

UC San Diego

UC San Diego Previously Published Works

Title

The effect of anomalous utterances on language production

Permalink

<https://escholarship.org/uc/item/50w368pg>

Journal

Memory & Cognition, 45(2)

ISSN

0090-502X

Authors

Ivanova, Iva
Wardlow, Liane
Warker, Jill
[et al.](#)

Publication Date

2017-02-01

DOI

10.3758/s13421-016-0654-3

Peer reviewed

The effect of anomalous utterances on language production

Iva Ivanova^{*1}, Liane Wardlow², Jill Warker³, and Victor S. Ferreira¹

¹University of California, San Diego, ²Pearson Education and ³University of Scranton

*Corresponding author, now at the University of Texas at El Paso

Mailing address:

Department of Psychology
University of Texas at El Paso
500 W. University Ave.
El Paso, TX 79902
USA

Email: iva.m.ivanova@gmail.com

Abstract

Speakers sometimes encounter utterances that have anomalous linguistic features. Are such features registered during comprehension and transferred to speakers' production systems? Two experiments explored these questions. In a syntactic priming paradigm, speakers heard prime sentences with novel or intransitive verbs as part of prepositional dative or double object structures (e.g., *The chef munded the cup to the burglar* or *The doctor existed the pirate the balloon*). Speakers then described target pictures eliciting the same structures, using the same or different novel or intransitive verbs. Speakers overall described targets with the same structures as primes (abstract syntactic priming), but more so when primes and targets had the same novel or intransitive verbs (a *lexical boost*), an effect that was only observed when novel words served as verbs both in prime and in target sentences. Such a lexical boost can only manifest if speakers formed associations between verbs and structures in the primes during comprehension, and these associations were then transferred to their production systems. We thus show that anomalous utterance features are not ignored but persist (at least) in speakers' immediately subsequent production.

Keywords: language production; anomalous verb subcategorizations; syntactic persistence; syntactic priming; lexical boost.

The effect of anomalous utterances on language production

If a friend told you, *I munded a gift to my kid*, you would most likely infer that the child received a gift, and that the family uses a special word for bestowing gifts on each other. But what would your language system make of the word *mund*? You might take less time to understand what your friend is saying the next time she or he uses this word. You might also respond with something like *My mom gave a toy to my nephew last month*, mirroring the structure of your friend's utterance but avoiding the novel word. But, if you decided to follow suit and use the word *mund* yourself, what would you say? You could say *My mom munded last month too* if your language system has not made an association between the novel word and the structure, or if such an association does not readily transfer to production. Or, you could say *My mom munded a toy to my nephew last month* if your comprehension system has registered that *mund* occurred in a prepositional dative structure and transferred the association to your production system. In this study, we aimed to distinguish between these alternatives using a structural priming paradigm.

The language that people encounter may have such anomalous features for a number of reasons. Speakers are often disfluent (as starkly revealed by perusing faithfully transcribed everyday utterances; see Clark, 1996) and can make speech errors (see Bock, 1996, for estimates). Creative uses of language are often valued, in poetry, the media and dialogue. And individual speakers sometimes produce language idiosyncratically, because of their own diverse language experience, ongoing acquisition (in children or second-language learning adults), or brain damage. But what is the influence of anomalous language on the cognitive system underlying comprehension and production?

Let us first consider the influence of anomalous linguistic features on comprehension. Some evidence suggests that the comprehension system aims to reach stable representations when experiencing variability and anomalies in the input by relying on the comprehender's existing knowledge. By some views, the speech perception system copes with articulatory variability and anomalies by aiming to normalize comprehended speech in terms of invariant phonemes or articulatory gestures (for discussion, see Creel, Aslin, & Tanenhaus, 2008). Furthermore, comprehenders at least sometimes interpret implausible utterances (e.g., *The mother gave the daughter to the candle*) as plausible. They could do this by using heuristics (Ferreira, 2003) or by performing adjustments to make it plausible (e.g., deleting the preposition *to* which results in *The mother gave the daughter the candle*). This might happen especially if the respective speakers are unlikely to produce such utterances and the overall linguistic context does not contain anomalies (noisy channel accounts of comprehension; e.g., Gibson, Bergen, & Piantadosi, 2013). Also, comprehenders seem to construct the same abstract syntactic representations for anomalous as for well-formed sentences (Ivanova, Branigan, Pickering, McLean, & Costa, 2012a; see below). Such evidence suggests that at least some anomalies are “stripped away” from the linguistic input in an attempt to make the input match existing representations. But this does not discard the possibility that anomalies are retained at least temporarily in the language system and even influence its subsequent behavior.

Multiple studies suggest that anomalous linguistic features are registered and not simply discarded or left unattended. Experience with shifted segments (e.g., an /s/ pronounced with acoustics midway between an /s/ and a /f/) causes a corresponding shift in listeners' boundaries between the corresponding speech sounds (Kraljic & Samuel, 2005; Norris, McQueen, & Cutler, 2003); although, importantly, this does not happen when the segment shift is attributable to a

temporary state, such as a pen in the speaker's mouth (Kraljic, Samuel, & Brennan, 2008). Brief exposure to atypical or ungrammatical sentences makes them faster to process, or more acceptable. For example, Kaschak and Glenberg (2004) exposed comprehenders to sentences with an ungrammatical structure in Standard English (the needs-construction, e.g., *The meal needs cooked*), and observed that reading times for such sentences decreased with consecutive presentations. This effect generalized to a different verb (*want*, e.g., *The dog wants walked*) and a different sentence context (e.g., *What the meal needs is cooked*; Kaschak, 2006). Furthermore, Luka and Barsalou (2005) exposed comprehenders to moderately ungrammatical sentences (e.g., *Sam recites poems as well as playing the piano* or *Who did you hire because he said would work hard?*), and observed that such sentences were rated as more grammatical when participants had seen them before (even only once) than when they had not. This effect generalized to sentences sharing only structure but no content words with the initial-exposure sentences. These results suggest that the comprehension system adapts to processing anomalous or atypical utterances, and thus, that anomalous or atypical features of utterances are retained, to the extent that they influence (at least the immediately) subsequent processing.

The next question is whether anomalous linguistic features influence subsequent *production*. It is possible that speakers do not readily reproduce anomalous linguistic features they have recently comprehended. Indeed, comprehension and production do not always go hand-in-hand (see Clark & Hecht, 1983). For example, many adult native speakers of a language understand a range of dialects of this language but are able to produce a few at most. Second-language learners consistently report understanding much more than they can say. A range of studies addressing second-language learning and testing both comprehension and production show better performance in comprehension than in production (Barcroft & Sommers, 2005;

Kang, Gollan, & Pashler, 2013; Sommers & Barcroft, 2013). Persistence of anomalous language from comprehension to production would in fact seem suboptimal after exposure to speech patterns due to language disorders or odd grammatical usages (e.g., some features of utterances from second language speakers). There might be transfer between comprehension and production only when the language system has accumulated enough evidence that an experienced atypical feature might have some future relevance (for a discussion of the differences between atypical and completely ungrammatical language features, see Hofmeister, Jaeger, Arnon, Sag, & Snider, 2013). For example, after comprehending disfluent utterances involving repeated or corrected words, speakers typically do not start producing such utterances in their own speech (e.g., *John walked walked in the park* or *Susan danced played under the tree*), unless they are disfluent themselves (see Ferreira & Bailey, 2004, on how comprehenders deal with such disfluencies).

But there are also reasons to hypothesize that anomalous linguistic features might persist in production: A host of evidence suggests that language experience modifies speakers' production preferences on an ongoing basis. For example, experience affects speakers' knowledge of where speech sounds can appear in syllables (Dell, Reed, Adams, & Meyer, 2000; Warker & Dell, 2006). Experiencing novel isolated words causes speakers to represent those words in their lexicon, as shown by the fact that such words can induce a shift in perceptual boundaries (Leach & Samuel, 2007), cause cohort competition (Gaskell & Dumay, 2003) or, after only a short training period, give rise to cumulative semantic interference (Oppenheim, 2015).

An adult individual's language system may not be fixed but may change throughout her lifetime. Languages themselves may also undergo global changes. The mechanisms behind both

of these changes might be at least partly related to the tendency of conversation partners to mirror each other's lexical (Garrod & Anderson, 1987) and structural choices (Branigan, Pickering, & Cleland, 2000; see Loebell & Bock, 2003, for relevant discussion regarding language change). Indeed, experience with sentence structures causes what appear to be long-lasting shifts in speakers' production preferences for those structures; for example, if speakers experience a large number of double-object structures, they will be more likely to produce double-object structures, even a week later, at least when in a comparable task setting (Kaschak, Kutta, & Schatschneider, 2011). As a mechanism underlying such effects, a number of recent processing accounts propose a direct relationship between language comprehension and language production. Dell and Chang (2014) suggest that the comprehension system uses the production system to generate top-down predictions of upcoming utterance constituents. Pickering and Garrod (2007) suggest that the comprehension system uses the production system to generate predictions by constructing an emulator and integrating its output with the received linguistic input. Both accounts thus assume not only that comprehension and production use the same linguistic representations (MacDonald, 2013), but that they operate using shared processes. Such frameworks predict a straightforward mechanism of transfer from comprehension to production for anomalous utterance features initially experienced in comprehension.

The question we ask in this study is whether comprehended anomalous linguistic features persist in production (which could only happen if they are also registered during comprehension). More specifically, we ask whether incongruencies between verbs and the syntactic structures they occur in (i.e., *subcategorizations* for novel or incongruent verbs) persist in production. A tool to measure persistence from comprehension to production is *syntactic priming*. Syntactic priming reflects the fact that when speakers hear (or say) sentences that have

particular sentence structures (called *prime* sentences), they are more likely to use those structures themselves when subsequently given an opportunity (in a *target* production), even if the prime and target do not overlap in sound or meaning (Bock, 1986). Syntactic priming has been observed across a range of sentence structures, production modalities, and languages (see Pickering & Ferreira, 2008, for review). It is a robust effect that is generally taken to derive from a tendency to repeat specifically the syntactic structures of experienced sentences.

Ivanova et al. (2012a) studied the effect of anomalous subcategorizations for verbs on subsequent production, but they assessed persistence of abstract syntactic structure rather than persistence of the specific subcategorizations. Specifically, these authors found that ditransitive sentences with novel and intransitive verbs caused equivalent syntactic priming to well-formed sentences. That is, sentences such as *The waitress brunks the book to the monk* and *The waitress exists the book to the monk* primed the production of prepositional dative targets as much as *The waitress gives the book to the monk*. These results suggest that comprehenders were just as able to build a prepositional dative or a double object structure (inasmuch as that structure was then repeated in their subsequent descriptions) for novel and intransitive verbs, which do not have such structures in their subcategorization profiles, as they were for verbs like *give*, which do have such structures in their subcategorization profile. Ivanova et al. thus concluded that comprehenders do not need to use syntactic information carried by verbs to build syntactic representations; they can build syntactic representations using only the abstract syntactic information in the sentence.

But Ivanova et al.'s (2012a) findings are silent about whether the anomalous subcategorizations for the novel and intransitive verbs would themselves persist in production. It is possible that they do not. Comprehenders might register anomalous or novel language

features, or transfer them to production, only after such features reach a certain exposure threshold; a mechanism safeguarding against producing ungrammatical language. Or, in a noisy-channel account, comprehenders might simply assume that the speaker has said a known verb (e.g., *hand*) instead of the novel verb *mund*, and process the sentence in the same way as they would process the sentence *I handed the gift to my kid*; in other words, comprehenders might correct the novel verb to a known verb. In either scenario, the ditransitive use of the novel verb, constituting the anomaly in the sentence *I munded the gift to my kid*, would not be retained by the language system after the sentence is processed, or would be retained only in the comprehension system, but would not transfer to production. If so, the prepositional dative subcategorization for the verb *mund* in this example would not persist in production if *mund* were to be used again.

This possibility is supported by recent evidence that comprehenders do not retain a sentence's anomalous form but "correct" it, and it is the corrected representation which persists in subsequent production. In a test of the noisy-channel account of comprehension, Slevc and Momma (2015) exposed participants to plausible (e.g., *The authors sent an abstract to the conference*) and implausible dative prime sentences (e.g., *The authors sent the conference to an abstract*), and recorded their subsequent descriptions of pictures of ditransitive events, and their responses to comprehension questions (e.g., *Did the abstract receive something?*). Notably, the structure of the prime sentences persisted in participants' subsequent production only for the sentences interpreted according to their actual form (for the implausible sentence above, a "yes" response to the question *Did the abstract receive something?*), but not for the sentences interpreted according to a mentally "corrected" form (for the implausible sentence above, a "no" response to the question *Did the abstract receive something?*). It thus seems that what participants' comprehension systems ultimately registered for an implausible prepositional-object

sentence such as *The authors sent the conference to an abstract* in the latter case was in fact a double-object representation corresponding to a plausible sentence (*The authors sent the conference an abstract*). While this finding does not directly inform the persistence of anomalous subcategorizations, it suggests that comprehenders can correct anomalies related to structure, and that such anomalies do not always persist in their subsequent production. In the context of the present study, it suggests that comprehenders might correct the novel verb *mund* to a known verb (e.g., *hand*), and hence not register the novel verb's structural preferences.

It is also possible, however, that anomalous subcategorizations do persist in production. That is, for the sentence *I munded the gift to my kid*, comprehenders might not only construct an abstract syntactic representation; they might register and (at least temporarily) store the association between *mund* and the prepositional dative and then transfer it to their production system. If so, they would be more likely to say *My mom munded the toy to my nephew* in a future utterance.

This possibility is supported by evidence from first language acquisition that young children deduce the meanings of novel verbs from the structure in which such verbs appear (in support of the *syntactic bootstrapping* hypothesis) and presumably then store the novel verbs' experienced structural preferences together with their deduced meaning (Brown, 1957; Fisher, 1996; Fisher, Hall, Rakowitz, & Gleitman, 1994; Naigles, 1990). But there might be a difference between language acquisition in childhood, when the language system is still developing, and adulthood, when the language system is largely in place and changes to it might be suboptimal for communication.

Ivanova, Pickering, McLean, Costa, & Branigan (2012b) found that, in adult production, strongly dispreferred subcategorizations for verbs (the double object structure used with so called

non-alternating verbs, e.g., **?The wealthy widow donated the church a million dollars*) can persist in speakers' subsequent picture descriptions. This effect held only when primes and targets shared a verb, suggesting persistence of subcategorizations rather than abstract syntactic structure (see also Slevc & Ferreira, 2012, for persistence of subcategorizations of known verbs produced in error). However, in Ivanova et al. (2012b), the new association of a syntactic structure to a verb was across the alternative forms of a known alternation – participants showed that they newly associated a double object subcategorization to a verb for which they already had associated a prepositional dative subcategorization. It is unclear, however, if such effects would extend to novel verbs or verbs whose ditransitive use is unquestionably ungrammatical. That is, it is unclear if we would observe persistence in production of previously comprehended anomalies which do not relate to the comprehender's current linguistic knowledge, or even violate it.

In the present study, we thus investigate whether two types of anomalous sentence features that do not match speakers' existing linguistic knowledge persist in their subsequent production. One are verbs that speakers have never heard before, but used with known grammatical sentence structures, such as *The chef munded the cup to the burglar* (a prepositional dative structure) or *The waitress kelled the ballerina the shoe* (a double object structure). The other are English verbs that are restricted in typical language use to intransitive structures, but used here with ditransitive structures such as *The monk stayed the hat to the pirate* or *The doctor existed the pirate the balloon*. For both novel and intransitive verbs, speakers do not have ditransitive structures represented as part of the verbs' subcategorization profiles. In the case of the novel verbs, there is no preexisting subcategorization since the verb does not (yet) have a

lexical representation. In contrast, intransitive verbs are lexically represented, but their profile includes only intransitive subcategorization.

We use comprehension-to-production syntactic priming to study whether ditransitive subcategorizations for novel and intransitive verbs persist in subsequent production. Although syntactic priming is robust even when prime and target sentences do not overlap in lexical content (Bock, 1986), the priming effect is significantly larger when the prime and target sentences have the same main verb (the *lexical boost*; Pickering & Branigan, 1998). In the experiments presented here, we use this effect to assess whether subjects create an association between a novel or intransitive verb and a ditransitive structure.

Specifically, if the comprehension system does not make an association between a novel or intransitive verb and a ditransitive structure, or if such an association does not transfer to the production system, the anomalous subcategorization should not persist if comprehenders subsequently produce a target sentence with *that same* novel or intransitive verb. In other words, an anomalous sentence such as *I munded the gift to my kid* should still cause syntactic priming, but this priming would come about as a verb-independent property (Ivanova et al., 2012a) and be similar if the target sentence has the same verb as the prime or a different (novel or intransitive) verb. Thus, if anomalous sentence features do not persist in production after brief exposure, we should not observe a lexical boost.

In contrast, if the comprehension system does make an association between a novel or intransitive verb and a ditransitive structure, and that association transfers to the production system, structure repetitions should be more likely when the target sentence has the same verb as the prime, relative to when the target has a different verb. Thus, if anomalous sentence features persist in production after brief exposure, we should observe a lexical boost. Note that a

ditransitive structure might more readily persist with novel verbs than with intransitive verbs, insofar as the latter, but not the former, would violate existing rules in the language system; looking at intransitive verbs would thus present a stronger test of our hypotheses.

Note also that there are two possible explanations for the lexical boost, and they make different assumptions about what persists in production. The lexical boost could stem from the same architecture which gives rise to verb-independent syntactic priming, and come about through priming of the link between words' abstract representations and their structural preferences (Pickering & Branigan, 1998). According to this proposal, a lexical boost in our experiments would indicate that the language system has *encoded* the anomalous features. That is, the language system would have created abstract representations for novel verbs as well as links between both novel and intransitive verbs and the prepositional or double object structures. On the other hand, the lexical boost could be a fundamentally different phenomenon than syntactic priming itself, and come about as a result of a fleeting trace of a just-experienced sentence in episodic memory (Chang, Dell, & Bock, 2006; Chang, Janciauskas, & Fitz, 2012). According to this proposal, a lexical boost in our experiments would indicate that the ditransitive use of novel or intransitive verbs has been only temporarily retained in memory. Despite the very different nature of these proposals about the origin of the lexical boost, our current predictions are consistent with both. This is because we ask here whether anomalies would persist in production (and thus whether the comprehension system registers them) and not how long they are retained.

In Experiment 1, participants heard critical prime sentences that were ditransitive (prepositional dative and double object) structures with verbs that were either novel or intransitive, and then described target pictures that elicited ditransitive productions. Each picture

was presented with a printed verb, which speakers were to use in their target descriptions. The printed verb was either the same novel or intransitive verb presented in the prime sentence, or was a different verb (novel or intransitive, respectively). If the association between a novel or intransitive verb and a prepositional dative or a double object structure forms and transfers to production, then we should observe a lexical boost: More target descriptions should use the same structure as prime sentences when target and prime have the same verb than when they do not. If the association between a novel or intransitive verb and a prepositional dative or a double object structure does not transfer to production, then we should observe only priming of abstract structure but no lexical boost: Targets that have the same verbs as the primes should show the same amount of priming as targets that have different verbs from the primes.

Experiment 2 was designed to assess an alternative explanation for the results of Experiment 1. We defer introduction of that experiment until after the results of Experiment 1 are described.

Experiment 1

Method

Participants. Forty-eight members of the University of California, San Diego community participated either for course credit or for a small payment (\$10/hour). All participants were native speakers of English.



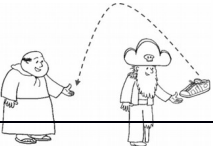
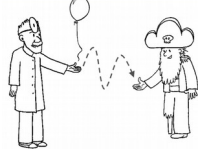
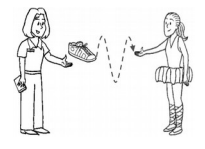
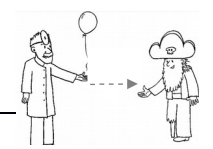
Materials. Five novel verbs (*dess*, *kell*, *mund*, *niss*, and *tay*) and five intransitive verbs (*exist*, *remain*, *dwel*, *stay*, and *peak*) were used to construct 40 quadruplets of prime-sentence – target-picture pairs (20 with novel verbs, 20 with intransitive verbs). Within a quadruplet, the same target picture with the same novel or intransitive verb was used for all four prime sentences. Two of the prime sentences were prepositional dative and two were double object

structures; one of each of these had the same verb as the target and the other had a different (respectively novel or intransitive) verb. For the primes in each quadruplet, a picture was designed for the picture verification task (see below); half of these depicted the primes' content (and thus required a "yes" response) and half did not (and thus required a "no" response). The verification pictures requiring a "no" response differed from the prime sentence in one entity (either the theme or the goal). For the novel and intransitive verbs, a distinctive path of transfer was depicted in the verification picture, purportedly as the meaning of the verb (pilot work showed that subjects did not encode this distinctive path information, and so, though still depicted, these were not systematically manipulated or controlled in the current experiments; however, they were consistent across verification pictures and targets in the same verb conditions). Each novel and intransitive verb was used in an equal number of prime and target sentences and in an equal number of prepositional dative and double object prime sentences. Nominal arguments came from a set of humans and objects that were easily nameable for production, each used approximately equally across the prime and target sentences. Examples of a novel quadruplet and an intransitive quadruplet are shown in Table 1.

In addition, participants were presented with 12 filler prime-target pairs. Fillers used both novel and known verbs. Filler primes were intransitive (i.e., they included no post-verbal arguments); filler targets similarly elicited intransitive descriptions (e.g., sneezing). Fillers were intermixed with experimental items and order was randomized such that no more than two items of the same type (novel, intransitive, or filler) occurred in a row. Four lists were created, each containing one prime sentence from each experimental item quadruplet and an equal number of experimental items from the four conditions. Twelve participants were assigned at random to each list.

Table 1

Example materials for Experiment 1

Prime-Target Verb Match	Prime Structure	Example Sentence	Prime Verification Picture	Target Picture
Novel Verb				
Same	Prepositional Dative	The pirate nissed the shoe to the waitress.		
Same	Double Object	The pirate nissed the waitress the shoe.	NISSED	
Different	Prepositional Dative	The pirate desseed the shoe to the waitress.		
Different	Double Object	The pirate desseed the waitress the shoe.	DESSED	NISSED
Intransitive Verb				
Same	Prepositional Dative	The doctor existed the balloon to the pirate.		
Same	Double Object	The doctor existed the pirate the balloon.	EXISTED	
Different	Prepositional Dative	The doctor remained the balloon to the pirate.		
Different	Double Object	The doctor remained the pirate the balloon.	REMAINED	EXISTED

Procedure. Each trial began with a tone, signaling to the experimenter to read the prime sentence. After the experimenter read the prime, the subject pressed a button on the PsyScope button box, causing a verification picture to appear on the screen. The subject pressed buttons labeled “yes” or “no” to indicate whether the prime sentence described the verification picture. Subjects then saw a target picture with a past tense verb printed beneath it; subjects were asked to describe the target picture using a sentence that included the printed verb. Subjects were told that the pictures might seem “funny to them,” both in that they include various characters performing assorted actions with various objects, and that they would include novel words or

words used in novel ways. The voice key caused the target picture to disappear. The next trial began after a 500 ms inter-trial interval.

The experiment began (after the subject provided informed consent) with interactive instructions that stepped the subject through the procedure. Four practice trials preceded the experiment proper.

The experiment was implemented using PsyScope X 57, running on iMac computers with 20" monitors. Head-worn microphones provided input to digital voice recorders and PsyScope button boxes (so a voice key could advance task events).

Scoring. All target descriptions were coded for whether they were prepositional datives, double objects, or some other structure. A prepositional dative included a noun phrase after the verb that described the depicted theme and was followed by a prepositional phrase describing the depicted goal (...*the cake to the artist*), whereas a double object included a noun phrase describing the depicted goal followed by another noun phrase describing the depicted theme (...*the artist the cake*). To be coded as either a prepositional dative or double object, the sentence had to be acceptable in the alternative form. Targets coded as a structure other than a prepositional dative or a double object were discarded. Whether subjects used the printed verb was also coded; targets where speakers did not use the printed verb were discarded (as this is integral to the manipulation of the same versus different verbs in prime and target sentences).

Data analysis. We analyzed the data using logit mixed effects regression (LMER) modeling (Jaeger, 2008) in R (Version 2.15.3). All models included the maximal random effects structure justified by the design (Barr, Levy, Scheepers, & Tily, 2013) unless otherwise stated. Since we expected that novel and intransitive verbs may produce different patterns, we fitted separate models to the novel and intransitive verb data, with verb match (same, coded as 0.5;

different, coded as -0.5), prime structure (prepositional dative, coded as -0.5; double object, coded as 0.5) and their interaction as fixed predictors. In the dependent variable, double object responses were coded as 1 and prepositional dative responses, as 0. For easy visualization, we plot by-participant averages of the percentage of double objects produced in each experimental condition (out of all prepositional datives and double objects produced). The choice of double objects rather than prepositional datives was motivated by an easier comparison with previous related studies.

Results and discussion

In all, 1,920 trials were eligible for analysis. Speakers produced target descriptions with structures other than a prepositional dative or a double object on 41 trials (2.1%), varying between 1 (0.4%) and 11 (4.6%) per condition; more of these were produced in the double object (37 trials) than in the prepositional dative prime-structure condition (4 trials). Speakers produced target descriptions that were otherwise unsuitable for analysis (because utterances did not satisfy the coding conditions noted above, including because they did not use the printed verb) on 152 trials (7.9%), varying between 10 (4.2%) and 27 (11.3%) per condition; again, more trials were excluded in the double object (101) than in the prepositional dative (51) prime-structure condition. Note that some trials violated both of these exclusion criteria. In all, 1,785 trials (93%) were entered into the statistical analyses.

The mean percentages of double object targets produced for each combination of prime verb type, prime-target verb identity, and prime structure are shown in Figure 1. When primes and targets used different verbs, speakers produced more double object target descriptions after double object primes than after prepositional dative primes – a priming effect of 14.5% for sentences with novel verbs and 13% for sentences with intransitive verbs. However, the

corresponding priming effects were larger when primes and targets used the same verb – 21.1% for sentences with novel verbs and 19.2% for sentences with intransitive verbs.

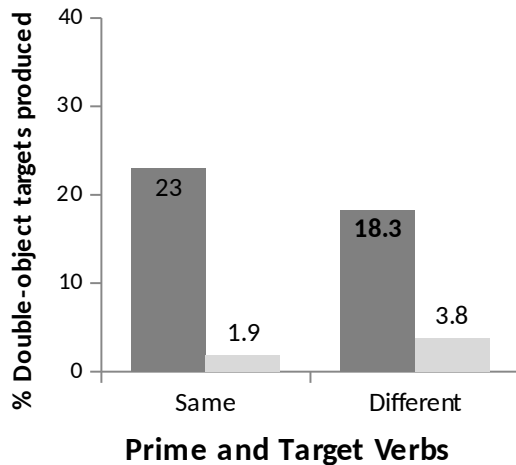


Figure 1. Percentages of double object descriptions produced after prepositional dative and double object primes with the same or different verbs as targets. Error bars show 95% confidence intervals.

In the model fitted to the novel verb data (excluding items' random intercept due to the non-convergence of the full model), prime structure was a significant predictor [*Estimate* = -3.08, *SE* = .68, *z* = -4.54, *p* < .001], indexing the presence of a priming effect. Importantly, the interaction between verb match and prime structure was also a significant predictor [*Estimate* = -2.30, *SE* = .80, *z* = -2.88, *p* = .004], indicating that there was more priming when primes and targets shared verbs than when they did not (a lexical boost). Likewise, for the intransitive verb data, there was a significant priming effect [prime structure: *Estimate* = -1.62, *SE* = .67, *z* = -2.41, *p* = .02] and a significant lexical boost [verb match x prime structure interaction: *Estimate* = -1.95, *SE* = .92, *z* = -2.11, *p* = .04].

In sum, speakers produced target sentences with novel or intransitive verbs with the same structure as they had just heard in a prime, but more so when the prime and target used the same verb compared to when prime and target used different verbs. The presence of a lexical boost suggests that participants' comprehension systems had registered that the specific prepositional dative or double object structure they heard in the prime occurred with a specific novel or intransitive verb in that prime, and this association transferred to their production systems. Thus, these results suggest that when speakers hear sentences with anomalous features – a novel verb or a verb that does not normally subcategorize for the structure used with that verb – they register the association between verb and structure, and at least temporarily retain it in their language system, to the extent that it persists in their immediately subsequent productions.

There is an alternative explanation, however, for why a lexical boost was observed in Experiment 1. It is possible that what persisted in participants' production was not the unusual verb-structure combinations, but only the novel or intransitive verbs. That is, it is possible that the novel or intransitive verbs *alone* left a memory trace sufficient to evoke the sentence structures they occurred in, but independently of the specific associations between these verbs and the respective structures, and perhaps independently of the fact that they were verbs. To test this possibility, in Experiment 2 primes and targets always had a novel word in common. For half of the sentences, the novel word in the prime was a verb, whereas for the other half, the novel word in the prime was not a verb but was instead the subject noun. If what persists in production is indeed an association between a verb and a syntactic structure, then a lexical boost should be observed in Experiment 2, but only when the novel word in the prime is used as a verb.

Experiment 2

Critical sentences in Experiment 2 all included novel words. For half the primes, the novel words were used as the main verb in the sentence (e.g., *The ballerina tayed the burglar the cup*), as in Experiment 1. For the other half, the novel words were used as the main subject noun (ostensibly as the name of a type of alien species, as depicted in the subsequent verification picture), with the verb being a known English dative verb (e.g., *The tay brought the burglar the cup*). Target sentences were always to be produced with verbs that were the same as the novel word used in the prime (e.g., *The waitress tayed the ball to the ballerina*). If the lexical boost observed in Experiment 1 was due to a persistence of verb subcategorizations, then this boost should not be observed in Experiment 2 when the same novel word is used as a noun in the prime but as a verb in the target. That is, more priming should be observed when the same novel word is used as a verb in the prime sentence than when it is used as a noun. If the lexical boost seen in Experiment 1 was not due to the novel words' use as verbs but only to their novelty, then the same-sized priming effect should be observed from prime sentences that have novel words used either as nouns or as verbs.

The use of novel words in primes as verbs or nouns is possible because our novel words can reasonably be construed as nouns (here as the name of an alien species). For intransitive verbs, an analogous test would be awkward, if not impossible (e.g., *The exist gave the pirate the balloon*). As such, Experiment 2 only tested the alternative explanation with sentences with novel verbs. For present purposes, we assume that whatever conclusion is supported by the results with novel verbs should parsimoniously be extended to intransitive verbs.

Note that the novel nouns in the primes and the novel verbs in the targets can be expected to differ slightly in form because participants naturally inflect target verbs (e.g., *The monk*

nissed...vs. The niss passed...). This difference is difficult to avoid because it would be problematic to present the nouns as though they were inflected (*The nissed passed...*). However, differences in inflections between prime and target sentences do not seem to modulate the priming effect (Pickering & Branigan, 1998). Still, the printed verbs presented to participants on both target and prime's verification pictures (see below) were always in a bare form (e.g., NISS), which was identical to the novel nouns in the prime sentences.

Method

Participants. Forty-eight members of the University of California, San Diego community participated either for course credit or for a small payment (\$10/hour). All participants were native speakers of English.

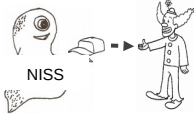

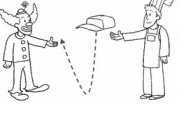
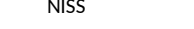
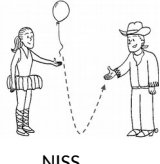
Materials. Six novel verbs (*dess, kell, mund, niss, reen, and tay*) and six known verbs (*bring, give, hand, offer, pass, and toss*) were used to construct 24 new quadruplets of prime-sentence – target-picture pairs. Examples of a novel-verb quadruplet and a known-verb quadruplet are shown in Table 2. Within a quadruplet, the same target picture with the same novel verb was used for all four prime sentences. Two of the prime sentences were prepositional dative structures and two were double object structures; one of each of these had the novel word used as the verb of the sentence, whereas the other had the novel word used as the subject noun of the sentence. When serving as the subject noun, the novel word was presented as the name of an alien species. The novel verb or noun in the prime was always presented as the to-be-used verb (in the present tense) in the target picture. Verification pictures were used to ensure comprehension of prime sentences as in Experiment 1 (the verification pictures corresponding to primes with novel nouns depicted the purported aliens with the novel words written on them; see

Table 2). Each novel word was used in an equal number of prime and target sentences. Nominal arguments were as in Experiment 1.

In addition, participants were presented with 24 filler prime-target pairs. Filler primes were datives and targets were dative-eliciting pictures, all including known verbs. To try to increase double object production across the experiment, 18 filler primes were double objects and 6 were prepositional datives. Twelve primes included novel nouns in a post-verbal position, and targets all had novel words as the subject noun (as the name of an alien species).

Table 2

Example materials for Experiment 2

Novel Word in Prime	Prime Structure	Example Sentence	Prime Verification Picture	Target Picture
Noun	Prepositional Dative	The niss passed the apple to the clown.		
Noun	Double Object	The niss passed the clown the apple.		
Verb	Prepositional Dative	The chef nissed the apple to the clown.		
Verb	Double Object	The chef nissed the clown the apple.		

Procedure, scoring, and analysis. These were as in Experiment 1. The fixed predictors in the LMER model were prime novel-word role (verb, coded as -0.5; noun, coded as 0.5), prime structure (prepositional dative, coded as -0.5; double object, coded as 0.5), and their interaction.

Results and discussion

In all, 1,152 trials were eligible for analysis. Speakers produced target descriptions with structures other than a prepositional dative or a double object on 14 trials (1.2%), varying between 1 (0.3%) and 6 (2.1%) per condition; more of these were produced in the novel noun

(10 trials) than in the novel verb condition (4 trials). Speakers produced target descriptions that were otherwise unsuitable for analysis (including because they did not use the printed verb) on 4 trials (2.6%), varying between 0 (0%) and 2 (0.7%) per condition.

The mean percentages of double object targets produced for each prime novel-word role condition and prime structure are shown in Figure 2. When primes had novel nouns (with targets having the same novel words as verbs), speakers produced 4.0% more double object target descriptions after double object primes than after prepositional dative primes. When primes had novel verbs (again with targets having the same novel words as verbs), speakers produced 14.5% more double object target descriptions after double object primes than after prepositional dative primes. That is, a substantial priming effect is evident, but only when primes and targets both used novel words as verbs.

Statistical analyses confirmed these observations. Prime structure was a significant predictor [*Estimate* = 5.15, *SE* = 1.46, *z* = -3.52, *p* < .001], indexing the presence of an overall priming effect. The interaction between prime novel-word role and prime structure was also significant [*Estimate* = -7.01, *SE* = 2.91, *z* = -2.41, *p* = .02], indicating that there was more priming when the novel words in the primes were used as verbs than when they were used as nouns. We ran an additional model to test for simple effects by removing the prime structure predictor from the main model. Due to non-convergence, the model was simplified by step-wise removal of the random effects accounting for least variance; the final model did not include subject random slopes and prime novel-word role in the item random effects. This model indicated that, when primes used novel words as verbs, the 14.5% priming effect was significant [*Estimate* = -2.76, *SE* = .48, *z* = -5.78, *p* < .001]; when primes used novel words as nouns, the

4.0% priming effect was also significant, although the effect was smaller [$Estimate = -1.13$, $SE = .51$, $z = -2.22$, $p = .03$].

Figure 2. Percentages of double object descriptions produced after prepositional dative and double object primes with novel verbs or nouns (identical to the verb in the target descriptions). Error bars show 95% confidence intervals.

In this experiment, we also recorded participants' performance on the picture verification task. Participants correctly matched verification pictures on 94.97% of the trials. The number of incorrect responses was similar across the prime novel-word role conditions (Novel Verb prime: $n = 23$; Novel Noun prime: $n = 34$; [$p = .29$]), and were similar between trials on which participants described the target picture with the prime structure and trials on which they described the target picture with the alternative structure (Trials showing priming: 27; Trials not showing priming: 30; [$p = .09$]). These analyses thus indicate that the magnitude of priming we report was not influenced by participants' performance on the picture verification task.

In sum, Experiment 2 replicates Experiment 1 in that, when prime and target shared a novel verb, a large priming effect was observed. In contrast, when prime and target sentences both included the same novel word, but as a noun in the prime and a verb in the target, a smaller priming effect was observed. This is consistent with the observation of a lexical boost, but only when the identical (novel) word is used in the prime sentence specifically as a verb. In turn, this suggests that comprehenders do register associations between novel verbs and the structures they are used in, and these associations persist in their subsequent productions.

Note that the use of novel words as both nouns and verbs (in primes and targets, respectively) in the novel-noun condition of Experiment 2 might have left participants uncertain about how to use the novel word (printed on the target pictures in bare form), and thus reduced priming in this condition. This possibility, however, does not undermine our conclusions, for several reasons. First, in a pilot experiment replicating Ivanova et al.'s (2012a) results with novel verbs, we found similarly small priming effects (4.5% between known-verb primes and different known-verb targets), in the absence of grammatical category ambiguity of the target verbs. Also note that different-verb priming effects are generally not consistent in magnitude across published studies, and range from 28% to 4% (to a negative difference of 3% in Ivanova, Branigan, McLean, Costa, & Pickering, in press). Second, confusion about the grammatical category of the novel words would have reduced priming also in the novel-*verb* condition, but this is not what we found: A comparison of the novel-verb condition of Experiment 2 and the same (novel) verb condition of Experiment 1 indicated that the magnitude of priming in the two conditions was similar [interaction between condition and prime structure: *Estimate* = -.14, *SE*

= .82, $z = -.17$, $p = .87$].¹ Third, a reduction of priming because of grammatical category ambiguity in the novel-noun condition of Experiment 2 would not be at odds with our conclusions. For a sentence such as *The niss handed the apple to the clown*, such a reduction would presumably be caused by a memory trace of the association between *niss* and the immediately preceding and following sentence constituents (e.g., Det-NISS-V). This association would then be evoked when participants had to produce *niss* as a verb and compete with the use of *niss* in the prepositional dative structure. Such a scenario would thus suggest that participants' language systems actually retained something about the grammatical category and structural usage of experienced novel words, in accordance with our conclusions.

General Discussion

The experiments presented here showed that when speakers heard prepositional dative or double object prime sentences with novel verbs or with intransitive (non-dative) verbs, they subsequently described targets with the same structure as the prime more when prime and target had the same (novel or intransitive) verb than when prime and target had different verbs. However, when speakers heard prepositional dative or double object prime sentences with a novel word used either as a noun or a verb, and then they described target pictures with that same novel word used as a verb, a larger priming effect was observed when the prime used the novel

¹ This model included the data from Experiment 2 and the novel verb data from Experiment 1. It had as fixed predictors condition (same verb condition in Experiment 1, same verb condition in Experiment 2, between participants and items) and prime structure (prepositional dative, double object, within participants and items). In the condition predictor, the same verb condition of Experiment 1 was coded as 0.5, and the same verb condition of Experiment 2, as -0.5; the remaining condition in each of the two experiments was coded as 0.

word as a verb compared to as a noun. In short, novel and intransitive verbs exhibit a lexical boost, and novel words cause a lexical boost only when serving as verbs in primes and targets.

When speakers hear *I munded a gift to my kid*, they might understand the sentence and process its syntactic structure (Ivanova et al., 2012a), but nonetheless take no notice that they heard the new verb *mund* with the prepositional dative sentence structure. It is also possible that, when speakers hear *I munded a gift to my kid*, they register that *mund* occurred with the prepositional dative structure (and take less time to understand this combination if they hear it again), but they do not use the combination in their own productions. Ignoring or at least not repeating the novel verb's subcategorization would be reasonable if it were a speech error or an idiosyncratic feature of the speaker (e.g., if it were due to a speech impediment or the speaker's incorrect knowledge of the language). The fact that such sentences cause a lexical boost suggests that this is not what happens. Rather, when comprehenders hear *I munded a gift to my kid*, they register the association between *mund* and the prepositional dative structure, and that association is transferred to their production system and ultimately persists in their immediately following utterances.

We found persistence in production of specific anomalous features of utterances. But what persists? As noted in the Introduction, there are two possible explanations of the lexical boost. It could stem from changes of speakers' linguistic knowledge, instantiated by encoding novel verbs and establishing links between these verbs (or intransitive verbs) and ditransitive structures (henceforth encoding account; Pickering and Branigan, 1998). It could also stem from a transient episodic memory trace, which does not change speakers' linguistic knowledge (henceforth episodic memory account; Chang et al., 2006; Chang et al., 2012). Although, as previously noted, our main purpose here was not to distinguish between these accounts, the data

may be consistent with aspects of both. For example, the episodic memory account might predict reduced priming when novel words are used as nouns in (known-verb) primes but verbs as targets, relative to when they are used as (different) verbs in both primes and targets. On this account, seeing a novel word (e.g. *niss*) used as a noun would leave a trace in explicit memory, and this trace would then induce conflict when participants are subsequently asked to use *niss* as a verb. The extra processing necessary to resolve the explicit-memory-induced conflict would interfere with abstract syntactic persistence and reduce the overall magnitude of priming. There is an indication of such a scenario in our data, insofar as priming in the noun-verb (also different-verb) condition of Experiment 2 was numerically smaller than priming in the different verb condition of Experiment 1.² Note, however, that such a difference might also be explained in a modified encoding account, by assuming that nouns are also linked to and activate structural nodes, which – if a word is used as both noun and verb – would interfere with the structural nodes activated by the use of this word as a verb.

A clear point of difference between the encoding and explicit memory accounts lies in the duration of persistence. The encoding account predicts longer-term persistence, to the extent that

² A model on the data from Experiment 2 and the novel verb data from Experiment 1 with condition (noun-verb condition in Experiment 2, different verb condition in Experiment 1), prime structure (prepositional dative, double object) and their interaction as fixed predictors did not show any statistical difference between the two conditions [interaction between condition and prime structure: *Estimate* = .54, *SE* = .83, *z* = .64, *p* = .52]. However, the interaction term was correlated with the condition predictor ($r^2 = .57$), which was marginally significant [*Estimate* = -.85, *SE* = .45, *z* = -1.91, *p* = .06]. It is possible that the model attributed to the condition predictor some variance accounted for by the interaction term.

the linguistic system has been changed – the anomalous associations between verbs and structures in our experiments have been encoded into speakers’ linguistic knowledge. The explicit memory account predicts only short-term persistence, insofar as the explicit memory traces left by the anomalous verb-structure associations would quickly dissipate. Indeed, the experiments reported here demonstrate only that effects carry over from one trial to the next – from prime to target; it is thus possible that these effects might be short-lived (Hartsuiker et al., 2007: the lexical boost decays). On the other hand, an experiment similar to Experiment 1 but including a post-test (which we do not report because of a counterbalancing error) indicated that participants constructed more dative (prepositional dative or double object) sentences with verbs they had seen during the experiment, than with verbs they had not seen before. Future work is needed, however, to establish the robustness of this effect, and to determine whether the persistence we observed here might be long-lived.

Real language spoken in real situations may seem orderly when it is not. Evidently – at least as far as the kinds of features explored in the experiments here – this is not because speakers disregard anomalous language features. Rather, we have shown that such features are registered by the comprehension system and persist in speakers’ immediately subsequent productions. Future work should aim to establish the scope of such persistence, and thus, whether it could be a mechanism driving language change within and across individuals.

Author Note

This research was supported by National Institutes of Health R01 grants HD051030 and DC011492. We thank Erika Bickel, Deanna Frank, Sarah Bae, Elizabeth Jimenez and David Weiss for assistance with data collection.

ReferencesX

- Barcroft, J., & Sommers, M. S. (2005). Effects of acoustic variability on second language vocabulary learning. *Studies in Second Language Acquisition*, 27(03), 387-414.
- Barr, D.J., Levy, R., Scheepers, C., & Tily, H.J.(2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, 68, 255-278.
- Bock, J. K. (1986). Syntactic persistence in language production. *Cognitive Psychology*, 18, 355-387.
- Bock, J. K. (1996). Language production: Methods and methodologies. *Psychonomic Bulletin & Review*, 3, 395-421.
- Branigan, H. P., Pickering, M. J., & Cleland, A. A. (2000). Syntactic co-ordination in dialogue. *Cognition*, 75(2), B13-B25.
- Brown, R. (1957). Linguistic determinism and the part of speech. *Journal of Abnormal and Social Psychology*, 55, 508-523.
- Chang, F., Dell, G. S., & Bock, K. (2006). Becoming syntactic. *Psychological Review*, 113(2), 234-272.
- Chang, F., Janciauskas, M., & Fitz, H. (2012). Language adaptation and learning: Getting explicit about implicit learning. *Language and Linguistics Compass*, 6(5), 259-278.
- Clark, H. H. (1996). *Using language*. Cambridge, England: Cambridge University Press.
- Clark, E. V., & Hecht, B. F. (1983). Comprehension, production, and language acquisition. *Annual Review of Psychology*, 34(1), 325-349.
- Creel, S. C., Aslin, R. N., & Tanenhaus, M. K. (2008). Heeding the voice of experience: The role of talker variation in lexical access. *Cognition*, 106, 633-664.

- Dell, G.S., & Chang, F. (2014). The P-chain: Relating sentence production and its disorders to comprehension and acquisition. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 369(1634).
- Dell, G. S., Reed, K. D., Adams, D. R., & Meyer, A. S. (2000). Speech errors, phonotactic constraints, and implicit learning: A study of the role of experience in language production. *Journal of Experimental Psychology: Learning Memory and Cognition*, 26(6), 1355-1367.
- Ferreira, F. (2003). The misinterpretation of noncanonical sentences. *Cognitive Psychology*, 47, 164-203.
- Ferreira, F., & Bailey, K.G. (2004). Disfluencies and human language comprehension. *Trends in Cognitive Sciences*, 8, 231-237.
- Fisher, C. (1996). Structural limits on verb mapping: The role of analogy in children's interpretation of sentences. *Cognitive Psychology*, 31, 41-81.
- Fisher, C., Hall, D. G., Rakowitz, S., & Gleitman, L. R. (1994). When it is better to receive than to give: Syntactic and conceptual constraints on vocabulary growth. *Lingua*, 92, 333-375.
- Garrod, S., & Anderson, A. (1987). Saying what you mean in dialogue: A study in conceptual and semantic co-ordination. *Cognition*, 27(2), 181-218.
- Gaskell, M. G., & Dumay, N. (2003). Lexical competition and the acquisition of novel words. *Cognition*, 89, 105-132.
- Gibson, E., Bergen, L., Piantadosi, S.T. (2013). Rational integration of noisy evidence and prior semantic expectations in sentence interpretation. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, 110, 8051-8056.

- Hofmeister, P., Jaeger, T. F., Arnon, I., Sag, I. A., & Snider, N. (2013). The source ambiguity problem: Distinguishing the effects of grammar and processing on acceptability judgments. *Language and Cognitive Processes, 28*(1-2), 48-87.
- Ivanova, I., Branigan, H. P., McLean, J. F., Costa, A., & Pickering, M. J. (in revision). Do you what I say? People reconstruct the syntax of anomalous utterances. *Language, Cognition and Neuroscience*.
- Ivanova, I., Pickering, M. J., Branigan, H. P., McLean, J. F., & Costa, A. (2012). The comprehension of anomalous sentences: Evidence from structural priming. *Cognition, 122*, 193-209.
- Ivanova, I., Pickering, M. J., McLean, J. F., Costa, A., & Branigan, H. P. (2012). How do people produce ungrammatical utterances? *Journal of Memory and Language, 67*, 355-370.
- Jaeger, T. F. (2008). Categorical data analysis: Away from ANOVAs (transformation or not) and towards logit mixed models. *Journal of Memory and Language, 59*, 434-446.
- Kang, S. H., Gollan, T. H., & Pashler, H. (2013). Don't just repeat after me: Retrieval practice is better than imitation for foreign vocabulary learning. *Psychonomic Bulletin & Review, 20*(6), 1259-1265.
- Kaschak, M. P., & Glenberg, A. M. (2004). This construction needs learned. *Journal of Experimental Psychology: General, 133*(3), 450-467.
- Kaschak, M., Kutta, T., & Schatschneider, C. (2011). Long-term cumulative structural priming persists for (at least) one week. *Memory & Cognition, 39*, 381-388.
- Kraljic, T., & Samuel, A. G. (2005). Perceptual learning for speech: Is there a return to normal? *Cognitive Psychology, 51*, 141-178.

- Kraljic, T., Samuel, A. G., & Brennan, S. E. (2008). First impressions and last resorts. *Psychological Science, 19*, 332-338.
- Leach, L., & Samuel, A. G. (2007). Lexical configuration and lexical engagement: When adults learn new words. *Cognitive Psychology, 55*, 306-353.
- Loebell, H., & Bock, K. (2003). Structural priming across languages. *Linguistics, 41*(5; ISSU 387), 791-824.
- Luka, B. J., & Barsalou, L. W. (2005). Structural facilitation: Mere exposure effects for grammatical acceptability as evidence for syntactic priming in comprehension. *Journal of Memory and Language, 52*(3), 436-459.
- MacDonald, M. C. (2013). How language production shapes language form and comprehension. *Frontiers in Psychology, 4*(226).
- Naigles, L. (1990). Children use syntax to learn verb meanings. *Journal of Child Language, 17*, 357-374.
- Norris, D., McQueen, J. M., & Cutler, A. (2003). Perceptual learning in speech. *Cognitive Psychology, 47*, 204-238.
- Oppenheim, G. M. (2015). Competition in the expanding lexicon: Production reveals immediate semantic integration of newly acquired words. Poster presented at the 21th Annual Conference on Architectures and Mechanisms for Language Processing (AMLaP), Valletta, Malta.
- 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., & Ferreira, V. S. (2008). Structural priming: A critical review. *Psychological Bulletin, 134*, 427-459.

Pickering, M. J., & Garrod, S. (2007). Do people use language production to make predictions during comprehension? *Trends in Cognitive Sciences*, 11(3), 105-110.

Sommers, M. S., & Barcroft, J. (2013). Effects of referent token variability on L2 vocabulary learning. *Language Learning*, 63(2), 186-210.

Slevc, L. R., & Ferreira, V. S. (2013). To err is human; To structurally prime from errors is also human. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 39(3), 985-992.

Slevc, L.R., & Momma, S. (2015). Noisy evidence and plausibility influence structural priming. Poster presented at the 21st Annual Conference on Architectures and Mechanisms for Language Processing (AMLaP), Valletta, Malta.

Warker, J. A., & Dell, G. S. (2006). Speech errors reflect newly learned phonotactic constraints. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 32, 387-398.