Lombardi & Potter, 1992) experiments show how recall can be used to tap into mechanisms of speech production. In remembering a sentence, people do not remember the surface syntax of the sentence or the actual words in the original utterance. Instead the sentence's gist is memorized and used to select the lexical items with the most residual activation. These items in turn activate syntactic procedures to reconstruct the grammatical form of the original sentence. When a verb is selected, it activates the syntactic routines it needs to create a grammatically correct sentence. Although the syntax of the recalled sentence will depend on the verb selected, prior use of a syntactic routine can enhance the likelihood of its being used again when the syntactic routine is compatible with the verb chosen.

The finding that people might under some circumstances reuse previously activated syntactic routines in a recall task suggests that syntactic priming can also be found in speaking situations that are more constrained than those studied by Bock (1986; 1989; Bock & Loebell, 1990). In the picture description task, speakers were not told in advance how to describe what they saw, and so their syntax was relatively unconstrained. It could have been possible that syntactic priming occurred only in unconstrained situations where speakers might have been less concerned about how they expressed themselves and chose to reduce their work by reusing earlier structures. In addition people were told that they were doing a recognition memory experiment and so may have viewed their wording as relatively unimportant compared to whether they correctly identified a picture or sentence as having occurred earlier. Were they to focus on the structure of their speech, they might have expressed themselves using different words and syntactic shapes. Lombardi and Potter's (1992) priming results suggest that syntactic priming transfers to situations in which speakers try to recall sentences as accurately as possible without deviating from the original sentence.

Developing the Recall Task for Use with Whole Sentence Primes. In the current paper we varied the recall task so that syntactic intrusions instead of lexical intrusions could be manipulated. As in the Potter and Lombardi (1990; Lombardi & Potter, 1992) experiments, people read a target sentence for later recall. The sentence always contained a double-object (NP-NP) construction. People then read a prime sentence which contained either a prepositional-object (NP-PP) construction (critical condition) or a double-object construction (control condition). In a subsequent distraction task, people saw a word and had to indicate whether this word did or did not appear in the prime sentence. After making this decision the original target sentence had to be recalled aloud. We compared the number of NP-PP switches in the target sentences after critical and control prime sentences. If the syntactic structure in the prime sentence does not affect processing of the target sentence, then switch rates should be the same in both conditions. But if the syntactic structure in the prime sentences can prime the abstract routines used to reconstruct the target sentence, more switches should occur in the critical condition.

The advantage of the current recall task is that it allows greater control of syntactic structures than other tasks used to investigate syntactic priming. The processing of the target sentences is identical to that in the recall task employed by Potter and Lombardi (1990; Lombardi & Potter, 1992), so this recall task will tap into speech production processes as their task did. However, by presenting prime sentences instead of prime words we can test syntactic structures other than verb argument structures. Furthermore, we are not limited to using syntactic structures that are easily depictable as is necessary with picture description tasks.

Our Experiments. In the first experiment we tested the validity of our immediate recall task by attempting to replicate two syntactic priming phenomena, (1) that the syntax a speaker uses can be primed by previously encountered syntax (Bock, 1986), and (2) that the lexical status of a preposition will not affect the likelihood of syntactic priming (Bock, 1989). We tested whether a prime sentence containing a prepositional phrase could cause NP-PP switches in an otherwise correctly recalled target sentence originally presented with an NP-NP structure. The PP prime contained a preposition that either matched the one the NP-NP target sentence would have if switched to NP-PP, or one that did not match.

In the second experiment we investigated the relationship between the syntactic routines used to generate simple versus complex noun phrases. If they are both created from the same underlying routines, then one should prime the other. But if they are created from different syntactic routines, priming should be blocked.

Let's look at these predictions more closely. We know that simple noun phrases can prime each other in double-object and prepositional-object constructions (Bock, 1986). But would the same be true if the prime and target noun phrases did not match in complexity? Would a simple NP-PP prime, like she wrote letters to her family, cause a target sentence containing a complex NP, like the widow gave the university she had attended before marrying a million dollars, to be remembered with a complex PP, like the widow gave a million dollars to the university she had attended before marrying? One answer is yes. In this scenario an overarching syntactic routine represents the order of direct and indirect objects regardless of the objects' syntactic complexity. The verb would activate one of two possible overarching routines, either NP-NP or NP-PP, to create the basic framework of the sentence. Afterwards, additional subroutines would be activated to fill out the complex phrases. If this scenario is correct, syntactic priming should occur despite differences in complexity between primes and targets.

But another answer to the question is no. Separate routines might exist for simple and complex phrases. This approach dispenses with the first phase described above, where a primary routine, NP-NP or NP-PP, calls on secondary subroutines. Instead of first accessing the primary routine, the syntax production process would go straight to the routines that activate each possible syntactic combination. In the activation metaphor, each syntactic possibility would make up an independent knowledge unit. If this scenario is correct, syntactic priming should not occur when primes and targets differ in complexity. A simple NP-PP structure could not prime a complex NP-NP structure to be misrecalled as an NP-PP. In Experiment 2 the recall of both simple and complex target sentences was tested, looking at both complex direct and complex indirect objects.

Experiment 1

Method

Participants. Thirty-seven students from the University of California, Santa Cruz participated in this experiment for course credit.

Materials. Fifteen target sentences were made containing an indirect and a direct object in a double-object (NP-NP) construction. The dative verb in each sentence allowed for either a double-object (NP-NP) construction or a prepositional-object (NP-PP) construction. These verbs were bring, give, hand, lend, loan, make, offer, pass, read, sell, send, serve, show, teach, and write. Each target sentence could occur with a prime sentence that either had the same preposition as the target sentence or had a different preposition, creating 30 pairs in all. All but 2 prime sentences contained an NP-PP construction (the other two contained an indirect object in a simple prepositional phrase but were missing a direct object; this different construction went unnoticed until after completion of the experiments, but analyses excluding these items produced the same results). The verbs used for the prime sentences that had the same prepositions as the target sentences were address, carry, communicate, convey, describe, display, donate, explain, exported, mail, mention, present, speak, submit, and suggest. The verbs used for the prime sentences that had different prepositions from the target sentences were announce to, borrow from, carry across, describe for, display in, hauled across, receive from, take from, transmitted across, and yell at. Five of these verbs were repeated to make the full 15 prime sentences.

In addition to the critical targets and primes, 10 control targets and primes were written. Like the critical targets, the control targets had an NP-NP construction, using 10 of the 15 verbs that were used to create the critical target sentences. But unlike the critical primes, the control primes also had an NP-NP construction. Table 1 contains examples of the critical and control pairs.

Finally, 20 pairs of filler sentences and 5 pairs of practice sentences were made. None of the filler or the practice sentences had either an NP-NP or an NP-PP construction. In total, 65 pairs of sentences were created. All sentences contained between 10 and 15 words. The sentences in a pair were unrelated in meaning.

After the sentences were written, target words were selected for the distraction task where participants were asked whether or not a particular word had occurred in the prime sentence. The target word was in the prime sentence in 30 cases and was not in the prime sentence (nor in the target sentence) in the remaining 35 cases. The word appeared in the prime sentence in 7 of the 15 sentence pairs containing the same preposition manipulation, in 7 of the 15 sentence pairs containing the different preposition manipulation, in 5 of the 10 controls, in 9 of the 20 fillers, and in 2 of the 5 practice sentences. For the critical trials, the target word was never the dative verb nor a preposition.

Design. Two lists of 50 trials were created. Both lists contained the same 5 practice, 20 filler, and 10 control pairs. The 30 critical pairs were evenly divided across lists such that each target sentence only occurred once per list, either in the same preposition condition or in the different preposition condition (7 same and 8 different in one list, and 8 same and 7 different in the other). So both the critical versus control conditions and the different versus same preposition conditions were within-subject variables.

Procedure. Participants were tested one at a time. They read the instructions and were seated in front of a computer screen. They received one of the two lists. After the 5 practice trials were administered, the other pairs were administered in a pseudo-random order, with the constraint that no more than two control or critical pairs appeared on consecutive trials. The experiment was subject-paced and took between 30 and 45 minutes. Each trial had the following structure. First the target sentence appeared and participants were instructed to read it carefully. After 3500 ms the target sentence disappeared and the prime sentence appeared. Participants also read this sentence carefully and then pressed a key on the keyboard to continue. Participants were then presented with a distraction task. The sentence Did you see the word X in the previous sentence? then appeared on the screen and participants were instructed to press the y key if that word X was in the second sentence and the n key if it was not. After a key was pressed, a message on the screen told participants to recall aloud the first sentence that they had seen. After they had finished recalling the sentence, participants pressed a key to go to the next trial. Their verbal responses were recorded on tape and their key responses were recorded by computer.

Results

All sentences were scored as remembered, forgotten, or as containing an NP-PP switch. Sentences were considered remembered if most of the lexical items were recalled in a well-formed sentence, allowing up to two non-critical words to be forgotten. Six participants were excluded because they forgot at least 1/3 of the critical and control sentences. The remaining data were analyzed with participants ($t1$) and items ($t2$) as random factors. Of the 775 utterances produced, 16.6% of the critical target sentences were forgotten compared to 21.6% of the control target sentences. This difference is significant over participants only ($t1(30) = -2.99$, $p < .01$; $t2(23) = -.80$, $p = .43$). An NP-PP switch occurred in 63 cases (8%). If there is syntactic priming, then these switches should occur more often after an NP-PP prime sentence than an NP-NP prime sentence. This is what happened. An NP-PP switch occurred in 11.6% of the sentences recalled after the interfering NP-PP construction but in only 4.2% of the sentences recalled after the control NP-NP construction ($t1(30) = 4.57$, $p < .001$; $t2(23) = 2.47$, $p < .025$). The 4.2% of NP-NP switches can be seen as the baseline rate of spontaneous switches in recall.

Recall of the target sentences was not influenced by the preposition used in the prime sentence. Target sentences were forgotten 15.3% of the time after a prime sentence with the same preposition, and 17.8% of the time after a prime sentence with a different preposition ($\underline{t1}(30) = -.81$, $p = .42$; $\underline{t2}(14) = -.81$, $p = .43$). Switch rate was also not influenced by the preposition used in the prime sentences. Switches occurred in 11.7% of the targets recalled after prime sentences containing the same preposition the switched target contained, and 11.5% of the targets recalled after prime sentences containing different prepositions ($\underline{t1}(30) = .94$, $p = .35$; $\underline{t2}(14) = .05$, $p = .96$). The syntactic role of the preposition was important for priming, not its lexical identity.

Some may wonder whether the high rate of accuracy on target sentence recall, around 80%, is a result of peoples' not paying sufficient attention to the prime sentences. Analysis of performance on the distraction task puts this concern to rest. Of the 775 responses, the correct response was given in 88.8% of the critical trials and 86.8% of the control trials. These high percentages demonstrate that the participants were paying attention to the prime sentences.

At the same time, the distraction task was not contributing to the difference in switch rates across conditions. The distraction task accuracy rates were not reliably different across conditions ($\underline{t1}(30) = .91$, $p = .37$; $\underline{t2}(23) = .61$, $p = .55$), nor was the amount of time taken to complete the distraction task (1688 ms in the critical condition, 1744 ms in the control condition; $\underline{t1}(30) = -.64$,
$p = .53$; $\underline{t2}(23) = -.41$, $p = .69$). There is no indication that the distraction task might have caused the observed differences in syntactic switching.

There is also no indication that the distraction task caused the observed similarity between preposition conditions. Participants gave the correct distraction task response in 89.5% of the same preposition trials and 88.2% of the different preposition trials ($\underline{t1}(30) = .48$, $p = .64$; $\underline{t2}(14) = .58$, $p = .57$), and took 1623 ms for the same preposition trials and 1745 ms for the different preposition trials ($\underline{t1}(30) = -.72$, $p = .48$; $\underline{t2}(14) = -1.00$, $p = .33$).

Discussion

A recall task using prime sentences instead of prime words can successfully replicate known syntactic priming effects. NP-NP target sentence were recalled as NP-PP sentences after presentation of NP-PP primes. There were almost three times as many NP-PP switches after NP-PP prime sentences than after non-NP-PP prime sentences. The overall amount of syntactic switching also accords with known priming effects. In the current experiment, switches occurred in 8% of all the sentences spoken including those forgotten or misrecalled, which is similar to the percentage of word intrusions in Lombardi and Potter's (1992) experiments. Finally, the lack of an effect for preposition type also agrees with earlier findings (Bock, 1986, 1989).

Switches occurred equally often after prime sentences containing prepositions that the switched targets would use as they did after primes sentences containing different prepositions. The lack of a preposition effect in both our and Bock's studies is important because it provides evidence for the existence of abstract syntactic routines. Rather than being triggered by the reactivation of a particular lexical item, such as the preposition to, switches are triggered by reactivation of a lexically empty abstract representation of a preposition. At first, this conclusion may seem to contradict Potter and Lombardi's (1990; Lombardi & Potter, 1992) findings that lexical items with different subcategorizations can influence the syntax used, suggesting that there may not be free-floating syntactic routines but only lexically linked routines used in production. But recall that when the lexical items they studied, verbs, did not have a rigid syntactic structure, the syntactic form of an earlier presentation was retained. This argues for some non-lexically bound syntactic priming. Also note that the lexical items we used, prepositions, had the same subcategorization as each other, so this factor would be constant across preposition conditions.

The fact that the current results replicate those of other production experiments not only lends support to the validity of this task, but also shows that the task will produce results that are similar to those found in the less constrained speech production settings of picture description. The results bolster the argument that the syntactic priming effect found in picture description experiments was not dependent on people's ability to use whatever descriptions they liked. It is not the case that picture description priming effects were a result of people's opting to recycle syntax heard earlier to reduce workload. In the current experiment people were explicitly instructed to accurately recall the target sentences. Despite their efforts, their recall still recycled syntax from the prime sentences.

Like other priming effects in production, syntactic priming is robust. It occurs across different speaking situations. This robustness is fully in line with models of syntax production that describe priming as residual activation on abstract syntactic routines (e.g., Kempen & Hoenkamp, 1987; Kempen & Vosse, 1989). Because the most active routine is chosen in generating the sentence, residual activation from a recently used routine will enhance the chances of that routine's being reused in a new utterance.

Now that we know that our recall task is sensitive to syntactic switches and that the results replicate earlier effects, we can confidently move on to the second experiment. In Experiment 2 we investigated whether prime sentences with NP-PP structures can induce syntactic priming in target sentences whose noun phrases have different internal grammatical structures from the prime sentences'. For example, a prime sentence with a simple direct object might be tested against a target sentence with a complex direct object. Whether or not syntactic priming occurs will have implications for exactly what syntactic routines a verb calls in designing a sentence. If there is syntactic priming, this would be evidence that verbs point to general routines that can be symbolically described as <u>get direct object</u> or <u>get indirect object</u>. But if there is no syntactic priming, then verbs would point to more specific routines such as <u>get direct object with a relative clause modifier</u>.

To give a more precise example, imagine the sentence <u>the widow gave the university a million dollars</u> as depicted in a traditional syntactic tree. Under the main S node, there is an $NP_{subject}$ and a VP. Under the VP, there is a V, an $NP_{indirect\ object}$ and an $NP_{direct\ object}$. This tree structure would be the same for <u>the widow gave the university she had graduated from a million dollars that was bequeathed from her great aunt</u>. In other words, the major constituents of both sentences are the same. If syntactic switching occurs because the major constituents are primed, then either sentence would be just as likely to switch. But if syntactic switching is more complex than that, switching should be different for the simple and the complex objects.

Experiment 2

Method

Participants. Seventy students from the University of California, Santa Cruz participated in this experiment for course credit.

Materials. Ten simple target sentences were made containing two simple noun phrases in the double-object (NP-NP) construction. The dative verb in each sentence allowed for either a double-object (NP-NP) construction or a prepositional-object (NP-PP) construction. These verbs were bring, give, hand, lend, offer, pass, sell, show, teach, and write. All were to be accompanied by the preposition to in the alternative NP-PP construction. In addition, ten complex sentences were made containing a relative clause in the direct object. The same ten dative verbs were used to construct these sentences. The simple target sentences contained between 9 and 11 words and the complex target sentences contained between 12 and 15 words. Each target sentence was combined with three types of prime sentences to create the following conditions:

(A) Switch, Complexity Match: The prime sentence contained an NP-PP construction and its phrases had the same complexity as the target sentence.

(B) Switch, Complexity Mismatch: The prime sentence contained an NP-PP construction and its phrases were different in complexity from those in the target sentence.

(C) No Switch, Complexity Mismatch: The prime sentence contained an NP-NP construction and its phrases were different in complexity from those in the target sentence.

The No Switch sentences, paired with the two target types, provided baselines for spontaneous switches. The No Switch condition will also be referred to as the Control condition.

If complexity does not affect priming, the number of syntactic switches should be similar after Switch primes (A) and (B). This number should also be larger than that after No Switch primes (C). But if a mismatch in complexity prevents syntactic priming, the number of syntactic switches should be higher after Switch primes (A) than after Switch primes (B), with the Complexity Match in (A) causing switching and the Complexity Mismatch in (B) blocking switching. The same low number of switches should occur after primes (B) and (C) because both types of primes mismatch in complexity with the targets.

For the simple target sentences, primes in the complexity matched pairs (A) contained two simple phrases. Primes in the complexity mismatched pairs (B) and (C) contained a simple direct object and a complex indirect object. For the complex target sentences, primes in the complexity matched pairs (A) contained a complex direct object and a simple indirect object. Primes in the complexity mismatched pairs (B) and (C) contained two simple phrases. An example of simple and complex target pairs and their primes is given in Table 2. As can be seen in Table 2, the three prime sentences paired with a target sentence were kept as similar as possible in meaning and number of words. The prime sentences contained between 9 and 15 words. The 10 dative verbs used to create the prime sentences were bring, give, loan, read, sell, send, serve, show, teach, and write. None of the filler or the practice sentences had either an NP-NP or an NP-PP construction. As with the critical pairs, the sentences in filler and practice pairs were unrelated in meaning.

After the sentences were written, target words were selected for the distraction task where participants were asked whether or not a particular word had occurred in the prime sentence. The target word was in the primes in half the simple target pairs, in half the complex target pairs, in half the fillers, and in 3 of the 5 practices. For the critical trials, the same target word was chosen for the three versions of the prime sentences. The target was never the dative verb nor a preposition. Presence of distractor targets in the prime sentences was counterbalanced across simple and complex target sentences. For example, if a simple target sentence were matched with a prime sentence containing the distractor word, then the corresponding complex sentence created with the same verb was matched with a prime sentence not containing the distractor word.

Design. Twelve lists of 55 trials were created. Each list contained all practice and filler trials, each of the simple target sentences matched with one type of prime sentence, and each of the complex target sentences matched with another type of prime sentence. This design yields 6 possible combinations of simple and complex target sentences (see Table 3). Each combination was furthermore divided into two blocks. Each block contained 5 simple and 5 complex target sentences, with each of the target sentences within a block having a different dative verb. Filler trials were equally divided over the two blocks. The 6 combinations times 2 block orders made up the 12 lists.

The trials in the lists were ordered so that there was a maximum distance between sentences containing identical dative verbs and semantically similar trials. At least one filler trial separated any two critical trials. Apart from the switching of the blocks, the relative order of the various trials was identical across the twelve lists. So any spurious effect of one trial on a nearby trial in that block would be constant across conditions.

Procedure. Participants were tested one at a time. They read the instructions and were seated in front of a computer screen. They received one of the 12 lists. After the 5 practice trials, the other pairs were administered in the pseudo-random order described above. Between the two blocks participants completed a short additional task that was unrelated to the current experiment. This task took about 3 minutes and was inserted to minimize any possible cross-over effects of the repeated use of the same set of dative verbs across the two blocks. The experiment was subject-paced and took between 30 and 45 minutes.

Each trial had the following structure. First the target sentence appeared and participants were instructed to read it carefully. After 8000 ms the target sentence disappeared and the prime sentence appeared. Participants read this sentence carefully for 5000 ms. The sentence Did you see the word X in the previous sentence then appeared on the screen and participants were instructed to respond aloud whether the word X was in the second sentence. After a key was pressed, a message on the screen told participants to recall aloud the first sentence that they had seen. After they had finished recalling the sentence, participants pressed a key to go to the next trial. Their responses were recorded on tape and their key responses were recorded by computer.

Results

Participants' responses were analyzed by one of four judges who were blind to the condition in which the target sentences appeared. First we determined how many target sentences were remembered and how many were forgotten, using the same scoring scheme as in Experiment 1 with the following addition: Complex sentences for which the complexity was forgotten during recall were counted separately. Ten participants were excluded because they forgot at least 1/3 of the critical sentences. The data of the remaining 60 participants, 5 per list, were analyzed with participants ($F1$) and items ($F2$) as random factors. Of the 1200 utterances, participants forgot 18.8% of the Complexity Matched, 18.0% of the Complexity Mismatched, and 18.8% of the Control sentences ($F1 < 1$; $F2 < 1$).

An NP-PP switch occurred in 59 cases (4.9%), about half with simple and half with complex targets (27 to 32). If complexity is irrelevant in the initial choice of an NP-NP versus an NP-PP structure, more switches should be found in the Complexity Matched (A) and Complexity Mismatched Switch (B) conditions than in the Control condition (C), and the amount of switches in the Complexity Matched (A) and Complexity Mismatched (B) conditions should be similar. This is exactly what was found: Participants switched 7.3% of the Complexity Matched (A), 6.3% of the Complexity Mismatched (B), and only 1.3% of the Control (C) sentences ($F1(2,117) = 6.39$, $p < .01$; $F2(2,38) = 8.10$, $p < .01$). Orthogonal contrasts showed a difference between the two Switched conditions and the Control condition ($F1(1,117) = 12.46$, $p < .01$; $F2(1,19) = 30.05$, $p < .001$), and no difference between the Complexity Matched and the Complexity Mismatched conditions ($F1 < 1$; $F2 < 1$).

Separate analyses of the simple and complex target sentences revealed the same pattern of results. Remember that the simple targets were combined with prime sentences containing complex indirect objects in the Complexity Mismatched conditions. The complex sentences were combined with primes containing complex direct objects.

Of the 600 simple target utterances, participants forgot 17.0% of the Complexity

Matched, 17.0% of the Complexity Mismatched, and 17.5% of the Control sentences ($F1 < 1$; $F2 < 1$). Participants switched 5.5% of the Complexity Matched (A), 7.0% of the Complexity Mismatched (B), and 1.0% of the Control (C) sentences ($F1(2,57) = 4.12$, $p < .05$; $F2(2,18) = 5.75$, $p < .01$). Orthogonal contrasts showed a difference between the two Switched conditions and the Control condition ($F1(1,57) = 12.95$, $p < .01$; $F2(1,9) = 21.00$, $p < .01$), and no difference between the Complexity Matched and the Complexity Mismatched conditions ($F1 < 1$; $F2 < 1$).

Of the 600 complex target utterances, participants forgot 20.5% of the Complexity Matched (A), 19.0% of the Complexity Mismatched (B), and 20.0% of the Control (C) sentences ($F1 < 1$; $F2 < 1$). Participants switched 9.0% of the Complexity Matched, 5.5% of the Complexity Mismatched, and 1.5% of the Control sentences ($F1(2,57) = 3.39$, $p < .05$; $F2(2,18) = 4.21$, $p < .05$). Orthogonal contrasts showed a difference between the two Switched conditions and the Control condition ($F1(1,57) = 5.31$, $p < .05$; $F2(1,9) = 11.31$, $p < .01$), and no difference between the Complexity Matched and the Complexity Mismatched conditions ($F1(1,57) = 1.48$, $p = .23$; $F2(1,9) = 1.29$, $p = .29$).

In some cases complex target sentences were recalled as simple sentences, with the complexity in the direct object forgotten. This occurred in 2.5% of the Complexity Matched (A), 6.5% of the Complexity Mismatched (B), and 2.5% of the Control (C) sentences ($F1(2,57) = 2.33$, $p = .11$; $F2(2,18) = 4.18$, $p < .05$). Complex target sentences were recalled as simple sentences while making an NP-PP switch in none of the Complexity Matched (A), 1.0% of the Complexity Mismatched (B), and .5% of the Control (C) sentences ($F1(2,57) = 2.28$, $p = .11$; $F2(2,18) = 1.00$, $p = .39$).

There is no indication that the distraction task caused any of the observed differences. The correct response was given in 92.8% of the Complexity Matched, 91.8% of the Complexity Mismatched, and 91.0% of the Control trials ($F1 < 1$; $F2 < 1$). In addition, participants took a similar amount of time completing the distraction task in the various conditions, with an average response time of 2268 ms in the Complexity Matched, 2310 ms in the Complexity Mismatched, and 2374 ms in the Control condition (F1 < 1; F2(2,38) = 1.29, p = .29). For the simple target sentences, the correct response was given in 92.0%, 90.0%, and 93.0% of the trials (F1 < 1; F2 < 1), taking 2267 ms, 2411 ms, and 2352 ms to complete (F1 < 1; F2(2,18) = 1.74, p = .20). For the complex sentences, the correct response was given in 93.5%, 93.5%, and 89.0% of the trials (F1(2,57) = 2.13, p = .13; F2(2,18) = 2.52, p = .11), taking 2269 ms, 2209 ms, and 2395 ms to complete (F1 < 1; F2(2,18) = 1.88, p = .18).

Discussion

The data support a two-tiered system of syntax generation, where the major syntactic units making up the verb phrase are accessed first, followed by other syntactic structures, such as relative clauses modifying direct or indirect objects. Complexity is not initially represented. NP-PP primes induced a syntactic switch in NP-NP target sentences more often than control NP-NP primes both when the primes and targets matched in complexity and when they did not. In fact, NP-PP primes with complex phrases induced the same amount of syntactic switches as NP-PP primes with simple phrases. Additionally, both complex direct objects and complex indirect objects could prime an NP-NP target to be misrecalled with an NP-PP structure. The internal structure of a noun phrase seems to be secondary to its major syntactic form.

The picture of speech productions that emerges from this recall task is as follows. First words in a sentence are remembered using the gist of the sentence and residual activation of lexical items. Then the verb calls the appropriate syntactic routines to build either an NP-PP or an NP-NP construction. The words that are to be placed in the relative clause call subroutines for the construction of this relative clause, and this clause gets merged into the larger phrase. The locus of priming in the recall task is the verb. For the dative verbs in our materials there are two ways to syntactically represent each target sentence. Priming affects which is selected. Because the verb calls the routines that build the major constituents, syntactic priming is not sensitive to the internal structure of these constituents.

There is one more finding for Experiment 2 that merits some discussion. The separate analysis of complex sentences revealed that participants tended to forget the complexity in an otherwise correctly recalled sentence more often in the Switch, Complexity Mismatched condition than in either the Switch, Complexity Match or the No Switch, Complexity Mismatch conditions. We are not sure how to explain this tendency, but we can exclude two possible accounts. A mismatch in complexity alone cannot be driving the tendency because the complexities in the Switch, Complexity Mismatch condition are forgotten just as frequently as in the Switch, Complexity Match condition. Also, type of prime, switch-inducing or not switch-inducting, cannot be driving the tendency because both the Complexity Match and the Complexity Mismatch conditions contain switch-inducing primes. Although an exact explanation is lacking, one suggestion is that particular words appearing in primes can somehow block recall of subclause words in target sentences, and that the Switch, Complexity Mismatch primes happen to contain more of these words than the other conditions. Whatever the reason, this tendency to forget the relative clauses more in one condition than the others does not affect the main findings of this experiment, the switch rate differences in critical and control conditions.

General Discussion

In two experiments we observed that sentences with the same major constituent structure shared syntactic routines. These syntactic routines are likely to be stored in a hierarchical structure and to be activated hierarchically. That is, major constituents are activated first after which subroutines are called to build the structures within these constituents. Our data support lemma-driven speech production models (Bresnan, 1982; Kempen & Hoenkamp, 1987; Kempen & Vosse, 1989, Lombardi & Potter, 1992).

In Experiment 1 we demonstrated that sentences can be used to induce syntactic priming in recall. In this task, people (1) read and memorized a target sentence, (2) read a prime sentence, (3) performed a short distraction task involving the prime, and then (4) recalled the target sentence. The distraction task ensured that the people actually read and processed the prime sentences. According to theories of syntax production, recently produced structures tend to be reused in upcoming speech because residual activation on abstract syntactic routines increases the chances of these routines being selected anew. We found that reading a prime sentence with a particular structure enhanced the use of that structure during recall of a target sentence. Target sentences with a direct and indirect object that were originally memorized in a double-object (NP-NP) construction were more likely to be recalled with a prepositional object (NP-PP) construction if the prime sentence contained an NP-PP construction than when the prime did not.

This sentence recall task produced the same results as picture description tasks with respect to (1) inducing syntactic priming and (2) ignoring the lexical status of prepositions. Priming was not affected by whether or not the preposition used in the prime was the same one the target sentence would contain were it switched from NP-NP to NP-PP. As with less constrained picture description tasks, the recent activation of the switch-appropriate prepositions did not increase the likelihood of a switch.

The sentence recall task provides further evidence for the robustness of syntactic priming. In picture description tasks, people are free to describe pictures using any syntax they like. They tend to reuse syntax they had just used, but this could have happened because subjects, aware that previously given structures could be used again, decided that reusing structures was less demanding than building alternative structures. Bock showed that such an explanation is unlikely because syntactic priming persists even when many filler trials fall between the prime and the target picture. Experiment 1 further demonstrated that syntactic priming does not depend on preferential use because priming occurred even when people tried to recall target sentences exactly as they had read them.

In Experiment 2 we demonstrated that simple and complex noun phrases are created by the same major constituent syntactic routines. A complex NP-NP target sentence can be induced to switch to NP-PP by both primes containing complex phrases and those containing simple phrases. Similarly, a simple NP-NP target can be induced to switch to NP-PP by both primes containing simple phrases and those containing complex phrases. Not only did syntactic priming occur across conditions varying in complexity, but it was equally frequent across conditions. Furthermore, it did not matter whether the complexity was on the direct object or the indirect object for priming to occur.

According to our data, dative verbs like give activate either the routine to build a double-object construction or the routine to build a prepositional-object construction. This major constituent routine is then enhanced by additional routines that fill out complex phrases' internal structure. The choice of major constituent constructions, NP-NP or NP-PP, is not affected by the complexity of the indirect or direct objects.

The recall task used here can help uncover exactly how words cooperate in creating sentence structure. We manipulated complexity by adding relative clauses to the direct or indirect objects, but countless other variations are possible.

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Table 1
Experiment 1: Examples of Materials Used

	Repeated Preposition
Target	While the poet traveled in France, she wrote her family many letters.
Prime	When she finishes it, the grandmother will display her quilt to the family.
	New Preposition
Target	While the poet traveled in France, she wrote her family many letters.
Prime	The musician needs to borrow a microphone from his friend tonight.
	Control
Target	After the production, the actors wrote their director a thank-you note.
Prime	The father promised to lend his dishonest son the family's car.

Table 2

Experiment 2: Examples of Materials Used

Simple Target	The representative of the western nation offered the country an agreement.
Prime	
Switch, Match	The nurse read the most recent letter to the wounded soldier.
Switch, Mismatch	The nurse read the most recent letter to the soldier who was wounded.
No Switch, Mismatch	The nurse read the soldier who was wounded the most recent letter.
Complex Target	The professor offered his students the theories that had insulted many people.
Prime	
Switch, Match	The politician read the memo that would ruin his career to the intern.
Switch, Mismatch	The famous politician read the disturbing memo to the new intern
No Switch, Mismatch	The famous politician read the new intern the disturbing memo.

Table 3
Experiment 2: Design

	Target Type	Prime Type
Combination 1	Simple	Switch, Complexity Match
	Complex	Switch, Complexity Mismatch
Combination 2	Simple	Switch, Complexity Match
	Complex	No Switch, Complexity Mismatch
Combination 3	Simple	Switch, Complexity Mismatch
	Complex	Switch, Complexity Match
Combination 4	Simple	Switch, Complexity Mismatch
	Complex	No Switch, Complexity Mismatch
Combination 5	Simple	No Switch, Complexity Mismatch
	Complex	Switch, Complexity Match
Combination 6	Simple	No Switch, Complexity Mismatch
	Complex	Switch, Complexity Mismatch

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