



Brief article

Recent experience affects the strength of structural priming

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Received 11 May 2005; revised 5 July 2005; accepted 6 July 2005

Abstract

In two experiments, we explore how recent experience with particular syntactic constructions affects the strength of the structural priming observed for those constructions. The results suggest that (1) the strength of structural priming observed for double object and prepositional object constructions is affected by the relative frequency with which each construction was produced earlier in the experiment, and (2) the effects of relative frequency are not modulated by the temporal placement of the tokens of each construction within the experiment.

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Keywords: Structural priming; Relative frequency; Cumulative effect

Structural priming refers to speakers' tendency to repeat syntactic structures across utterances (Bock, 1986). The canonical structural priming finding is that when speakers produce a given structure (e.g. a double object [DO]: "Meghan gave her mom a toy") on a prime trial, they are more likely to reuse that structure on a subsequent target trial than to use an alternative structure (e.g. a prepositional object [PO]: "Meghan gave a toy to her mom"). The tendency for speakers to repeat structures has been studied almost exclusively by exploring the extent to which the production of a single prime sentence affects the production of a single target sentence (e.g. Bock, 1986; Bock & Griffin, 2000; Pickering & Branigan, 1998). Comparatively little is known about how the priming observed on a given trial is affected by the cumulative effect of priming developed across many previous trials.

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Although the influence that cumulative effects of priming across trials have on the production of sentences later in the experiment has not been systematically explored, incidental reports from the literature suggest that experience beyond a single prime sentence affects the production of subsequent utterances. [Hartsuiker and Kolk \(1998\)](#) and [Hartsuiker and Westenberg \(2000\)](#) report that the repeated production of particular dative and transitive constructions increases the overall availability of those constructions. Because of this increased availability, participants were more likely to produce the constructions at later points in the experiment (as compared to earlier trials) independent of any structural priming effects. Additionally, [Bock and Kroch \(1989\)](#) report that after producing several examples of one construction, priming on a competing construction was reduced. These data suggest the possibility that there are cumulative effects of structural priming across many trials, but this conclusion is weakened by the fact that the relevant evidence consists of informal observations from experiments conducted for other purposes.

The question of whether there are cumulative effects of structural priming has important theoretical implications. There is currently a debate about whether structural priming reflects the operation of transient, short-term priming mechanisms (e.g. [Pickering & Branigan, 1998](#)) or the operation of longer-term mechanisms of implicit learning (e.g. [Bock & Griffin, 2000](#)). A clear demonstration of cumulative priming effects would be fairly strong evidence in favor of the view that structural priming reflects the presence of a long-lasting adaptation within the language production system. The work presented here is intended to provide such a demonstration by exploring how the cumulative effect of recent experience with particular constructions (DO and PO) affects the priming that is subsequently observed for those constructions.

We examined structural priming in written sentence production, using a stem completion methodology similar to that of [Corley and Scheepers \(2002\)](#) and [Pickering and Branigan \(1998\)](#). For each priming trial, a triplet of sentences was used:

- (1a). Meghan gave her mother...
- (1b). Meghan gave the doll...
- (1c). The soldier gave...

Participants received a prime stem designed either to induce the production of a DO construction (1a: “Meghan gave her mother a doll”), or to induce the production of a PO construction (1b: “Meghan gave the doll to her mother”). Immediately after the prime stem, participants received a target stem such as (1c), which gives participants the opportunity to produce either a DO or a PO construction. The same verb was used in the prime and target stems because [Pickering and Branigan’s \(1998\)](#) data show that repeating the verb leads to stronger priming than having different verbs in the prime and target stem. As such, it allows for a stronger test of whether recent experience with the target structures can affect the strength of priming between a prime and target stem.

The experiments were conducted in two phases (see [Table 1](#) for details). In the “Recent Experience” phase, participants’ pattern of recent experience with the DO and PO constructions was manipulated. Participants saw only prime stems during this phase of the experiment, as the reliability with which these stems induced participants to generate

Table 1
Design structure for Experiments 1 and 2

Experiment 1: recent experience condition						
	EE		EE-B		UE	
Prime type	DO	PO	DO	PO	DO	PO
RE trials 1–5	DO/PO	PO/DO	DO	PO	PO	DO
RE trials 6–10	DO/PO	PO/DO	PO	DO	PO	DO
Priming trials	DO	PO	DO	PO	DO	PO
Experiment 1: recent experience condition						
	EE-B		UE-75		UE-100	
Prime type	DO	PO	DO	PO	DO	PO
RE trials 1–10	DO	PO	PO/DO	DO/PO	PO	DO
RE trials 11–20	PO	DO	PO	DO	PO	DO
Priming trials	DO	PO	DO	PO	DO	PO

Note: DO: double object; PO: prepositional object; DO/PO or PO/DO means alternating DO and PO prime stems, presented in the order indicated; RE trials: the critical prime stems presented in the Recent Experience phase; Priming trials: the critical trials in the Priming phase of the experiment.

the desired structure provided a reasonable amount of control over how frequently each structure was produced in this phase of the experiment. Immediately after the Recent Experience phase, participants entered the Priming phase. During this phase, participants were presented with prime–target pairs for one type of construction.

1. Experiment 1

Experiment 1 had three Recent Experience conditions. Participants in the Equal Exposure (EE) condition produced an equal number of DO and PO constructions in the Recent Experience phase, and the tokens of each construction were evenly spaced through this part of the experiment. It was expected that participants in the EE condition would show priming effects similar to those reported elsewhere in the literature. Participants in the Equal Exposure-Block (EE-B) condition also produced an equal number of the target constructions in the Recent Experience phase, but the tokens of each construction were blocked such that the tokens of one construction appeared entirely in the first half of the Recent Experience phase, and the tokens of the alternative construction appeared entirely in the second half of this phase. The question of interest is whether having a run of one construction at the end of the Recent Experience phase affects the strength of priming observed on the alternative construction in spite of the fact that both constructions have appeared equally often in the experiment. Participants in the Unequal Exposure (UE) condition produced examples of only one construction in the Recent Experience phase. We expected that skewing one's recent experience towards a single construction would weaken the structural priming observed on the alternative construction.

1.1. Method

1.1.1. Participants

The participants were 180 introductory psychology students. The data from 10 participants were replaced because the proportion of each kind of construction produced in the Recent Experience phase of the experiment deviated strongly from the target proportions for their assigned condition.¹

1.1.2. Materials

Sixteen stem triplets were selected from the materials of Pickering and Branigan's (1998) Experiment 1 (see Appendix). Each triplet consisted of a DO prime stem, a PO prime stem, and a target stem. All stems in the triplet used the same verb. Ten triplets were assigned to appear in the Recent Experience phase of the experiment. Because only priming stems were presented in this phase of the experiment, the target stem for each triplet was replaced by an intransitive sentence stem. The remaining six triplets were assigned to appear in the Priming phase of the experiment. In addition, 64 filler stems (a mix of transitive and intransitive constructions) were created. The stems were designed such that it would be nearly impossible to provide a grammatical completion that was a DO or PO construction.

1.1.3. Procedure

Participants were randomly assigned to the EE, EE-B or UE Recent Experience conditions. Half of the participants in each condition were assigned to complete DO priming trials, and half were assigned to complete PO priming trials (see Table 1). Participants were told that they would be presented with a series of sentence stems. They were instructed to complete each stem such that it produced a grammatical English sentence. On each trial, the stem was presented in a text box at the top of a computer screen. The participants typed their completions in a text box located beneath the stem. Once they finished typing their completion, the participants pressed a button on the keyboard to see the next stem. Participants completed a total of 96 sentences. In the Recent Experience phase, there were 10 prime stems and 50 filler stems, with five filler items appearing between each prime stem. In the Priming phase, there were six prime–target stem pairs (12 stems total) and 24 filler stems, with four filler items appearing between each prime–target pair. The order of presentation for the items was randomized for each participant.

¹ We excluded participants from the experiment when the proportion of DO and PO constructions produced in the Recent Experience phase deviated strongly from the intended proportions. In Experiment 1, we used an 80/20 split between constructions as our criterion. Participants in the EE and EE-B conditions whose recent experience was skewed more strongly than 80/20 for one construction were excluded, and participants in the UE condition whose recent experience was not skewed as strongly as the 80/20 split were excluded. The same criteria were used in Experiment 2 (EE-B and UE-100 conditions), except that participants in the UE-75 condition could not have a skew weaker than 60/40 or stronger than 90/10 in favor of the intended construction. The choice of criteria for eliminating participants did not affect the pattern of results observed in either experiment.

1.2. Results and discussion

The stem completions were scored as “double object”, “prepositional object”, or “other” according to the criteria outlined by Pickering and Branigan (1998).² Participants produced DO and PO constructions at close to the rates intended for each Recent Experience condition (EE: 54% DO, 46% PO; EE-B: 53% DO, 47% PO; in the UE condition, participants produced the intended structure 98% of the time, and the alternative structure 2% of the time). The target completions from the priming trials were analyzed using a 3 (Recent Experience: EE, EE-B, UE) × 2 (Prime Type: DO vs. PO) × 2 (Target Response: DO vs. PO) mixed factor ANOVA, with Recent Experience and Prime Type as between-participants factors (all factors are within items).³ The results are presented in Table 2.

The key statistical effect was an interaction of Recent Experience, Prime Type, and Target Response [$F(1,174)=4.86$, $P=0.009$; $F(2,10)=9.82$, $P=0.004$].⁴ Examining the DO target responses, participants in the EE and EE-B conditions produced more DO completions following DO primes than following PO primes, but participants in the UE condition did not. An interaction contrast testing the hypothesis that this structural priming effect was equally strong in the EE and EE-B conditions, and stronger in these conditions than in the UE condition was significant [$F(1,174)=5.52$, $P=0.019$; $F(2,10)=13.70$, $P=0.004$]. Regarding the PO target responses, participants in the EE and EE-B conditions produced more PO target completions following PO primes than following DO primes, a tendency that was absent from the UE condition. An interaction contrast testing the hypothesis that this structural priming effect was equally strong in the EE and EE-B conditions, and stronger in these conditions than in the UE condition was significant [$F(1,174)=9.23$, $P<0.001$; $F(2,10)=17.23$, $P=0.002$]. The only other significant effect in the main analysis was the Prime Type × Target Response interaction [$F(1,174)=32.19$, $P<0.001$; $F(2,10)=26.83$, $P=0.004$].

These results demonstrate that the relative frequency with which the DO and PO constructions were produced in the first part of the experiment affected the strength of structural priming observed later in the experiment. When the constructions were produced in equal numbers, priming was strong. When participants’ recent experience was heavily skewed towards one construction, priming for the alternative construction was greatly reduced. Additionally, it appears that the temporal distribution of tokens of each construction produced in the Recent Experience phase did not affect the strength of structural priming observed later. Priming was equally strong in the EE and EE-B conditions, despite the fact that the priming trials for one construction were preceded by a run of productions of the alternative construction in the EE-B condition.

² The proportion of “other” responses was as follows. Experiment 1: EE, DO Prime (27% others); EE-B, DO Prime (19%); UE, DO Prime (19%); EE, PO Prime (19%); EE-B, PO Prime (27%); UE, PO Prime (28%). Experiment 2: EE-B, DO Prime (25%); UE-75, DO Prime (24%); UE-100, DO Prime (18%); EE-B, PO Prime (21%); UE-75, PO Prime (36%), UE-100, PO Prime (25%).

³ Here and elsewhere, analyses denoted $F1$ are conducted with participants as a random factor, and analyses denoted $F2$ are conducted with items as a random factor.

⁴ In the interest of brevity, we do not report the null effects from the main ANOVA in the text.

Table 2
Mean proportion of DO and PO target completions in Experiment 1 (standard deviations in parentheses)

Recent experience condition						
	EE		EE-B		UE	
Target response	DO	PO	DO	PO	DO	PO
DO prime	0.46 (0.31)	0.27 (0.27)	0.52 (0.24)	0.29 (0.22)	0.38 (0.28)	0.43 (0.27)
PO prime	0.19 (0.19)	0.62 (0.32)	0.22 (0.27)	0.51 (0.32)	0.29 (0.27)	0.44 (0.30)
Difference	0.27****	−0.35****	0.30***	−0.22***	0.09	−0.01

Note: ****denotes $P < 0.01$ in analysis by participants and items; ***denotes $P < 0.05$ in analysis by participants and items; **denotes $P < 0.05$ for one analysis (by participants or items), and $P < 0.10$ for one analysis (by participants or items); *denotes significant in analysis by participants, but $P > 0.10$ in the analysis by items.

2. Experiment 2

Experiment 1 suggests that the strength of structural priming is affected by the relative frequency with which particular constructions are produced in the participants' recent experience, but not by the temporal distribution of the tokens of each construction in that recent experience. Experiment 2 was designed to remedy two shortcomings of the previous experiment. First, it is possible that the run of one construction at the end of the Recent Experience phase in the EE-B condition did not affect priming on the alternative construction because the run was not long enough to disrupt the priming. Second, Experiment 1 used only two levels of relative frequency between the target constructions: 50/50 and 100/0.

There were three Recent Experience conditions in this experiment (see Table 1). The EE-B condition replicates the EE-B condition from Experiment 1, save that participants now complete 20 prime stems in the Recent Experience phase. If the relative frequency with which the constructions are produced, but not the temporal distribution of the tokens of each construction, affects structural priming, this condition should show strong priming as in the first experiment. However, if the temporal distribution of the tokens does matter, then a run of 10 examples of one construction should disrupt priming for the alternative structure (as a run of 10 examples of one construction disrupted priming in the UE condition of Experiment 1). The second condition was the UE-75 condition, in which participants produced one construction 75% of the time, and the alternative construction 25% of the time. Finally, there was the UE-100 condition, where participants produced only one construction during the Recent Experience phase. If the relative frequency with which each construction is produced directly affects the strength of structural priming, the UE-75 condition should produce priming weaker than in the EE-B condition, but stronger than in the UE-100 condition.

2.1. Method

2.1.1. Participants

The participants were 180 introductory psychology students. The data from four participants were replaced because the proportion of each kind of construction produced in

the Recent Experience phase of the experiment deviated strongly from the target proportions for their assigned conditions.

2.1.2. *Materials*

The materials from Experiment 1 were used. To fill out the number of prime stems needed for the Recent Experience condition, an additional 10 items were selected from Pickering and Branigan's materials. These items were assigned to the first half of the Recent Experience phase (leaving the original 10 prime stems to be presented in the second half of the Recent Experience phase). A further 40 filler stems of the sort used in Experiment 1 were generated to fill out the rest of the experiment.

2.1.3. *Procedure*

The procedure was the same as in Experiment 1. Trials in the EE-B and UE-100 conditions were structured as they were in the parallel conditions from Experiment 1. In the UE-75 condition, participants produced five examples of each construction (in alternating order) in the first half of the Recent Experience phase, and produced 10 examples of only one construction in the second half of the Recent Experience phase.

2.2. *Results*

The stem completions were scored as in Experiment 1. Participants produced DO and PO constructions at rates close to those intended for each Recent Experience condition (52% DO, 48% PO in the EE-B condition; in the UE-75 condition, participants produced the dominant construction 72% of the time, and the alternative structure 28% of the time; in the UE condition, participants produced the intended structure 97% of the time, and the alternative structure 3% of the time). The target completions from the priming trials were analyzed using a 3 (Recent Experience: EE-B, UE-75, UE-100) \times 2 (Prime Type: DO vs. PO) \times 2 (Target Response: DO vs. PO) mixed factor ANOVA, with Recent Experience and Prime Type as between-participants factors (all factors are within items). The results are presented in Table 3.

The key statistical effect was an interaction of Recent Experience, Prime Type, and Target Response [$F(2,174)=4.89$, $P=0.009$; $F(2,10)=3.57$, $P=0.069$]. Examining the DO target responses, participants in the EE-B condition produced more DO completions following DO primes than following PO primes, and this tendency became progressively weaker as the participants' recent experience was skewed more heavily towards the PO construction. An interaction contrast was conducted to test the hypothesis that the difference in the number of DO responses made following DO primes and PO primes was strongest in the EE-B condition, was weaker in the UE-75 condition, and was weakest in the UE-100 condition. This test was significant [$F(1,174)=4.71$, $P=0.03$; $F(1,10)=7.92$, $P=0.018$]. Regarding the PO target responses, participants in the EE-B condition produced more PO target completions following PO primes than following DO primes, and this tendency became progressively weaker as the participants' recent experience was skewed more heavily towards the DO construction. An interaction contrast identical to the one conducted on the DO target responses was significant for the PO responses [$F(2,174)=10.10$, $P<0.001$; $F(2,10)=19.15$, $P=0.001$]. The main

Table 3
Mean proportion of DO and PO target completions in Experiment 2 (Standard Deviations in parentheses)

Recent experience condition						
	EE-B		UE-75		UE-100	
Target response	DO	PO	DO	PO	DO	PO
DO prime	0.45 (0.29)	0.30 (0.25)	0.38 (0.26)	0.38 (0.23)	0.38 (0.30)	0.44 (0.29)
PO prime	0.12 (0.18)	0.67 (0.26)	0.11 (0.18)	0.53 (0.28)	0.25 (0.27)	0.50 (0.29)
Difference	0.33****	−0.37****	0.27**	−0.15*	0.13	−0.06

Note: **** denotes $P < 0.01$ in analysis by participants and items; *** denotes $P < 0.05$ in analysis by participants and items; ** denotes $P < 0.05$ for one analysis (by participants or items), and $P < 0.10$ for one analysis (by participants or items); * denotes significant in analysis by participants, but $P > 0.10$ in the analysis by items.

analysis also revealed an interaction of Prime Type and Target Response [$F(1,174) = 42.12, P < 0.001$; $F(1,5) = 22.64, P = 0.005$], and a main effect of Target Response [$F(1,174) = 31.12, P < 0.001$; $F(1,5) = 5.01, P = 0.075$].

These data provide further evidence for the claim that the relative frequency with which participants produce particular constructions in the recent past affects the strength of the structural priming for those constructions. Additionally, the strength of the priming effects in the EE-B condition bolster the claim that it is the relative frequency of the constructions produced, rather than the temporal distribution of those tokens, that most strongly affects structural priming.

3. General discussion

These data demonstrate that recent experience with the double object and prepositional object constructions affects the strength of the structural priming later observed for those constructions. When one has produced roughly equal numbers of each construction in the experiment, priming is strong. As one's recent experience with the constructions is skewed towards one construction, priming on the alternative construction becomes weaker. The data also suggest that it is the relative frequency with which the competing constructions are produced in the recent past, and not the temporal distribution of the tokens of each construction, that most strongly affects priming on later trials.

We have argued that our results show that the temporal distribution of the tokens of particular constructions in the Recent Experience phase has no substantial impact on participants' production of later sentences. As with all null effects, this conclusion should be treated with caution. It remains possible that a stronger temporal manipulation of the target structures, or a more sensitive test of structural priming would show effects of the ordering of the tokens of each construction as well as the effects of the relative frequency with which the constructions were produced.

The demonstration of cumulative priming effects across trials supports the claim that structural priming reflects a long lasting adaptation (or learning) within the language production system (c.f. Bock & Griffin, 2000). If we accept that the temporal distribution

of tokens of each construction in the Recent Experience phase does not affect the pattern of priming observed later, our data point towards a learning-based account of structural priming in which the prime sentence and the nature of one's recent experience weigh against each other in influencing the selection of a particular structure for the production of the target sentence. In developing this approach, it will be important to clarify how different grains of experience (i.e. experience across one's whole life, vs. experience over the past month, vs. experience in the last hour) affect the production of sentences. This will be a central question for future explorations of structural priming, and for developing the idea that structural priming plays a role in language acquisition and language change.

Acknowledgements

This work was supported in part by funding from the Florida State University Council for Research and Creativity. Thanks to Erik Anderson, Destin Stewart, Joni Aspiras, Tara Sununu, Heather Maturo, Latoya Beckford, and Sarah Buonanno for their assistance in running these experiments. Thanks to Rolf Zwaan, Mark Aveyard, Lawrence Taylor, and two anonymous reviewers for comments on a previous version of this manuscript.

Appendix. Prime and target stems from Experiments 1 and 2

Prime and Target Stems from Experiments 1 and 2 are presented below. For each prime stem, the material in parentheses was altered to produce a double object or prepositional object stem. This material is presented with the double object completion of the stem first, and the prepositional object completion second. For items presented in the Priming phase, the prime stems are presented above the target stem.

Experiments 1 and 2, Recent Experience (Primes only)

- (1) The racing driver showed (the helpful mechanic/the torn overall)
- (2) The efficient secretary handed (the grumpy businessman/the long fax)
- (3) The enthusiastic child gave (his young friend/the colorful book)
- (4) The car salesman sold (the couple/the minivan)
- (5) The lifeguard threw (the surfer/the life jacket)
- (6) The photographer sent (the editor/the prints)
- (7) The man lent (the neighbor/the lawnmower)
- (8) The youngster lent (the kind teacher/the toy)
- (9) The builder showed (the surveyor/the drill)
- (10) The architect gave (the cheerful engineer/the model of the building)

Experiment 2, Recent Experience (Primes only)

- (1) The captain gave (the old sailor/the spare life jacket)
- (2) The millionaire loaned (the struggling artist/the valuable painting)

- (3) The researcher handed (the experienced surgeon/the detailed results)
- (4) The mother handed (the hungry toddler/the expensive toy)
- (5) The travel agent sold (the young fan/the last ticket)
- (6) The grandmother sent (the little girl/the big present)
- (7) The secretary sent (the manager/the novice)
- (8) The swimmer loaned (the diver/the towel)
- (9) The woman sent (the insurance company/the insurance claim)
- (10) The lecturer gave (the professor/the book)

Experiments 1 and 2, Priming phase (Primes and Targets)

- (1) The fashion designer lent (the famous journalist/the pink jacket)
The diver lent
- (2) The woman loaned (the new neighbor/the rusty bike)
The librarian loaned
- (3) The disgruntled employee sent (the manager/the long letter)
The famous novelist sent
- (4) The teacher handed (the student/the certificate)
The consultant handed
- (5) The bartender gave (the customer/the cocktail)
The mailman gave
- (6) The spy sent (the double agent/the submarine blueprints)
The kidnapper sent

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