Syntactic Entrainment: The Repetition of Syntactic Structures in Event Descriptions

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Abstract

Syntactic structures convey not only event relationships (e.g., who did what to whom), but also certain emergent properties of events. For example, the double-object dative (“The nurse gave the doctor the stethoscope”) can convey successful transfer of possession, rather than just transfer to a location (as is conveyed by a prepositional dative like “The nurse gave the stethoscope to the doctor”). Six experiments provide evidence for a cognitive mechanism that is well positioned to underlie how linguistic communities acquire and potentially continue to tune the associations that allow structures to convey such emergent properties. Speakers first heard twelve picture descriptions, each using one of two suitable syntactic structures. Speakers then described the same twelve pictures themselves. Results showed that speakers were more likely to describe pictures using the same structures they heard them described with when speaking to the same interlocutor, when speaking to a different interlocutor, and when describing the same depiction of a different event. Two further experiments show that the effect is sensitive to the event-semantic properties of picturesdescribed within blocks of descriptions. This is the first report we know of such an effect, which we term *syntactic entrainment*.

Keywords: Linguistic communication, language production, sentence production, syntactic production.

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Language conveys information about the real world through conventions governing how meanings map onto sounds. For example, the fact that the sounds of the word “donkey” describe the animal that it does is arbitrary; the phonology of the lexical item “donkey” expresses that meaning because English speakers learn the conventions that map sounds onto meanings. Though the conventionality of language is notably apparent through the relationships between words’ sounds and meanings, conventionality is also relevant at other linguistic levels. In particular, the rules that guide how we combine words into sentences – namely, syntax – also exhibit their own conventions, permitting us to express and interpret the aspects of meaning that syntax conveys. In the current study, we report a newly discovered effect that can be seen as revealing the operation of a mechanism that could underlie the learning or tuning of one particular type of syntactic convention.

**Syntactic Conventions**

The syntactic structure of a sentence can convey at least two types of information. First and most prominently, syntactic structure conveys relational information about roles in events – who did what to whom. Such relational information is expressed by conventions that map event roles onto grammatical functions. For example, in English active sentences, the agent of an event (the thing doing the action) is mapped onto the grammatical subject, whereas the theme (the thing the action is done to) is mapped onto the grammatical object. Thus, in the sentence “the donkey chased the man,” the donkey is the pursuer, but in “the man chased the donkey,” the man is the pursuer.  When learning any language, speakers must acquire the conventions that map event roles onto grammatical functions, so that they can convey who did what to whom in the events they describe, and understand the same in the events they hear described.

However, another type of information that may be conveyed by syntactic structure relates not to event roles, but to event content. That is, at least according to some linguistic approaches (Goldberg, 1995; Pinker, 1989), in addition to conveying the elements of events (via words) and event roles (via grammatical functions), sentences may also convey what we term here *emergent properties* of events. For example, “The man sent the woman the check” (a double object dative) and “The man sent the check to the woman” (a prepositional dative) convey the same relational information – in both sentences, “the man” is the grammatical subject and corresponds to the role of sender, “the woman” is the indirect object and corresponds to the potential receiver, and “the check” is the direct object and corresponds to the thing being sent (and potentially received). However, according to some theories (e.g., Goldberg, 1995), these sentences convey subtly different emergent properties. In particular, the double object dative implies that possession of the direct object was successfully transferred, whereas the prepositional dative does not imply that possession was transferred – only that the location was changed.  Thus, in “The man sent the woman the check,” it is implied that the woman has taken possession of the check; in “The man sent the check to the woman,” there is no implication that the woman took possession. Though subtle, the difference can be illustrated by changing the recipient so that it is unable to take possession: “\*The man sent the address the check” is generally rated as (at best) only marginally acceptable, because “the address” cannot actually take possession of a check, whereas “The man sent the check to the address” is generally rated as acceptable, because the prepositional dative does not imply successful transfer of possession (Pinker, 1989).

If indeed the syntactic alternatives that convey the same relational information are used to convey different emergent properties, the conventions that govern how these emergent properties are mapped onto corresponding syntactic forms must be learned. We address this question in the current study by presenting a novel paradigm to test whether adult language users associate specific event content with particular syntactic structures. In analogy to a related literature (see, Chang, Dell, & Bock, 2006), we suggest that such an effect could reflect the mechanism by which language users learn how the emergent properties of events map onto particular syntactic structures.

**Syntactic priming and the tuning of conventions that express event roles**

A large number of studies have investigated language users’ tendency to repeat the syntactic structures that they have recently experienced. This behavior has been described as *syntactic priming* and it is widespread in language production and comprehension. Syntactic priming has been shown to occur in the spoken (e.g., Bock, 1986), written (e.g., Pickering & Branigan,1998), and signed modalities (e.g., Hall, Ferreira, & Mayberry, 2015); it has been shown to occur in both comprehension (e.g., Thothathiri & Snedeker, 2008) and production (e.g., Bock, 1986), and between the two (Bock, Dell, Chang, & Onishi, 2007; Branigan, Pickering, & Cleland, 2000; Ferreira, Kleinman, Kraljic, & Siu, 2012; Potter & Lombardi, 1998). People even repeat syntactic structures between different languages (Hartsuiker, Pickering, & Veltkamp, 2004). Syntactic priming has been shown to persist after numerous intervening trials (Bock & Griffin, 2000), and for periods of up to a week (Kaschak, Kutta, & Schatschneider, 2010). Crucially, syntactic priming may be observed for any subsequent utterance that permits the repeated structure, regardless of differences in the phonological (Bock & Loebell, 1989), lexical (Bock, 1986, 1989) or semantic (Bock, 1986; Bock & Loebell, 1989) content between the new sentence and the sentence whose syntax is repeated.  Furthermore, syntactic priming does not appear to depend on explicit memory, and indeed, it has been demonstrated in patients who have anterograde amnesia – although these patients have significantly compromised memory for the content of sentences, they nonetheless show robust syntactic priming (Ferreira, Bock, Wilson, and Cohen, 2008).

Although mechanistic (e.g., Pickering & Branigan, 1998) and functional (e.g., Pickering & Garrod, 2004) explanations for syntactic priming have been proposed, in one prominent account that is especially relevant to the current research, Chang, Dell, and Bock (2006) present a connectionist model that explains syntactic priming as an artifact of the language-learning process. Specifically, the model initially learns the grammar of the language it is presented with by trying to predict upcoming words in sentences. When making these predictions, the model has access to a representation of the event meaning and the event roles played by particular constituents in the sentence. When its predictions are incorrect, the model updates its parameters to increase the accuracy of its predictions in the future. Thus, functionally, the system learns how to order event roles into grammatically interpretable sequences that are similar to the grammatical sequences that it encounters in its input language. (Note that the sequencing system only has access to the roles played by particular constituents of the sentence. As a consequence, the actual content of those event roles is not relevant to the prediction or learning of grammatical knowledge in the model.)

One crucial aspect of this model is that its syntactic learning mechanism continues to operate even after it has acquired a mature language system. In both the initial acquisition process and in the mature system, the learning mechanism continuously recalibrates the model’s language (predicted and produced) to be more like its input. Functionally, this leads the model to repeat recently encountered syntactic structures, which allows it to account for the range of syntactic priming effects that have been observed in the literature.

Interestingly, the continued learning (or perhaps more precisely, the tuning) of the mappings between event roles and grammatical sequences in the model can explain not only the range of syntactic priming effects in the literature, but can serve a functional role as well. According to a number of theories, learning to use the same distribution of linguistic forms as one’s linguistic community (and one’s conversational partner in particular) leads to enhanced communicative efficiency (Fine & Jaeger, 2013; Jaeger & Snider, 2013; Pickering & Garrod, 2004). For example, when a language user relocates to a new linguistic community, she or he may be relatively less efficient at understanding (and being understood by) speakers of the local dialect because his or her speech would exhibit different distributions of grammatical forms. However, over time, if the new speaker recalibrates his or her linguistic knowledge to align with the community, she or he will expect (and produce) the same distribution of grammatical forms as his or her new interlocutors, thus becoming more efficient.

In sum, syntactic priming studies have shown that language users tend to repeat the mapping of particular sets of event roles onto particular syntactic structures. This has been argued to reflect an underlying learning process that continually recalibrates language users’ knowledge of the conventions that map sets of event roles onto grammatical functions. In the present study, we aim to discover whether there is an analogous effect for a different form of syntactic knowledge, specifically, the recalibration of the associations that map the content of events onto particular syntactic structures.

**Syntactic entrainment and the tuning of conventions that express emergent properties**

As noted, apart from expressing event roles, it has been argued that syntactic structures can also express aspects of event content (termed here emergent properties) that convey more holistic aspects of events. For instance, although both the double-object dative and prepositional dative syntactic structures express the same event roles (an agent, a theme, and a goal), they have also been argued to express subtly different meanings. Specifically, the double-object structure conveys the meaning that the transfer event resulted in a change of possession, whereas the prepositional dative expresses only that the event resulted in the transfer to a location or recipient (Goldberg, 1995). As the expression of such emergent properties of events through the use of particular syntactic structures is a conventionalized aspect of language, the mappings that underlie them must be learned on a community-wide basis. As with syntactic priming, the process by which language users learn (and potentially recalibrate) their knowledge of these emergent event properties could serve a functional role in linguistic communication. Specifically, the extent to which the members of a linguistic community are able to maintain similar conventions that govern the mapping of event content (i.e., emergent properties) onto syntactic structures could serve to enhance communicative efficiency within the linguistic community and (specifically) between conversational partners. Above, we described accounts that view syntactic priming as a recalibration of the mappings of event roles onto syntactic structures. Accordingly, we might expect a similar recalibration of the mappings of emergent event properties onto syntactic structures.

Consider again syntactic priming. Language users know that certain sets of event roles can be expressed by certain grammatical structures. In (relatively) fixed word-order languages like English, grammatical functions – and the event roles they express – are conveyed through the sequences of words in sentences. According to Chang, Dell, and Bock (2006), syntactic priming reflects the operation of a mechanism that learns the mappings between event roles and grammatical sequences: If a language user hears or produces a set of event roles (irrespective of their content) through a particular grammatical sequence, then subsequently, when the language user wants to express those same event roles again, she or he is more likely to use that same grammatical sequence.

Crucially, syntactic priming effects are independent of the specific semantic content of sentences. That is, syntactic priming reflects a change in the likelihood that some set of *abstract* event roles (i.e., irrespective of their content) will be mapped onto particular syntactic structures. Thus, in order to explain how syntactic structures come to conventionally express particular aspects of event content, or emergent properties of events, a repetition that is different from syntactic priming needs to be involved. Specifically, rather than a general repetition of syntactic structure contingent on a particular set of event roles, speakers could repeat syntactic structures when describing particular (emergent) event content.

The experiments reported below provide evidence to begin to address this hypothesis. In these experiments, subjects were told they were going to play a language game. In this game, each round proceeded through a prime block followed by a target block. In the prime block, experimental subjects heard experimenters describe twelve events (depicted as partially colored line drawings). Each of the twelve events could be described with two opposing syntactic structures; for example, a double object dative and a prepositional dative. Within each block of prime trials, subjects heard an equal number of opposing structures (e.g., subjects heard two double object dative and two prepositional dative structures in each prime block). Next, in the target block, subjects described those same twelve events back to an experimenter. For example, in the prime block, a subject might hear a double-object dative like “the man is giving the doctor a prescription,” used to describe a particular event depiction. Then during the target block, the subject was given the same event depiction to describe back to the experimenter. If listeners map event content onto a particular syntactic structure after hearing that event described with a double object dative structure once, then they should be more likely to reuse a double-object dative structure (as compared to a prepositional dative) to describe the same picture later on. With this design, an average of 12 (comprehended or produced) descriptions intervened between when a picture was heard described and when the subject described it back, and up to five of those descriptions could be opposite to the structure of the heard description.

We give this hypothetical effect the descriptive label *syntactic entrainment*, as a specific form of entrainment in general. Generally, linguistic entrainment refers to conversational partners’ tendency to re-use aspects of each other’s referring expressions. For example, if one participant in a conversation refers to an abstract (Tangram) shape as “a skater,” another participant is more likely to refer to that same item as “a skater” as well (Clark & Wilkes-Gibbs, 1986). This re-use of referring expressions (e.g., “skater”) to refer to particular referents in a dialogue has been termed *lexical entrainment*.  Analogously, if speakers re-use the syntactic structures their interlocutors used to refer to particular events, this would constitute syntactic entrainment.

Importantly, the task design implemented in the experiments reported below ensures that the repetition of syntax in syntactic entrainment, if observed, cannot be explained as a consequence of syntactic priming. As mentioned earlier, within each round, subjects heard twelve events described with a balanced number of opposing syntactic structures (in the prime block), before describing those same pictures back again (in the target block). For example, in the prime block, subjects always heard two scenes described with double-object datives and two scenes described with prepositional datives, before describing those same pictures in the target block. Thus, any syntactic priming effect should be offset, since subjects heard an equal number of both (for example) prepositional datives and double-object datives. If a tendency to re-use a particular structure to describe a particular scene is nonetheless observed, it must be independent of the influence of any overall syntactic priming effect.

In the first three experiments, we explore the possibility that a mapping between the overall content of an event – the representation of an entire scene – and a particular structure can be strengthened. In the final three experiments we test whether such mappings involve the specific event depictions subjects were asked to describe, or the more abstract aspects of event meaning that have been argued to be relevant to how structure-meaning mappings are learned (Pinker, 1989). Although due to experimental limitations, we do not test the specific sets of emergent properties that have been claimed to be expressed by English structures, we argue that the abstract event meaning content we do test is a reasonable first step in the formation of the observed associations between emergent event properties and particular syntactic structures.

**The Present Study**

All experiments reported here used the same basic experimental paradigm, described above. Experiment 1 aimed to establish the basic syntactic entrainment effect. After hearing a block of pictures described by an experimenter (prime block), subjects described the same pictures back (target block). We measured which structure subjects used in their target descriptions of each picture. If subjects tend to use the structure they heard to describe each scene more than the alternative structure (e.g., if subjects use more double object datives to describe scenes they heard described with double objects, compared to scenes they heard described with prepositional datives), it would constitute evidence for syntactic entrainment.

Experiments 2 and 3 then assessed whether syntactic entrainment is partner-independent or partner-specific. The procedures for Experiments 2 and 3 were largely similar to Experiment 1, except that in these experiments, on half of target trials, the subject described pictures to the same experimenter that described the pictures in the prime block, whereas on the other half of trials, the subject described pictures to a different experimenter. If subjects are more likely to describe events using the same syntactic structure when speaking to the same experimenter than a different experimenter, then it will demonstrate partner specificity in syntactic entrainment. On the other hand, the hypothesis that syntactic entrainment reflects the learning of community-wide conventions is more plausible if such learning is *not* partner-specific, such that when a content-structure association is strengthened with one partner, that strengthened association is observed also with another partner. (Note that this does not mean that if a form of learning *is* partner-specific, that it cannot form the basis of an eventual community-wide convention, only that if learning is *not* partner-specific, it is better positioned to explain the conventionalization of learning.)

Finally Experiments 4 through 6 assessed how “deep” the source features are that drive the syntactic entrainment effect. Experiment 4 used a similar procedure, but measured whether hearing one depiction of an event described with a particular syntactic structure entrains the descriptions of a different depiction of that same event. If subjects are equally likely to describe a different depiction with the same syntactic structure as they are for an identical depiction, it suggests that they are learning mappings to something more abstract than the visual features of scenes. In Experiment 5 and 6, subjects heard descriptions of events in blocks that were either composed of events with similar abstract event features (as defined by Pinker, 1989, and discussed at length below), or events with dissimilar event features. If the abstract event features that describe event similarity participate in the entrainment effect, then when a block is composed of events with similar features, entrainment effects should result in interference, compared to when a block is composed of events with different features (an effect that is analogous to cumulative semantic interference that is observed at the lexical level; Damian, Vigliocco, & Levelt, 2001).

**Experiment 1**

**Method**

**Subjects.**Twenty-seven undergraduates from the UC San Diego community participated in the study in exchange for course credit. All subjects reported being native English speakers.

**Materials and design.** Fifty-one line drawn pictures of action scenes were used in the study. These pictures were partially colored to highlight task-relevant aspects of the scenes, and were printed and laminated individually as 4 1/2” x 3 2/3” cards. Four experimental decks of these cards were printed. The actions depicted on the cards were equally divided into three verb/event classes: transitive events, dative events, and locative events. Three of the pictures (one of each verb class) were used in the practice round, while the remaining forty-eight pictures appeared in 4 blocks of 12 pictures each. Each block contained equal numbers of transitive, dative, and locative events.

Two experimental lists were constructed to serve as scripts for the confederate to read in her role as the director. Each list contained 48 prime sentences, with 16 from each event type (transitive, dative, locative).  The event depicted on each card could be described using two alternative syntactic structures, which we classify as the *preferred* (active transitive, double object dative, and on-variant locative) and the *dispreferred* structures (passive transitive, prepositional object dative, and with-variant locative) on the basis of general observed preferences for each structure in previous studies that used the similar materials, as well as in English as a whole. For each event type, the confederate described half of the pictures using the preferred and half using the dispreferred structure, both within each round and across the experiment (e.g., half of transitive events were described with passive sentences and half with active sentences). The lists were counterbalanced such that each picture was described equally with each alternation across subjects.

Participants were seated across from the confederate at a large table separated by a 24-inch high divider that allowed them to see each other’s faces but not their respective workspaces. Printed arrays of 12 rectangles of the same dimensions as the cards were placed in front of the participant and confederate to serve as placeholders for the cards. The sessions were audio recorded using a digital recorder.

**Procedure.**The cover task was that participants were playing a collaborative picture-matching game. Participants alternated between two roles in the game, the *director* and the *matcher*. The job of the director was to describe his or her set of 12 cards in the order they were placed on the table, and the job of the matcher was to rearrange his or her cards into the order they were described by the director (adapted from Clark & Wilkes-Gibbs, 1986). Each round consisted of two phases, such that the subject and the confederate served as both the director and the matcher for each set of cards. At the beginning of the experiment, the experimenter ostensibly randomly selected the confederate to be the first director. During the first block of each round, the confederate described 12 cards by reading the scripted sentences (maintaining the cover that they were spontaneous picture descriptions), which served as the prime stimuli. Next, the subject described the same set of 12 pictures back to the confederate in a different order. This concluded one round of the experiment. The experiment consisted of four rounds, each with a different set of 12 cards.

**Scoring and analysis.**Audio recordings of the sessions were transcribed by trained research assistants. Each sentence was then coded for its syntactic structure. Only targets that conformed to the intended syntactic alternation were included in the final analysis. Transitive targets were coded as either active or passive; dative targets were coded as either double object or prepositional object dative; and locative targets were coded as either with-variant or on-variant. Target sentences that did not fall into these categories were marked as unscorable. Sentences were scored only if the main verb could have been used in either form of the syntactic alternation.

Three subjects were excluded from the analysis due to recording errors, and two additional subjects were excluded because they produced scorable responses on fewer than 30% of trials. We used R (R Core Team, 2014) and *lme4* (Bates, Maechler, Bolker, & Walker, 2014) to perform a mixed effects logistic regression of the effect of the confederate’s prime syntactic structure on the subject’s target syntactic structure. Prime type (preferred or dispreferred structure), verb class (transitive, dative, and locative), and their interaction (prime type x verb class) were entered into the model as fixed effects. We included the maximal random effects structure in our model (Barr, Levy, Scheepers, & Tily, 2013). As random effects, we had intercepts for subjects and items, as well as by-subjects and by-items random slopes for the effect of prime type, the effect of verb class, and the interaction between prime type and verb class. Our models were run using the *bobyqa optimizer* to aid convergence. All reported *p*-values were obtained using likelihood ratio tests. Interaction effects were tested by comparing the full model against the model with the interaction term removed. Fixed main effects were tested by comparing the full model against the model with the relevant fixed main effect removed.

**Results and discussion**

Subjects produced scorable responses on 68.1% of trials overall (784 out of 1152 trials), including on 79.2% of transitive trials (304 out of 384), 71.9% of dative trials (276 out of 384), and 53.1% of locative trials (204 out of 384). The low percentage of scorable responses for locative trials was primarily due to the fact that subjects often used verbs that conveyed a similar meaning as the intended verbs but did not allow both syntactic alternatives.

The results of Experiment 1 are shown in Figure 1. Subjects overall were 12.6% more likely to produce the preferred syntactic structure (corresponding to the active transitive, double object dative, and on-variant locative, as discussed above) when primed with the preferred structure (66.5%) than when primed with the dispreferred (53.9%), and including prime type in the model significantly improved the model fit (*χ*2(1) = 19.90, *p* < .0001). The main effect of verb class on subjects’ responses was not significant (χ2(1) = 4.08, *p* = .13). Note that this effect is theoretically uninteresting, as it would only indicate that the different verb classes express their separate preferences to different degrees.

There were also numerical differences in the prime effect for the different verb classes, although these differences (i.e., the interaction between prime structure and verb type) did not reach statistical significance. For transitive targets, subjects were 10.1% more likely to produce an active structure when primed with an active structure (66.6%) than when primed with a passive (56.5%). For dative targets, subjects were 10.2% more likely to produce a prepositional dative structure when primed with a prepositional dative (57.0%) than when primed with a double object (46.8%). For locative targets, subjects were 17.3% more likely to produce an on-variant structure when primed with an on-variant (79.6%) than when primed with a with-variant structure (62.3%). However, model comparison revealed that these differences in prime effect for different verb classes were not significantly different from one another (χ2(1) = 2.35, *p* = .31). Verb class was excluded from further analyses as it is not relevant to our experimental questions.



Figure 1. Proportion of preferred structure responses by whether subjects heard events described with preferred or dispreferred structures and verb class. In this and subsequent graphs, the error bars represent standard errors.

These results indicate that conversational partners demonstrate syntactic entrainment: When a speaker hears an event described using a particular syntactic structure, she or he is more likely to use that structure subsequently when describing the same event. Above, we suggested that such an effect could lead to the establishment of conventions within the linguistic community regarding how particular event content is mapped to particular syntactic structures. Such a possibility is rendered more likely if syntactic entrainment is partner-independent, in that any tendency to describe an event with a structure that was heard used to describe that event with one partner is exhibited also when addressing a new partner. The next two experiments aim to determine whether syntactic entrainment shows partner-specificity.

**Experiment 2**

In Experiment 2, we tested the partner-independence (or specificity) of the syntactic entrainment effect found in Experiment 1. The paradigm mirrored that used in Experiment 1, except that on half of the trials, subjects described cards back to the same experimenter who they heard describe those same cards, whereas on the other half of trials, subjects described cards to a different experimenter from the one who had described the cards initially. Partner-specificity is evident to the extent that the entrainment effect is larger when subjects describe pictures back to the same experimenter than to the different experimenter; partner-independence is evident if entrainment effects are about equal in the two cases. If we find entrainment to be partner-specific, then it would not be suitable for establishing conventions for the linguistic community. Finding partner-independence would be compatible with the possibility that syntactic entrainment reflects the process by which linguistic communities converge on conventional mappings of particular event content onto particular syntactic structures.

**Method**

**Subjects.** Ninety-six undergraduates from the UCSD community participated in the study in exchange for course credit. Because of the partner-identity manipulation, subjects in Experiment 2 had half as many trials in each condition as compared with Experiment 1. For this reason, and also to increase power to find any interaction between entrainment and partner identity, we quadrupled the number of participants for this experiment. All subjects reported being native English speakers.

**Materials and design.**The same basic materials and design of Experiment 1 were used in Experiment 2. However, in Experiment 2 subjects interacted with two different experimenters. The same 51 line-drawn action scenes used in Experiment 1 were reused in Experiment 2, with three of those cards being used in an abbreviated practice round. Four experimental lists were constructed to serve as scripts for the experimenters.

**Procedure.** Each subject was tested by two experimenters.  (Note that unlike Experiment 1, subjects’ task partners were presented as experimenters, and not as confederates.)  The experiment consisted of four rounds. In two of the rounds, subjects directed utterances (target descriptions) to the same experimenter who described the pictures to them in the prime phase, and in the other two rounds they directed utterances to the other experimenter. Each *experimenter condition* occurred equally in each round across subjects (e.g., half of subjects spoke to the same experimenter in the first round and half spoke to a different experimenter) in order to control for order effects. Experimenters switched rooms throughout the experiment to maintain the correct partner condition for each subject. Verb class (transitive, dative, and locative) and prime structure (preferred and dispreferred) were counterbalanced both within each round and within the two experimenter conditions.

After each prime and target round, subjects were given one minute to solve four two-digit multiplication problems, which served to make the changing of experimenters less conspicuous. After giving the subjects the materials for the multiplication task, the experimenters left their respective rooms, waited one minute for the subjects to complete the multiplication task, and then returned to either the same room or the other room according to the partner switching schedule.

**Scoring and analysis.** The same coding procedure was used in Experiment 2 as in Experiment 1. As in Experiment 1, the data were submitted to a mixed effects logistic regression. However, because the verb class factor did not have a significant effect on syntactic entrainment in Experiment 1 (and because it carries no theoretical interest), it was excluded from the model. Prime structure (preferred vs. dispreferred structure), and experimenter condition (whether the same experimenter vs. different experimenter administered the prime and target trials), and their interaction were entered as fixed effects into the model. We included the maximal random effects structure in our model. As random effects, we had intercepts for subjects and items, as well as by-subjects and by-items random slopes for the effect of prime type, the effect of experimenter condition, and the interaction between prime type and experimenter condition. All other details of the analyses were identical to Experiment 1.

**Results and discussion**

Three subjects were excluded due to experimenter error, and a fourth subject was excluded from analysis for producing scorable responses on fewer than half of trials (a criterion that was established a priori for all experiments). Subjects produced scorable responses on 77.1% of trials (3405 out of 4416 trials), including on 84.8% of transitive trials (1248 out of 1472), 86.8% of dative target trials (1277 out of 1472), and 59.8% of locative target trials (880 out of 1472).

The results are shown in Figure 2. Replicating Experiment 1, there was a significant overall syntactic entrainment effect across experimenter conditions. Subjects were 10.6% more likely to produce the preferred structure when primed with the preferred structure (69.0%) than when primed with the alternative (58.4%); including prime structure significantly improved our model fit (*χ*2(1) = 26.20, *p* < .0001).  The (theoretically uninteresting) main effect of experimenter condition was not significant (*χ*2(1) = 1.67, *p* =.20).

Most critically, there was no prime type x experimenter condition interaction: When speaking to the same experimenter, subjects were 10.1% more likely to produce the preferred structure when primed with the preferred structure (68.0%) than when primed with the dispreferred structure (57.9%); when speaking to a different experimenter, subjects were 11.5% more likely to produce the preferred structure when primed with the preferred structure (70.3%) than when primed with the dispreferred structure (58.8%). The numerically larger priming effect for the different experimenter (i.e., in the direction opposite to that corresponding to partner-specificity) was not statistically significant, and removing the interaction term did not significantly alter the model fit (*χ*2(1) = .1661, *p* = .68).



Figure 2. The proportion of preferred structure responses by whether subjects heard preferred or dispreferred descriptions and whether subjects described target events to the same versus different experimenter who had originally described those events to them.

Thus, the results of Experiment 2 demonstrate that the association found in Experiment 1 between event meaning and syntactic structure was not contingent on whether they described pictures to a partner who did or did not describe those same pictures to them. This suggests that syntactic entrainment effects can “transmit” across members of a linguistic community, and so it remains positioned to reflect the process by which emergent properties of events become associated with particular syntactic structures.

However, it is worth noting that in previous studies assessing partner-specificity in lexical entrainment, conversational partners engaged in more extensive interaction than they did in our Experiment 2. Subjects in Metzing and Brennan’s (2003) study heard an object described four times by a confederate before demonstrating partner-specificity for lexical entrainment in comprehension. In Brennan and Clark (1996), two naive participants showed partner specificity in production after four trials with a particular object. In Experiment 2 of our study, the confederate described each event only once before partner specificity was assessed. It is possible that to elicit a partner-specific pattern of syntactic entrainment, conversational partners require more extensive interaction. In Experiment 3, we test the hypothesis that partner-specific syntactic entrainment can be demonstrated if given greater experience with a partner’s syntactic preferences for a given picture.

**Experiment 3**

In Experiment 3, as in Experiment 2, we sought to determine whether syntactic entrainment would demonstrate signs of partner-specificity. Although the results of Experiment 2 indicated no partner-specificity (and numerically the effect was slightly in the opposite direction), in that experiment, subjects experienced notably less exposure to their partner’s preference compared with previous demonstrations of partner-specificity in lexical entrainment. If subjects are indeed sensitive to their interlocutors’ syntactic preferences for particular picture depictions, then they might require more exposure to infer that their syntactic choices reflected a stable preference. Thus, in Experiment 3 we increased exposure to each picture description from one to four.

**Method**

**Subjects.** Ninety-six undergraduates from the UC San Diego community participated in the study in exchange for course credit. All subjects reported being native English speakers.

**Materials and design.** Experiment 3 employed a similar procedure as Experiment 2. However, in Experiment 3, subjects heard 4 prime sentences for each picture. Due to considerations of time, subject fatigue, and to maintain a similar number of trials across experiments that subjects experienced overall, we reduced the number of pictures from 48 to 24, and the number of target rounds from four to two.

**Procedure.** As in Experiment 2, subjects were tested simultaneously by two experimenters. However, in Experiment 3, rather than hearing a single description for each picture (prime round) before describing those pictures themselves (target round), subjects heard each picture described four times in an extended *prime phase* before describing it themselves. First, in the prime phase, one experimenter described a set of six pictures. Next, the other experimenter came into the room and described a different set of six pictures. Then the first experimenter came back and described the same six pictures s/he had originally described, and then the second experimenter came back and described the same six pictures s/he had originally described. This occurred twice more, so that ultimately each experimenter had described a set of six unique pictures four times each to the subject. Then, in the target phase, the subject described these same 12 pictures to one of the two experimenters. That entire process was repeated, with a different set of 12 cards. Thus, each experimenter described a total of 12 cards (four times each), and the subject described a total of 24 cards (12 to each experimenter).

The experimenters always used the same syntactic structure when describing each particular picture throughout the prime phase. In the target phase, subjects described the same 12 pictures from the prime phase (six that had been described by one experimenter and six by the other) to one or the other of the experimenters. Thus, of the 12 events the subject described in each target phase, six had been previously described by the experimenter currently administering the target phase (i.e., the same experimenter condition), and six had been previously described by the other experimenter (i.e., the different experimenter condition).

As in Experiment 2, subjects were given two-digit multiplication problems as a cover task between every prime and target phase.

**Scoring and analysis.** The same scoring procedure was used as in Experiment 2.   Analyses for Experiment 3 used the same statistical analysis approach as in Experiment 2.

**Results and Discussion.**

Two subjects were excluded from analysis because they produced scorable responses on fewer than half of trials. Subjects produced scorable responses on 85.0% of trials (1918 out of 2256 trials), including on 96.1% of transitive target trials (723 out of 752), on 88.7% of dative target trials (667 out of 752), and on 70.2% of locative target trials (528 out of 752).

The results are shown in Figure 3. Replicating the main result from Experiments 1 and 2, there was a significant overall syntactic entrainment effect across experimenter conditions. Subjects were 23.0% more likely to produce the preferred structure when primed with the preferred structure (73.0%) than when primed with the alternative (50.0%); including prime type significantly improved our model fit (*χ*2(1) = 31.5, *p* < .0001). The numerically larger effect of prime in Experiment 3 compared to Experiments 1 and 2 is likely due to the fact that in Experiment 3, subjects heard each prime sentence four times, rather than once as in Experiments 1 and 2. The (theoretically uninteresting) main effect of experimenter condition was not significant (*χ*2(1) = 0.17, *p* =.68).

Most importantly, when speaking to the same experimenter, subjects were 25.8% more likely to produce the preferred structure when primed with the preferred structure (73.7%) than when primed with the alternative (47.9%). But, when speaking to a different experimenter, they were 20.4% more likely to produce the preferred structure when primed with the preferred structure (72.7%) than when primed with the alternative (52.3%). This led to a marginally significant interaction between experimenter condition and prime type (*χ*2(1) = 2.91, *p* = .0883).



Figure 3. Proportion of preferred structure responses by whether subjects heard preferred or dispreferred descriptions and whether subjects described target events to the same versus different experimenter who had originally described those events to them.

These results indicate that subjects may demonstrate a small (marginally significant) person-specific effect in addition to a larger basic syntactic entrainment effect that is present regardless of conversational partner. However, some caution is warranted in interpreting the marginally significant results of Experiment 3 as evidence for partner specificity in syntactic entrainment. Numerically, the partner-specific effect was much smaller (5.4% greater priming when speaking to the same experimenter) than the partner-independent effect of syntactic entrainment (20.4% priming effect when speaking to the different experimenter). Furthermore, the increase in exposure not only revealed a partner-specific effect of syntactic entrainment, but also substantially increased the partner-independent effect of syntactic entrainment. This suggests that while partner-specificity may be induced in syntactic entrainment given enough exposure, syntactic entrainment has a much greater partner-independent component than partner-specific component.

Thus far, given the nature of the materials used in Experiments 1-3, it may be that speakers exhibited entrainment by forming associations between aspects of the specific *depictions* of the events – that is, representations of the line drawings themselves – and the structures they heard those drawings described with. Experiment 4 assesses this possibility. To do so, we created two depictions of each event that varied on a number of dimensions (the perspective, the relative size of actors and objects, along with coloring and other stylistic differences), such that both could be described with the same sentence. If syntactic entrainment reflects the formation of an association between a representation of the line drawing and the syntactic structure used to describe that line drawing, then when subjects describe back a different drawing of the same event, they should be less likely to use the (hypothetically) entrained syntactic structure, compared to when they describe back the same drawing of the same event.

**Experiment 4**

In this experiment, we tested whether subjects would use the same syntactic structures as used by an experimenter not only to describe the same event depiction, as shown in Experiments 1-3, but also when describing a different depiction of that same event. If so, it would suggest that the syntactic entrainment effect reflects associations between syntactic structures and something more abstract than the specific depiction of the event.

**Method**

**Subjects.** Forty-eight undergraduates from the UCSD community participated in exchange for course credit. All subjects reported being native English speakers.

**Materials and design.** Ninety-nine line-drawn pictures similar to those used in Experiments 1-3 were used in this experiment. Three cards were used for an abbreviated practice round, while the remaining ninety-six cards were divided into two groups, Version A and Version B. Each event depicted in the Version A group had a matching event in the Version B group. The Version B images portrayed the same elements and the same relationships within the event as the Version A images, but varied the perspective, the relative size of actors and objects, the coloring of the event participants, along with other stylistic differences. The artist who drew the drawings was given latitude in deciding how to implement these modifications, with the requirements that the Version B depiction could be described using the same sentence, and that it was clearly distinct from the Version A depiction.

The design of the linguistic materials, procedure, and scoring and analysis were as in Experiments 1-2.

**Results and Discussion**

Subjects produced scorable responses on 74.1% of trials overall (1707 out of 2304 trials). For transitive targets they did so on 87.5% of trials (672 out of 768); for dative targets they did so on 81.0% of trials (622 out of 768); for locative targets they did so on 53.8% of trials (413 out of 768).

Overall, subjects were 11.8% more likely to produce the preferred syntactic structure when primed with the preferred structure (72.6%), than when primed with the alternative (60.8%), and including prime type in the model significantly improved the model fit (*χ*2(1) = 24.033, *p* < .0001). On trials where the subject described the same event depiction as the one described by the experimenter, they were 11.0% more likely to produce the preferred structure when primed with the preferred structure (74.4%) than when primed with the dispreferred structure (63.4%). On trials where the subject described a different version of the event that had been described by the experimenter, they were 12.9% more likely to produce the preferred structure when primed with the preferred structure (71.4%) than when primed with the dispreferred structure (58.5%). Although there was a small numerical difference (1.9%) opposite the predicted direction, this difference was not statistically significant, and including the interaction term (event condition X prime type) did not improve our model fit (*χ*2(1) = 0.0004, *p* = .98).



Figure 4. Proportion of preferred structure responses for target descriptions in which subjects either described the same or a different depiction of an event.

In sum, after hearing descriptions of particular event depictions, subjects are subsequently more likely to use the same syntactic structures to describe both identical event descriptions and distinct event depictions that share similar sets of event semantic features. That is, syntactic entrainment applies to classes of very similar events regardless of how they are depicted. This suggests that syntactic entrainment involves associations not with particular depictions of events, but instead with something more abstract than those depictions. Experiment 5 and 6 assess a specific possibility.

**Experiment 5**

Experiment 1 established the basic syntactic entrainment effect, Experiments 2 and 3 showed it to be (largely) partner-independent, and Experiment 4 showed that language users learn associations between syntactic structures and something more abstract than representations of the visual depictions of the events themselves. In Experiment 5, we aim to test whether syntactic entrainment reflects the formation of an association between a representation of syntactic structure and the event-semantic features of the kind that are associated with syntactic structures in natural language. Such a result would quite directly support the possibility that syntactic entrainment is well positioned to be part of the process of conventionalizing the associations between syntactic structures and particular event meanings that are observed in natural language.

To test this hypothesis, Experiment 5 follows a similar logic as demonstrations of semantic interference effects in word production (Damian, Vigliocco, & Levelt, 2001). In such studies, subjects name pictures of objects and their production latencies are measured. If the objects within a set are categorically related, subjects show longer naming latencies than if objects are not categorically related. These results follow from the hypothesis that the semantic system underlying object meaning is be organized according to semantic categories. The idea is that when naming blocks of semantically homogenous objects, associations between the semantic features that are common to all of the objects and each object name are all strengthened, causing interference; when naming blocks of event depictions from distinct event semantic categories, the absence of common semantic features within the set circumvents such interference (Oppenheim, Dell, & Schwartz, 2010). For example, if a subject names a set of pictures that include a dog, a cat, a pig, and a cow, then associations between a feature such as “mammal” (common to all four in the set) and each object name will be strengthened as each object that is named. As each picture is named again, the fact that an association to a different name was previously strengthened slows production onsets. But if instead a subject names a set of pictures that include a dog, a chair, a sun, and a house, the reduction in the number of common semantic features correspondingly reduces such interference; that is, the “mammal” feature of dog will not have its association to names other than “dog” strengthened (because “mammal” only participates when “dog” is to be named), and so the naming of “dog” will not be slowed.

Experiment 5 adopted an analogous logic, but for semantically related events described with syntactic structures. Specifically, we tested whether naming blocks of events from a common event-semantic category causes interference in the syntactic entrainment effect. For example, dative events, which can be described with prepositional dative or double-object structures, come from (at least) four event-semantic categories: give-type events, where something is (potentially) transferred from one entity to another; tell-type events, where information is (potentially) transferred from one entity to another; show-type events, where information is displayed from one entity to another; and throw-type events, where something is projected through the air from one entity to another. In *homogeneous* blocks, all four dative events within the block came from the same event-semantic category (e.g., all four dative events were give-type events, though different verbs can be used, such as “give” and “hand”). Recall that in the standard entrainment procedure (like that used in Experiments 1, 2, and 4), two dative events are heard described with prepositional dative structures and two with double-object structures. Thus, if an event-semantic feature that represents give-type events (as distinct from the other dative event-semantic categories) participates in the entrainment effect – that is, if it is the give-type event-semantic feature that becomes associated to the syntactic structure used to describe the picture – then that give-type event-semantic feature will be associated twice with the prepositional dative structure and twice with the double-object structure. By hypothesis, this should reduce the entrainment effect to the extent that the effect is driven by the representation of the event-semantic feature. In contrast, in *heterogeneous* blocks, all four dative events within the block came from different event-semantic categories – one each from the give-type, tell-type, show-type, and throw-type categories. If the representations of event-semantic categories participate in the entrainment effect, then one syntactic structure (e.g., the prepositional dative) will be associated to two of the event-semantic category representations and the other syntactic structure (e.g., the double-object dative) will be associated to the other two of the event-semantic category representations. If such event-semantic category representations participate in the entrainment effect, then when (e.g.,) the give-type event is to be described, its event-semantic representation was associated with only one structure, and so any interference elicited in the homogeneous block should be reduced.

**Method**

**Subjects.** Forty-eight undergraduates from the UCSD community participated in the study in exchange for course credit. All subjects reported being native English speakers.

**Materials and design.** Sixty-seven cards – similar to those used in Experiment 1 – were used in Experiment 5. Three cards were used for an abbreviated practice round. Of the remaining cards, 16 were used as filler items and 48 as experimental items. The 48 experimental items were divided into 8 event-semantic categories of dative and locative events (see appendix), consisting of 6 items each. Over the course of the experiment, subjects were presented with descriptions of events from every class, however, each subject saw only four of the six items from each class. Due to counterbalancing demands, an unbalanced items design needed to be used, so that a procedure otherwise comparable to Experiments 1-2 and 4 could be implemented (for this reason, Experiment 6 replicates Experiment 5 with a balanced items design, but this necessitated changing other aspects of the procedure). And so, 16 event depictions were presented to every subject, whereas 32 were each only presented to one half of the subjects. Four different decks of cards were created to ensure that across the experiment each event depiction occurred equally in each condition.

Eight experimental lists of picture descriptions were constructed for the experimenter to read in his or her role as director. Each list contained 32 experimental sentences, including 16 dative sentences and 16 locative sentences. As in Experiment 1, the events depicted on the cards could be described using two alternative syntactic structures. Within each block, subjects heard four locative and four dative event descriptions (subjects also heard four transitive event descriptions, however these items were used as fillers), which were balanced with respect to the syntactic structure used. Thus, two dative events were described using the prepositional dative and two using the double object dative, and two of the locative events were described using the “with”-variant, and two using the “on”-variant. Our manipulation of interest was whether the four events of the syntactic alternation (dative or locative) within a block came from the same event-semantic category (homogenous condition), or whether they came from distinct event-semantic categories (heterogenous condition).

**Procedure.** The same basic procedure was used as in Experiment 1. In Experiment 5 there were four experimental decks of cards with partially overlapping sets of event depictions. For each experimental run one of these four decks was used.

**Scoring and analysis.**The same coding procedure was used as in Experiment 1. The data were again analyzed using R (R Core Team, 2014) and *lme4* (Bates, Maechler, Bolker, & Walker, 2014) to perform a linear mixed effects analysis. We tested the main effect of the confederate’s prime syntactic structure on the subject’s target utterances, and the interaction of the *prime condition* and the *homogeneity condition*. Prime type (preferred or dispreferred structure), homogeneity (homogenous or heterogenous event), and their interaction (prime type X homogeneity) were entered into the model as fixed effects.

We included the maximal random effects structure in our model (Barr et al., 2013). As random effects, we had intercepts for subjects and items, as well as by-subjects and by-items random slopes for the effect of the prime condition, the effect of the homogeneity condition, and the interaction between prime and homogeneity conditions. Three items lacked data in at least one of the four cells. Models run including these items failed to converge, and they were removed for the final analysis. All reported *p*-values were obtained using likelihood ratio tests by comparing the full model against the model with the fixed effect in question removed.

**Results and Discussion**

Subjects produced scorable responses on 63.2% of trials overall (970 out of 1536 trials). For dative targets they did so on 77.1% of trials (592 out of 768), and for locative targets on 49.2% of trials (378 out of 768).

Overall, subjects were 5.0% more likely to produce the preferred syntactic structure when primed with the preferred structure (75.0%), than when primed with the alternative (70.0%), and including prime type in the model did not improve the model fit (*χ*2(1) = 2.29, *p* = .13). For the effect of homogeneity, speakers showed an 8.6% greater effect on trials in heterogeneous blocks than on trials in homogeneous blocks. On trials in heterogeneous blocks, subjects were 10.4% more likely to produce the preferred structure when primed with the preferred structure (78.9%) than when primed with the dispreferred structure (68.5%). On trials in homogeneous blocks, subjects were 1.8% more likely to produce the preferred structure when primed with the preferred structure (73.0%) than when primed with the dispreferred structure (71.2%). However, this numerical difference between the homogenous and heterogenous conditions was not statistically significant, and including the interaction term (prime type X homogeneity) did not improve our model fit (*χ*2(1) = 2.11, *p* = .15).



Figure 5. Proportion of preferred structure responses for target descriptions of events that were either in homogenous blocks (4 event semantically similar depictions).

Overall, in Experiment 5, we found a relatively large numerical moderation of the entrainment effect by homogeneity, though this effect was not significant in the mixed effects modelsWe suspect that statistical support for this interaction effect was compromised by the unbalanced items design. In Experiment 6 we aim to replicate the effect in Experiment 5 using a balanced items design. (We nonetheless report Experiment 5 here both so as to avoid “file drawering” it, but also because developing a balanced items design required changing other aspects of the overall procedure. The observed outcomes from Experiment 5 are thus numerically more comparable to Experiments 1-2 and 4, given the similarity of the overall procedures in these experiments, than the outcomes of Experiment 6.)

**Experiment 6**

Experiment 5 tested the hypothesis that the entrainment effect is modulated by event homogeneity, i.e., the entrainment effect reflects the strengthened association between event-semantic features (shared within a narrow conflation class) and syntactic constructions rather than between specific events and syntactic constructions. We however failed to observe the statistically significant interaction effect between the event homogeneity and the entrainment effect, perhaps due to the imbalanced items design. We therefore designed a new experiment that is similar to Experiment 5, but this time using the balanced items design.

**Method**

**Subjects.** Forty-eight undergraduates from the UCSD community participated in the study in exchange for course credit. All subjects reported being native English speakers.

**Materials and design.** Forty-eight cards – the subset of the pictures used in Experiment 5 – were used in Experiment 6. 16 were used as filler items and 32 as experimental items. The 32 experimental items were divided into 8 event-semantic categories of dative and locative events (see appendix), consisting of 4 items each. Over the course of the experiment, each subject was presented with descriptions of events from every class. The total number of experimental items, as well as the number of items in each block, was set to be smaller in order to meet the counterbalancing needs with reasonable number of distinct cards necessary to create the stimulus set.

Four experimental lists of picture descriptions were constructed for the experimenter to read in his or her role as director. Each list contained 32 experimental sentences, including 16 dative sentences and 16 locative sentences. As in Experiment 5, the events depicted on the cards could be described using two alternative syntactic structures. Within each block, subjects heard two locative and two dative event descriptions (as in Experiment 5, subjects also heard two transitive event descriptions, however these items were used as fillers), which were balanced with respect to the syntactic structure used. Thus, one dative event was described using the prepositional dative and one using the double object dative, and one of the locative events were described using the “with”-variant, and one using the “on”-variant. As in Experiment 5, our manipulation of interest was whether the four events of the syntactic alternation (dative or locative) within a block came from the same event-semantic category (homogenous condition), or whether they came from distinct event-semantic categories (heterogenous condition).

**Procedure.** The procedures were overall similar to Experiment 5 but were somewhat different. As in Experiment 5, the cover task was that participants were playing a picture-matching game. Unlike in Experiment 5, however, after participants played role as the matcher, they simply re-described the pictures in the same order that the director described them. This change was made to ensure that the prime and target utterances for each pictures is always intervened by all other pictures (either in the prime phrase or in the response phase). In other words, the current design ensures that the potential source of interference (pictures of within-category events) always intervene the prime and target utterances in the homogeneous condition. We reasoned that this design may maximize the potential homogeneity effect on entrainment. Hence we adopted this modification of the procedure.

**Scoring and analysis.**The same coding procedure was used as in Experiment 5. The data were again analyzed using R (R Core Team, 2014) and *lme4* (Bates, Maechler, Bolker, & Walker, 2014) to perform a linear mixed effects analysis. We tested the main effect of the prime sentences’ syntactic structure on the subject’s target utterances, the main effect of the homogeneity of each event type (datives and locatives) within a block, and the interaction of the *prime condition* and the *homogeneity condition*. Prime type (preferred or dispreferred structure), homogeneity (homogenous or heterogenous event), and their interaction (prime type X homogeneity) were entered into the model as fixed effects.

We included the maximal random effects structure in our model (Barr et al., 2013). As random effects, we had intercepts for subjects and items, as well as by-subjects and by-items random slopes for the effect of the prime condition, the effect of the homogeneity condition, and the interaction between prime and homogeneity conditions. All reported *p*-values were obtained using likelihood ratio tests by comparing the full model against the model with the fixed effect in question removed.

**Results and Discussion.** Subjects produced scorable responses on 90.4% of trials overall (1388 out of 1536 trials). For dative targets they did so on 95.1% of trials (730 out of 768), and for locative targets on 85.7% of trials (658 out of 768).

Overall, subjects were 20.5% more likely to produce the preferred syntactic structure when primed with the preferred structure (58.8%), than when primed with the alternative (38.3%), and including prime type in the model improved the model fit (*χ*2(1) = 24.01, *p* < .001). For the effect of homogeneity, speakers showed an X.X% greater effect on trials in heterogeneous blocks than on trials in homogeneous blocks. Including homogeneity did not improve our model fit (χ2(1) = 0.18, p = 0.67). Most critically, there was prime type x homogeneity condition interaction: When an experimental block did not contain the two pictures depicting the same event type (i.e., in heterogeneous condition), subjects were 24.8% more likely to produce the preferred structure when primed with the preferred structure (60.3%) than when primed with the dispreferred structure (35.5%). In comparison, when an experimental block contained the two pictures depicting the same event type (i.e., in homogeneous condition), subjects were 16.3% more likely to produce the preferred structure when primed with the preferred structure (57.3%) than when primed with the dispreferred structure (41.0%). Thus, the entrainment effect was 8.5% stronger in the heterogeneous than in the homogeneous conditions; including interaction term significantly improved our model fit  (χ2(1) = 5.28, p = .02).



Figure 6. Proportion of preferred structure responses for target descriptions of events that were either in homogenous blocks (4 event semantically similar depictions).

In Experiment 6, we found a statistically significant moderation of the entrainment effect by homogeneity. These results, which are consistent with the numerical patterns observed in Experiment 5, support the hypothesis that syntactic entrainment at least partially reflects the association between event-semantic categories and syntactic structures, not just the association between a specific event and a syntactic structure.

One clear difference between the results of Experiment 5 and Experiment 6 is the size of the entrainment effect. This difference deserves an explanation. In Experiment 5, speakers were overall 5.0% more likely to use preferred syntactic structures when primed with sentences with preferred structure (10.6% in the heterogeneous condition and 0.8% in the homogeneous condition). In comparison, in Experiment 6, speakers were overall 20.5% more likely to use preferred syntactic structures when primed with sentences with preferred syntactic structures (24.8% in the heterogeneous condition and 16.3% in the homogeneous condition). This difference may be due to the difference in the number of pictures used per experimental block. In Experiment 5, each block contained 12 distinct pictures (4 dative, 4 locative, and 4 transitive pictures). In Experiment 6, each block contained only 6 (2 dative, 2 locative, and 2 transitive pictures). Thus, speakers in Experiment 6 have less number of intervening sentences between the prime sentences and the target sentences, so they may have stronger memory of the sentences that they heard as prime sentences. The stronger sentence memory may strengthen the overall effect of prime structure type, because participant could be more faithful to the original sentences that they heard form the experimenter. This is congruent with the observation that Experiment 6 yielded many more scorable responses than Experiment 5, and that the across-participant variability is smaller.

**General Discussion**

The three experiments reported above demonstrate two primary findings. First, speakers tend to describe particular scenes with the same syntactic structures that had been used to describe those scenes earlier in the experimental task. We call this basic effect – as demonstrated in Experiment 1 – syntactic entrainment, in analogy to the lexical entrainment effect reported previously in the literature (e.g., Brennan & Clark, 1996). To our knowledge, this is the first demonstration of speakers reusing syntactic structures when describing particular events. Furthermore, syntactic entrainment was observed despite the fact that prime and target descriptions were separated by an average of 12 intervening sentences (comprehended or produced), some of which had the opposite syntactic structure.

Second, the syntactic entrainment effect demonstrated in Experiment 1 seems to be primarily partner-independent. In Experiment 2, when subjects heard one description of each scene, the magnitude of the syntactic entrainment effect was statistically and (approximately) numerically equivalent whether subjects described the pictures back to the experimenter who initially described them or to a different experimenter (about a 10% effect in each case). In Experiment 3, when subjects heard four descriptions from each experimenter of each scene, they showed overall greater syntactic entrainment in both the same and different experimenter conditions. However, this increase resulted in a numerically larger syntactic entrainment effect when speaking to the same experimenter (about a 26% effect) than when speaking to a different experimenter (about a 20% effect), an interaction effect that was marginally significant. Although the small but marginally significant effect of partner specificity may reflect a genuine partner-specific component separate from the much larger partner-independent effect, we leave further investigation and analysis of any such partner-specific component to future research.

Third, syntactic entrainment appears to reflect an association between event-semantic categories and syntactic structure. Experiment 4 demonstrated that equivalent entrainment is observed when speakers describe back pictures that differ from the ones they heard described originally, compared to pictures that were identical to the ones they heard described originally. This shows that the syntactic entrainment effect reflects an association between syntactic structure and something deeper than a representation of the visual scene. Experiments 5 and 6 then implicated event-semantic categories in the entrainment effect, in that both experiments showed greater entrainment when a block of descriptions included events that were heterogeneous with respect to event-semantic categories, compared to when blocks were homogeneous with respect to these categories (this interaction was not significant in Experiment 5, with an unbalanced items design, but it was in Experiment 6, with a balanced items design).

Taken together, syntactic entrainment appears to reflect a process by which speakers develop associations between the event content expressed by sentences and the syntactic structures used in those sentences. At least a component of this effect appears to involve features that define event-semantic categories, as shown by the results of Experiments 5 We suggest that this evidence is consistent with the possibility that syntactic entrainment serves an important function for linguistic communication. Specifically, syntactic entrainment could lead to associations between not just specific events and syntactic structures, but, also between more general *types of events* and syntactic structures, which would allow speakers an additional means for expressing meaning (in addition to using words to express semantic content and grammatical functions to express relational content). Although not without debate (cf. Bock, 1986; Chang, et al., 2006; Chomsky, 1957; Jackendoff, 1997; Michaelis, 2003), there is evidence consistent with the possibility that syntactic structures convey distinctive meaning content about the events they describe (Goldberg, 1995, 2003; Gropen, Pinker, Hollander, Goldberg, & Wilson, 1989; Pinker, 1989). These meanings tend to reflect holistic aspects of the event, such as successful transfer of possession (in the case of the double object dative structure), or the fact that an action results in a container or surface being completely (rather than partially) filled with objects or covered with a substance (in the case of the *with*-variant locative structure) – meaning features we have here termed emergent properties.

By allowing speakers to convey meaning with their choice of syntactic structure, associations between emergent properties and syntactic structures could allow more efficient and precise linguistic communication. For example, the choice of the double object dative structure, as in “The coach tossed the little leaguer the baseball,” (by some points of view) conveys that possession was transferred. In principle, approximately the same meaning can be conveyed using the prepositional dative structure and additional words, as in, “The coach tossed the baseball to the little leaguer and he caught it.” However, since the double object dative uses fewer words (than the full paraphrase), it is a more efficient way of expressing the same meaning. Furthermore, adding the second clause to the prepositional dative sentence (“...and he caught it”) may not express precisely the same idea, for example by imposing a different information structure (Lambrecht, 1994). That is, certain aspects of the sentence’s meaning are changed in the new sentence, such as the topic (e.g., in the changed sentence, the little leaguer becomes relatively more prominent than the coach), and the focus (e.g., the changed sentence implies that the outcome where the little leaguer *did not* catch the ball may have been considered more likely to the speaker). Overall, this suggests that adding words might be an inefficient and less effective way of conveying potential emergent properties conveyed by syntactic structure. Rather, the fact that syntactic structures take the scope of an entire clause or sentence makes them better positioned to convey information that relates to the event as a whole.

The phenomenon of syntactic entrainment reflects a speaker’s propensity to associate particular event content with syntactic structures. Analogously, the conjecture here is that specific emergent event meanings become associated with particular syntactic structures (both for individual speakers and for the linguistic community in general) through a similar process. The direct evidence for such an effect in these experiments is limited, mainly in Experiments 5 and 6’s demonstration that some aspect of event-semantic categories is implicated in the effect. If indeed syntactic entrainment reflects the process by which syntactic structures become associated with specific emergent event meanings, then additional processing interactions must work to refine the associations between meaning and structure down to the emergent properties that languages actually exhibit.

It is not unreasonable to expect that as associations between syntactic structures and event meanings spread through a linguistic community, they could become refined down to the emergent properties we see expressed by syntactic structures. For example, after hearing a dative event that results in the successful transfer of possession described with a double object sentence, as in “The coach tossed the little leaguer the baseball,” speakers may strengthen the association between the double object dative and coaches, little leaguers, baseballs, and successful transfer. Subsequently, when speakers encounter other dative events, they could be more likely to use the double object dative in their description if the event included any of these aspects of the syntactically entrained event. Accordingly, any of these event meaning features could, in principle, become associated with a specific syntactic structure. However, there is an important difference between aspects of event meaning that relate to only part of the event (i.e., the constituents of the event – coaches, little leaguers, and baseballs), and aspects of event meaning that relate to the event as a whole (i.e., emergent event meanings – successful transfer of possession). Whereas coaches, little leaguers, and baseballs are involved in relatively few transfer events, whether or not a transfer was successful is relevant to most all transfer events. Thus, because a speaker is likely to hear (and syntactically entrain) many more double object dative sentences that involve successful transfer of possession than double object sentences that express any particular referent, the association between the double object dative structure and successful transfer of possession (and other emergent event meanings) may be more readily available to become strengthened through successive iterations (within a conversation and throughout the linguistic community).

The demonstration that syntactic entrainment is primarily partner-independent (Experiments 2 and 3) supports the foregoing account of syntactic structures becoming associated with emergent event meanings. The fact that speakers tend to repeat the association between event content and syntactic structures when speaking to new interlocutors means that these associations could spread efficiently from one partner to the next, in an ultimately open-ended manner throughout the linguistic community. This suggests that – to the extent that it has a functional purpose for language processing – the function of syntactic entrainment may be more specifically about calibrating the linguistic conventions of the entire linguistic community.

The involvement of event-semantic features in syntactic entrainment, as suggested by Experiments 5 and 6, is relevant to the interpretation of entrainment as the mechanism by which we learn and tune the expression of emergent properties. Note that certain syntactic generalizations are constrained by event semantic categories. For example, the event semantic category that involves continuous causation of accompanied motion (e.g., *pull*) and causation of ballistic motion (e.g., *throw*), at least in principle seem to be equally compatible with the transfer of possession meaning (though see Pinker, 1989, for a different view). However, only the throw-type events permit the double object structure (“Max threw the baseball to Naomi” and “Max threw Naomi the baseball”); pull-type events forbid double objects (“Max pulled the box to Naomi,” but \*“Max pulled Naomi the box”). If the account presented here is correct, syntactic restrictions of this type come from language users’ experience with events from that class. In particular, if indeed the double object conveys the meaning of successful transfer of possession, then when an event indeed involves successful transfer of possession, the verb used to describe that event is more likely to be used with the double object. This implies that verbs that describe events that are more compatible with transfer of possession will be heard described with double objects more than verbs that describe events that are less compatible with transfer of possession. Indeed, perhaps in actual language use, throw-type events are more likely to involve transfer of possession than pull-type events, which could explain the observed pattern of syntactic restrictions. For example, in our linguistic community, throw-type events often involve sports, in which the aim of the action is often to transfer possession of a game ball to a teammate, as in “the pitcher tossed the catcher the ball,” whereas pull-type events may be more likely to involve movement of heavy objects, such as furniture, to different locations where they would remain, as in, “The mover pulled the large sofa to the living room.” Thus, according to the current account, we would expect the pull-type events to be less likely to be described using a double object dative, which may lead to a restriction on the usage of the double object with such events – which is what we observe in English. (One might speculate that if we lived in a very- high gravity environment – where we would be more likely to transfer possession through the continuous causation of motion than through ballistic motion – verbs like “push” and “pull” might permit the double-object construction, whereas verbs like “throw” and “kick” might restrict the construction.)

Overall, in the current study, we demonstrate the novel effect of syntactic entrainment, whereby language users seem to associate syntactic structures with particular event content. We have argued that this association is different from what we see reflected in syntactic priming, where particular sets of abstract event roles become associated with syntactic structures. However, just as syntactic priming has been interpreted as reflecting the acquisition of knowledge of how event roles map onto syntactic structures, syntactic entrainment can be viewed as reflecting the acquisition of knowledge of how event content maps onto syntactic structures. Due to the enduring nature of the change, which was observable after (on average) 12 intervening trials, and the fact that it was present after only a single exposure to an event-structure pairing, we suggest that this process may reflect some basic function of language. Specifically, syntactic entrainment may reflect a first step in the process by which syntactic structures come to express emergent event meanings, and their dissemination throughout the linguistic community.

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