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An Exploration of the Relationship Between Event Meaning and Syntactic Structure

A dissertation submitted in partial satisfaction of the requirements for the degree
Doctor of Philosophy

in

Psychology

by

Nicholas Gruberg

Committee in charge:

Professor Victor Ferreira, Chair
Professor David Barner
Professor Sarah Creel
Professor Roger Levy
Professor John Wixted

2017

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The Dissertation of Nicholas Gruberg is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Chair

University of California, San Diego

2017

DEDICATION

First, I dedicate the dedication section of this dissertation to my father, without whom this dedication section would have been too facetious.

To Nadine Martin, who first nurtured my passion for studying language processing and language disorders, who allowed me to follow some hunches about how humans process syntactic structure, which, with relatively few intermediate steps, led me to a doctoral program in psychology.

Next, for his impossible patience, unerring guidance, and unwavering faith in my ability to finish this dissertation even after moving across country – as evidenced by such quotes as, “when you left town, I didn’t think you’d finish this up” – my inimitable advisor, Vic Ferreira.

To the remainder of my esteemed committee, Dave Barner, Sarah Creel, John Wixted, and Roger Levy, your continued support has been invaluable.

To the labmates who were there in my darkest hours of linear mixed regression modelling, counterbalancing nightmares, and other more sordid affairs.

To Kara and Peanut, who made being a grad student a little less bluenus.

To Mop, Jordy LeForge, Bear Jew, and Hans/Pooh Bear – it was niiiithe.

To Red, HEY LOOK IT’S FINE JUST LIKE I TOLD YOU IT WOULD BE!

To Arn, you are my rock.

To Beetlejuice Daria, without whom I wouldn’t be where I’m at.

Finally, what dedication section would be complete without a shout out to one’s mom? Here’s to all that you do, even after all your celebrated mural painting, Olympic level rowing, competitive gardening, teaching art to college & grade school students, and taking responsibility for the care of your aging parents, you still found time to make sure that I was eating enough brownies in San Diego.

– Thanks –

EPIGRAPH

“...Imitating in this the example of travellers who, when they have lost their way in a forest, ought not to wander from side to side, far less remain in one place, but proceed constantly and in as straight a line as possible, without changing their direction for weak reasons, although perhaps it might have been chance alone which at first determined the selection; for in this way, if they do not exactly reach the point they originally desired, they will very likely end up beside a stream or in a hamlet, or in some other place that will be preferable to being lost in the middle of a forest.”

—Descartes

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Chapter 3, in part, is currently being prepared for submission for publication of the material. Gruberg, N., & Ferreira, V. S. Speakers associate syntactic structures with abstract event meanings. The dissertation author was the primary investigator and author of this paper.

Chapter 4, in part, is currently being prepared for submission for publication of the material. Gruberg, N., Wardlow, L., & Ferreira, V. S. The role of verbs in children's syntactic-semantic associations. The dissertation author was the primary investigator and author of this paper.

VITA

EDUCATION

- 2017 Doctor of Philosophy, in Psychology
University of California, San Diego
- 2007 Master of Arts, in Linguistics
Temple University
- 2003 Bachelor of Arts, in Linguistic Anthropology
The University of Chicago

PROFESSIONAL EXPERIENCE

- 2007-2009 Research Assistant, Eleanor Saffran Center for Cognitive
Neuroscience, Temple University

PAPERS IN PREPARATION

- Gruberg, N., Ostrand, R. & Ferreira, V. S. (in preparation). Syntactic entrainment: The repetition of syntactic structures in event descriptions.
- Gruberg, N., & Ferreira, V. S. (in preparation). Speakers associate syntactic structures with abstract event meanings.
- Gruberg, N., Wardlow, L. & Ferreira, V. S. (in preparation). The role of verbs in children's syntactic-semantic associations.

REFEREED RESEARCH PRESENTATIONS

- Gruberg, N., Ferreira, V. S., & Ostrand, R. (2014) Speakers don't just syntactically prime, they syntactically entrain: Event-specific syntactic adaptation in language production. Oral presentation at *The 55th Annual Meeting of The Psychonomic Society*, Long Beach, CA, USA.
- Gruberg, N., Wardlow, L., & Ferreira, V. S. (2014) Young children represent syntax abstractly, but prefer to use it concretely. Poster presentation at *AMLaP 2014: Architectures and Mechanisms for Language Processing*, Edinburgh, Scotland.

- Gruberg, N., Wardlow, L., Espiritu, J., & Ferreira, V. S. (2013) The abstraction of syntax by fits and starts. Poster presentation at *The 26th Annual CUNY Conference on Human Sentence Processing*, Columbia, South Carolina.
- Gruberg, N., Ostrand, R., & Ferreira, V. S. (2013). Syntactic entrainment is sometimes partner-specific. Poster presentation at *AMLaP 2013: Architectures and Mechanisms for Language Processing*, Marseille, France.
- Gruberg, N., & Ferreira, V. S. (2012). Conversational pacts for syntax. Poster presentation at *The 7th International Workshop on Language Production*.
- Gruberg, N., & Ferreira, V. S. (2011). Representing syntax: Priming various syntactic representations. Poster presentation at *AMLaP 2011: Architectures and Mechanisms for Language Processing*, Paris, France.
- Martin, N., Schmitt, K., Kamen, R., Bunta, F., & Gruberg, N. (2012). Receptive and Expressive Learning of Novel Words (Object and Proper Names) in Aphasia. *Procedia-Social and Behavioral Sciences*, 61, 112-114.
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- Martin N., Gruberg N., & Afman R. (2009). Analysis of sentence repetition in aphasia (part 1): System for coding responses. Poster presentation at the *Academy of Aphasia 47th Annual Meeting*, Boston, MA.
- Martin N., & Gruberg N. (2009). Analysis of sentence repetition in aphasia (part 2): Semantic influence on position and type of errors. Poster presentation at the *Academy of Aphasia 47th Annual Meeting*, Boston, Massachusetts.
- Gruberg N., & Martin, N. (2008). The preposition's role in syntactic priming. Poster presentation at *CUNY 2008 Conference on Human Sentence Processing*, Chapel Hill, North Carolina.

ABSTRACT OF THE DISSERTATION

An Exploration of the Relationship Between Event Meaning and Syntactic Structure

by

Nicholas Gruberg

Doctor of Philosophy in Psychology

University of California, San Diego, 2017

Professor Victor Ferreira, Chair

In this dissertation we investigate the relationships between syntactic structures and the meanings of the events they are used to describe, how such relationships may develop within language, and how they may be acquired by language learners. We employ a novel paradigm to assess these relationships through an effect termed *syntactic entrainment*. Over the course of 9 experiments we explore the possibility that syntactic entrainment reflects a process by which these relationships may be introduced into natural languages, and acquired by children learning language.

Study 1 demonstrates syntactic entrainment. In Experiment 1, we show that when a speaker hears an event described with a particular syntactic structure they will tend to use the same structure when subsequently describing the same event. In Experiment 2, we demonstrate that this effect is equally likely to be present when speaking to the same or a different interlocutor. However, in Experiment 3 we demonstrate a small but significant partner specific component of the syntactic entrainment effect, but only when subjects are given four identical descriptions of the same picture. This result suggests that speakers are creating enduring, primarily partner independent associations between syntactic structures and event content.

In Study 2 we show that the associations reflected in syntactic entrainment apply not just to the particular depictions of events, but also to visually distinct depictions of the same events (Experiment 2), and even to larger categories of events defined by specific event semantic features (Experiment 3). This suggests that syntactic entrainment could reflect the mechanism by which language users learn about the associations between syntactic structures and particular event meanings, which we find in natural language.

Finally, in Study 3 we show that for children – but not adults – the magnitude of the syntactic entrainment effect is sensitive to the main verb used in the encoding sentences and their target descriptions. These results suggest that 4–6 year old children may still be using the identity of verbs to learn about associations between syntactic structures and event meaning features found in natural language, whereas adults may no longer rely on this information for grammatical language use.

CHAPTER 1:
INTRODUCTION

Human language allows its speakers to communicate any possible meaning in a way that can be immediately understood by any other speaker of the same language. This expressive power is in large part due to the characteristic *compositionality* of human language. That is, broadly, the ability to combine linguistic units into larger and more complicated ones, in rule governed ways that obey conventions shared within linguistic communities. The effect that this ability has on our expressive repertoire cannot be overstated. The only comparable compositional system in the animal kingdom may be found in songbirds. Songbirds combine sounds to form an unbounded set of intricate, rule governed patterns. However, crucially, the patterns of sounds that songbirds produce do not seem to be associated with specific meanings – as sound-strings are in human language – perhaps with the exception of the universal meaning of all birdsong, which we might paraphrase as, ‘I have a large and complex vocal repertoire and am therefore an exceptionally good choice of mate.’ For humans, on the other hand, sound strings can be associated with various meanings, and the composition of a finite number of such sound strings (i.e., words) allows for the expression of an unbounded set of more complex concepts (i.e., sentences).

In this dissertation, we explore the choices that language users make when combining words into sentences. People often have their choice between two different sentence types to express a given meaning; these are called syntactic alternations. Like synonyms at the word level, syntactic alternations often have subtly different connotations with respect to the phenomenon being described. Although *couch*, *sofa* and *settee* can mostly be used interchangeably, they express subtly different

connotations. Similarly, the double object and prepositional dative syntactic structures can mostly be used to describe the same events (e.g., “The man gave the woman a rose,” “The man gave a rose to the woman”), however there are subtle distinctions in the meanings they express. For example, the double object dative structure seems to imply that possession of an object was transferred to a recipient whereas the alternative syntactic structure, the prepositional dative, carries no such implication. As such, in transfer events in which the recipient is inanimate – and therefore cannot properly take possession of the transferred object – the double object structure is prohibited, as in, “*The man mailed the address the letter,” whereas the prepositional dative structure is permitted, as in, “The man mailed the letter to the address.”

Users of a language must somehow acquire knowledge of the distinctions between alternate syntactic structures in (at least) two respects. First, there are the aforementioned subtle meaning differences expressed through the use of different syntactic structures. Second, there may be restrictions on the use of one member of a syntactic alternation in descriptions of particular *types of events*. Certain of these restrictions are predictable based on the compatibility of the meanings expressed by the particular syntactic alternants with the events being described (e.g., the double object dative is restricted when the *recipient* or *goal* of the transfer is not animate and therefore cannot rightly *take possession*). However, other such restrictions seem to be independently motivated. For example, events that involve the “continuous causation of accompanied motion,” prohibit the double object dative structure, as in, “*The man pushed the woman the box,” but permit the prepositional dative, as in, “The man

pushed the box to the woman.”¹ Alternatively, events that involve “the instantaneous causation of ballistic motion,” allow both the double object dative structure, as in, “The coach threw the little-leaguer the baseball,” and the prepositional dative structure, as in, “The coach threw the baseball to the little leaguer.” Since both of these event types are plainly compatible with the transfer of possession meaning, which is associated with the double object structure, but only one can be described with that structure whereas the other cannot, we suggest that such restrictions are somewhat arbitrary (though not entirely arbitrary, see discussion in Chapter 3) and must, to some extent, be learned by language users (though see Pinker, 1989 for a different view).

The working theory that motivated much of the research presented in this dissertation is that associations between particular syntactic structures and specific event meaning content may, in part, explain how language users choose particular syntactic structures when describing particular types of events. In order to observe the existence and, potentially, the acquisition of these associations we used a paradigm adapted from research on lexical entrainment. The research conducted by Clark and

¹ More recent studies have questioned whether the purported syntactic restrictions on dative semantic classes (e.g., the restricted use of the double object dative for events involving “the continuous causation of accompanied motion”) are in fact valid. Citing corpus evidence, Bresnan and colleagues propose instead that such apparent restrictions are the product of graded judgments based on pragmatic factors, not grammaticality per se (Bresnan & Nikitina, 2003, 2009). In the present dissertation we are not committed to Pinker’s semantic categories, we accept that such restrictions may be graded and subject to various constraints, and, in Chapter 2, we directly test whether whether Pinker’s division of verbs into event semantic categories (or narrow conflation classes) is in fact empirically justified.

colleagues was concerned with how conversational partners tended to repeat the labels they used when describing particular objects under discussion. At some level, therefore, language users were creating associations between linguistic forms and real-world meaning content. Although Clark and colleagues described this process narrowly as facilitating communication within the context of particular conversations, and in the current work we are interested in longer term learning processes, we now discuss their basic research, before highlighting the points of departure of the research presented in this dissertation.

Previous research on entrainment

The work of Clark and colleagues has demonstrated that when describing objects, conversational partners tend to repeat the specific labels that have been used to describe those objects previously in the conversation (Clark & Wilkes-Gibbs, 1986). The authors describe this phenomenon as lexical entrainment, and propose that its purpose is to facilitate communication between conversational partners. Specifically, conversational partners should find it easier to understand each other if they consistently use the same labels to describe the same objects.

There are two potential communicative benefits to associating particular lexical labels with objects within the context of a conversation. First, it could help differentiate between objects under discussion. Second, conversational partners may come to expect particular labels to be used for descriptions of particular types of objects. The work of Clark and colleagues seems to suggest that both are at play to some extent. First, the labels that language users produce are sensitive to the number

of close semantic competitors to which the interlocutors could refer (within their experimentally contrived situation). Accordingly, interlocutors tend to settle on labels that are sufficiently complex to differentiate referents under discussion from one another. This is a fairly predictable result, since avoiding referential ambiguity would seem to be a high priority when expressing meanings to an interlocutor. More interestingly, conversational partners also seem to maintain such naming conventions independent of the necessity of differentiating objects from one another. Specifically, language users will continue to use lexical labels that have been used previously in the conversation even when such labels are unnecessarily complex given the discourse context (e.g. elaborate descriptions of objects even when all semantically similar competitors have been removed). Interestingly, this tendency holds only when speaking with the same conversational partner. Thus, the behavior seems to be somewhat strategic. Specifically, if a speaker hears their conversational partner use a particular label to describe a particular object, they can safely assume that they would also expect that label to be used when describing the same object in the future, especially within the same conversation. However, the language user would have no reason to assume that a new conversational partner would also have the same expectation. Accordingly, their research has shown that speakers are significantly less likely to produce (Brennan & Clark, 1996), or expect their conversational partners to produce (Metzing & Brennan, 2003), lexically entrained labels with new conversational partners who were not privy to the previous use of the entrained label, than conversational partners who were privy to the entrained label.

Current research questions

But what about more complex conceptual content, as expressed in sentences and syntactic structures? Are the syntactic structures people choose when describing events influenced by how those events were described previously in the conversation? Specifically, do speakers' descriptions of events tend to use the same syntactic structures as earlier descriptions of the same events within the conversation?

Our initial hypothesis was that the more complex labels for events (i.e., sentences) might behave similarly to labels for objects. Just as lexical entrainment involved the association of a lexical label with a real world object, a new phenomenon we term *syntactic entrainment* could involve associations between syntactic structures and real world events. If syntactic entrainment did in fact mirror lexical entrainment, then language users might tend to repeat the syntactic structures used to describe events in order to enhance communicative efficiency. That is, a listener might expect and a speaker might use the same syntactic structure to describe a particular event as they used previously in the conversation. Furthermore, in analogy to lexical labels, speakers might not be as likely to use the same syntactic structure when speaking to new conversational partners who were not privy to the initial act of entrainment.

To anticipate our results, this basic hypothesis appears to be incorrect. In Chapter 2, we show that although speakers do tend to repeat the syntactic structures which were previously used to describe particular events, as they do for lexical labels, this tendency to repeat occurs with equal magnitude when language users are speaking with new conversational partners as well as old. This suggests that the purpose or

function of syntactic entrainment may be different from that of lexical entrainment. Specifically, we suggest that whereas lexical entrainment, as demonstrated by Clark and colleagues, may be more specifically geared towards facilitating communication within the narrow context of conversations, syntactic entrainment may reflect a process by which language users are able to learn about the usage restrictions and preferences for syntactic structures by members of the linguistic community.

This hypothesis marks a departure from the theory proposed by Clark and colleagues. Their basic hypothesis was that lexical entrainment served to enhance communicative efficiency in a relatively narrow way, with respect to particular objects within the context of a conversation. On the other hand, if syntactic entrainment reflects how speakers learn about the syntactic conventions of linguistic communities, we would expect it to operate in systematically different ways than lexical entrainment. Specifically, lexical entrainment applied not only to specific conversations – which syntactic entrainment does not – but also only to specific real world objects. Alternatively, if syntactic entrainment were to reflect language learning processes, we would expect it to apply not only to specific events – since by their very nature events are transitory phenomena, and learning something about how to describe a specific event would not serve any useful purpose – but instead such learning could perhaps apply to larger categories of events. That is, syntactic entrainment could reflect the process by which language users learn the conventional ways that the linguistic community uses syntactic structures when describing particular *types of events*.

Accordingly, in Chapter 3 we show that when language users hear a particular event described with particular syntactic structure they are subsequently more likely to describe not only the same event depiction with that syntactic structure, but they are also more likely to use that syntactic structure when describing different depictions of the same event. Thus, speakers seem to be learning not only how to describe particular instantiations of events but also how to describe more abstract representations of those events. Furthermore, in the second experiment of Chapter 3 we show that speakers appear to be learning something about how to describe broad categories of *event types*. Specifically, they seem to be learning about the syntactic preferences for entire classes of events, such as the ones that Pinker and colleagues describe as *narrow conflation classes*, (e.g., ones involving, “the instantaneous causation of ballistic motion”).

In Chapter 4 we present evidence that children are not only engaging in the same sort of syntactic entrainment, but their behavior is consistent with the hypothesis that syntactic entrainment may reflect the process by which children are learning the associations between syntactic structures and specific meaning content in the first place. Specifically, we show that, unlike adults, children are sensitive to the specific verb that is used in the syntactic entrainment process. That is, they are more likely to repeat syntactic structure when they are experimentally manipulated to use the same verb in their target descriptions as the one used by the experimenter to describe the same pictures. Given that children of this age have not fully acquired the semantic event categories (narrow verb classes) characteristic of adult linguistic competence (Ambridge, Pine, Rowland, & Young, 2008; Ambridge, Pine, Rowland, Jones, &

Clark, 2009; Ambridge, Pine, & Rowland, 2011; Ambridge, Pine, Rowland, Freudenthal, & Chang, 2012), we might expect them to rely on associations between syntactic structures and specific verbs when endeavoring to produce grammatical and appropriate sentences. Upon acquiring adult competence with event semantic categories, which prescribe particular syntactic usage (including the exceptions, as discussed in Chapter 4), older children and adults could thus cease to rely on associations between specific verbs and syntactic structures, and still avoid ungrammatical sentences by relying on rules associated with event types rather than particular verbs.

This dissertation begins with the question of how language users choose which syntactic structures to use when describing particular events. The answer suggested by the research presented here is that language users are continually learning associations between syntactic structures and certain events and types of events, which is reflected in a process termed syntactic entrainment. Thus, language users may continually refine which syntactic structures they use for particular events and event types, by repeating the usage of other members of the linguistic community. Such a process could maintain conventions of syntactic usage across the linguistic community. Furthermore, the associations reflected in syntactic entrainment may in part account for the ability of children to acquire fully adult syntactic usage, and more speculatively, they may account for how such conventions of syntactic usage were introduced into the language in the first place.

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CHAPTER 2:

SYNTACTIC ENTRAINMENT: THE REPETITION OF SYNTACTIC
STRUCTURES IN EVENT DESCRIPTIONS

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 a four-legged cloven hooved mammal with big floppy ears is arbitrary; the “donkey” sounds express that meaning because English speakers learn the same conventions that map sounds onto meanings. Though the conventionality of language is most apparent through the relationship 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 – syntactic rules – 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

At least two types of information are conveyed by syntactic structure. First (and most prominently), syntactic structure conveys relational information about roles in events – who did what to whom. Such relational information is conveyed 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_{SUBJ} chased the man_{OBJ},” the donkey is the pursuer, but in “the man_{SUBJ} chased the donkey_{OBJ},” the man is the pursuer. When learning English, 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 is conveyed by syntactic structure relates not to event roles, but to event content. That is, in addition to conveying the elements of events (via words) and event roles (via grammatical functions), sentences can also convey certain (what are termed here) *emergent properties* of events. For example, “the man sent the woman the check” and “The man sent the check to the woman” convey the same relational information – in both sentences, “the man” is the grammatical subject which corresponds to the role of sender, “the woman” is the indirect object, which corresponds to the potential receiver, and “the check” is the direct object, which corresponds to the thing being sent (and potentially received). However, these sentences convey subtly different emergent properties. In particular, the former (*double object dative*) sentence implies that possession of the direct object was successfully transferred, whereas the latter (*prepositional dative*) does not imply that possession was transferred – only that the location was changed (Goldberg, 1996). 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 more clearly illustrated by changing the recipient so that it is unable to take possession: “*The man sent the address the check” is odd, because “the address” cannot actually take possession of a check, whereas “the man sent the check to the

address” is fine, because the prepositional dative does not imply successful transfer of possession.

If indeed syntactic alternatives that convey the same relational information nonetheless convey different emergent properties, the conventions governing the mapping of these emergent properties (*vis a vis* the events that possess these properties) onto corresponding syntactic forms are likely to have been learned somehow. In the current study we present a novel procedure that demonstrates that adult language users do seem to associate specific event content with particular syntactic structures. In analogy to a related literature (see, Chang, Dell, and Bock, 2006), we suggest that such an effect may reflect the mechanism by which language users learn how the emergent properties of events map onto particular syntactic structures. In the next section, we discuss the evidence for how language users might learn to associate different meanings with alternative 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 tendency has been described as *syntactic priming* and it is widespread in language use. Syntactic priming has been shown to occur in the spoken (Bock, 1986), written (Pickering & Branigan, 1998), and signed modalities (Hall, Ferreira, & Mayberry, 2015); it has been shown to occur in comprehension (Thothathiri & Snedeker, 2008) and production (Bock, 1986), and between the two (Bock, Dell, Chang, & Onishi, 2007; Branigan, Pickering, & Cleland, 2000; 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 occurs on a *global* basis, that is, it holds 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 being 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).

Both mechanistic and functional explanations for such *global syntactic priming* have been proposed. Pickering and Branigan (1998) present a cognitive model that posits that syntactic structures can be represented as nodes in a spreading activation network. In this account, the use of a syntactic structure temporarily increases the activation of the corresponding syntactic node; that increased activation makes it more likely that the structure will be used subsequently. In another account, Pickering and Garrod (2004) proposed that speakers in communicative settings tend to repeat aspects of each other's utterances in order to achieve what the authors describe as *alignment* of linguistic representations. This alignment included but was not limited to syntactic structures. Under this theory, the alignment of linguistic representations serves to

facilitate alignment of conversational partners' *situation models* – that is, their shared understanding of what is being discussed, and how it should be interpreted in the context of the conversation. The authors argue that the alignment of situation models plays a central role in producing mutual understanding between conversational partners.

However, in one prominent account that is especially relevant to the current research, Chang, Dell, and Bock (2006) present a connectionist model that explains global syntactic priming as coming about 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. Thus, 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 continues

to make the model's language (predicted and produced) 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 not only explain the range of syntactic priming effects in the literature, it can serve a functional role as well. According to a number of theories, learning to use linguistic forms in the same way as one's linguistic community (and one's conversational partner in particular) leads to enhanced communicative efficiency (Jaeger & Snider, 2013, Pickering & Garrod, 2004). Several studies have demonstrated this enhanced efficiency based on conversational partners' use of the same distribution of linguistic forms (Fine & Jaeger, 2013; Jaeger & Snider, 2013). Thus, the recalibration of linguistic knowledge is argued to be beneficial by allowing language users' representations of the distribution of grammatical forms to align with the distribution of grammatical forms of their conversational partners and that of the linguistic community. For example, this process could be especially useful when language users relocate to new linguistic communities that might have different linguistic patterns. If language users are able to produce and comprehend language in the same way as their new linguistic community, then they will maximize their communicative efficiency.

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 be a reflection of 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 conventions that map *emergent event properties* onto particular syntactic structures.

Syntactic entrainment and the tuning of conventions that express emergent properties

As noted, apart from expressing event roles, syntactic structures can also express certain emergent properties that convey more holistic aspects of events. For instance, although both double-object and prepositional dative syntactic structures express the same event roles (*someone transferring something to someone or somewhere*), they also express subtly different meanings. Specifically, the double-object structure expresses 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. If the expression of such emergent properties of events through the use of particular syntactic structures is a conventional aspect of language, then the mappings that underlie such expression are likely to have been learned. Furthermore, as with syntactic priming, the process by which language users learn (and potentially recalibrate) their knowledge of the *emergent event properties* of syntactic structure 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

to 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. It was suggested that syntactic priming reflects such a process for the mapping of event roles onto grammatical functions. Thus, we might expect a similar process to exist for the tuning of knowledge of emergent event properties.

Consider again global syntactic priming. Language users have knowledge that certain sets of event roles can be expressed by certain grammatical functions. In 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, they are more likely to use that same grammatical sequence.

Crucially, global syntactic priming effects are independent of the specific content of sentences. That is, global 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 content, or emergent properties of events, a different kind of repetition needs to be involved. Specifically, rather than a

general repetition of syntactic structure contingent on a particular set of event roles, we need instead to observe the repetition of syntactic structure contingent on particular (emergent) event content.

The experiments reported below test this possibility. In these experiments, subjects were told they were going to play a language game. In each of four rounds there was a prime block followed by a target block. In the prime block, experimental subjects heard an experimenter describe twelve events (depicted as partially colored line drawings). These twelve events could each be described with one of two syntactic structures, and 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 the 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 line-drawing of such an event. Then during the target block, the subject was given the same scene to describe back to the experimenter. If subjects are more likely to use a double-object structure again to describe the scene (relative to another condition where subjects heard a scene described with a prepositional dative, with full counterbalancing across subjects and scenes), it would indicate that when subjects hear particular event content described with a particular structure once, they are likely to map that event content onto that same structure again in their own productions.

We term such a hypothetical effect *syntactic entrainment*, as a specific form of entrainment in general. Entrainment occurs when conversational partners re-use aspects of each other's referring expressions. For example, if one participant in a conversation refers to a particular item of footwear as "a loafer," the other participant is likely to refer to that same item of footwear also as a "loafer" (Brennan & Clark, 1996). This re-use of referring expressions (e.g., "loafer") to refer to the same 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 syntactic entrainment, if observed, cannot be explained as global 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 (different) scenes described with double-object datives and two (other) scenes described with prepositional datives, before describing those same pictures in the target block. Thus, any global syntactic priming effect should be offset, since subjects heard an equal number of opposing structures. 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 global syntactic priming effect.

Note that although we motivate this study as an effort to identify the mechanism that underlies the learning of the mapping of emergent properties (e.g., successful transfer of possession) onto particular structures (e.g., the double-object dative), in the current experiments, we do not investigate the specific sets of emergent properties that have been claimed to be expressed by English structures. For example, we do not measure whether knowledge that “successful transfer of possession” events ought to map onto the double-object dative is recalibrated in this process. Instead, we explore the more general possibility that a mapping between the overall content of an event – the representation of an entire scene – and a particular structure can be strengthened. This would be the first step toward a process that (through ongoing learning over a number of interactions throughout the linguistic community) could lead the language to converge on conventional associations between particular emergent properties of events and particular syntactic structures. That is, with repeated experience hearing successful-transfer-of-possession events described with double-object datives, the idiosyncratic aspects of particular events could hypothetically wash out, and the relevant emergent property in particular would become uniquely associated with the syntactic structure.

Conventions of linguistic communities: partner independence

The observation of syntactic entrainment would be consistent with the possibility that language users continually tune the mappings between aspects of event content (ultimately, honing in on emergent properties) and particular structures. But for syntactic entrainment to reflect the process by which these mappings are

conventionalized, it must be propagated to the entire linguistic community. Thus, when a language user hears a particular mapping, their language system must learn and repeat that mapping in general, not specifically to the current context or conversational partner. That is, the hypothesis that syntactic entrainment reflects the learning of conventions requires that the learning apply to the entire linguistic community – it must be *partner-independent*.

However, other forms of entrainment that have been observed in the literature are not partner-independent. Brennan and Clark (1996), for example, showed that the signature form of entrainment – lexical entrainment – is *partner-specific*. In their study, pairs of subjects played an interactive language game in which they took turns describing objects to each other. Initially, subjects tended to describe objects using basic-level terms (given a general preference for the basic level; Mervis & Rosch, 1981; Rosch, Mervis, Gray, Johnson, and Boyes-Braem, 1976), such as “shoe” or “fish”. Then, in the subsequent block of interaction, additional members of the basic-level category for each picture were included (e.g. a loafer, a sneaker, and a tennis shoe were all included in the same display), which led subjects to use more informative subordinate terms, such as “loafer” or “trout,” thereby allowing the speaker to distinguish the target from the other members of the same category. Then in the final block of interaction, the display no longer included the additional members of the basic-level category. Because only one instance of each basic-level category remained, speakers could in principle revert to the basic level terms they had originally chosen (e.g., “shoe”) as the most suitable referring expressions. Instead,

speakers tended to maintain the more informative labels (e.g., “loafer”) even after the comparison set members were removed. This suggests that speakers choose the words they use to refer to objects based in part on what words were used to refer to those referents previously in the conversation – that is, speakers show lexical entrainment.

Most importantly for present purposes, these lexical entrainment effects held primarily when language users spoke with the same conversational partner with whom the entrained labels were established in the first place, and not when they spoke to a new interlocutor. In their Experiment 3, Brennan and Clark used the same procedure that yielded lexical entrainment effects in Experiments 1 and 2, except in the final round they manipulated whether the subject spoke to the same or to a new conversational partner. They found that subjects used the entrained labels (e.g., “loafer”) significantly less when speaking to a new conversational partner, demonstrating partner-specificity for lexical entrainment.

Brennan and Clark (1996) argue that lexical entrainment displays partner specificity because these effects are a form of *conceptual pact*. Conceptual pacts are tacit agreements between conversational partners about how to conceptualize and refer to real-world referents. According to this theory, conceptual pacts come about implicitly in the course of conversation through a three step process. First, one interlocutor uses a particular referring expression to describe a real-world referent. Second, there is a referential repair phase, in which the other interlocutor may offer a different label for the same referent. If the conversational partners agree on the label immediately this step can be skipped, or, if they do not agree, this step may be

repeated until agreement is reached. Third, the conversational partners agree to the label by reusing the same referring expression. Once agreement is reached, the label becomes entrained for that particular referent. (Note that this process can play out entirely implicitly, in which case the initial label, rephrasing, and ultimate adoption for use in the conversation signifies agreement, or it can play out explicitly, in which case conversational partners explicitly negotiate a label for a referent.) Since this agreement is made between specific conversational partners, it should not hold for other interlocutors who were not involved in the initial process of entrainment. As noted, the evidence is consistent with this interpretation, as lexical entrainment effects exhibit partner specificity (Brennan & Clark, 1996, Experiment 3; Metzinger & Brennan, 2003).

The fact that lexical entrainment is partner-specific demonstrates that language users have a notable capacity to quickly create temporary linguistic conventions on the fly. Critically, however, it suggests that lexical entrainment – at least as it has been observed in the experimental settings contrived by Brennan and Clark (1996) – may not directly reflect the process that underlies the formation of longer-term linguistic conventions for the community at large.

As speculated above, if syntactic entrainment reflects the learning of community-wide conventions for mapping aspects of event content onto particular syntactic structures, then – unlike its conceptual relative lexical entrainment – syntactic entrainment should not be partner specific. Therefore, in the current study, in addition to determining whether entrainment effects exist for syntactic structure, we also test whether the effect is partner specific. If indeed syntactic entrainment does

show partner specificity, that will suggest that it may be a form of conceptual pact, and is less likely to be related to the learning of community-wide conventions that map event content onto syntactic structures. Alternatively, if syntactic entrainment is partner-independent, it would be consistent with the possibility that it reflects the learning and tuning of the conventions governing the mapping of emergent event content onto syntactic structures.

The Present Study

All experiments reported here used the same basic experimental paradigm, described earlier. Experiment 1 aimed to establish the basic syntactic entrainment effect. After hearing a block of pictures described by an experimenter (prime round), subjects described the same pictures back (target round). We measured the structure that 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 the scenes they heard described with prepositional datives), it constitutes evidence for syntactic entrainment.

Experiments 2 and 3 then assessed whether syntactic entrainment is partner-independent. 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, and on the other half of trials, the subject described pictures to a different experimenter. If subjects are less likely to describe events using the same syntactic

structure when speaking to a different experimenter than the same experimenter, then it will demonstrate partner specificity in syntactic entrainment.

Experiment 1

Method

Subjects. Twenty-four undergraduates from the UCSD community participated in the study in exchange for course credit. Three subjects were excluded due to experimenter error. 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 on 80-solar white paper and laminated individually as 4 1/2" x 3 2/3" cards. Three cards were used for an abbreviated practice round, and the remaining forty-eight were used in the experiment. Four experimental decks of these cards were printed. The actions depicted on the cards were divided into three verb/event classes: transitive events (17), dative events (17), and locative events (17). 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 (4) transitive, (4) dative, and (4) 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 sentences corresponding to each event type (transitive, dative, locative). The events depicted on the cards 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 their overall observed frequency in previous studies that used the same materials. The confederate's script was balanced with respect to the preferred and dispreferred structures used 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 occurred 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 it was the job of the matcher to rearrange his or her cards into the order described by the director (adapted from Clark & Wilkes-Gibbs, 1986). Each round consisted of two phases, such that the subject and the confederate could serve 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 phase of each round the

confederate read 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. 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 undergraduate 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. For transitive targets, utterances were coded as either active or passive; dative targets were coded as either double object or prepositional object dative; 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 experimenter error. 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 utterances. 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* in order to ensure convergence. 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 68.1% of trials overall (784 out of 1152 trials). Subjects produced scorable responses 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.

In Experiment 1 we were primarily interested in determining whether subjects would repeat the syntactic structures used by a confederate to describe particular pictures. Such a result would be evidence of what we've termed syntactic entrainment. Indeed, overall, subjects 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 alternative (53.9%), and including prime type in the model significantly improved the model fit ($\chi^2(1) = 13.37, p = .0003$). There were also numerical differences in the prime effect within the different verb classes. 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%), 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 (i.e., the interaction between prime structure and verb type) were not significant ($\chi^2(2) = 1.84, p = .40$). Verb class was excluded from further analyses as it is not relevant to our experimental questions.

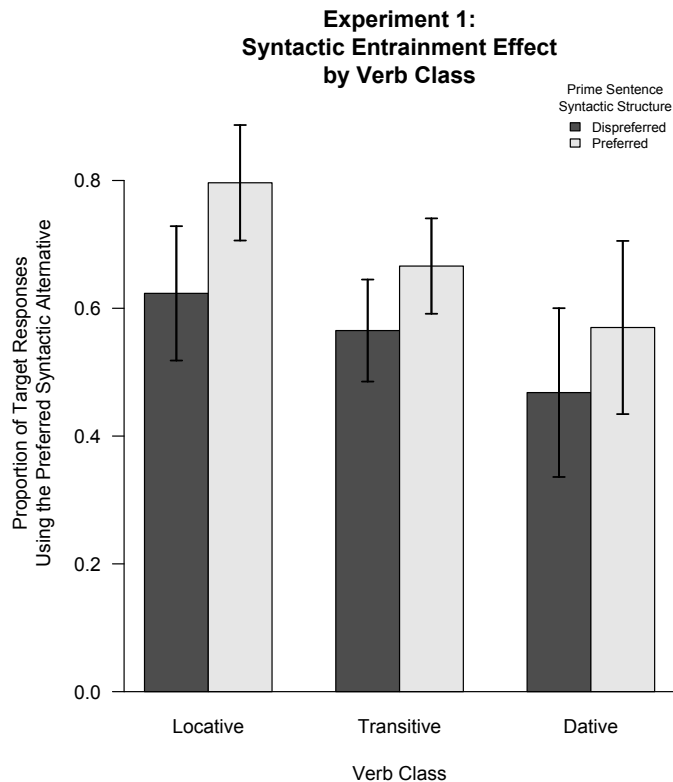


Figure 2.1. Proportion of preferred structure responses by verb class for Experiment 1. For the locative class, the with-variant was considered preferred, for the dative class the prepositional dative was, and for the transitive class it was the active structure.

These results indicate that conversational partners demonstrate syntactic entrainment; when a speaker hears an event described using a particular syntactic structure, they are more likely to use that structure subsequently when describing the same event. In the introduction we suggested that such an effect could reflect the establishment of conventions for the linguistic community regarding how particular event content is mapped to particular syntactic structures. However, in order for this to be the case syntactic entrainment must be partner independent, unlike other forms of

entrainment (e.g. lexical entrainment, discussed earlier). In the next two experiments, we aim to determine whether syntactic entrainment shows signs of partner specificity.

Experiment 2

In Experiment 2 we sought to test the partner independence (or specificity) of the syntactic entrainment effect found in Experiment 1. If we find the effect 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.) Three subjects were excluded due to experimenter error. All subjects reported being native English speakers.

Materials and design. The same basic materials and design of Experiment 1 was used in Experiment 2. However, in Experiment 2 two subjects were tested simultaneously by two experimenters in two similar rooms. The same fifty-one 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. Subjects were also given eight sets of two-digit multiplication problems as part of a cover task.

Procedure. Subjects were tested in pairs by two experimenters in separate rooms. (Note that unlike Experiment 1, subjects' task partners were presented as experimenters, and not confederates.) The experiment consisted of four rounds. In two of the rounds, the subject directed utterances (target descriptions) to the same experimenter that described the pictures to them in the prime phase, and in the other two rounds they directed utterances to a different experimenter. Each *experimenter condition* occurred equally in each round across subjects (i.e., half of subjects spoke to the same experimenter in the first round and half spoke to a different experimenter) in order to control for any possible order effects. Experimenters switched rooms throughout the experiment to maintain the correct partner condition for each subject. In Experiment 2, event type (transitive, dative, and locative) and prime structure (preferred and dispreferred) were balanced both within each round and within the two experimenter conditions.

After every round (i.e., each prime and target round), subjects were given a minute to solve four two-digit multiplication problems, which served to make the changing of experimenters less conspicuous. After handing the subjects the multiplication task, the experimenters left their respective rooms, 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. One subject was excluded from analysis because she or he produced scorable responses on fewer than half of trials. We also performed 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 or dispreferred structure), and experimenter condition (whether the same experimenter administered the prime and target trials, or if the experimenter switched), 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 analyses details were as in Experiment 1.

Results and discussion

Subjects produced scorable responses on 77.1% of trials (3405 out of 4416 trials). Subjects produced scorable responses 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).

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 type significantly improved our

model fit ($\chi^2(1) = 28.49, p < .0001$). Most critically, 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 alternative (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 alternative (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 ($\chi^2(1) = .0761, p = .78$).

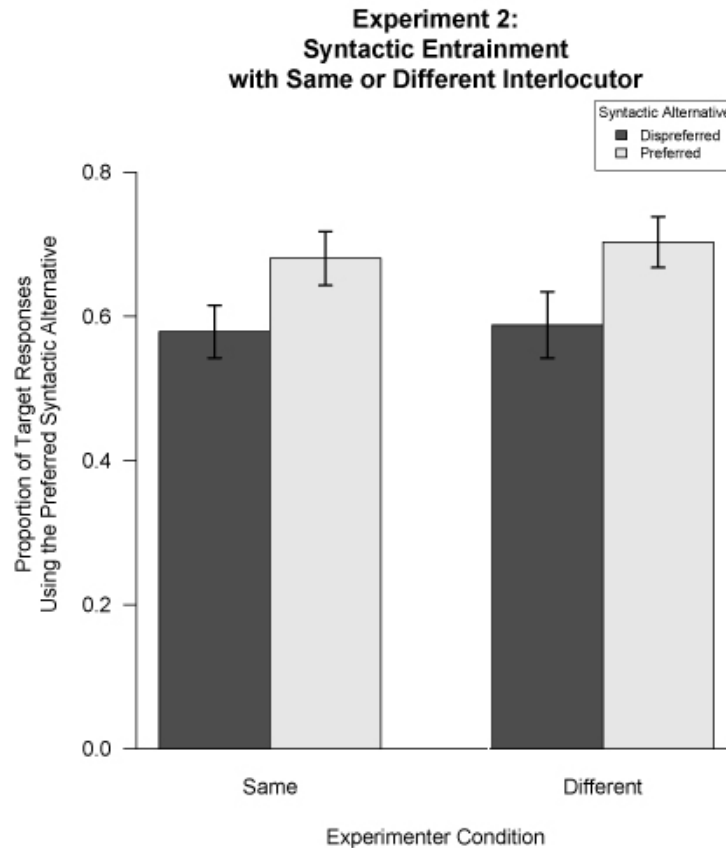


Figure 2.2. Experiment 2, proportion of preferred structure responses by experimenter condition. In the *same experimenter* condition subjects gave target event descriptions to the same experimenter that had described the event originally. In the *different experimenter* condition subjects gave their target event descriptions to a different experimenter from the one that had originally described the event.

Thus, the results of Experiment 2 confirm that the association demonstrated in Experiment 1 was not specific to one's conversational partner. We found that subjects exhibited entrainment of syntactic structure equally when they were speaking to the same or a different partner. This suggests that syntactic entrainment may reflect the process by which emergent properties of events become associated with particular syntactic structures in the language.

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 in order 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 in the opposite direction, with slightly more entrainment with a different interlocutor), in that experiment subjects experienced notably less exposure to their partner's preference, compared with previous demonstrations of partner specificity in entrainment. If subjects are indeed sensitive to their interlocutors' syntactic preferences for particular picture depictions, then they might require more exposure to conclude 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 UCSD community participated in the study in exchange for course credit. All subjects reported being native English speakers.

Materials and design. As in Experiment 2, subjects were tested by two experimenters in two different rooms. However, in Experiment 3, subjects received 4 prime sentences for each event. Due to concerns of time, subject fatigue, and to maintain a similar number of prime and target trials subjects experienced overall, we reduced the number of rounds from four to two, and correspondingly we used only 24 target cards. Subjects were given 18 sets of two-digit multiplication problems as part of a cover task.

Procedure. As in Experiment 2, subjects were tested in pairs by two experimenters in two separate rooms, and the experimenters alternated between subjects for each round. In each prime round the subject was given 12 cards, as in Experiments 1 and 2. However, unlike previous experiments, each prime phase was split into 8 rounds. In each of these rounds, one of the experimenters described 6 of the 12 cards, and the other experimenter described the remaining 6 cards, so that over the course of a prime phase, each picture was described 4 times using the same syntactic structure. In each prime phase, each experimenter always described the same 6 cards, and always used the same structure. The subject's target descriptions were

addressed to one or the other of the experimenters. Thus, half of the target descriptions were spoken to the experimenter who previously described those pictures, and the other half were described to the experimenter who did not previously describe those pictures.

Due to the greater length of the prime phase (8 rounds rather than 1), subjects completed only two rounds of target descriptions rather than four. As in Experiment 2, subjects received (a total of 18) two-digit multiplication problems (8 per prime phase, and another after each target round), each time the experimenters switched rooms.

Scoring and analysis. The same scoring procedure was used as in Experiment 2. Two subjects were excluded from analysis because they produced scorable responses on fewer than half of trials. Analysis for Experiment 3 used the same logistic mixed effects model as in Experiment 2.

Results and Discussion

Subjects produced scorable responses on 85% of trials (1918 out of 2256 trials). Subjects produced scorable responses on 96.1% of transitive 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).

Replicating the result from Experiments 1 and 2, there was a significant overall syntactic entrainment effect across experimenter conditions. Subjects were 23% more likely to produce the preferred structure when primed with the preferred structure (73%) than when primed with the alternative (50%); including prime type significantly improved our model fit ($\chi^2(1) = 29.536, p < .0001$). The numerically larger effect of

prime 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 (which is likely responsible for the larger percentages of scorable responses overall as well).

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%). There was a significant interaction between experimenter condition and prime type, and including the interaction term improved our model fit ($\chi^2(1) = 3.8829, p = .0488$).

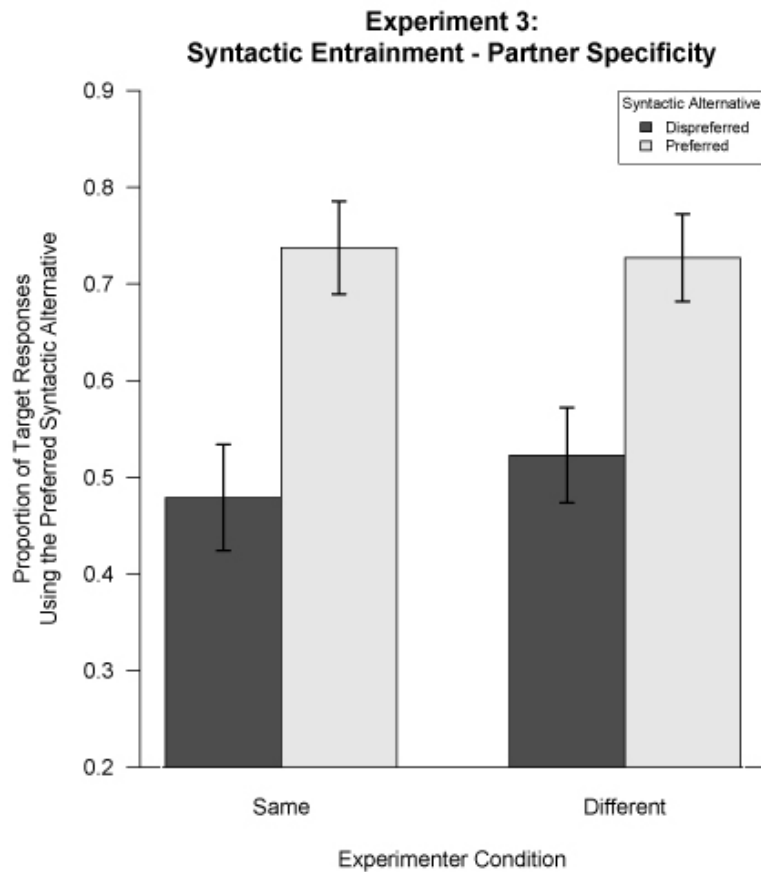


Figure 2.3. Proportion of preferred structure responses by experimenter condition for Experiment 3. In the *same experimenter* condition subjects gave target event descriptions to the same experimenter that had described the event originally. In the *different experimenter* condition subjects gave their target event descriptions to a different experimenter from the one that had originally described the event.

These results indicate that subjects demonstrate a small but significant person-specific effect in addition to a larger effect of prime type that is present regardless of conversational partner. However, some caution is warranted in interpreting the results of Experiment 3 vis a vis 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 can be induced in syntactic entrainment given enough exposure, syntactic entrainment has a much greater partner-independent component than partner-dependent component. We turn now to the implications of these results.

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. This basic effect, demonstrated in Experiment 1, is here termed 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 – but not entirely – partner-independent. Experiment 2 demonstrated that the magnitude of the syntactic entrainment effect was statistically and 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 were given greater exposure to descriptions of each scene, subjects showed greater syntactic entrainment in both the same and different experimenter conditions. However, this increase resulted in a statistically 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). We will first discuss the potential importance of the partner independent syntactic entrainment effect before discussing the implications of the small but statistically significant partner specificity we find in Experiment 3.

Fundamentally, syntactic entrainment appears to reflect a process by which speakers develop associations between the content of sentences and the syntactic structures used to express that content. That is, when a speaker hears an event described with a prepositional dative (e.g. “the coach threw the baseball to the little leaguer”), they are more likely to use the prepositional dative when subsequently describing the same scene. The fact that this effect was observed after (on average) 12 intervening trials suggests that speakers are forming enduring associations between event content and syntactic structures.

We suggest that syntactic entrainment may serve 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), recent evidence is consistent with the possibility that syntactic structures do in fact convey distinctive meaning content about the events they describe (Goldberg, 1995, 2003; Gropen, Pinker, Hollander, Goldberg, and Wilson, 1989; Pinker, 1989). These meanings tend to reflect more holistic aspects of the event, such as the 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 conveys that possession was transferred, as in, “The coach tossed the little leaguer the baseball.” In principle, the same meaning (approximately) can be conveyed using the prepositional dative structure and additional verbiage, as in, “The coach tossed the baseball to the little leaguer and he caught it.” However, since the double object dative uses fewer words, 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”) only awkwardly expresses the same idea. In addition to confirming the transfer-of-possession meaning, the

modified sentence also has a different information structure. That is, certain aspects of the sentence 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 verbiage might be a poor and inefficient 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.

Because syntactic entrainment reflects speakers' propensity to associate particular event content with syntactic structures, the conjecture here is that specific emergent event meanings came to be associated with particular syntactic structures (both for individual speakers and for the linguistic community in general) through a similar process. However, this suggestion is not directly supported by the results of the present study. Here we demonstrated only that speakers develop associations between whole events and syntactic structures; it does not provide direct evidence that syntactic entrainment builds or tunes the associations between syntactic structures and the emergent event meanings that we actually find in languages. For example, transfer events involve specific actors (e.g. a coach and a little leaguer) and specific objects (e.g. a baseball), which are not conveyed by syntactic structures, in addition to the emergent properties of those events (e.g. whether the transfer was successful), which may be conveyed by syntactic structures. Whereas in a particular instance of syntactic

entrainment, a speaker may associate all components of an event with a particular syntactic structure, the associations between syntactic structure and specific meanings ultimately adopted by the linguistic community seem only to involve the emergent properties of events. 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 they spread through a linguistic community, the associations between syntactic structures and event meanings 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 syntactic structures, however, there is a crucial difference between aspects of event meaning that relate to only part of the event (i.e. the constituents of the event), and aspects of event meaning that relate to the event as a whole (i.e. emergent event meanings). Whereas coaches, little leaguers, and baseballs are involved in relatively few transfer events, whether or not a

transfer was successful is relevant to almost 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 constituent, 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) is crucial to 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 be spread 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 honing the linguistic conventions of the entire linguistic community.

Although the current results are compatible with the foregoing interpretation of syntactic entrainment leading to associations between syntactic structures and emergent event features, it is possible that our demonstration of syntactic entrainment does not actually involve the event itself per se. Another possible interpretation is that subjects formed an association between syntactic structures and the low level visual features of the pictures depicting those events. In Chapter 3 of this dissertation, we

investigate specifically whether memory for the picture itself drives the syntactic entrainment effect, or whether the effect is driven by an association with more abstract features of the event (esp. emergent event features). Our research is ultimately aimed at discovering how these associations between event types (with common event semantic features) and particular syntactic structures come to be part of language.

Partner specificity in syntactic entrainment

Although syntactic entrainment appears to be largely a partner-specific effect, the small but reliable partner specific effect observed in Experiment 3 deserves some discussion. Specifically, in Experiment 3, we found that speakers were about 6% more likely to repeat syntactic structures when speaking to the same experimenter (26% effect) than when speaking to a different experimenter (20% effect). Though the difference between the two conditions was small compared to the overall syntactic entrainment effect, it was statistically significant, and may indicate another process at work. One possibility is that this difference is due to lexical entrainment in Experiment 3. In previous demonstrations of lexical entrainment, subjects were given at least 4 exposures (Metzing and Brennan, 2003; Brennan and Clark, 1996). Thus, lexical entrainment may have operated in Experiment 3 – where subjects were given four exposures to each prime sentence, but not in Experiments 1 and 2 – where subjects were given only one exposure to each prime sentence. The presence of lexical entrainment may have made it more likely that subjects repeated sentences verbatim, or that they repeated function words that could uniquely determine their choice of syntactic structure in target sentences. However, a post hoc analysis revealed no

difference in the degree of lexical repetition in the same versus different experimenter condition, nor was there any difference in subjects' lexical repetition in trials where they repeated the experimenter's syntactic structure (i.e. demonstrating syntactic entrainment) compared to trials where they did not repeat the experimenter's syntactic structure. Thus, we have no evidence that lexical entrainment was responsible for the greater entrainment for the same experimenter compared with the different experimenter condition that was observed in Experiment 3.

Another way to explain the partner specificity in our final experiment is that subjects form something like a conceptual pact for the meanings expressed by syntactic structures. Brennan and Clark (1996) describe conceptual pacts as agreements between interlocutors about how they are to refer to objects under discussion in the context of a conversation. These authors argue that these agreements involve particular conceptualizations of the objects under discussion. For example, although *couch* and *divan* may both be used to refer to many of the same items of furniture, they convey slightly different meanings, which may be more or less appropriate depending on what aspects of the object are deemed important by the conversational partners. If in fact syntactic structures convey emergent event meanings, it is possible that the partner specific effect observed in Experiment 3 was due to a similar agreement between conversational partners about what emergent event meaning (i.e. what syntactic structure) ought to be used to describe the specific events they were asked to describe. For example, if the subject observed the experimenter consistently referring to a particular event depiction with the double object dative, they

may assume that the experimenter considers the successful transfer of possession meaning to be important to the conceptualization of the specific scene that was depicted in the experiment. And so, the subject may be relatively more likely to use the double object to describe that event in subsequent utterances when speaking to the same experimenter with whom they formed the conceptual pact, than when speaking to another experimenter. The fact that the partner specific effect in syntactic entrainment is relatively small when compared to that of lexical entrainment may be due to the fact that emergent event meanings are a comparatively small part of what syntactic structures convey. That is, syntactic structures seem to primarily express relational information (who did what to whom in the sentence), and emergent event meanings can be seen as a somewhat secondary function. Meanwhile, lexical items convey comparatively less relational information, and the expression of conceptual meaning can be seen as their primary expressive role in language.

Concluding Remarks

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 12 intervening trials, and the fact that it was present after only a single exposure (as seen in Experiment 1 and 2), 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.

Chapter 2, in part, is currently being prepared for submission for publication of the material. Gruberg, N., Ostrand, R., & Ferreira, V. S. Syntactic entrainment: The repetition of syntactic structures in event. The dissertation author was the primary investigator and author of this paper.

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CHAPTER 3:

SPEAKERS ASSOCIATE SYNTACTIC STRUCTURES WITH ABSTRACT
EVENT MEANINGS

In language, a particular event can often be described with multiple sentence types. For example, the sentence, “The queen passed her handmaiden the sceptre” describes the same basic event as, “The queen passed the sceptre to her handmaiden.” Sentence forms such as these that vary minimally in structure and express the same basic meaning are often termed *syntactic alternations*. Syntactic alternations are ubiquitous within languages (Levin, 1993), as well as across the world’s languages (Levin, 2008; 2011). The existence of such alternations poses an interesting puzzle for the study of language and how people produce it: Why do languages offer speakers different ways of describing essentially the same event?

Attempts to formally explain the nature of syntactic alternations lies at the core of most syntactic theory since the middle of the twentieth century. In Chomsky’s (1957) seminal theoretical account of syntax, he proposed that syntactic alternations are actually alternative surface manifestations of the same *underlying terminal string*, which is often termed a sentence’s *deep structure*. Chomsky posited that one of the members of each syntactic alternation was primary, and that the other was formed by the application of a *grammatical transformation* that involved moving linguistic elements from their deep structure positions, in order to satisfy certain well-formedness principles of language. For example, in his theory, *active* sentences correspond to the deep structure of the *transitive* alternation. The *passive* transformation involves first a change in the predicate verb (V -> is + V + en + by), and then movement of the constituents from their positions in the deep structure to the positions corresponding to the passive sentence (e.g., *[the boy] bites [the girl]* ->

[The girl] is bit-ten by [the boy]). According to this account, active and passive sentences (or any two members of a structural alternation) convey the same propositional content, despite their superficial differences. However, the question of why language would include this seemingly unnecessary complication at all is outside the scope of Chomsky's theory of syntax.

Subsequently, psycholinguistic theories proposed that syntactic alternations may exist in order to facilitate the efficient production of sentences. In particular, Bock (1982) proposed that by giving speakers options, syntactic alternations allow them to better manage the information-processing challenges involved in sentence production. For example, sentence production must occur in tandem with lexical retrieval. To convey propositional content, speakers cannot just produce haphazard sequences of words; they must retrieve those words in grammatically permissible sequences to produce well-formed sentences. However, speakers might find certain constituents of sentences easier to retrieve than others. Thus, they may select syntactic structures that allow them to produce more easily retrieved constituents earlier, affording them more time to retrieve difficult to retrieve constituents. For example, if a speaker wanted to express the meaning, *the unstable man wearing the red fedora bit the dog*, she or he could use the passive structure, which would allow "the dog" to be uttered first, affording the speaker more time to process what is likely the more difficult phrase, "the unstable man wearing the red fedora." Accordingly, several studies have shown that speakers tend to select syntactic structures that allow earlier production of constituents that are more accessible due to *lexical accessibility* (the

ease with which representations of word forms are retrieved from memory; for review see, Bock, 1982), *conceptual accessibility* or *imageability* (the ease with which an image of the constituent is brought to mind; Bock & Warren, 1985), animacy (Bock, Loebell, and Morey, 1992; Branigan, Pickering, and Tanaka, 2008), salience within the discourse context (Prat-Sala & Branigan, 2000) or the length of constituents (Kimball, 1973; Stallings, MacDonald, & O'Seaghdha, 1998). According to this account, as in Chomsky's account, the members of syntactic alternations are relatively interchangeable (in the absence of other processing limitations), and their function is to provide the processing benefits that accrue from having more expressive options.

It is important to note that the alternative forms of an alternation have long been considered to convey some distinct content. In particular, the *information structure* (Chafe, 1976; Lambrecht, 1994) of a sentence varies based on the order of constituents in sentences. For example, referents that are already known or *given information* may be distinguished from referents that are *new* contributions to the discourse. In general, speakers of language tend to phrase their sentences such that given information is mentioned before new information. Different word orders can also convey different degrees of foregrounding or backgrounding of information. However, it is worth noting that such information-structure effects generally do not have truth-conditional consequences. For example, violations of given-new ordering may be dispreferred, but they are neither ungrammatical nor false, and these preferences are not related to propositional content per se. Thus, although syntactic

alternations may convey distinct information structures, they do not necessarily convey different propositional content to an addressee.

However, other more recent analyses suggest that syntactic alternations may in fact convey different aspects of the meanings of events. One source of evidence of these differences is that certain events permit description by one member of a syntactic alternation but not the other. For example, to describe events that involve the transfer of an object from one location or possessor to another, speakers can often use either a double-object dative structure (e.g., “The queen tossed her handmaiden the sceptre”) or a prepositional dative structure (e.g., “The queen tossed the sceptre to her handmaiden”). However, transfer events in which the destination cannot take possession of the object (e.g., if the destination is inanimate) cannot be described with both structures. Such events can be described with prepositional dative sentences, as in, “The queen tossed the sceptre to the desk”, but cannot be described with double-object dative sentences, as in, “*The handmaiden tossed the desk the sceptre.” According to some analyses (Goldberg, 1996; Pinker, 1989), this restriction is due to the fact that syntactic structures convey specific types of meaning content. Specifically, the use of the double-object structure implies that an object was successfully transferred to a new possessor (thus barring inanimate objects from the role of recipient), whereas the prepositional dative only implies that the object was transferred to a new location.

If indeed particular syntactic structures convey particular meanings, it would suggest an additional purpose for syntactic alternations apart from helping to manage

the burdens of sentence production. Specifically, speakers may be able to more parsimoniously express their intended meanings by conveying certain aspects of that meaning through their selection of syntactic structures rather than by producing additional words. In the current study, we aim to address the viability of a particular explanation for how syntactic structures (or *constructions*) might come to acquire the specific aspects of event meaning that they express within a linguistic community and for individual language users.

One recent study has suggested that associations between syntactic structures and particular meaning content may be conventionalized, learned, and fine-tuned by mechanisms that underlie a newly discovered effect, *syntactic entrainment* (see Chapter 2 of this dissertation). Specifically, Gruberg and colleagues demonstrated that subjects come to associate particular events with the particular syntactic structures with which they've heard those events described. In that study, experimenters described 48 scenes to participants in blocks of 12. Each block of scenes depicted 4 dative, 4 locative, and 4 transitive events. The experimenter used an equal number of each syntactic alternation when describing each type of event (e.g., in each block two transitive events were described with active structures, and two with passive structures). After hearing a block of scene descriptions, subjects then described the same scenes back to the experimenter. Results showed that subjects were more likely to use the same syntactic structures in their scene descriptions as were used by the experimenter for each same scene, although their overall experience with each alternation was balanced with respect to syntactic structures. In analogy to lexical

entrainment (a similar effect for object descriptions, see Clark & Wilkes-Gibbs, 1986; Brennan and Clark, 1996), the authors described this effect as *syntactic entrainment*. The effect was shown to be enduring (lasting over an average of 12 intervening trials), and it applied whether the subject was speaking to the same or a different interlocutor.

According to Gruberg and colleagues, this result suggests a mechanism by which particular meanings can come to be associated with syntactic structures. Specifically, they suggest that the process of syntactic entrainment could – over successive iterations across the linguistic community – refine the associations between syntactic structures and event meanings down to the features of events that we actually see conventionalized in language. Such a process of refinement would require that syntactic entrainment apply not only to events as a whole, but to the specific features of events. For example, if a language user associated a particular instance of a successful transfer event with the double object dative, as in, “the coach threw the little-leaguer the baseball,” they might strengthen the associations between that structure and the features of that event, such as *coaches*, *little-leaguers*, and *baseballs*, and *successful transfer of possession*. Thus, when they subsequently describe events that possess any of those features, they would be more likely to use the double object structure. However, most transfer events that language users hear described will not involve certain idiosyncratic features of particular events – such as coaches, baseballs, and little leaguers – whereas features that are more generally applicable to transfer events – such as whether an event resulted in a successful transfer of possession – could be a part of almost any transfer event in their linguistic input. Therefore, if

syntactic entrainment is iterated over many interactions within the linguistic community, the associations between syntactic structures and the features that apply narrowly to specific events would likely not become significantly strengthened, whereas the associations between syntactic structures and features that apply more generally to many or all transfer events would be more readily available to become strengthened. Then, as (for example) the double object dative structure comes to convey the transfer-of-possession meaning within the linguistic community, language users will be more likely to hear events that result in the successful transfer of possession described with the double object (rather than the prepositional dative structure). This would lead to the continual strengthening of the association between the double object structure and transfer of possession as a convention within the linguistic community, and could facilitate the learning of this association by language learners. This account parallels a theoretical point of view that suggests that a different type of priming effect, *syntactic priming* (Bock, 1986), might reflect a mechanism whereby people come to learn to express sets of abstract event roles with particular syntactic structures (Chang, Dell, and Bock, 2006).

However, the results of the Gruberg et al. (2017) study do not provide evidence that syntactic entrainment applies to the kinds of abstract features of events that are conveyed by syntactic structures in natural language. The results of that study demonstrated only that specific event depictions were associated with syntactic structures. It may have been that subjects in that study were simply creating associations between syntactic structures and memory representations of the specific

visual content, or something else unique to the event depictions. If syntactic entrainment is in fact responsible for the conventionalization of the associations between syntactic structures and particular meaning content we observe in natural language, then the process must involve more than just the demonstrated associations with specific event depictions. Instead, syntactic entrainment must be able to involve associations with the kinds of abstract event features that are conventionally conveyed by syntactic structures in language. In the current study, we test whether the syntactic entrainment effect demonstrated by Gruberg et al. (2017) involves an association between syntactic structure and more abstract features of event meaning.

In Experiment 1, we test whether the associations reflected in the syntactic entrainment effect apply not only to specific depictions of events, but also to visually distinct depictions of similar events with the same sets of abstract event features. For this manipulation, 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 they could be appropriately described with the same sentence. If syntactic entrainment is found between two different depictions of events with similar sets of event features, it would suggest that the association reflected in syntactic entrainment applies not to specific depictions of events, but to something more abstract about those events.

In order to provide further evidence that syntactic entrainment may be responsible for the meanings associated with syntactic structures, in Experiment 2 we aimed to test whether the effect can apply specifically to abstract event features that

are similar to those that are actually associated with syntactic structures in natural language. For the purpose of this study, we used the event semantic features that Pinker and colleagues (Pinker, 1989; Gropen, Pinker, Hollander, Goldberg, and Wilson, 1989) have used to divide events into what they call *narrow conflation classes*. Crucially, events within narrow conflation classes share syntactic usage restrictions, suggesting that associations may exist between syntactic structures and the event semantic features that define these categories. Furthermore, these categories are defined by fairly specific event semantic features, which draw distinctions between various kinds of events within the same broad category. For example, one class of *transfer events* involves “the instantaneous causation of ballistic motion” (a narrow conflation class), which can be described with verbs such as *throw* and *toss* (Gropen, Pinker, Hollander, Goldberg, and Wilson, 1989). Such events allow both the double-object and prepositional dative constructions, as in, “The coach threw the little-leaguer the baseball,” and “The coach threw the baseball to the little-leaguer.” Another class of transfer events involves, “continuous causation of accompanied motion,” which can be described with verbs such as *pull* and *push* (Gropen et al., 1989). Such events allow the prepositional dative structure (“the boy pulled the box to the girl”), but prohibit the double-object structure (*“The boy pulled the girl the box”); though for a different view on these restrictions, see Bresnan & Nikitina, 2003, 2009). These narrow conflation classes may provide a principled way to test associations between syntactic structures and particular event semantic features. Specifically, finding that the syntactic entrainment effect reflects associations with the features of narrow

conflation classes would provide further support for the theory that syntactic entrainment may be part of the mechanism responsible for conventionalizing the associations between syntactic structures and the event semantic meanings that we find in natural language.

Accordingly, in Experiment 2, we tested whether the syntactic entrainment effect applies not only to abstract representations of particular events (as tested in Experiment 1), but also to categories of events defined by the kinds of event semantic features outlined by Pinker and colleagues. To test this, we used a similar paradigm as the one in Experiment 1. Again subjects heard blocks of 12 scenes described by an experimenter. However, in this experiment, subjects were exposed to two conditions within each block. In one (*homogeneous*) condition, subjects heard descriptions of 4 events from the same narrow conflation class that allowed description by a particular syntactic alternation (in this experiment, either the dative or the locative alternation). In the other (*heterogeneous*) condition, subjects heard descriptions of 4 events from 4 distinct narrow conflation classes. In both the homogeneous condition and the heterogeneous condition, the experimenter's descriptions were balanced with respect to the two syntactic structures of the alternation. For example, in the homogeneous condition, subjects heard descriptions of four "throwing"-type events – two using the double object structure, and two using the prepositional dative structure; in the heterogeneous condition, subjects heard descriptions of one "throwing"-type event, one "handing"-type event, one "showing"-type event, and one "reading"-type event

(see appendix for a complete list of event categories) – two using the double object, and two using the prepositional dative.

If the abstract event features corresponding to (for example) “throwing”-type events participate in the association that forms the basis of the syntactic entrainment effect, then in homogeneous blocks subjects will tend to associate the *throwing* feature equally with both members of the syntactic alternation. Meanwhile, in heterogeneous blocks subjects will associate the throwing feature with a single syntactic structure (whichever was used to describe that event) – although subjects heard the opposite syntactic structure in the same block, it was in descriptions of events that did not have the throwing-feature. Thus, if the types of abstract event features that correspond to narrow conflation classes participate in syntactic entrainment, the effect should be diminished in homogeneous blocks relative to heterogeneous blocks.

Experiment 1

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 demonstrated by Gruberg et al. (2017), but also when describing a different depiction of that same event. Such a result would suggest that the syntactic entrainment effect may reflect 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 the study in exchange for course credit. All subjects reported being native English speakers.

Materials and design. Ninety-nine line-drawn pictures were used in this experiment. The line drawings were partially colored to highlight task-relevant aspects of the scenes, and were printed on 80-solar white paper and laminated individually as 4 1/2" X 3 2/3" cards. 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. We allowed the artist who drew the drawings 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.

Each of the paired event depictions (consisting of an A and a B version) could be described with one of three syntactic alternations: transitive events (16), dative events (16), and locative events (16). These 48 events appeared in 4 blocks of 12 events each. The events depicted on the cards could be described using two alternative syntactic structures. We categorized alternants into *preferred* (active transitive, double object dative, and on-variant locative) and *dispreferred* structures (passive

transitive, prepositional object dative, and with-variant locative) on the basis of their observed frequency in previous studies conducted with the same materials, so that they could be collapsed in the final analyses. For the experimental task, two lists of 48 picture descriptions were constructed. Each list contained 16 sentences corresponding to each event type (transitive, dative, locative), which the experimenter read as prime sentences over the course of the experiment.

Participants were seated across from the experimenter 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. Both the participant and the experimenter had printed arrays of 12 rectangles in their workspace where the experimenter placed their cards at the beginning of each round. The sessions were recorded using a digital audio-recorder.

Procedure. The cover task was that the participant and experimenter were playing a collaborative picture-matching game. Players alternated between two roles in the game, the *director* and the *matcher* (terminology and task adapted from Clark & Wilkes-Gibbs, 1986). 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 it was the job of the matcher to rearrange his or her cards into the order described by the director. Each block began with a prime round where the experimenter acting as the director described 12 events, which were read from the experimental list (though experimenters were instructed to appear to be offering spontaneous descriptions), and the participant acted as matcher. Next, in the target round, the experimenter acted as the matcher, and the subject acted as the director and described a new set of 12 cards. These cards depicted the same 12

events described by the experimenter, though they were arranged in a different order; 6 of the cards (two from each syntactic alternation) were modified versions of the original events (Version B), and 6 (the other two from each syntactic alternation) were identical depictions of the original event (Version A). This concluded one block of the experiment. The experiment consisted of four blocks, each with a different set of 12 events.

Scoring and analysis. Audio recordings of the sessions were transcribed by trained undergraduate research assistants. Each sentence was then coded for its syntactic structure. Target sentences that did not conform to the intended syntactic alternation, or that were not interchangeable with either form of the syntactic alternation (e.g., the verb “put” allows the “in”-variant locative, but not the “with”-variant) were excluded from the final analyses. Transitive target utterances were coded as either active or passive; dative targets were coded as either double object or prepositional object dative; locative targets were coded as either “with”-variant or “on”-variant. Target sentences that did not fall into these categories were marked as unscorable.

We used R (R Core Team, 2014) and *lme4* (Bates, Maechler, Bolker, & Walker, 2014) to perform mixed effects logistic regression analyses. Prime type (preferred or dispreferred structure), target event type (whether the target event depiction was the same as or different from the one described by the experimenter), and their interaction (prime type X target event type) 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, event type, and the interaction between prime type and event type. We tested the main effect of the confederate's prime syntactic structure on the subject's target utterances, and the interaction of the confederate's prime structure and the target event type, obtaining *p*-values by using likelihood ratio tests comparing the full model against the model with the fixed effects in question removed.

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 ($\chi^2(1) = 28.97, p < .001$).

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 modified 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 ($\chi^2(1) = 0.073, p = .79$).

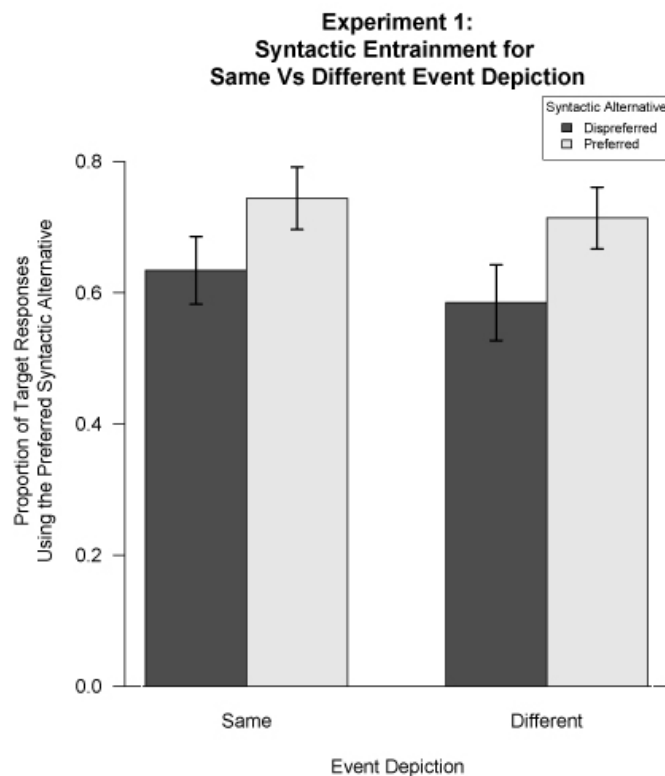


Figure 3.1. Proportion of preferred structure responses for target descriptions in which subjects either described the same or a different depiction of an event.

This result demonstrates that 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 the more abstract event features that underlie the described events.

Experiment 2

Gruberg et al. (2017) showed that language users learn associations between syntactic structures and particular event depictions. Experiment 1 of the current study refined this finding to show that language users learn associations between syntactic structures and the abstract features of events, rather than the depictions of events themselves. In Experiment 2, we aim to test whether syntactic entrainment can target individual event semantic features of the kind that we see associated with syntactic structures in natural language. Specifically, we test whether the event semantic features that Pinker and colleagues use to define their narrow conflation classes – which are associated with particular syntactic structures but not others – can be involved in the associations reflected in the syntactic entrainment effect. Such a result would provide converging evidence that syntactic entrainment could be part of the process of conventionalizing the associations between syntactic structures and particular event meanings that we observe in natural language.

To test this hypothesis, Experiment 2 follows a similar logic as demonstrations of semantic interference effects (Abdel Rahman & Melinger, 2007). In such studies, subjects name pictures of objects and their reaction times are measured. If those

objects are semantically related (either categorically or associatively), then subjects show longer naming latencies. Based on such results it has been proposed that the semantic system may be organized according to semantic categories, and thus naming blocks of semantically homogeneous objects causes interference, which is not present when naming blocks of event depictions from distinct event semantic categories. In Experiment 2, we adopted an analogous logic, but for semantically related events. Specifically, we tested whether naming blocks of events from the same narrow conflation class will cause interference in the syntactic entrainment effect. If so, it suggests that syntactic entrainment involves associations between syntactic structures and the type of abstract event semantic features that can apply to larger categories of events.

Note that this logic assumes that the syntactic entrainment effect and the associations that it reflects are sensitive to cumulative experience. There is some evidence that this is indeed the case. In Gruberg et al. (2017, Experiment 3), subjects demonstrated a much larger (23%) syntactic entrainment effect when they heard four instances of the same event description than in other experiments where they only heard a single event description (around a 10% effect). Although subjects in Gruberg et al. (2017, Experiment 3) showed an increase in the syntactic entrainment effect through repeated experience of the pairing of particular event depictions with the same syntactic structures, it is possible that such cumulative experience could also lead to interference if that experience were contradictory (e.g., the pairing of a particular event depiction with different syntactic structures).

The basic design of Experiment 2 was similar to Experiment 1. In each round, the experimenter described four dative, four locative, and four transitive events. However, since the transitive event depictions in our materials did not form coherent narrow conflation classes, they were used as filler trials. As in Experiment 1, the four dative and four locative events were described equally with each syntactic alternant (e.g., two double object and two prepositional dative structures). The key manipulation was whether the four events in the round all possessed features consistent with a particular narrow conflation class (e.g., “Verbs of instantaneous causation of ballistic motion,” like *throw* and *kick*), or if they were each unique with respect to these features. If syntactic entrainment applies to these types of abstract event features, then we expect subjects to show a smaller syntactic entrainment effect in blocks where they heard multiple events that possessed features that were consistent with a particular narrow conflation class, compared to when each event was unique with respect to its narrow conflation class. On the other hand, if syntactic entrainment does not apply to such features, then we expect to see the same magnitude effect whether there were multiple members of the same narrow conflation class within the block, or if each event was unique in its narrow conflation class.

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 2. 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 narrow conflation classes 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, 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

possessed features consistent with a single narrow conflation class (homogeneous condition), or if they were each unique within their narrow conflation class (heterogeneous condition). Accordingly, in each block, either the dative or the locative events were from the same narrow conflation class, whereas each event from the other syntactic alternation was unique in its narrow conflation class.

Procedure. The same basic procedure was used as in Experiment 1. In Experiment 2 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 mixed effects logistic regression 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 (homogeneous or heterogeneous 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); for locative targets they did so 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%), but including prime type in the model did not improve the model fit ($\chi^2(1) = 1.79, p = .18$).

For the effect of homogeneity, speakers showed an 8.6% greater effect on trials where the target was unique in its event semantic class, than on trials where there were other targets from the same narrow conflation class within the same round. On trials where the target was unique in its narrow conflation class, 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 where the target was not unique in its narrow conflation class, 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 homogeneous and heterogeneous conditions was not

statistically significant, and including the interaction term (prime type X homogeneity) did not improve our model fit ($\chi^2(1) = .1507, p = .698$).

Although this interaction did not reach significance, the fact that the numerical difference was so large led us to conduct a supplemental analysis of the data. We chose to do a resampling analysis of the data to determine how likely it was that the difference between the homogeneous and heterogeneous conditions was due to chance. Resampling analyses are non-parametric tests that randomly re-assign target trial outcomes across experimental conditions in a large number of iterations. By measuring how often this reassignment of trials resulted in larger effect sizes than those observed in the original experiment, the resulting analyses yield a non-parametric estimate of the probability that the observed effect occurred by chance. Unlike mixed effects models, these tests must be conducted using either subjects or items as aggregating units (such that random reassignment is conducted within subject or within item). Thus, we report the probabilities from our resampling analyses along with the test values from repeated measures ANOVAs.

In the repeated measures ANOVA and resampling analysis, we did find evidence of significant effects in the main effect of prime condition, and marginally significant effects in the interaction of prime condition and confusability when averaging across subjects. However these effects were not consistent across items. Overall, speakers were 5.0% more likely to produce the preferred syntactic structure when primed with the preferred structure (75%) than when primed with the alternative, (70%; $F(1, 47) = 5.53, p = .029; p < .024$ by resampling analysis; $F(1,$

44) = .81, $p = .374$; $p < .033$ by resampling analysis). Speakers showed a 8.6% greater effect on trials where the target was unique in its event semantic class (10.4% effect), than when there were other targets from the same event semantic category within the same round, (1.8% effect; $F(1, 47) = 3.03$, $p = .089$; $p < .052$, by resampling analysis; $F(1, 44) = .045$, $p = .833$; $p < .455$, by resampling analysis).

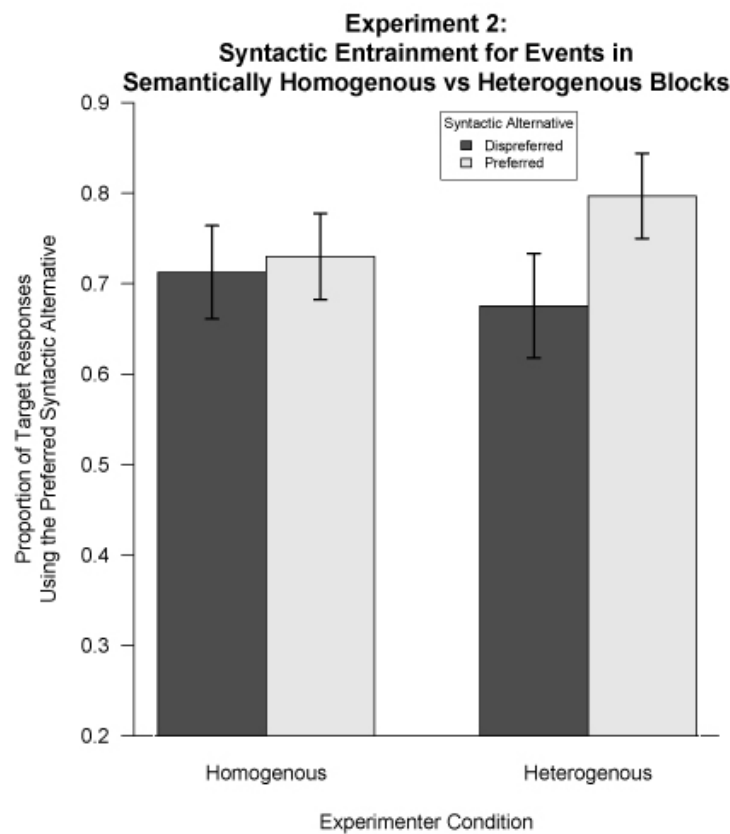


Figure 3.2. Proportion of preferred structure responses for target descriptions of events that were either in homogeneous blocks (4 event semantically similar depictions).

In Experiment 2 we found a marginally significant interaction effect (of confusability X prime type) when averaging over subjects. However, this effect was

not consistent across items, and thus our F2 analyses and the overall mixed models did not confirm the significance of the effect. There are two plausible explanations for why the effect of confusability was marginally significant across subjects but was not consistent across items.

First, due to counterbalancing issues, one third of items were seen by every subject, and thus had a maximum of 12 observations per condition (prime type X homogeneity), whereas two thirds of items were each seen by half of subjects, and thus had a maximum of only 6 observations per cell. This may have increased variability within items, making them worse predictors of any actual effect that may have been present. Due to these counterbalancing issues with the current study, in planned follow-up studies in our lab we will increase the number of experimental card sets from 4 to 12. By increasing the number of experimental card sets, we will be able to maintain the same number of observations in each cell of our analyses. Our aim in running the modified version of the experiment is to decrease the variability within items, which we suspect may have been affecting our statistical analyses.

Secondly, there were inherent differences between the narrow conflation classes, which may also have increased variability between items. This variability seems to be inherent to the narrow conflation classes; events in certain narrow conflation classes are extremely similar, whereas events in other narrow conflation classes are much more distinct. In our experimental stimuli, for example, all events in the “reading” class were extremely similar (i.e., in each event, one person is reading to another person or group of people), whereas events in the “sprinkle” class were

relatively more diverse (e.g., “god sprinkling the people with rain,” “man drizzling nachos with cheese,” “farm worker scattering seeds in a field,” “man scattering the bed with rose petals”). These differences may have introduced additional variability between items in the various event categories.

Therefore, we cautiously interpret the results from Experiment 2 as suggesting that there may be an effect of homogeneity, adding that follow-up studies are required to confirm this finding. For the sake of avoiding monotonous repetition of caveats, below we discuss the interaction with homogeneity as if it were a certain effect, but we explicitly acknowledge that such certainty does not follow from the current dataset.

General Discussion

The two experiments reported here demonstrate two primary findings. First, the syntactic entrainment effect demonstrated by Gruberg et al. (2017), in which subjects used the same syntactic structures as an experimenter when describing the same event depictions, also applies to visually distinct depictions of those events. This result suggests that syntactic entrainment involves associations between syntactic structures and features of events that are more abstract than their visual depictions. Second, subjects showed a smaller syntactic entrainment effect when they heard descriptions of multiple events from the same event-semantic category (i.e., Pinker’s narrow conflation classes) within a block of trials. In line with earlier studies of semantic interference, we interpret this result as suggesting that the syntactic

entrainment effect involves associations with the semantic features that those events share.

Along with the consistent observation that the syntactic entrainment effect appears to be long lasting – we observed the effect after, on average, 12 intervening trials – these results suggest that such effects reflect the operation of mechanisms that are well positioned to explain how language users learn certain conventional associations between syntactic structures and meaning content observed in natural language. In support of such a view, Gruberg et al. (2017) showed that syntactic entrainment was partner independent. That is, after speakers were syntactically entrained with a particular association between a syntactic structure and an event, they were more likely to use that syntactic structure when subsequently describing the event regardless of whether the subject spoke to the same or a different interlocutor. This finding suggests that the syntactic entrainment effect could reflect the mechanism by which associations between syntactic structures and particular meaning content are spread, partner-independently, throughout the linguistic community.

In general, at least two types of meaning content have been reported to be associated with syntactic structures in natural language. First, whether events can be described with particular syntactic structures seems to be partially based on their membership in narrow conflation classes (Pinker, 1989). Thus, it is plausible that the event features that define narrow conflation classes have associations with certain syntactic structures (e.g., the “push”-class is associated with the prepositional dative structure) and not others (e.g., the “push”-class is not associated with the double object

structure). The fact that we provide evidence consistent with the possibility that syntactic entrainment may participate in associations between syntactic structures and these kinds of event features (Experiment 2) suggests a possible mechanism by which the corresponding syntactic restrictions associated with narrow conflation classes may be conventionalized in language. Specifically, when language users hear events of a particular class described with a particular syntactic structure, they may strengthen an association between that structure and the event features that define that category. Furthermore, and in a manner analogous to error-based theories of lexical selection (e.g., Oppenheim, Dell, & Schwartz, 2010), when particular event classes are experienced as having been expressed with one syntactic structure, the system can also decrease associations between the relevant event features and other, unselected syntactic structures. Over successive iterations, such a process could lead certain event categories to develop preferences for one member of a syntactic alternation, as well as to prohibitions on expressing those meanings with other syntactic structures. For example, upon hearing an event involving transfer by the *continuous causation of accompanied motion* (e.g., a pushing event) described with a prepositional dative structure, learning mechanisms may strengthen associations between the relevant event features and the prepositional dative, increasing the preference for using prepositional datives to describe such events in the future; meanwhile, learning mechanisms can also weaken associations between the relevant event features and the unselected double-object structure, potentially leading to prohibitions on using the

double-object with such event features in the future, which is what we observe for such events in English.

A second type of meaning content that is associated with syntactic structures in natural language seems to be directly conveyed by the use of particular syntactic structures. For example, the double object dative seems to convey the *transfer of possession* meaning (Goldberg, 1995). Although we did not directly test associations between these aspects of event meaning and syntactic structures in the current study, these meanings seem to be closely related to the event features that correspond to particular narrow conflation classes, which were tested in Experiment 2. Specifically, Pinker (1989) observes that if the event semantic definition of a narrow conflation class is highly compatible with the meaning expressed by a syntactic structure it is likely that the structure can be used to describe events of that class. For example, the narrow conflation class of transfer events involving inherent acts of giving, (e.g., events that can be described by verb like *give* and *hand*) is highly compatible with the transfer of possession meaning, which is expressed by the double object structure, and can therefore be described with sentences using that structure. In general, there seems to be a strong correlation between the meanings expressed by syntactic structures and the syntactic restrictions associated with particular narrow conflation classes. According to Pinker (1989) this correlation is a direct consequence of the logical compatibility between the two types of meaning. Accordingly, that theory posits that language learners are able to exploit innate knowledge of how particular types of event meanings are logically related to the meanings associated with syntactic structures –

what he describes as *cognitive construability* – in order to determine syntactic restrictions.

On the other hand, we suggest that both the syntactic restrictions on narrow conflation classes as well as the meanings expressed by certain syntactic structures could be explained by the same mechanism reflected in the syntactic entrainment effect. According to our theory, in general, associations between syntactic structures and meaning content can be formed by experience through the mechanism reflected in the syntactic entrainment effect. Above we argued that this process could give rise to the syntactic restrictions on narrow conflation classes, but, by assuming a simple associative learning mechanism, this process could also apply to the meanings conveyed by syntactic structures. For example, if a language user hears an event with the transfer of possession feature described with the double object dative, they may strengthen the connection between the double object structure and the transfer of possession feature. (As noted earlier, under this theory, other idiosyncratic aspects of the event may become associated with the double object structure as well, however, since those features would only infrequently be part of transfer events in general, their association with the double object would not be as readily available to be strengthened). Subsequently, speakers would be more likely to describe events that include the transfer of possession feature with the double object structure, which could ultimately lead to the conventional association of that meaning feature with that syntactic structure.

Such an account does not require any additional assumptions regarding language learners' knowledge of the logical compatibility between the meanings expressed by syntactic structures and the event semantic definitions of narrow conflation classes to account for the observed correlation between them – as Pinker's (1989) theory does. Namely, since events in certain narrow conflation classes (e.g., “give”-type events) may be more likely to include the transfer of possession feature than events in other narrow conflation classes (e.g., “push”-type events), the positively-associated narrow conflation classes will be more likely to be described with the double object structure, which expresses that meaning. Accordingly, such narrow conflation classes are more likely to have their association with the double object structure strengthened, whereas narrow conflation classes whose members tend not to possess the transfer of possession feature will be less likely to have this association strengthened, which could lead to the observed restrictions on the double object structure for “push”-type events. Crucially, the narrow conflation classes whose meanings are more compatible with the transfer of possession meaning will, naturally, be more likely to represent events that possess that feature. Thus, an account based on syntactic entrainment could account for the observed correlation between the meanings conveyed by syntactic structures and the meaning features of the narrow conflation classes without requiring additional assumptions about children's knowledge of the inherent or logical compatibility between the definitions of narrow conflation classes and the meanings expressed by syntactic structures.

Furthermore, the theory presented here may be able to provide a more principled account for the syntactic restrictions of marginal cases of narrow conflation classes whose event features are logically compatible with, but do not directly imply the transfer of possession meaning. For such narrow classes, particular syntactic structures are sometimes permitted and sometimes restricted. For example, the narrow conflation classes that involve, “continuous causation of accompanied motion of some kind” (e.g., push or pull), and, “instantaneous causation of ballistic motion” (e.g., throw or kick), 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, which is prohibited for “pull”-type events. According to the account presented here, syntactic restrictions on narrow conflation classes are based on language users’ experience with members of the class, independent of the logical compatibility of the meaning features associated with the class. We suggest that in actual language use, “throw”-type events may be 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 sporting events in which the aim of the action is often to transfer possession of a game ball to a teammate, as in, “Messi kicks Neymar 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 husband pulled the large sofa to the living room, where he promptly collapsed.” Thus, according to the current account, we would expect the “pull”-type

events to be more likely to have a restriction on the double object dative, which is what we actually 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.)

Thus, both the current account and that of Pinker and colleagues can explain the associations between syntactic structures and meaning content found in natural language, and the correlations between these two domains. However, the account presented here does so with fewer assumptions, and is better able to explain the syntactic restrictions of certain marginal cases of narrow conflation classes that are not easily classified in Pinker’s account.

Concluding remarks

The results of the present study suggest that the syntactic entrainment effect – first demonstrated by Gruberg et al. (2017) – may involve associations between syntactic structures and the abstract features of events. The results of Experiment 2 suggest that associations between syntactic structures and the event features that define Pinker and colleagues’ narrow conflation classes may be reinforced by the mechanism reflected in the syntactic entrainment effect. Based on this finding, and the demonstration by Gruberg et al. (2017) that the syntactic entrainment effect is partner independent, we suggest that the mechanism reflected in this effect may be involved in

the process by which associations between meaning and syntax come to be conventionalized in natural language. That is, syntactic entrainment may reflect how these associations may be learned by users of the language, how they may spread throughout the linguistic community, and how they may be continually refined by adults language users. Finally, we suggest a reformulation of Pinker's (1989) explanation for the correlation between the meanings conveyed by syntactic structures and the syntactic restrictions on event classes. Whereas Pinker and colleagues argue that these restrictions are based on learners' a priori understanding of the meanings that can logically be mapped onto syntactic structures (cognitive construability), we suggest that the two may have a common cause. Namely, if both kinds of associations are formed by the mechanism reflected in the syntactic entrainment effect, then the fact that they are correlated would follow naturally from the fact that they are based on the same instances of linguistic experience. These findings give us a deeper understanding of the relationships between syntax and event meaning in natural language.

Chapter 3, in part, is currently being prepared for submission for publication of the material. Gruberg, N., & Ferreira, V. S. Speakers associate syntactic structures with abstract event meanings. The dissertation author was the primary investigator and author of this paper.

Appendix

Event semantic classes used in Experiment 2:

Locative events (categories adapted from Pinker, 1989):

1. Simultaneous forceful contact and motion of a mass against a surface (e.g., *slather, spread, smear, rub, brush, dab*)
2. Force is imparted to a mass, causing ballistic motion in a specified spatial distribution along a trajectory (e.g., *spray, spritz, splash*)
3. A mass is forced into a container against the limits of its capacity (e.g., *load, pack, cram, stuff*)
4. Mass is caused to move in a widespread or nondirected distribution (e.g., *scatter, sprinkle, dust*)

Dative events (categories adapted from Gropen et al., 1989):

1. Verbs that inherently signify acts of giving (e.g., *give, hand*)
2. Verbs of instantaneous causation of ballistic motion (e.g., *throw, toss*)
3. Verbs of type of communicated message, *Read-variety* (e.g., *read*)*
4. Verbs of type of communicated message, *Show-variety* (e.g., *show*)*

*(Note that according to Pinker, 1989, both varieties of communicated message would be categorized in the same narrow conflation class. However, there is no objective sense to judge whether two types of events with the same syntactic restrictions ought to be categorized in the same or different classes. Therefore, since in our materials these events seemed better suited to separate categories, we categorized them as such.)

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CHAPTER 4:

THE ROLE OF VERBS IN CHILDREN'S SYNTACTIC-SEMANTIC
ASSOCIATIONS

Often, speakers can express the same idea using different sentences. For example, a speaker can say either, “The man gave food to the needy children,” or, “The man gave the needy children food.” Although these two sentence structures seem interchangeable, in some cases one or the other structure is restricted. For example, if the speaker chooses a different verb, like *donate*, to describe the same event, she or he can still use the prepositional dative structure, as in, “The man donated food to the needy children,” but the double object dative structure is restricted, as, “*The man donated the needy children food” is considered ungrammatical. Whereas many of the restrictions on seemingly interchangeable sentences come from the meanings that the sentences express (an issue we discuss below), others are based on the identity of the verb used in the descriptions. Here, we investigate accounts of how speakers might come to acquire such verb-specific restrictions on the use of different syntactic alternatives.

There have been two general approaches to how children may acquire adult-like syntactic restrictions. According to statistical learning approaches (e.g., Braine & Brooks, 1995; Elman, 1991), children learn which verbs allow which syntactic structures based on a statistical learning mechanism that operates over the patterns of words found in their linguistic input. Thus, they learn that verbs permit particular syntactic structures when they are experienced in patterns (sentences) that correspond to that structure in their input language. For example, by hearing that *give* occurs both in the prepositional dative structure (“the man gave the food to the needy children”) and the double object structure (“the man gave the needy children food”), children

come to represent that *give* can be used with both of these structures generally. Furthermore, according to this theory, children come to learn syntactic restrictions based on negative evidence as well. That is, if they never hear a particular verb with a particular syntactic structure, the system learns that the verb is incompatible with that syntactic structure. For example, because children rarely or never hear the verb *donate* used in the double object structure, as in the ungrammatical sentence, “*The man donated the needy children food,” they infer that the double object structure is ungrammatical (or at least unconventional) in their language. For such theories, syntactic restrictions are learned based on the co-occurrence of specific verbs with certain syntactic structures but not others.

According to another theory, syntactic restrictions in language are based on the compatibility of particular syntactic structures with the semantic features of events (Pinker, 1989). Crucially, for this theory, syntactic structures express certain types of meanings based on what Pinker (1989) terms their *thematic cores*. Thematic cores are schematic meaning representations associated with certain classes of events, which can be described using corresponding syntactic structures. The alternative structures of a syntactic alternation are generally associated with two distinct thematic cores, which convey similar but distinct event semantic meanings. For example, the “*in*”-variant *locative*, as in, “The men load boxes into the truck,” expresses the thematic core, [X causes Y to move into/onto Z], whereas the “*with*”-variant *locative*, as in, “The men load the truck with boxes,” expresses the thematic core, [X causes Z to change state by means of moving Y into/onto it]. Certain alternating verbs, such as *load*, are

compatible with both thematic cores of a syntactic alternation, but express subtly different event meanings depending on the structure with which they are used. For example, when used with the “in”-variant locative structure, *load* highlights features of the event related specifically to the movement of the boxes (i.e., that they moved into the truck), and when used in the “with”-variant structure *load* highlights features of the event related specifically to the truck (i.e., that it became loaded with boxes). However, other verbs may be compatible with only one or the other of the thematic cores of the syntactic alternation. For example since the verb *pour* expresses event features associated with the manner of movement of a liquid, it is compatible with the “in”-variant thematic core (e.g., “John pours water into the cup”), but not the “with”-variant (e.g., “*John pours the cup with water”), because it does not express features of the event associated with the state of the container. Alternatively, since the verb *fill* expresses features associated with the changed state of the container (i.e., becoming full) it is compatible with the “with”-variant thematic core (e.g., “John fills the cup with water”) but not the “in”-variant (e.g., “*John fills water into the cup”), since it does not express features of the event associated with the movement of the liquid. According to this theory, syntactic restrictions are predictable based on the types of event features that are expressed by verbs. Children are able to acquire knowledge of syntactic restrictions based on an analysis of the compatibility of these meanings with the relevant thematic core meanings. Furthermore, verbs with similar event semantic features form categories called *narrow conflation classes*, which children learn to associate with particular sets of syntactic restrictions.

However, there are exceptions to these rules. As noted previously, the specific identity of the verbs used in event descriptions can also be relevant to certain syntactic restrictions independent of the event semantic features they express. For example, verbs like *donate* and *contribute* express event semantic features that suggest they should have similar syntactic restrictions as the narrow conflation class of “verbs that inherently signify acts of giving” (Gropen, Pinker, Hollander, Goldberg, and Wilson, 1989), which permit both the double object and the prepositional dative structures (e.g., “The boy gives the girl a ring,” and “The boy gives a ring to the girl”). However, whereas event descriptions using the verbs *donate* or *contribute* permit the prepositional dative, as in, “The philanthropist donated food to the needy children,” but they do not allow the double object structure, as in, “*The philanthropist donated the needy children food.” As noted by Pinker (1989), such exceptions to syntactic restrictions based on narrow conflation classes tend to be polysyllabic verbs that only have stress on the first syllable. Pinker and colleagues propose that speakers are able to learn these exceptions based on such phonological (and possibly morphological) characteristics of the relevant verb-forms, which they describe as *Latinate*. However, not all verbs with *Latinate* features impose the same restriction on the double object dative (e.g., *assign*, *allot*, *award*, *allow*, *bequeath*, *telegraph*, *reserve*, *refer*, *promise*, *offer*, *guarantee*, *permit*, *envy*, *begrudge*, *deny*, *refuse*, *radio*, *telegraph*, *telephone*, *satellite*, *e-mail*, and *message*), and therefore speakers must learn these exceptions

based on the identity of specific verbs rather than an analysis of their event semantic features alone².

In the current study, we aim to test an account of syntactic restrictions that combines elements from both approaches. Similar to the statistical learning approach of Braine and Brooks (1995), we propose that a relatively simple associative mechanism may underlie the learning of verb-specific syntactic restrictions. However, whereas Braine and Brooks propose that statistical learning is based exclusively on the co-occurrence of particular syntactic structures with particular verbs in the sentences of the learner's input language, the suggestion here is that statistical learning could also be based on the co-occurrence of syntactic structures with certain semantic features of the events being described. According to this theory, children could thus learn syntactic restrictions based on both specific linguistic elements in the sound string (such as the main verb of the sentence), and also aspects of the meanings of the events being described. In this way, children could learn the syntactic restrictions related to Pinker's (1989) narrow conflation classes. However, in the current theory, the mechanism by which children learn these restrictions would be different from the one proposed by Pinker (1989). According to Pinker (1989), children's knowledge of

² Pinker (1989) proposes that there may in fact be a rule that children learn, which governs these exceptions. Such a rule would involve phonological and morphological characteristics of verb-forms, however, it would only apply to verbs with particular event-semantic features (i.e., only those in particular narrow conflation classes). However, this formulation only pushes the question to what differentiates the narrow conflation classes that do obey the rule from those that do not; no satisfactory answer to this question has emerged.

syntactic restrictions is a direct consequence of the compatibility of particular verb meanings (or the semantic definitions of narrow conflation classes of verbs) with the thematic core meanings associated with particular syntactic structures. Instead, we propose that simple associative learning could underlie this process, in particular, that a single mechanism could potentially account for the learning of both syntactic restrictions based on event semantic categories, and the learning of exceptions to these rules based on verb-identity.

Previous research

The theoretical account proposed here has emerged from a series of experiments conducted by Gruberg and colleagues. These experiments investigated how adults learn or tune associations between syntactic structures and specific events based on recent linguistic experience. We suggest that the tuning of such associations could form the basis of syntactic restrictions related to particular event semantic meanings. In a first series of studies, Gruberg et al. (2017) demonstrated that adults form durable associations between particular events and particular syntactic structures, an effect termed *syntactic entrainment*. Specifically, after hearing particular syntactic structures used to describe particular events, which could be described using either member of a particular syntactic alternation (e.g., either the double object or prepositional dative structure), subjects were then more likely to use the same syntactic structures to describe the same events, regardless of whether they described those events to the same or a different conversational partner. In a second pair of studies, Gruberg and Ferreira (in prep.) found that the syntactic entrainment effect

applied not just to identical depictions of the events that were originally encoded, but also to abstract features of those events as well. One experiment showed that after hearing a particular event depiction described with a particular syntactic structure, subjects also tended to describe a different depiction of that same event (one that varied in the style, perspective, relative size of the actors and objects, and coloration) with the same syntactic structure. This shows that syntactic entrainment involves features that are more abstract than the low-level visual features of the event depictions. In a second experiment, adult participants heard descriptions of multiple events that had the same event-semantic features (corresponding to Pinker's narrow conflation classes) before offering descriptions of the same events. For example, within an experimental block, subjects might hear four events that involve features of "throwing"-events (i.e., events that can be described with "verbs of instantaneous causation of ballistic motion," Gropen et al., 1989). These events were described with structures that were balanced with respect to the relevant syntactic alternations (e.g., two "throwing"-events were described with the prepositional dative and two with the double object structure). The results showed that the syntactic entrainment effect was not present for events in this condition, though it was still present for events that were unique with respect to their event semantic features within an experimental block (e.g., the experimenter only described one "throwing"-type event). This finding suggests that the associations between particular events and particular syntactic structures – as reflected in the syntactic entrainment effect – were offset by other events with the same abstract event semantic features being associated with the opposite syntactic

structure (e.g., the syntactic entrainment of the two “throw”-type events that were associated with a prepositional dative interfered with the syntactic entrainment of the two “throw” events that were associated with a double object). These results imply that syntactic entrainment may reflect associations between syntactic structures and, specifically, the event semantic features that define narrow conflation classes.

Based on these findings, we suggest that the mechanism that underlies syntactic entrainment is well positioned to explain how language users come to learn the syntactic restrictions found in natural language. For example, a language learner might hear a particular event described with a prepositional dative, as in, “The philanthropist pulled a crate of food to the needy children.” The verb *pulled* possesses event features consistent with the verb class that Gropen et al. (1989) describe as “verbs of continuous causation of accompanied motion in some manner.” Thus the language learner could form an association between the prepositional dative syntactic structure and the continuous-causation-of-motion feature. Furthermore, because the continuous-causation-of-motion feature is relatively common for transfer events, as in events described with verbs like *carry*, *push*, and *schlep*, this association could be available to be reinforced across the learner’s linguistic experience. When subsequently, the learner describes a transfer event that includes continuous-causation-of-motion, she or he would be more likely to use the prepositional dative, leading to further strengthening of the association between the prepositional dative and the continuous-causation-of-motion feature. At the same time, error-based learning mechanisms (e.g., the delta rule, Rumelhart, Hinton, & Williams, 1985) could also

weaken associations between the continuous-causation-of-motion feature and the unselected double object structure (in a way analogous to one hypothesis for how lexical-semantic associations may be learned; Oppenheim, Dell, & Schwartz, 2010), potentially leading to restrictions on the use of the double object dative structure with verbs that convey the continuous-causation-of-motion feature in the future – which is in fact what we observe for such events in English (e.g., “*The philanthropist pulled the needy children a crate of food” is ungrammatical; though see Bresnan & Nikitina, 2003, 2009, for a different view). According to this account, only features of events that are frequently found in the input language, such as those that define Pinker’s (1989) narrow conflation classes, would generally be available to become associated with (or restricted from) particular syntactic structures. On the other hand, since the idiosyncratic features of events, such as (in the current example) *philanthropists*, *boxes of food*, and *orphanages*, are relatively infrequently represented in transfer events in the child’s input language, their association with particular syntactic structures would not be readily available to be strengthened.

However, whereas previous evidence implicates event-semantic features in the syntactic entrainment effect, no study on syntactic entrainment has yet addressed the role of verb-identity per se in the acquisition of syntactic restrictions. As noted earlier, certain syntactic restrictions seem to be based on the identity of specific verbs, which are not predictable from their event semantic features (e.g., *donate* and *contribute*). To account for such verb specific syntactic restrictions, syntactic entrainment would need to reflect associations not only between syntactic structures and event semantic

features (as demonstrated in Gruberg & Ferreira, in prep.), but also associations between syntactic structures and specific verbs. If this were the case, we might expect that the syntactic entrainment effect would be bigger when subjects used the same verb in their target descriptions as the ones used by the experimenter in their descriptions of the same events, than when different verbs were used.

Because previous studies on syntactic entrainment allowed speakers to describe scenes with any verb, subjects sometimes repeated the verb used in the experimenter's description, and sometimes they used a different verb. Accordingly, we performed a post hoc analysis to determine whether the magnitude of the syntactic entrainment effect was greater on trials when subjects repeated the verb than on trials when they didn't. In Gruberg et al. (2017, Experiment 1), subjects were more likely to repeat the syntactic structure used in the encoding sentence when they repeated the verb (a 14.8% effect), than when they did not repeat the verb (a 4.9% effect). The results of this analysis suggest not only that subjects may have been creating associations between syntactic structures and specific verbs, but that the associations between specific event content and syntactic structures may be mediated by these verbs as well (hence the decrease in the effect on trials on which subjects did not repeat the verb). However, this analysis is correlational, showing only that when speakers repeated the verb of an event description, they were also more likely to repeat the syntactic structure of that event description. Thus, the observed difference could have been due to a third variable affecting repetition of both factors. For example, perhaps subjects' overall memory for sentences varied because they paid more or less

attention from trial to trial, and when the memory trace of a sentence was better, they were more likely to repeat both the verb and the syntactic structure. In the current study we aim to directly test the effect of verb repetition on the syntactic entrainment effect by manipulating whether subjects used the same or a different verb in their target descriptions as the one they heard in the experimenter's description.

In Experiment 1, we tested whether the syntactic entrainment effect in adults is sensitive to the identity of the verb. We used a procedure similar to that used in previous studies by Gruberg and colleagues (Gruberg & Ferreira, in prep; Gruberg et al., in prep); however, in this experiment we manipulated which verbs subjects used in their target descriptions. Specifically, after hearing an experimenter describe 12 events, subjects subsequently described the same 12 events with either the same or a different verb, which was printed below the event depiction. We measured how often subjects used the same syntactic structure as the experimenter when describing the same picture (the basic syntactic entrainment effect), and measured whether the magnitude of this effect varied based on whether the subject used the same or a different verb as the one used by the experimenter to describe the same event.

Experiment 1

Method

Subjects. Forty-eight 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. Beneath some of these events a verb was printed, which subjects used in their picture descriptions. The cards were printed on 80-solar white paper 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 divided into three verb/event classes: transitive events (17), dative events (17), and locative events (17). Three of the pictures (one of each syntactic alternation) were used as practice, while the remaining forty-eight pictures appeared in four blocks of 12 pictures each. Each block contained four transitive events, four dative events, and four locative events.

Two experimental lists were constructed to serve as scripts for the experimenter to read in their role as the director. Each list contained 48 prime sentences, with 16 sentences corresponding to each event type (transitive, dative, locative). The events depicted on the cards could be described using two alternative syntactic structures, which we refer to 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 their observed frequency in previous studies conducted with the same materials. Over the course of the experiment, within each block, and for each event type, the experimenter used an equal number of preferred and dispreferred structures in their prime descriptions. Across experimental subjects, each scene appeared equally in the preferred and dispreferred prime condition.

During prime rounds, the subjects were given cards depicting events with no printed verb, and during the target rounds they were given cards with the same event depictions, but with a verb printed beneath the picture. Over the course of the experiment, within each block, and for each event type, on half of target trials the verb printed beneath the picture was the same as the one used by the experimenter to describe that event in the prime round, and on the other half it was a different verb. Across experimental subject each scene appeared an equal number of times in the same picture condition and the different picture condition.

Participants were seated across from the experimenter 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 squares of the same dimensions as the cards were placed in front of the participant and the experimenter. The sessions were audio recorded using a digital recorder.

Procedure. Participants were brought into the lab and told they would be playing a collaborative game with the experimenter. The subject and experimenter 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 described by the director (adapted from Clark & Wilkes-Gibbs, 1986). Each round consisted of two phases, such that the subject and the experimenter served as both the director and the matcher for each set of cards. In each round, the experimenter acted as director first, 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. 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 undergraduate research assistants. Each target utterance was then coded for its syntactic structure. Only sentences that conformed to the intended syntactic alternation were included in the analysis. For transitive sentences, these were either active or passive sentences; for locative sentences, these were either “with”-variant or the “on”-variant; for dative sentences, these were either double object or prepositional dative. If a subject’s target sentence did not allow the intended complete alternation, it was removed from the analysis as unscorable.

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 utterances. Prime structure (preferred or dispreferred structure), and target-verb (same or different as the prime verb) 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 included intercepts for subjects and items, as well as by-subjects and by-items random slopes for the effect of prime structure, the effect of target verb, and the interaction between prime structure and target-verb. 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 89.4% of trials (2060 out of 2304 trials). For transitive targets, they produced scorable responses on 90.4% of trials (694 out of 768); for dative targets, they did so on 91.4% of trials (702 out of 768); for locative targets, they did so on 86.5% of trials (664 out of 768).

Overall, subjects were 9.7% more likely to produce the preferred syntactic structure when primed with the preferred structure (73.6%), than when primed with the dispreferred structure (63.9%), and including Prime Type in the model significantly improved the model fit ($\chi^2(1) = 25.285, p < .01$). On trials where the subject was given the same verb to use in their target sentence as they heard in the prime sentence, they were 10.8% more likely to produce the preferred structure when primed with the preferred structure (73.9%) than when primed with the dispreferred structure (63.1%). On trials where the subject was given a different verb to use in their target sentence than the one they heard in the prime sentence, they were 8.7% more likely to produce the preferred structure when primed with the preferred structure (72.8%) than when primed with the dispreferred structure (64.1%). The numerically different effect for the same and different verb conditions was not statistically significant, and including the interaction term (prime structure X target-verb) did not improve model fit ($\chi^2(1) = 1.3258, p = .25$).

In Experiment 1 we found that for adult language users, the syntactic entrainment effect seems to be insensitive to whether speakers' target descriptions used the same or different verb as was in the corresponding prime descriptions. Interestingly, the results of our post hoc analysis of the data reported in Gruberg et al. (2017, Experiment 1) demonstrated a different result. According to that analysis, adult subjects were more likely to repeat the syntactic structure of the prime sentence when they also repeated the main verb. However, as noted, that post hoc analysis was correlational, permitting an extraneous factor (e.g., overall memory strength) to explain the observed relationship between verb repetition and syntactic repetition. The fact that the relationship was no longer observed in Experiment 1, where verb repetition was directly manipulated, suggests that indeed another factor such as overall memory strength for the sentence was likely responsible for the results of the post hoc analysis. Thus, we can conclude that for adults, syntactic entrainment reflects associations between syntactic structures and event content, independent of the specific verb that is used in the sentence.

These results raise concerns for the claim that the associations reflected in syntactic entrainment may underlie the learning of syntactic restrictions. As noted, the syntactic restrictions observed in natural language are sometimes based on verb-identity (e.g., *donate* does not permit a double object structure, though the event semantic features it expresses suggest that it should). Thus, if the associations reflected in the syntactic entrainment effect are in fact related to how syntactic

restrictions are learned, then we need to explain why in Experiment 1, the syntactic entrainment effect was insensitive to the identity of verbs.

One possibility begins with the suggestion that language users' knowledge of linguistic representations generally may become increasingly abstract throughout the acquisition process (Chang, Dell, & Bock, 2006; Elman, 1990, 1991; Tomasello, 2000). Specifically, children might initially acquire verb-specific knowledge of syntactic restrictions; however, after experiencing a number of instances of verbs that express similar event semantic features being used with the same syntactic restrictions, language learners may be able to generalize from their knowledge of the syntactic restrictions of specific verbs to form larger categories of verbs with particular syntactic restrictions based on their event semantic features (i.e., narrow conflation classes). Thus, earlier in the acquisition process, we might expect that language learners would be more dependent on verb-identity for their knowledge of syntactic restrictions. Accordingly, we might expect children learning language to show sensitivity to verb-identity during syntactic entrainment (unlike adults). Such a result would suggest that the syntactic entrainment effect in children could reflect an early state in the process of acquiring adult-like syntactic restrictions, during which children use verb identity to learn about these restrictions (potentially both with respect to rules that apply across classes of semantically related verbs, and to verb-specific exceptions). We address this possibility in Experiment 3. However, since the basic syntactic entrainment effect has not yet been demonstrated in children, Experiment 2 first tests whether the basic syntactic entrainment effect is observed in children.

Experiment 2

In Experiment 2, we aimed to test whether 4-6 year-old children show the same basic syntactic entrainment effect as adults. Previous studies have suggested that at this age, children are still in the process of learning how to use syntactic structures in entirely adult-like ways (Ambridge, Pine, Rowland, & Young, 2008; Ambridge, Pine, Rowland, Jones, & Clark, 2009; Ambridge, Pine, & Rowland, 2011; Ambridge, Pine, Rowland, Freudenthal, & Chang, 2012). If we observe the syntactic entrainment effect in children at this age, it would provide necessary evidence to support the claim that syntactic entrainment reflects the process by which the associations between syntactic structures and particular meaning content may be learned during the acquisition process.

Method

Subjects. Twenty-four 5-6 year old children from a local elementary school participated in the study. All subjects were native speakers of English.

Materials and design. The design was similar to Experiment 1 with a few exceptions. First, the verb used by the child in the target round was not manipulated. Also, because we wanted to allow for the possibility that children may not stay on task for as long as adults, we used only 6 cards per round instead of 12. As in Experiment 1, there were four rounds, and so children in Experiment 2 saw half of the pictures that adults saw in Experiment 1.

Procedure. A similar procedure was used in this experiment as in Experiment 1. However, we modified the procedure slightly to be more amenable to the younger

population. Specifically, the dividers separating the experimenter and the children's workspaces were slightly shorter; when the child was the matcher the cards were spread out haphazardly; when the child found the correct card, s/he put it into a stack; and when the child was the director s/he was given a stack of the 6 cards to describe.

Scoring and analysis. IRB restrictions precluded audio recording of sessions. Therefore, each session was transcribed in real-time by a trained undergraduate research assistant. Target sentences were coded from the transcription using the same procedure as in Experiment 1. We performed a mixed effects logistic regression that was similar to Experiment 1, except the target verb condition was not included. Thus, prime type (preferred or dispreferred structure) was entered into the model as a fixed effect. 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 prime type. 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 85.6% of trials (493 out of 576). For transitive targets, they produced scorable responses on 90.1% of trials (173 out of 192); for dative targets, they did so on 95.8% of trials (184 out of 192); for locative targets, they did so on 70.3% of trials (135 out of 192).

Overall, subjects were 20.7% more likely to produce the preferred syntactic structure when primed with the preferred structure (65.7%), than when primed with

the alternative (45.0%), and including prime type in the model significantly improved the model fit ($\chi^2(1) = 12.016, p < .01$).

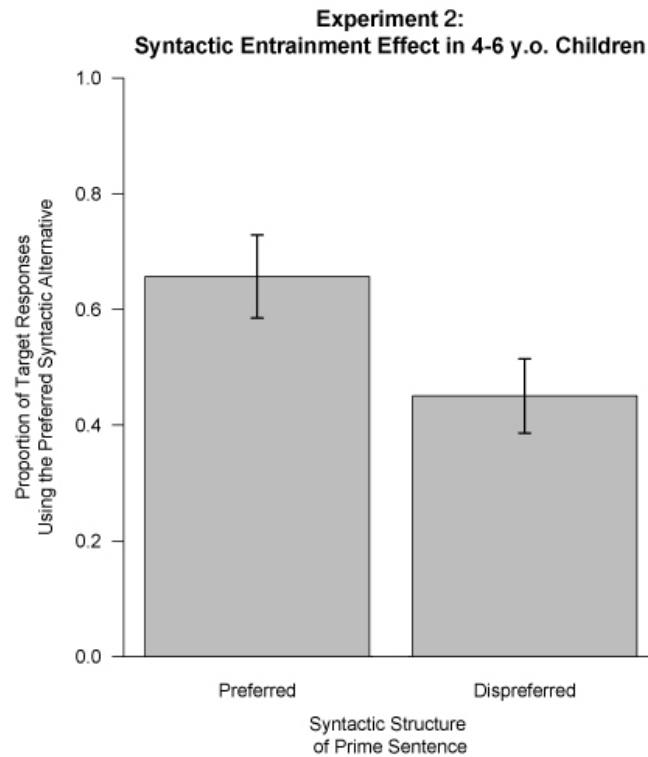


Figure 4.1. Proportion of preferred structure responses for target descriptions in 4-6 y.o. children. Children at this age seem to show a robust syntactic entrainment effect.

These results indicate that 4-6 year-old children do show a robust syntactic entrainment effect. This provides important evidence supporting the possibility that this process may in fact be related to the acquisition of syntactic restrictions based on event semantic features. However, our main question of interest was whether the syntactic entrainment effect might also be related to the acquisition of syntactic restrictions based on verb identity. Thus, we conducted a post hoc analysis to determine whether the magnitude of the syntactic entrainment effect in children was

sensitive to the repetition of the verb used in the encoding sentence. Overall, children used the the same verb as the experimenter more often (on 374 trials) than they used a different verb (on 119 trials), and they were more likely to repeat the syntactic structure of the encoding sentence when they repeated the verb (demonstrating a 27.7% syntactic entrainment effect) than when they did not (demonstrating a 1.6% syntactic entrainment effect in the opposite direction). This result suggests that the syntactic entrainment effect in children may be entirely dependent on the repetition of verbs. However, as with adults, this analysis is correlational. Thus, the relationship between verb and structure repetition may have been due to other variables (e.g., attention and memory). Thus, in Experiment 3, we test whether children of the same age range will show similar patterns of behavior if the verbs they used in their target descriptions are directly manipulated.

Experiment 3

Ambridge and colleagues (Ambridge et al., 2008; Ambridge et al., 2009; Ambridge et al, 2011; Ambridge et al., 2012) have shown that children do not possess adult-like narrow conflation classes until around 9-10 years of age. Since we have suggested that syntactic entrainment may reflect the process by which children learn about these narrow conflation classes and their syntactic restrictions, we might expect children to show different patterns of behavior than adults with respect to this effect. Specifically, since certain syntactic restrictions are related to abstract knowledge of event-semantic features that applies across categories of verbs, whereas others are related to the identity of specific verbs, we might expect that children in the process of

acquiring this knowledge would show greater reliance on verb identity than adults who have already acquired these distinctions. Thus, in Experiment 3 we tested whether the magnitude of the syntactic entrainment effect in 4-6 year-old children would be larger when their target descriptions used the same verb they heard in the encoding sentences than when they used a different verb.

Method

Subjects. Sixteen 5-6 year old children from a local elementary school participated in the study. We tested fewer subjects than in Experiment 2, because a change in IRB rules governing the research made it much more difficult to recruit larger numbers of subjects.

Materials and design. The design was similar to Experiment 2, with two exceptions. First, because we were unable to recruit as many subjects as in Experiment 2, we increased the number of rounds from 4 to 8, using every card from Experiment 1. However after testing 3 subjects, we removed six cards that depicted scenes that were unfamiliar to children of this age, and reduced the number of rounds to 7. Second, as in Experiment 1, on target trials the cards had a verb printed beneath the picture.

Procedure. The procedure was identical to that of Experiment 2, except on target trials, before the child described the picture, an experimenter read the verb that the child was supposed to use aloud (e.g., “SPRAY, can you use the word SPRAY to describe that picture?”).

Scoring and analysis. As in Experiment 2, each experimental session was transcribed by a trained undergraduate research assistant, and target sentences were coded from the transcription using the same procedure. We performed a mixed effects logistic regression similar to those run for Experiments 1 and 2, however the initial model showed signs of degeneracy and overparameterization indicated by high correlations between the random effects. This is likely due to the fact that the small number of subjects tested provided insufficient data points for the number of parameters in the maximal random effects structure. Following Bates, Vasishth, and Baayen (2015), we simplified the model by removing random effects terms starting with the highest-order term associated with high correlation ($r > .95$). This process was iterated by removing one term at a time, and rerunning the model until the overparameterization and degeneracy issues were resolved. In the final model the random effects structure included random intercepts for subjects and items, as well as by-items random slopes for the effect of prime type.

Results and discussion

Subjects produced scorable responses on 83.6% of trials (561 out of 672). Eight trials on which the child failed to use the correct verb were excluded. For transitive targets, subjects provided scorable responses on 92.4% of trials (207 out of 224); for dative targets, they did so on 84.4% of trials (189 out of 224); for locative targets, they did so on 73.7% of trials (165 out of 224).

Overall, subjects were 20.9% more likely to produce the preferred syntactic structure when primed with the preferred structure (79.2%), than when primed with

the alternative (58.3%), and including prime type in the model significantly improved the model fit ($\chi^2(1) = 17.441, p < .01$). On trials where the subject was given the same verb to use in their target description as they heard in the experimenter's description, children were 27.6% more likely to produce the preferred structure when primed with the preferred structure (82.1%) than when primed with the dispreferred structure (54.5%). On trials where the subject was given a different verb to use in the target than they heard in the experimenter's description, children were 12.7% more likely to produce the preferred structure when primed with the preferred structure (76.8%) than when primed with the dispreferred structure (64.1%). This difference resulted in a significant interaction effect between prime type and repeated (or non-repeated) verb, and including the interaction term significantly improved model fit ($\chi^2(1) = 4.64, p = .031$).

Because we did not use the maximal random effects structure for this model, we decided to run further statistical tests to confirm the results. Using traditional ANOVA methods, we confirmed the significant interaction effect when averaging both over subjects ($F(1,15) = 2.25, p = .04$) and over items ($F(2,41) = 2.23, p = .03$). Furthermore, we ran a resampling simulation, which non-parametrically tests the probability of finding an effect of a particular size by randomly reassigning the observed data across all conditions for each subject in the experiment, and then counting the number of simulations in which the effect is as large or larger than the observed result. The size of the interaction was measured as the difference between the prime effect in the repeated and non-repeated verb condition. For subjects

(averaging across items) this difference was 16.5%, which was larger than 988 of the 1,000 experimental simulations ($p < .02$). For items this difference was 15.5%, which was larger than 968 of the 1,000 experimental simulations ($p < .03$).

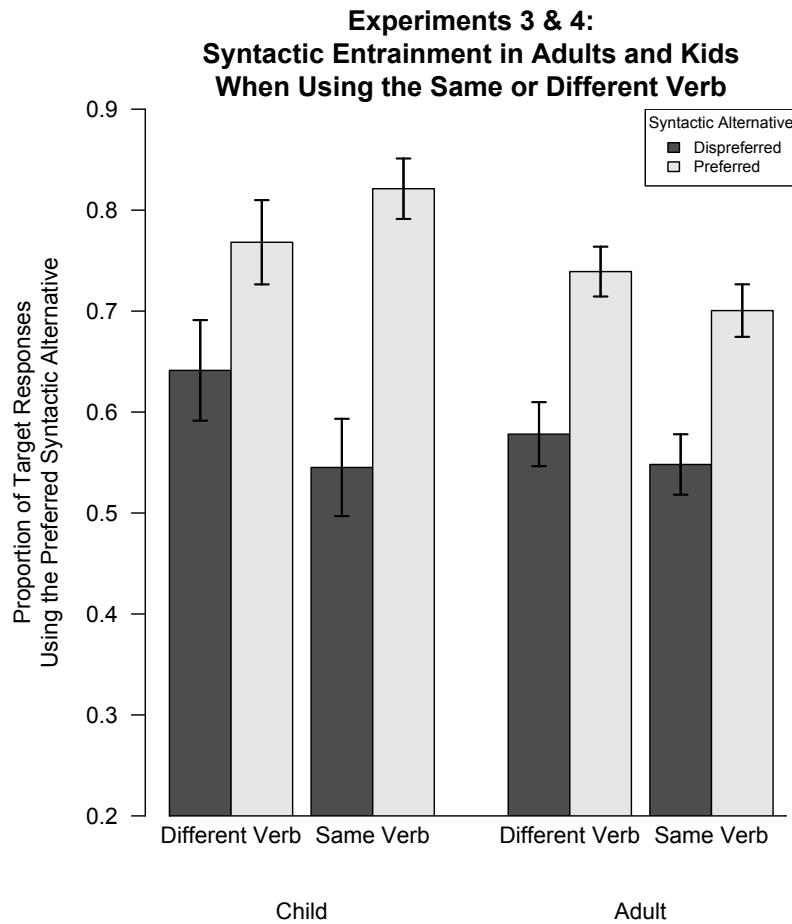


Figure 4.2. Results from Experiments 3 & 4. Proportion of preferred structure responses for target descriptions that were described with either the same or a different verb from the one used by the experimenter to describe the same picture initially. Children show a greater entrainment effect when using the same than a different verb in their target descriptions, whereas adults show no difference in the entrainment effect based on the identity of the verb.

These results demonstrate that syntactic entrainment in children appears to be sensitive to the main verb used, an interaction which is not present in our findings with adults. Elsewhere we have suggested that the associations reflected in syntactic entrainment may be related to the development and tuning of syntactic restrictions. Based on the results of Experiment 3, we suggest that children may use verb specific syntactic restrictions to facilitate the acquisition of adult-like narrow conflation classes. Accordingly, syntactic entrainment in children seems to reflect associations between verbs and syntactic structures, and also between event semantic features and syntactic structures. On the other hand, in the mature linguistic system, knowledge of syntactic restrictions may be mostly independent of specific verb identity. We suggest that differences in the syntactic entrainment effect across the lifespan may reflect the development and reinforcement of narrow conflation classes and their syntactic restrictions.

Experiment 4

In Experiment 1, we demonstrated that adults show the same degree of syntactic entrainment whether or not the same verb was used in prime and target sentences. In Experiment 3, we demonstrated that children show a significantly greater syntactic entrainment when they use the same verb in their target descriptions as the experimenter used in the prime descriptions. However, since we used slightly different materials and procedures in the two experiments, it is possible that the different pattern of data observed in adults in Experiment 1 was due to incidental experimental factors (most especially, the fact that rounds included twice as many pictures for

adults than for children). Therefore we ran a fourth experiment with adults that used nearly identical materials and procedures as Experiment 3.

Method

Subjects. Forty-eight undergraduate students participated in this study in exchange for course credit. One subject was excluded due to a failure of the audio recording equipment. We tested more adults in Experiment 4 than children in Experiment 3 because we had access to a larger subject pool, and, due to the small differences between conditions in Experiment 1, we wanted to maximize our power to detect any possible interaction. All subjects reported being native speakers of English.

Materials and design. We attempted to replicate the design and materials of Experiment 3 as closely as possible. One of our primary concerns about the differences between the procedure used for children and adults was that in Experiment 1, adults saw 12 pictures per round, whereas children in Experiment 3 only saw 6. This difference may have interacted with subjects' memory for the pictures to cause the different pattern of results in children and adults. In Experiment 4 we used the same 42 cards from Experiment 3, and presented them in 7 rounds of 6 cards each.

Procedure. The procedure was mostly identical to that of Experiment 3. One exception was that in Experiment 3, the experimenter told the child the verb they were supposed to use to describe the sentence on each target trial. Because this would not be appropriate for adult subjects, we removed this feature from the procedure of Experiment 4.

Scoring and analysis. A similar scoring procedure was used as in the previous experiments. We assessed significance by running a mixed effects logistic regression model with identical parameters as Experiment 1.

Results and discussion

Subjects produced scorable responses on 88.3% of trials (1780 out of 2016). Four trials were excluded because the subject failed to use the correct verb. For transitive targets, subjects produced scorable responses on 90.6% of trials (609 out of 672); for locative targets they did so on 86% of trials (578 out of 672); for dative targets they did so on 88.2% of trials (593 out of 672).

Overall, subjects were 15.3% more likely to produce the preferred syntactic structure when primed with the preferred structure (71.7%), than when primed with the alternative (56.4%), and including prime type in the model significantly improved the model fit ($\chi^2(1) = 16.26, p < .01$). On trials where the subject was given the same verb to use in the target as they heard in the prime sentence, they were 15.2% more likely to produce the preferred structure when primed with the preferred structure (70.1%) than when primed with the dispreferred structure (54.8%). On trials where the subject was given a different verb to use in the target, they were 16.1% more likely to produce the preferred structure when primed with the preferred structure (73.9%) than when primed with the dispreferred structure (57.8%). This interaction (verb condition X prime type) was not statistically significant, as including it did not improve our model fit ($\chi^2(1) = .0029, p = .96$). (Given that the observed numerical difference in

Experiment 4 was opposite to that predicted by a verb-identity effect, we elected not to conduct ANOVA and resampling analyses.)

General Discussion

The four experiments presented here demonstrate three primary findings. First, the syntactic entrainment effect first demonstrated by Gruberg et al. (2017) in adults is also present in 4-6 year-old children. This is the first study that has tested this effect in young children who are in the process of acquiring certain types of linguistic knowledge. Second, for adults, the syntactic entrainment effect seems to reflect associations exclusively between syntactic structures and aspects of event content, and appears to be insensitive to the identity of the verb used in prime and target sentences. Third, unlike adults, for 4-6 year old children, the syntactic entrainment effect does appear to be sensitive to the identity of the verbs. These results suggest a possible developmental trajectory whereby children, but not adults, rely on the identity of specific verbs when forming the associations reflected in syntactic entrainment.

These findings lead us to the question of what linguistic function may be served by the associations reflected in the syntactic entrainment effect, and why this effect seems to be different for children and adults. Previous research has shown that syntactic entrainment can apply to associations between syntactic structures and the specific event features that define certain narrow conflation classes (Gruberg & Ferreira, in prep.). Accordingly, we suggested that, through repeated experience, these associations could be refined into rules governing the syntactic behavior of particular narrow conflation classes of verbs. Thus, the function of these associations could be to

facilitate the acquisition of the syntactic restrictions associated with particular narrow conflation classes by language learners, and their refinement in the mature language system.

However, certain syntactic restrictions are not predictable from the semantic features of events alone. In some cases, the *identities of verbs* themselves seem to confer syntactic restrictions independent of event semantic features, as in the case of verbs like *donate* and *contribute*. Since previous studies on syntactic entrainment only tested the associations between syntactic structures and particular events and event features, they could not speak to how syntactic restrictions based on verb-identity may be learned. If syntactic entrainment reflects a more general learning process by which syntactic restrictions based on both event semantic features and verb identity may be learned and refined, then we might have expected it to be sensitive to the identities of the verbs used in the entrained sentences. However, in Experiments 1 and 4, we found that for adults the syntactic entrainment effect was not sensitive to verb identity. This result left open the question of how associations (and ultimately syntactic restrictions) based on the identity of specific verbs may be learned.

We suggest that our results from Experiment 3 provide a potential answer to this question. In that experiment, we found that for 4-6 year old children, the syntactic entrainment effect was sensitive to the identity of the verbs used in the prime and target sentences. Previous studies by Ambridge and colleagues (Ambridge et al., 2008; Ambridge et al., 2009; Ambridge et al., 2011; Ambridge et al., 2012) have demonstrated that children do not achieve adult-like competence in their use of the

syntactic restrictions related to narrow conflation classes until around 9 or 10 years of age. Thus, the fact that we observe sensitivity to verb identity in the syntactic entrainment effect for 4-6 year old children but not for adults may be related to how syntactic restrictions are acquired by children learning language. Specifically, we suggest that for 4-6 year old children, the syntactic entrainment effect may be sensitive to verb identity because they are still in the process of learning the syntactic restrictions observed in the mature language system.

The use of verb-specific information, as reflected in the sensitivity of the syntactic entrainment effect to verb identity, could facilitate children's acquisition of both the rules governing syntactic restrictions based on event semantic features (i.e., the definitions of certain narrow conflation classes), and the exceptions to these rules based on verb identity. First, for children, the event-semantic rules governing syntactic restrictions (i.e., narrow conflation classes) may involve more uncertainty than adults. Earlier we suggested that a central task in learning these definitions may involve generalizing over a number of experiences with descriptions of events that have particular event features and particular syntactic usage restrictions. Since verbs highlight particular event-semantic features of events, children could use them to narrow down which features are relevant to particular narrow conflation class definitions. For example, if a child hears similar transfer events described with the verbs *pull* and *give*, the child could use the event features highlighted by each verb to refine their knowledge of which event semantic features are relevant to particular narrow conflation classes. That is, if the child observes that the syntactic restrictions

on transfer events described with the verb *pull* – which permit the prepositional dative, “The man pulled the box to the lady,” but not the double object, “*The man pulled the lady the box” – are different than the syntactic restrictions on transfer events described with the verb *give* – which permit both the prepositional dative, “the man gave the box to the lady,” and the double object dative, “The man gave the lady the box” – they could learn that the event semantic features highlighted by both verbs (e.g., features of transfer events in general) were not relevant to the differences in their syntactic restrictions, whereas the event semantic features that were highlighted by one verb or the other could be relevant to their different syntactic restrictions. For example, over repeated exposures to transfer event descriptions using the verb *pull*, children could strengthen associations specifically with those features that are highlighted by the verb *pull*, such as the continuous-causation-of-motion feature, but not the features highlighted specifically by the verb *give*, such as the inherent-act-of-giving feature, nor the features highlighted by both verbs (e.g., features related to transfer events in general). Thus, children could use the identity of specific verbs to refine their knowledge of the event semantic features associated with particular narrow conflation classes.

Second, 4-6 year old children may use verb identity to learn the exceptions to the event semantic rules that define certain narrow conflation classes. For example, by relying on verb-specific knowledge of syntactic restrictions, children would not be at risk of making the incorrect generalization that verbs like *donate* and *contribute* belong to the narrow conflation class that corresponds to (for example), “verbs that

inherently signify acts of giving,” as their event semantic features would suggest. Such a generalization would lead to the mistaken assumption that they allow both the double object and the prepositional dative structures, although these verbs cannot be used with the double object structure (e.g., “*The philanthropist donated the needy children food”).

The changing role of verb identity in the knowledge of syntactic restrictions

Although Experiment 3 demonstrated that the syntactic entrainment effect was sensitive to verb-identity in 4-6 year old children, it should be noted that these children still showed a robust syntactic entrainment effect when using a different verb than the experimenter. This finding suggests that at this age, children may be forming associations between syntactic structures and particular event-meaning content that are independent of the verb, in addition to associations between syntactic structure and particular verbs. Thus, we suggest that syntactic entrainment in 4-6 year old children may reflect an intermediate point in the process of acquiring adult-like knowledge of syntactic restrictions, where they have some knowledge of the event semantic features associated with particular syntactic restrictions, but are still relying somewhat on the identity of verbs to refine this knowledge.

Furthermore, the apparent absence of verb sensitivity in adults suggests that syntactic entrainment may have a somewhat different functional significance in the mature linguistic system. One possibility is that once a language user acquires adult-like knowledge of narrow conflation classes, they no longer need to rely on their knowledge of specific verbs to know when particular syntactic structures are licensed.

Whereas it may have been useful to use verbs to learn how event semantic features are associated with particular syntactic restrictions, and which verbs constitute exceptions to these rules, it may be inefficient to rely on verb specific knowledge of syntactic restrictions once the language learner has reached adult-like levels of linguistic competence. Specifically, relying on knowledge of specific verbs would require accessing knowledge from a much larger database than if they were able to rely on a smaller number of narrow conflation class rules. Although exceptions to the event semantic rules that define these classes, such as *donate* and *contribute*, would also need to be stored somehow, once these entries have been categorized as exceptions, mature language users could rely on their membership in *categories of exceptions* (e.g., the Latinate narrow conflation class proposed by Pinker and colleagues) to assess their syntactic restrictions rather than relying on verb-identity per se.

Another possibility is that the observed difference in the verb sensitivity of the syntactic entrainment effect in adults and children may be a natural consequence of the continuation of a fairly basic associative mechanism. Specifically, we have suggested that language users may make relatively unconstrained associations between syntactic structures and various features of utterances, which could be reflected in syntactic entrainment. As previously stated, according to such a theory, only those features that are frequently found to co-occur with syntactic structures would be available to be strengthened, whereas more idiosyncratic features of utterances would not be available to be strengthened. Thus, when adults hear an event from the narrow conflation class of “verbs that inherently signify acts of giving” described with the verb *give* and the

double object dative structure, they may strengthen associations between the double object structure and both the verb, *give*, and the event feature, *inherently-signifies-an-act-of-giving*. However, in adults' overall linguistic experience, *give* may be used relatively infrequently in double object sentences, as compared to the event feature *inherently-signifies-an-act-of-giving*, which is a feature of events that can be described with many verbs other than *give*, such as, *hand, pass, sell, pay, lend, loan, serve, trade, and feed*. Thus, the association between *give* and the double object structure may not be as readily available to be strengthened as the more frequently strengthened event feature such as *inherently-signifies-an-act-of-giving*.

In contrast, children's linguistic experience consists of relatively limited vocabularies, both in terms of their own usage, and (according to the CHILDES database; MacWhinney, 2000) in the speech of their parents. Thus, any particular verb may be significantly more likely to co-occur with a particular syntactic structure for children than would be true for adults. Accordingly, for children there may be less of a difference in the relative frequency of the co-occurrence of the double object structure and the verb *give*, and the co-occurrence of the double object structure and the feature *inherently-signifies-an-act-of-giving*. Thus, for children, the association between *give* and the double object could be relatively more likely to become significantly strengthened than for adults with much larger vocabularies.

Concluding remarks

The results of the current study demonstrate developmental differences in the syntactic entrainment effect between adults and children who have not yet acquired

fully adult-like knowledge of syntactic restrictions. The fact that for children, but not adults, this effect is sensitive to verb identity is consistent with the suggestion that syntactic entrainment may reflect the mechanism by which children acquire syntactic restrictions based on both event semantic features and the identity of specific verbs. We presented several possibilities for why this sensitivity to verb-identity might decrease through the acquisition process, and further experiments are necessary to determine the exact cause of this developmental change. Provisionally, however, we propose that children may acquire adult-like competence in their use of syntactic restrictions through a simple associative mechanism, which may be reflected in syntactic entrainment. For the 4-6 year old children we tested, this effect seems to be sensitive to both the semantic features of events, and the identities of specific verbs. Thus, the process reflected in syntactic entrainment in children could facilitate both the learning of syntactic restrictions based on event semantic features, and the exceptions to these rules based on verb identity. We suggest that for adults, this associative mechanism may cease to be sensitive to verbs because facilitation of the learning process is no longer necessary, and may in fact be deleterious to language processing. However, the fact that for adults, the syntactic entrainment effect continues to apply to the event semantic features that define narrow conflation classes suggests that knowledge of the abstract rules that define syntactic restrictions may be subject to continual refinement throughout the lifespan. This process of continual refinement of linguistic knowledge has been proposed in a number of linguistic domains (Bock & Griffin, 2000; Kleinschmidt & Jaeger, 2012; Toscano, Munson,

Kleinschmidt, & Jaeger, 2015), which may facilitate communication between interlocutors and the maintenance of linguistic rules throughout the linguistic community (Pickering & Garrod, 2004).

Chapter 4, in part, is currently being prepared for submission for publication of the material. Gruberg, N., Wardlow, L., & Ferreira, V. S. The role of verbs in children's syntactic-semantic associations. The dissertation author was the primary investigator and author of this paper.

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CHAPTER 5:
CONCLUSION

The primary goal of the research conducted in this dissertation was to explore the repetition of syntactic structures in the descriptions of events – a phenomenon that we refer to as syntactic entrainment. The motivating hypothesis was that creating associations between events and syntactic structures may serve to facilitate linguistic communication. Accordingly, the associations between syntactic structures and events could form part of the common ground by which conversational partners are able to quickly and easily understand which referents they are talking about – similar to the associations between lexical labels and particular objects, which we observe in lexical entrainment. Instead, syntactic entrainment did not primarily seem to reflect the facilitation of communication between particular conversational partners. Rather the effect seemed to apply more generally, independent of the language user's interlocutor. We therefore proposed that syntactic entrainment could reflect the facilitation of linguistic communication more broadly throughout the linguistic community. Specifically, these associations between syntactic structures and event meanings could reflect the process by which language users learn and refine their knowledge of the conventions governing the use particular syntactic structures (i.e., what types of events tend to be described with which syntactic structures) within the linguistic community.

Overall, we found that language users do tend to create associations between syntactic structures and events. However, we find that these associations differ from those reflected in lexical entrainment in some crucial ways. First of all, syntactic

entrainment appears to reflect longer term changes, which apply not only to particular conversations and conversational partners, but also apply when speaking with new conversational partners. This suggests that syntactic entrainment may serve a somewhat different function than lexical entrainment. We suggest that whereas lexical entrainment may reflect a process by which speakers make their speech more predictable for particular conversational partners, syntactic entrainment may reflect a more general learning process whereby language users learn how to associate syntactic structures with particular types of event content. In Chapter 3 we provided converging evidence for this hypothesis. Specifically, in that study we showed that speakers tend to use entrained syntactic structures more frequently not only for identical event depictions, but also for different depictions of the same event, and even different events of the same event semantic type (defined as narrow conflation classes). Finally, in Chapter 4 we showed that children demonstrate similar effects to adults, but differ in particular ways that are consistent with their incomplete acquisition of this linguistic knowledge.

The ability of human language to combine words into sentences allows the expression of an unbounded set of possible concepts. The communication of sentences requires that speakers of a language share rules for interpreting these combinations – syntactic structures. Research into the nature of syntactic structures has often focused on their independence from other aspects of linguistic meaning. In this dissertation we have presented evidence that speakers' knowledge of when to use which syntactic structures may be intimately tied with the semantic content of the events being

described. That is, although syntactic structures may have an independent psychological existence, the conventions governing their usage may be *learned*, *refined*, and *introduced into language in the first place* based on the subject matter they are used to describe.