

Structural priming in language production: syntactic or semantic?

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Kim, Sanghee. 2015. Structural priming in language production: syntactic or semantic? *SNU Working Papers in English Linguistics and Language* 13, 63-84. This paper demonstrates an underlying mechanism for language production in structural priming. The study examines which among syntactic argument or semantic argument is a more essential factor for conceptualization in language production. Native speakers of English read a series of words and produced target sentences out loud in an RSVP sentence recall task. The experiment used *hit* verbs and *spray-load* verbs, which allowed locative alternation construction. There were three conditions, and both syntactic and semantic properties of the two arguments preceded by a verb varied by condition. The result showed neither syntactic nor semantic argument structure had significant influence on participants' conceptualization. A post-hoc analysis, however, presented participants' propensity to constructions that had the same thematic role. The present study thus suggests that structural priming is sensitive to thematic roles and that information on semantic arguments is an influential cause for conceptualization in language production. (Seoul National University)

Keywords: structural priming; language production; syntactic argument; semantic argument; thematic role

1. Introduction

Structural priming has received great attention in psycholinguistic literature in that it reveals much about mechanism that underlies language production and comprehension. Along with the first experimental study on structural repetition (Levelt & Kelter, 1982), Bock (1986) demonstrated a tendency to repeat or reuse syntactic structures that people recently processed than an alternative structure, which is now referred to as *structural priming*. Following studies explained that *structural priming* is not a simple memory task but a psychological process which leaves a syntactic trace in speakers' mind

(Bock & Griffin, 2000; Branigan, Pickering, & Cleland, 2000).

Scholars also started to ask what drives structural priming (i.e. what makes structural priming happen?). In one side, “autonomous syntax” (Pickering & Ferreira, 2008, p.4) was pointed out as the driving force. Studies demonstrated that syntactic structure by itself independently engenders structural priming (Bock, 1986; Bock, 1989; Bock, Loebell, & Morey, 1992; Loebell & Bock, 2003). Following studies supported this point of view by showing prosodic characteristics, which are separate considerations from syntactic features, have no impact on priming effect (Bock & Loebell, 1990), and by presenting experiments where closed-class morphemes did not disturb priming effect (Pickering & Branigan, 1998).

In the other side of autonomous syntax stood scholars, who argued that syntactic structure does not rule structural priming. By separating *syntactic priming* from *structural priming*¹, they claimed semantic properties should be taken into consideration. A part of their argument was that semantic features such as information on animacy of the entities should be given attention when we explicate structural priming (Bock et al., 1992; Ferretti, McRae, & Hatherell, 2001). Additionally and more importantly, a leading account in support for semantic argument as crucial component for structural priming put information on the number and/or order of thematic roles as influential factors (Bock & Griffin, 2000; Chang, Bock, & Goldberg, 2003; Chang, Dell, & Bock, 2006; Griffin & Weinstein-Tull, 2003; Hare & Goldberg, 1999). They posited that information about thematic roles weighs more than syntactic structure argument in conceptualization process, and thus in priming effect.

¹ While *structural priming* has been used as the synonym of *syntactic priming*, (Pickering & Ferreira, 2008) noted that *structural priming* should be separated from *syntactic priming*. This is to distinguish the cause of *structural priming*: whether it is purely due to a syntactic argument or due to non-syntactic argument such as semantic features.

1.1 Current study

The current study focuses on structural priming observed in L1 production. We examine the mechanism that underlies L1 language production that proceeds from message conceptualization to final production stage. Our main interest is to evaluate how influential information about syntactic argument and semantic argument are on structural priming. We especially evaluate significance of each argument type on structural priming.

Contrary to supporters who propose structural priming is insensitive to thematic roles, other researchers suggest that priming effect is evidently sensitive to such semantic features, and that thematic information difference changes the final production. In support with this account, Chang et al. (2003) used *spray-load* verbs, which allowed locative and thematic alternation construction. Using the construction enabled them to separate thematic roles from structural positions and to clearly test which of either thematic information or syntactic information is a more dominant cause that influences conceptualization. An example set of *spray-load* verb construction is introduced in (1) (Chang et al., 2003, p. 35)

- (1a) Type 1: The maid rubbed polish onto the table.
- (1b) Type 2: The maid rubbed the table with polish.

There are two variations licensed by locative-thematic alternation. The constituent structure in noun phrase and prepositional phrase sequence (NP-PP) while thematic role is assigned as theme-location (type 1) or location-theme (type 2) order. Chang et al. (2003) fixed the constituent type and order but gave variations in thematic role order. The experiment results demonstrated that thematic role information is a dominant cause for conceptualization in language production. Their conclusion was in contrast with those who support autonomous syntax

in structural priming.

Although the current study adopted experiment design much from Chang et al. (2003), we took account of one more condition. One among the conditions had a different type of constituent structure from the previous two but overlapped in thematic features in one of the conditions. This design construction was to overcome a limitation in Chang et al. (2003), which might have stalled participants from showing syntactic variations. Since prime type was given in one syntactic construction but in two types with thematic features, it was high likely that thematic role information may have been influential factor for participants. In order to clearly test mechanism for conceptualization, the conditions should include the same number of each syntactic feature and semantic feature.

Therefore, while Chang et al. (2003) had a fixed constituent structure (NP-PP), this study added a different construction as prepositional phrase followed by another prepositional phrase (PP-PP). The design used in the study enabled balancing the two factors. The revised design implemented in the present study helped us clearly verify which of either syntactic or semantic argument a more influential factor for conceptualization in production is. We included *hit* verbs along with *spray-load* verbs to include the new condition. Experiment design is described in the following section more in detail.

2. Experiment

2.1 Method

2.1.1 Participants

Seventeen participants consisted of undergraduate/graduate students at Seoul National University and Dongguk University, and U.S. soldiers at U.S. Army Garrison Yongsan took part in the experiment (age range: 19-50; age mean: 28.71; 10 males and 7 females). Participants were

paid 5,000 won for compensation. All participants were native speakers of English. A majority of the participants spoke two or more languages, but English was their dominant language. Participants had no identified language disorder.

2.1.2 Materials and design

We tested which of either syntactic information or thematic information mattered more in language production. Condition 1 and condition 2 had the same syntactic structure while their thematic order was different. Meanwhile, condition 2 and condition 3 overlapped in the order of thematic role but had a different syntactic structure. Table 1 summarizes the experiment design.

Table 1. Experiment design

Condition	1	2	3	Match
Syntactic order	NP-PP	NP-PP	PP-PP	Syntactically match
Thematic order	T-L	L-T	L-T	Thematically match

Note: NP-PP = noun phrase and prepositional phrase sequence

PP-PP = prepositional phrase and prepositional phrase sequence

T-L = theme role and location role sequence

L-T = location role and theme role sequence

Fifty four sentences were created with 18 verbs under three different conditions ($18 \times 3 = 54$; see Appendix A for target sentences used in the experiment). The verbs were modeled from (Levin, 1993)'s framework that allow locative alternation. There were two verb types: *hit* verbs and

spray-load verbs; twelve *hit* verbs and six *spray-load* verbs² were used. There were 36 fillers, and none of the fillers had alternative verbs nor did they have similar constructions as the target sentences (see Appendix B for sentences used as fillers). Three sets of materials were constructed using a Latin Square Design. A single set consisted of 18 target sentence and 36 filler sentences, making a total of 54 sentences. Both target and filler sentences had about the same number of words (nine to ten words each). The following are sample experiment materials with a *hit* verb.

- (2a) Condition 1: NP-PP / Theme-Location
The merchant hit a briefcase hard against the car.
- (2b) Condition 2: NP-PP / Location-Theme
The merchant hit the car hard with a briefcase.
- (2c) Condition 3: PP-PP / Location-Theme
The merchant hit at the car hard with a briefcase.

All of the experimental sentences had one of three constructions as in (2): SUBJECT VERB ARGUMENT1 ADVERB ARGUMENT2. The target sentences had a noun phrase functioning as the subject, followed by a verb—either *spray-load* verbs or *hit* verbs—that required two arguments. The two arguments were assigned by a theme role and a location role each, whose sequence changed depending on the types of condition. Condition 2 and condition 3 had the same thematic role order assigned to the two arguments: location-theme order. Sentences in condition 1, in contrast, had a theme-location order.

With regards to syntactic structures of two arguments, they also changed by condition. While the two arguments were in a noun phrase and a prepositional phrase sequence (NP-PP) in condition 1 and condition 2, condition 3 had a prepositional phrase proceeded by

² Chang et al. (2003)'s design utilized 'spray-load verbs' as experiment materials, but all the sentences used in this study were newly constructed.

another prepositional phrase (PP-PP). In condition 1, the second argument with a location role was led by a preposition of one of *against*, *on*, *over*, and *onto* considering the context. The second argument with a theme role had a fixed preposition of *with*. For the first argument in condition 3, *at* headed the prepositional phrase.

An adverb was inserted between the two arguments so as not to create any prepositional phrase attachment ambiguity. The adverb prevented the second argument in condition 2 and condition 3, headed by *with*, being construed as the complement of the first argument. In other words, an insertion of an adverb licensed participants will always consider the second prepositional phrases in condition 2 and condition 3 to have a high-attachment structure.

An acceptability judgment task was conducted on sentences targeted to be used as experimental materials to verify that conditions did not influence participants' sentence processability. Sixteen native speakers of English participated in the judgment task. A Kruskal-Wallis rank sum test, implemented with the *kruskal.test* function of the R stats package, showed no significant difference across the score of items by condition, $H(2)=5.4764$, $p>.05$ (mean score: 3.24 (condition 1); 3.11 (condition 2); 3.03 (condition 3)).

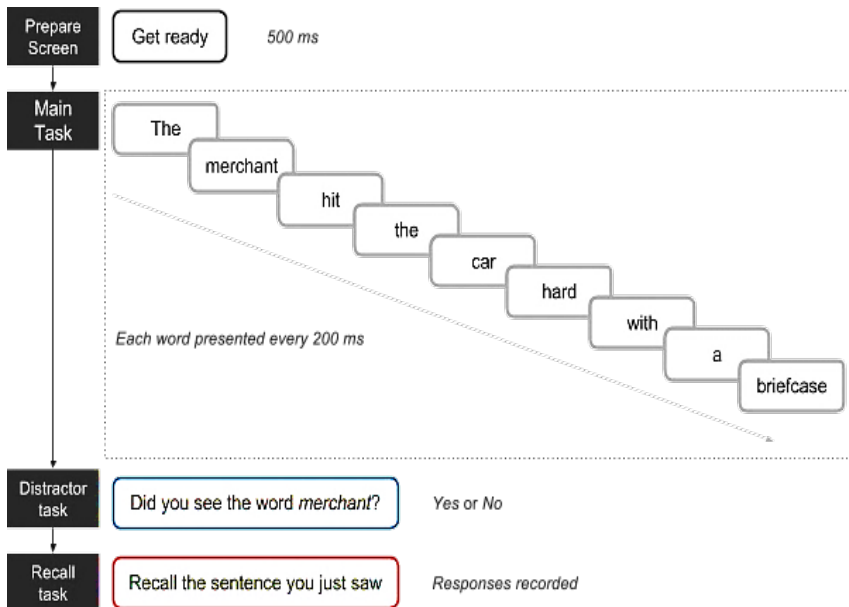
2.1.3 Procedure

A rapid serial visual presentation (RSVP) sentence repetition paradigm (Potter & Lombardi, 1998) was used to observe the cause influencing participants' language production mechanism. We chose a sentence recall task instead of a sentence-picture task as it allows control over syntactic structures (Meijer & Fox Tree, 2003). Experiments in Chang et al. (2003) also demonstrated it is not always the case that a RSVP task captures thematic role repetition than a picture description task does.

Participants were tested separately in a different room, seated in front of

a laptop. Trials were presented in a font Calibri of 32-point size with bold weight. All the tasks were run on two PC laptops of the same model. As shown in Fig. 1, first, a preparation screen appeared for 500 ms. Participants were then required to silently read a series of words rapidly presented in a computer screen. Each word was presented at a 200 ms rate. After the sentence was completely presented, a distractor task followed, where participants had to answer *yes* (“F” key) or *no* (“J” key) by pressing a button. Finally, participants were instructed to recall the target sentence and say it out loud. Their responses were automatically recorded through a built-in microphone in the laptop. Two practice trials were conducted before the main task (see Appendix B for sentences used for the practice session).

Figure 1. RSVP sentence recall paradigm (a sample trial)



2.1.4 Scoring

Participants' responses were transcribed and categorized according to two standards. First, the responses were scored in a binary way by whether they were successfully 'recalled.' The responses were coded '1' and tagged 'recalled' if they contained two constituents (NP and PP) and two thematic arguments (location and theme role) in the targeted order, but '0' if they did not. Since the issue of interest was to examine which of either syntactic or semantic argument has more influence on language production, we adopted a "standard coding" (Chang et al., 2003, p. 38) for scoring³. This type of coding accepted alternation of content words and minor changes as articles and adverbs. The responses that failed to include a noun in a prepositional phrase were also coded as 'recalled.'

Second, among the recalled sentences, only the responses that switched the order of either syntactic structure or thematic role were selected for the final analysis. This was to rule out instances that would illustrate a simple memory task but depict a phenomenon caused by structural priming (Fox Tree & Meijer, 1999). In other words, responses that had both the same syntactic and semantic structure were ruled out, and only those with alternation were included.

2.2 Results

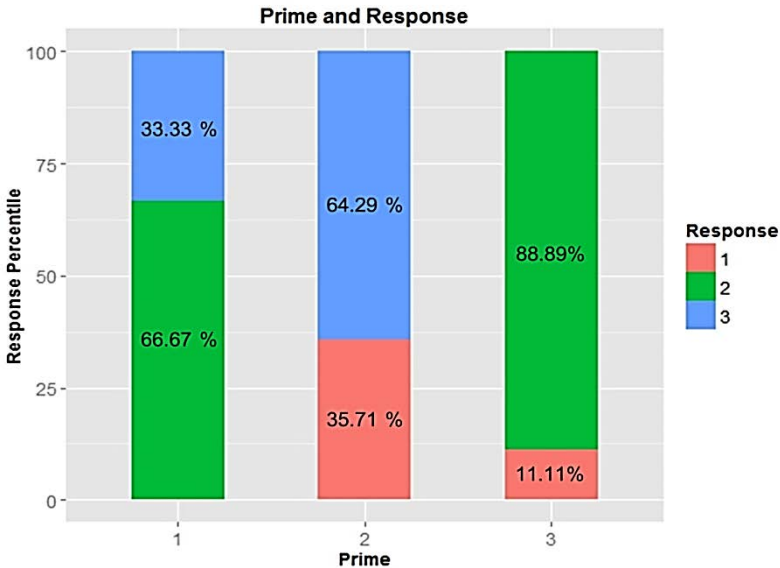
There were 306 objects produced by 17 participants in total. In order to prevent memory span as a variable, we excluded data from two participants who were 49 and 50 years old respectively. Out of 270 objects, 237 objects survived base on the recall standard we set. Among these results, 38 objects, which made alternation, were selected as the final data.

For analysis, the three conditions were grouped in two ways as in the

³ Chang et al. (2003) noted *standard coding* is a comparatively "looser coding" than "strict coding," which does not allow even a slight alternation from the targeted response (p. 38).

experiment design (Table 1). One way was to group condition 1 and condition 2, whose constituent order overlapped: syntactic match. The other was to combine condition 2 and condition 3, which had the same semantic argument order: semantic match. We coded the type of prime and responses by employing the reverse Helmert contrast test, which compared the last level of a factor with the rest of the previous levels. The reverse Helmert contrast showed that the combination of condition 1 and condition 2 did not differ from condition 3 ($t=.364$). The same method of contrast also indicated a group of condition 2 and condition 3 was not significantly different compared to condition 1 ($t=.121$).

Figure 2. A ratio of response type to prime type



Note: '1' = Condition 1; '2' = Condition 2; '3' = Condition 3

Additionally, participants' tendency to producing a certain type of condition by each prime is presented in Fig 2. When condition 1 (NP-PP / theme-location) was given as prime, it was more likely that

participants recalled the given sentence as condition 2 structure (NP-PP / location-theme) than condition 3 (PP-PP / location-theme). When participants were given condition 2 (NP-PP / location-theme) as prime, they produced more like condition 3 type (PP-PP / location-theme) than condition 1 (NP-PP / theme-location). When condition 3 (PP-PP / location-theme) was presented as a prime, participants tended to reproduce sentences in a structure of condition 2 (NP-PP / location-theme) than that of condition 3 (PP-PP / location-theme).

3. Discussion

First, the first analysis showed that there was no statistically notable difference between condition 1 (NP-PP) and condition 2 (NP-PP) group and condition 3 (PP-PP). The result reveals that syntactic sequence of ‘NP-PP’ and ‘PP-PP’ did not influence participants to reproduce the given sentences differently. That is to say that (the order of) syntactic arguments were not an important component to affect participants’ conceptualization.

The second analysis employed by the reverse Helmert contrast compared condition 1 (theme-location) to condition 2 (location-theme) and condition 3 (location-theme). This time, the latter two conditions were combined in the same group, allowing us to test the effect of semantic argument. The examination revealed that the two groups did not significantly differ from one another. Whether sentences were in a ‘theme-location’ order or in a ‘location-theme’ was not a crucial cause for participants’ preference for a certain condition. Namely semantic arguments did not affect how participants conceptualize ideas before they produce a sentence.

The analyses based on the reverse Helmert contrast, however, are not to indicate that neither of syntactic nor semantic argument (order) is a meaningful factor that underlies speakers’ language production

mechanism. The result in this experiment, in fact, may imply that both argument types were influential for participants by the effect of syntactic arguments and semantic arguments offsetting each other. Although two kinds of syntactic or semantic structures did not yield a statistical difference, we examine a general tendency for possible causes that drove participants to generate a certain type of construction. We initially posited two causes that would explain language production mechanism: a syntactic cause, and a semantic cause. As mentioned earlier, only the responses that had alternation were included in the final analysis. For instance, if a prime was given in condition 1, only the responses with a construction of condition 2 or condition 3 were extracted; the same for the other two conditions. Thus, there are two types of responses that we can expect from one prime type. In order to observe which affected participants' conceptualization more, we examined six cases (3 (condition types) x 2 (response types) = 6) that appeared from the experiment (Table 2).

Table 2. Prediction on the cause of response type

Prime type	Response type	Cause
Condition 1 (<u>NP-PP</u> / T-L)	Condition 2 (<u>NP-PP</u> / L-T)	Syntactic argument
	Condition 3 (PP-PP / L-T)	Event information
Condition 2 (<u>NP-PP</u> / L-T)	Condition 1 (<u>NP-PP</u> / T-L)	Syntactic argument
	Condition 3 (PP-PP / L-T)	Semantic argument
Condition 3 (PP-PP / L-T)	Condition 1 (NP-PP / T-L)	Event information.
	Condition 2 (NP-PP / L-T)	Semantic argument

Note: NP-PP = noun phrase and prepositional phrase sequence

PP-PP = prepositional phrase and prepositional phrase sequence

T-L = theme role and location role sequence

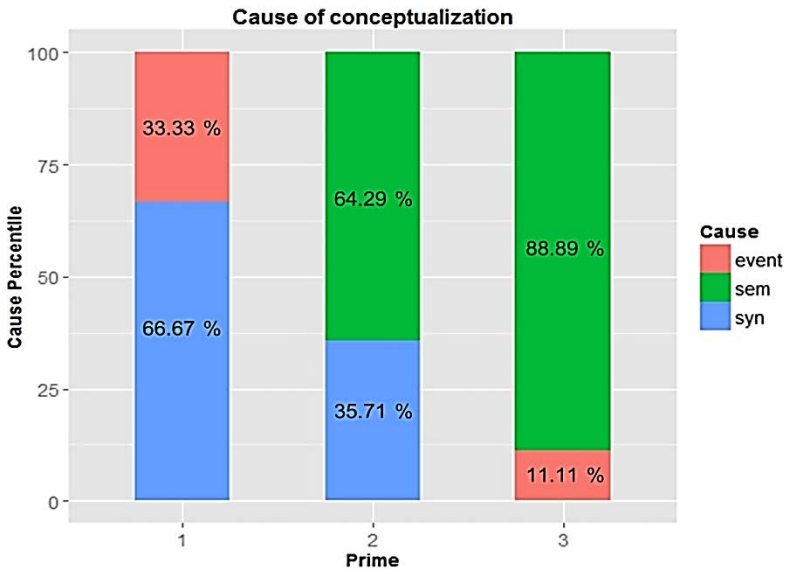
L-T = location role and theme role sequence

The result shows that three possible causes that affect conceptualization in language production observed in this study: (a) syntactic argument; (b) semantic argument; (c) event information. This is somewhat different from our initial prediction on cause for conceptualization: (a) syntactic argument; (b) semantic argument. Another possible cause, namely ‘event information’ was observed.

A stacked bar graph similar to Fig. 2 shows what the dominant causes were for each prime type in this experiment (Fig.3). The overlap between prime type and response type is highlighted by an underline (syntactic argument match) and a bold-face font (semantic argument match). The prime-response combinations that neither syntactic argument nor semantic argument corresponds are marked with ‘event information.’ This is because respondents delivered the same message as the prime type along with the required syntactic and semantic argument, but none of the entities overlapped. We leave further discussion on ‘event information’ for general discussion section.

Even though the reverse Helmert contrast did not present a significant difference among different types of conditions, an overall proportion of type of cause shows that semantic argument was the leading cause for conceptualization. Syntactic argument follows next, and the event information comes last. We cannot argue, however, that this is to say information on semantic argument outweighs that of syntactic one. This is because we did not find a meaningful statistical difference between the two components. We thus should interpret as both syntactic and semantic arguments are influential causes while participants are more sensitive to semantic argument information.

Figure 3. Cause of conceptualization in language production.



Note: ‘event’ = Event information; ‘sem’ = Semantic argument; ‘syn’ = Syntactic argument

As a recap, the results discussed so far can be summarized as follows. There was no statistical difference between semantic and syntactic arguments, which can be construed as either (1) neither of the two were important factors or (2) both were meaningful causes in conceptualization. The tendency of both factors taking up high proportion of the causes (Fig. 3) implies the second interpretation is more plausible. It can be assumed that the comparably equivalent influence of both types on conceptualization made the difference between the two statistically insignificant. A more specific investigation, however, denotes that semantic than syntactic argument structures had more impact on meaning conceptualization in language production (Fig. 3), though not significantly different. Therefore, we suggest that both syntactic and semantic arguments are essential causes that lead language production conceptualization while grasp on semantic

information being a more influential component.

4. General discussion

Even 38 objects analyzed for the final analysis showed a propensity to a certain type of conditions. Still, in order to observe the cause for structural priming effect more clearly, we should invite more participants for the experiment. If we collect more data from more participants, we can manifest a more evident result.

Moreover, we can examine priming effect meticulously by changing the RSVP recall task as in ‘target-prime-distractor-recall’ order. This would allow us to test whether structural priming is a transient memory task that requires conscious attention or an unconscious learning process. A revised experiment design will be able to tackle issue on discussing structural priming as a temporary memory effect versus implicit learning (Chang, Dell, Bock, & Griffin, 2000). The issue can also expand to the argument on two approaches on structural priming, namely “a lexicalist residual activation account”⁴ and “an implicit-learning account”⁵ (Shin & Christianson, 2012, p. 4), which we leave it for future study.

Some may ask how the current result can be related to the conceptualization process of message being grammatically encoded and represented as the final constituent structure. While a one-stage model account supports the idea that assigning linear order of thematic roles and grammatical function in a sentence happens within a single stage, a two-stage model separates the assignment process into two stages⁶. So

⁴ See Pickering & Branigan (1998), Potter & Lombardi (1998), Branigan et al. (2000), Cleland & Pickering (2003) for more on lexicalists’ view on structural priming.

⁵ See Bock & Griffin (2000), Chang et al. (2006), Chang et al. (2000) for more on implicit learning on structural priming.

⁶ In a one-stage model account, it is proposed that conceptual representation, namely information of thematic role, is encapsulated in a single stage, which assigns linear

as to investigate each model, the materials should be varied by their function assigned to each argument because constituent structures and syntactic functions were aligned in parallel in this study. We can test one-stage or two-stage model hypothesis by inviting a language that allows separating grammatical functions and grammatical constituents. We now revisit the issue on ‘event information’ that was briefly covered in the discussion section. Although the main emphasis of the study was to clarify the cause of conceptualization between syntactic and semantic arguments, ‘event information’ seemed to influence participants’ production though not in a statistically significant way. Just as our focus was to evaluate the influence of the two causes, ‘event information’ has not received much attention in structural priming literature. A growing body of research nonetheless suggests how accessible an event information is to parsers and how well they get the “gist of an event” critically influence structural priming effect (Konopka & Meyer, 2014)⁷. Studies showed that parsers’ incremental sentence processability changes due to different types of event information (Konopka & Kuchinsky, 2015; see also Kuchinsky & Bock, 2010), which is pointed as one crucial causes for production mechanism. Thus, we can include event types as a test variable, and discern the most powerful cause among syntactic, semantic, and event type information in a future study.

order and grammatical function at the same time (Cai, Pickering, & Branigan, 2012; Chang et al., 2003; Haskell & MacDonald, 2005). This is in contrast to a two-stage model, which separates the assignment of grammatical function and linear order (Hartsuiker & Westenberg, 2000) (see Shin & Christianson (2009) for L2 acquisition literature). Pickering, Branigan, & McLean (2002), however, observed a mixture of the two model accounts.

⁷ Konopka & Meyer (2014) noted “event codability” and “character codability” affects sentence processability.

References

- Bock, J. K. (1986). Syntactic persistence in language production. *Cognitive Psychology*, 18(3), 355-387.
- Bock, J. K. (1989). Closed-class immanence in sentence production. *Cognition*, 31(2), 163-186.
- Bock, J. K., & Griffin, Z. M. (2000). The persistence of structural priming: Transient activation or implicit learning? *Journal of Experimental Psychology: General*, 129(2), 177.
- Bock, J. K., & Loebell, H. (1990). Framing sentences. *Cognition*, 35(1), 1-39.
- Bock, J. K., Loebell, H., & Morey, R. (1992). From conceptual roles to structural relations: bridging the syntactic cleft. *Psychological review*, 99(1), 150.
- Branigan, H. P., Pickering, M. J., & Cleland, A. A. (2000). Syntactic co-ordination in dialogue. *Cognition*, 75(2), B13-B25.
- Cai, Z. G., Pickering, M. J., & Branigan, H. P. (2012). Mapping concepts to syntax: Evidence from structural priming in Mandarin Chinese. *Journal of Memory and Language*, 66(4), 833-849.
- Chang, F., Bock, K., & Goldberg, A. E. (2003). Can thematic roles leave traces of their places? *Cognition*, 90(1), 29-49.
- Chang, F., Dell, G. S., & Bock, K. (2006). Becoming syntactic. *Psychological review*, 113(2), 234.
- Chang, F., Dell, G. S., Bock, K., & Griffin, Z. M. (2000). Structural priming as implicit learning: A comparison of models of sentence production. *Journal of Psycholinguistic Research*, 29(2), 217-230.
- Cleland, A. A., & Pickering, M. J. (2003). The use of lexical and syntactic information in language production: Evidence from the priming of noun-phrase structure. *Journal of Memory and Language*, 49(2), 214-230.
- Ferretti, T. R., McRae, K., & Hatherell, A. (2001). Integrating verbs, situation schemas, and thematic role concepts. *Journal of Memory and Language*, 44(4), 516-547.
- Fox Tree, J. E., & Meijer, P. J. (1999). Building syntactic structure in speaking. *Journal of Psycholinguistic Research*, 28(1), 71-90.
- Griffin, Z. M., & Weinstein-Tull, J. (2003). Conceptual structure modulates structural priming in the production of complex sentences. *Journal of Memory and Language*, 49(4), 537-555.

- Hare, M. L., & Goldberg, A. E. (1999). *Structural priming: Purely syntactic*. In *Proceedings of the 21st annual meeting of the Cognitive Science Society* (pp. 208-211). Lawrence Erlbaum Associates London.
- Hartsuiker, R. J., & Westenberg, C. (2000). Word order priming in written and spoken sentence production. *Cognition*, 75(2), B27-B39.
- Haskell, T. R., & MacDonald, M. C. (2005). Constituent structure and linear order in language production: evidence from subject-verb agreement. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 31(5), 891.
- Konopka, A. E., & Kuchinsky, S. E. (2015). How message similarity shapes the timecourse of sentence formulation. *Journal of Memory and Language*, 84, 1-23.
- Konopka, A. E., & Meyer, A. S. (2014). Priming sentence planning. *Cognitive Psychology*, 73, 1-40.
- Kuchinsky, S., & Bock, J. (2010). From seeing to saying: Perceiving, planning, producing. *Paper presented at the 23rd CUNY human sentence processing conference, New York*.
- Levelt, W. J., & Kelter, S. (1982). Surface form and memory in question answering. *Cognitive Psychology*, 14(1), 78-106.
- Levin, B. (1993). *Verb Classes and Alternation*. Chicago: U of Chicago Press.
- Loebell, H., & Bock, K. (2003). Structural priming across languages. *Linguistics*, 41(5; ISSU 387), 791-824.
- Meijer, P. J., & Fox Tree, J. E. (2003). Building syntactic structures in speaking: A bilingual exploration. *Experimental Psychology*, 50(3), 184.
- Pickering, M. J., & Branigan, H. P. (1998). The representation of verbs: Evidence from syntactic priming in language production. *Journal of Memory and Language*, 39(4), 633-651.
- Pickering, M. J., Branigan, H. P., & McLean, J. F. (2002). Constituent structure is formulated in one stage. *Journal of Memory and Language*, 46(3), 586-605.
- Pickering, M. J., & Ferreira, V. S. (2008). Structural priming: a critical review. *Psychological bulletin*, 134(3), 427.
- Potter, M. C., & Lombardi, L. (1998). Syntactic priming in immediate recall of sentences. *Journal of Memory and Language*, 38(3), 265-282.

Shin, J. A., & Christianson, K. (2009). Syntactic processing in Korean–English bilingual production: Evidence from cross-linguistic structural priming. *Cognition*, *112*(1), 175-180.

Shin, J. A., & Christianson, K. (2012). Structural priming and second language learning. *Language learning*, *62*(3), 931-964.

Appendix A

These are the target sentences presented in the Experiment. “C” denotes “condition.”

1. *Hit*
 - C1. The merchant hit a briefcase hard against the car.
 - C2. The merchant hit the car hard with a briefcase.
 - C3. The merchant hit at the car hard with a briefcase.
2. *Tap*
 - C1. The teacher tapped a pencil skillfully on the notepad.
 - C2. The teacher tapped the notepad skillfully with a pencil.
 - C3. The teacher tapped at the notepad skillfully with a pencil.
3. *Beat*
 - C1. The cook beat a whisk hastily against the bowl.
 - C2. The cook beat the bowl hastily with a whisk.
 - C3. The cook beat at the bowl hastily with a whisk.
4. *Strike*
 - C1. The professor struck a suitcase hurriedly against the blackboard.
 - C2. The professor struck the blackboard hurriedly with a suitcase.
 - C3. The professor struck at the blackboard hurriedly with a suitcase.
5. *Pound*
 - C1. The postman pounded a parcel wildly against the mailbox.
 - C2. The postman pounded the mailbox wildly with a parcel.
 - C3. The postman pounded at the mailbox wildly with a parcel.
6. *Drum*
 - C1. The assistant drummed her fingers heatedly on the typewriter.
 - C2. The assistant drummed the typewriter heatedly with her fingers.
 - C3. The assistant drummed at the typewriter heatedly with her

fingers.

7. *Whack*

- C1. The clerk whacked a bag fiercely against the bed.
- C2. The clerk whacked the bed fiercely with a bag.
- C3. The clerk whacked at the bed fiercely with a bag.

8. *Rap*

- C1. The guard rapped a broom frantically against the fence.
- C2. The guard rapped the fence frantically with a broom.
- C3. The guard rapped at the fence frantically with a broom.

9. *Lash*

- C1. The detective lashed a whip angrily against the window.
- C2. The detective lashed the window angrily with a whip.
- C3. The detective lashed at the window angrily with a whip.

10. *Thump*

- C1. The mechanic thumped a sack furiously against the post.
- C2. The mechanic thumped the post furiously with a sack.
- C3. The mechanic thumped at the post furiously with a sack.

11. *Slap*

- C1. The banker slapped a folder carelessly on the desk.
- C2. The banker slapped the desk carelessly with a folder.
- C3. The banker slapped at the desk carelessly with a folder.

12. *Bash*

- C1. The painter bashed his palette hysterically against the closet.
- C2. The painter bashed the closet hysterically with his palette.
- C3. The painter bashed at the closet hysterically with his palette.

13. *Dab*

- C1. The pharmacist dabbed the ointment carefully on the rash.
- C2. The pharmacist dabbed the rash carefully with the ointment.
- C3. The pharmacist dabbed at the rash carefully with the ointment.

14. *Rub*

- C1. The nurse rubbed a towel gently on the wheelchair.
- C2. The nurse rubbed the wheelchair gently with a towel.
- C3. The nurse rubbed at the wheelchair gently with a towel.

15. *Spray*

- C1. The architect sprayed the paint evenly over the wall.
- C2. The architect sprayed the wall evenly with the paint.
- C3. The architect sprayed at the wall evenly with the paint.

16. *Squirt*

- C1. The clown squirted some oil madly on the door.

- C2. The clown squirted the door madly with some oil.
- C3. The clown squirted at the door madly with some oil.
- 17. *Splash*
 - C1. The mechanic splashed some water crazily onto the floor.
 - C2. The mechanic splashed the floor crazily with some water.
 - C3. The mechanic splashed at the floor crazily with some water.
- 18. *Swab*
 - C1. The sailor swabbed a mop arduously on the deck.
 - C2. The sailor swabbed the deck arduously with a mop.
 - C3. The sailor swabbed at the deck arduously with a mop.

Appendix B

These are the sentences used in the practical trails and that served as fillers in the Experiment.

Sentences for a practice trial

1. The lawyer did not believe that Jackson was guilty.
2. The carpenter hammered at the wall with a nail.

Sentences as fillers

1. The coach strongly persuaded Annie to be a careful skier.
2. The scientist politely asked Steve to be a harder worker.
3. The babysitter kindly told Lilly to be a better parent.
4. The retailer encouraged Robert to be a dedicated employee.
5. The servant begged Maggie to be a generous manager.
6. The director forced Eric to be a hard-working designer.
7. The soldier whom I desperately loved was Linda's brother.
8. The nurse whom I harshly criticized was Anthony's aunt.
9. The driver whom I secretly met was Helen's uncle.
10. The athlete who gave me his shirt was injured.
11. The writer who brought me her book was murdered.
12. The reporter who ordered me a pizza was arrested.
13. The model recognized that her colleague was struggling socially.
14. The plumber guaranteed that his boss will lower the price.
15. The critic claimed that the policy will bankrupt companies.

16. The chef realized that the restaurant is not famous.
 17. The mayor mentioned that he relied on small donations.
 18. The prosecutor noted that the criminal stabbed his wife.
 19. It was surprising that the librarian barely read books.
 20. It was unbelievable that the physicist wrote a novel.
 21. It was shocking that the pianist fainted after the recital.
 22. George was gloomy because the editor fired his son.
 23. Maria was excited because the salesperson hired her yesterday.
 24. Kenneth was upset because the inventor obtained a patent.
 25. The politician felt lonely even though he had followers.
 26. The miner could not rest even though he worked overnight.
 27. The officer passed by even though a girl called him.
 28. It rains heavily whenever the doctor examines a patient.
 29. The audience expressed their condolence to the famous actor.
 30. The director will always follow wherever the musician goes.
 31. The cashier used to deliver sandwich to earn money.
 32. The astronaut would jog every morning to become healthier.
 33. The captain sings every afternoon to relieve his stress.
 34. The dancer started to gain weight after the show ended.
 35. The janitor forgot to turn off the lights after dinner.
- The pilot finished eating his breakfast before Judy came home.

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