Argument types affect children's acquisition of a novel argument structure

Erin CONWELL^{*a} and Amanda AUEN^b

a. Department of Psychology, North Dakota State University

b. Department of Speech, Language, and Hearing Sciences, University of Colorado Boulder

*Corresponding Author

Word Count: 4761

Acknowledgments

We thank Gregor Horvath, Shanda Lauer, and Samantha Hamernick for their assistance creating the stimuli. Felix Pichardo helped to pilot the stimuli, and Allyson Kuznia and Stephanie Leach assisted with running child participants. We also thank the families of those children who participated in the lab, as well as the families and staff of the NDSU Center for Child Development for their support of this research. Comments from three reviewers significantly improved this article, and we thank them for their time and thoughts.

Keywords: language acquisition, argument structure, lexical diversity, pronouns

Abstract

Acquisition of an argument structure may be affected by the diversity of lexical types that appear in that structure (Conwell, et al., 2011; Yang, 2016). Seventy-two 5- and 6-year-old children completed a learning study where they were exposed to a novel argument structure and then tested on their ability to comprehend it. The number of verb types heard in the learning phase did not predict comprehension at test. However, learning with only full noun phrase arguments resulted in lower comprehension of the structure, particularly with pronouns. Hearing pronouns during learning supported comprehension of all arguments types at test. These results indicate that pronominal arguments support argument structure learning by providing multiple cues that can facilitate thematic role assignment.

Children acquiring language use the speech that they hear to determine how the structure of utterances encodes relationships between entities. For example, children learning English need to determine that grammatical subjects come before the verb and grammatical objects come after it, but they also need to understand how those structural roles are related to the meaning of the sentence. In addition to these challenges, they need to learn whether and how a grammatical structure extends to verbs beyond those that have been attested in it. The nature of the processes underlying this learning and the precise role of experience in those processes is at the heart of much research on first language development.

One aspect of experience with any linguistic structure is its frequency. Although frequency effects are widespread in the literature on language learning (see Ambridge, Kidd, Rowland & Theakston, 2015, for a review), frequency alone does not account for some of the acquisition patterns reported in the literature. Indeed, some highly frequent syntactic forms appear to be only weakly comprehended in lab settings. For example, the double-object (DO) form of the English dative alternation (i.e., *Elsa sent Anna some flowers*) is three times more frequent in speech to children than its prepositional (PP) counterpart (i.e., *Elsa sent some flowers to Anna*; Campbell & Tomasello, 2001; Conwell, O'Donnell & Snedeker, 2011; Snyder & Stromswold, 1997; Viau, 2007), but children between three and five years old show limited verb-general ability with the DO dative compared to the PP form in both comprehension and production tasks (Arunachalam, 2017; Conwell & Demuth, 2007; Osgood & Zehler, 1981; Rowland & Noble, 2010; Stephens, 2015). This is, on its surface, somewhat puzzling. Given widespread frequency effects in acquisition, why would children have less facility with the more frequent form of an alternation? One explanation is that, in addition to varying in frequency, the two forms of this alternation vary in their lexical diversity. The DO dative tends to occur with pronominal recipients and

lexical themes (e.g., *give me the flowers*), while the PP dative supports lexical arguments in both post-verbal roles (Conwell, et al., 2011; DeMarneffe, Grimm, Arnon, Kirby & Bresnan, 2012; Stephens, 2015). Children may perform poorly on dative comprehension tasks because the stimuli used in these studies typically use full lexical arguments, which is inconsistent with children's experience (Conwell, 2019). The DO dative also contains a somewhat smaller set of verbs than the PP dative (Bresnan & Nikitina, 2009; Levin, 1993). Such limited variability in a syntactic form may cause learners to conclude that it is less productive and more lexically-specified than other forms. If children draw such a conclusion, they might rely on high-frequency sequences for use and comprehension of a particular form, and show reduced lexically-general ability with that structure (see Conwell, et al., 2011, for a computational demonstration of this phenomenon specific to the dative alternation, and Yang, 2016, for a general discussion of such a process in terms of his proposed Tolerance Principle).

Cases such as the English dative alternation suggest that accounts of the role of experience in language learning need to include a role for variability as well as frequency. Casenhiser & Goldberg (2005) used an artificial language paradigm to examine how verb variability affected the acquisition of a novel construction. They presented 5- and 6-year-old English-speaking children with a set of events of appearance and utterances using novel verbs in a non-English word order (Subject-Object-Verb) to encode the manner and location of appearance. For example, when viewing an event in which a rabbit appeared in a hat, a participant would hear "the rabbit the hat moopo-ed." After 16 exposures to such videos, children were asked to make a two-alternative forced-choice judgment regarding which of two videos matched an utterance using the newly learned structure. All test trials used novel verbs that had not previously been heard during the learning phase. Because in natural language a single verb often accounts for a

large portion of exemplars of a given construction (Goldberg, Casenhiser & Sethuraman, 2004), Casenhiser & Goldberg (2005) manipulated the relative frequency of the novel verbs during the learning phase to determine whether that affected learning of the novel structure. In their balanced condition, participants heard an approximately equal number of learning trials with each of five novel verbs, while in their skewed condition, the participants heard one verb on four learning trials and the remaining four novel verbs on only one trial each. They found that, though children in both conditions performed better than chance, the skewed frequency group outperformed the balanced frequency group. This effect could not be attributed to prior experience with the verbs used at test, and therefore indicated that having a preponderance of exemplars containing the same verb supported learning the meaning of a construction. One account of this effect of skew is that children might use many exemplars containing the same lexical item to support analogizing to new structures, as in structural alignment (Markman & Gentner, 1993).

In further research using a similar paradigm, but where all participants were exposed to a skewed verb distribution, Boyd & Goldberg (2012) demonstrated that five-year-olds showed chance performance with novel verbs that they had not encountered during learning, while seven-year-olds were able to generalize their knowledge of the new construction to completely new verbs at test. This was taken to indicate that the ability to extend a construction to new verbs improves during childhood. With a modified version of the construction learning paradigm, Perek & Goldberg (2017) asked how construction meaning and verb distribution affected adults' ability to acquire an alternating pair of constructions. They found that skewed distributions of verb use induced higher levels of conservatism in learners due to statistical pre-emption. In another study using a novel argument structure learning paradigm with 4- and 5-year-olds,

Wonnacott, et al. (2012) showed that verb diversity without a skewed distribution during the learning phase supported extension of the structure to new verbs in both act-out and production tasks. However, additional work by Wonnacott, Brown & Nation (2017) demonstrated that a skewed distribution of types that occur with specific particles improved the learning of lexical restrictions on the use of those particles.

While the work by Goldberg and colleagues established that verb distribution, along with age and construction semantics, could affect learners' generalization of a novel form to new verbs, it did not address how argument variability might impact this process. Some syntactic structures show greater degrees of argument variability than others in speech to children, which could affect how learners decide that a verb can be used with a range of arguments (Conwell, et al., 2011). One source of low argument variability is pronoun use. Because pronouns are a closed class, a structure that tends to fill particular thematic roles with pronouns will have inherently low variability in those roles. The reduced variability in those positions could lead to the conclusion that the argument position does not generalize to other noun types (e.g., via Yang's, 2016, Tolerance Principle). Indeed, interventional research with toddlers has shown that increased exposure to lexical subjects can support children's grammatical growth (Hadley, et al., 2017). Alternatively, learners could use those pronominal arguments to support a processing strategy: when the high-frequency, low-variability nature of pronouns provides information about role assignment that aligns with children's prior experience, comprehension and production are easier than when those properties do not align. For example, Conwell (2019) demonstrated that three-year-olds' comprehension of the English DO dative improved significantly when the recipient was the personal pronoun *me*, which created a structure that was frequent in children's experience. However, no such advantage was seen for a pronominal

recipient in the PP dative, perhaps because pronominal recipients are vanishingly rare in natural productions of the PP dative. Those findings suggest that, although pronouns reduce variability that would support generalization, they could play an important role in children's language learning by providing stable cues to structure and thematic roles. Their high frequency, in particular, could make them easy-to-detect and familiar to learners, and thus, an important foothold for comprehending structures in which they are regularly heard.

Previous studies have considered the role of pronouns in building representations of grammatical structures. For example, Mintz's (2003) "frequent frames" all contained closed-class words, some of which were pronouns. Subject and objects in child-directed speech are overwhelmingly pronouns, and specific pronouns are more likely to occur as subjects or objects of particular semantic classes of verbs (Laasko & Smith, 2007). Pronouns also constitute the majority of subjects in children's own speech (Valian, 1991). Childers and Tomasello (2001) directly examined the role of pronouns in young children's generalization of the transitive construction. They used four training conditions to consider how differences in experience might affect two-and-a-half-year-olds' ability to describe transitive actions. These conditions were 1) familiar verbs with noun phrases, 2) familiar verbs with pronouns, 3) novel verbs with noun phrases, and 4) novel verbs with pronouns. At test, all children were shown fully novel transitive actions labeled with novel transitive verbs and asked to describe the events. Regardless of whether they heard familiar or novel verbs during training, children were more likely to use a novel verb in the transitive construction at test if their training experience had contained pronouns. Although Childers & Tomasello (2001) took this as evidence of a slot-and-frame based learning strategy (similar to that proposed by Braine, 1976), their result might also have been due to the information about case that is carried by personal pronouns in English, which

could have highlighted the thematic roles of the arguments and reduced the processing load on the participants.

English does not mark case widely, but some of the English personal pronouns do carry case information (e.g., *he* is nominative, while *him* is accusative). Ibbotson, Theakston, Lieven & Tomasello (2010) used a force-choice comprehension paradigm with novel verbs to show that two- and three-year-old children could use the case information present in pronouns to assign agent and patient thematic roles to pronouns in transitive events. Looking time studies by Yuan and colleagues (Yuan & Fisher, 2009; Yuan, Fisher & Snedeker, 2012) further demonstrated that toddlers could predict whether a novel verb would refer to a transitive event or an intransitive event after hearing a dialogue using that verb in either a transitive or intransitive structure. In Yuan & Fisher (2009), half of the exposure sentences contained pronominal subjects, while in Yuan, et al. (2012), *all* of the exposure sentences used pronouns in all argument positions. Therefore, pronouns could have supported argument structure mapping in these studies by differentiating the thematic roles of the arguments.

The research outlined above has indicated that verb type variability and pronoun use both play a role in argument structure acquisition and generalization. However, none of these studies has directly manipulated these two variables together to look at how they might interact. The study presented here used an artificial construction learning task to assess the relative contributions of lexical variability and pronoun use. Drawing on methods developed by Casenhiser & Goldberg (2005), this study involved teaching 5- and 6-year-old English-learning children a novel argument structure and then testing their comprehension of that structure. In the learning phase, the diversity of verb types was manipulated between subjects, as was the use of pronouns in the object position. If pronouns support the acquisition of a novel argument

structure, we would expect those children who learn the structure with pronominal arguments to show better comprehension of the structure at test than those who hear learn the structure with full NP arguments. If lexical diversity supports the acquisition of a novel argument structure, then we would expect those children who hear more verbs and those children who hear noun phrases instead of pronouns to comprehend the structure better at test. If, however, children learn these structures in a lexically-dependent way, we would expect them to show the highest levels of comprehension on those test trials that contained previously heard lexical items. Because previous research has found evidence in support of all of these possibilities, we did not have an *a priori* prediction about which of these patterns we were likely to see.

Method

Participants

Participants were 72 English-learning children (37 male; 35 female) who were five or six years of age (mean age 5;8, standard deviation 7.5 months; range 5;0-6;11). This age range was selected because children of this age have previously been successful on artificial language learning tasks (Boyd & Goldberg, 2012; Casenhiser & Goldberg, 2005; Wonnacott, 2011; Wonnacott, et al., 2012; Wonnacott, et al., 2017). An additional 16 children began the study, but were excluded from analysis due to side bias (i.e., selecting the same side on every trial; 13), failure to complete all trials (2), and technical difficulties with the videos (1). This sample was recruited through community events in the [redacted city name], area and advertisements published in local parent-oriented publications and sent to mailing lists. Although detailed demographic information was not collected, more than 90% of the children were white and from middle class backgrounds, which is consistent with the demographics of the [redacted city name]

community. Children were tested in a lab setting or, in the case of a few younger participants, in a quiet room in their child care center.

Stimuli

The video stimuli for this study consisted of short clips of cartoon animals engaging in novel, transitive actions in which an agent changed the pose of a patient (tilted, turned around, flipped upside down, bent backward, bent forward, and caused to lie down). These stimuli were created in AnimeStudioPro. The novel argument structure for this study used a Subject-Object-Verb (SOV) structure. The audio stimuli were sentences in the novel argument structure containing novel verbs and English nouns and/or pronouns. The novel verbs were *pilk*, *gofe*, *moog*, *blick*, *glorp*, and *meep*. Both English accusative personal pronouns (*him* and *her*) were used with equal frequency. The English nouns used in the study were *cat*, *dog*, *duck*, *lion*, *monkey*, *mouse*, *rabbit*, and *pig*. When full NPs were used, these included a determiner (i.e., *the mouse*), so the noun could not be interpreted as, for example, a proper name. The sentences were recorded by an adult female native speaker of American English using Audacity. An example stimulus is shown in Figure 1.

Design

This study was designed to test the effects of two different learning parameters on children's ability to understand this new structure. The first parameter was the variability in the number of verb types experienced in the structure (two vs. four). The second parameter was argument variability, defined as whether the patients were labeled with noun phrases (i.e., *the cat*) or pronouns (i.e., *her*). The two learning parameters with two levels each were fully crossed to create four between-subjects learning conditions: four verbs/NP patients; four verbs/pronominal patients; two verbs/NP patients; two verbs/pronominal patients. Example learning sentences are

presented in Table 1. Participants were randomly assigned to a learning condition. Participants completed a learning phase in which they watched videos described using the novel structure and then repeated what they heard. Within a learning condition, all verbs were used an equal number of times. Although natural speech to children tends to show skewed distributions of verb types within structures (Goldberg, et al., 2004), and many previous studies of artificial argument structures have used a skewed distribution of verbs (Boyd & Goldberg, 2012; Casenhiser & Goldberg, 2005; Perek & Goldberg, 2017), the primary focus of this research was to determine the role of lexical diversity while controlling for token frequency and skew.

The learning phase was immediately followed by a testing phase. All participants completed the same test trials. Two different parameters were manipulated within subjects to create the test trials. One of these parameters was the familiarity of the verb (familiar from the learning phase vs. novel to the testing phase; all verbs at both learning and test were nonce verbs). The other was whether the patient was expressed as a noun phrase or as a pronoun. These parameters were fully crossed to create four within-subjects test trial types: familiar verb/NP patient; familiar verb/pronominal patient; novel verb/NP patient; novel verb/pronominal patient. Then, four unique test trials were created for each of these trial types. All children completed the same test trials. Although some children heard four verbs during the learning phase, only the two verbs that had been heard by all children during learning (*pilk* and *gofe*) were included as familiar in the test phase. The two novel verbs in the test phase (*meep* and *glorp*) were novel for all participants. The two videos in each test trial involved the same characters, meaning that children needed to comprehend the argument structure itself to identify the target video. An example test trial is presented in Figure 2.

Procedure

Participants were seated 12-18 inches from a laptop computer. For the learning portion of the study, they were told to watch each video carefully and listen closely to the sentence that they heard so that they could repeat it after it was finished. Children who hesitated to repeat the sentences were prompted by the experimenter. Children in the two verb condition saw six unique videos for each of the two verbs they were learning, and each video was repeated twice. Children in the four verb condition saw three unique videos for each of the four verbs they were learning, and each video was repeated twice. Thus, every child saw 12 unique learning videos, each of which was played twice for a total of 24 trials. These videos were presented in random order for each participant.

Following the learning phase, children were told that they were going to see two videos at a time and that they should determine which video was being described, and then point to that video. Responses were recorded by the experimenter. Children saw a total of 16 test trials, 4 in each condition; all children completed the same test trials.

Results

The results of this study are depicted in Figure 3. The data from this study were analyzed using a binomial logistic regression implemented with the `glmer` function using the `bobyqa` optimizer in the `lme4` package (Bates, Maechler, Bolker & Walker, 2015) in R (R Core Team, 2015). The dependent variable was accuracy (correct/incorrect), and the fixed factors were the number of verbs heard during learning (4 vs. 2), argument type during learning (NP vs. Pronoun), verb familiarity at test (familiar vs. new), and argument type at test (NP vs. Pronoun). All fixed factors were centered prior to analysis using contrast matrices generated in R. A maximal model including by-participant random slopes for both argument type at test and verb familiarity at test failed to converge. However, a model including by-participant random slopes

for argument type at test was the most maximal model that successfully converged. The results of that model are reported below and in Table 2.

There was no evidence of a main effect of number of verbs in the learning phase ($z=0.494$, $p=0.622$), but there was a main effect of the type of arguments heard during learning ($z=-2.105$, $p=0.035$). Participants who heard pronouns during learning showed better comprehension during test (73.4% correct) than those who heard full noun phrases (61.8% correct). Turning to the two within-subjects factors, there was no evidence of a main effect of verb familiarity at test ($z=-0.782$, $p=0.434$), nor of argument type at test on accuracy ($z=1.306$, $p=0.192$). However, there was a significant interaction of argument type during learning and argument type at test ($z=3.417$, $p<0.001$). To further investigate this interaction, two more models were constructed, one including participants who had learned the structure with full NP arguments, and one including participants who had learned the structure with pronominal arguments. In both of these models, accuracy was the dependent measure, argument type at test was the fixed factor, and by-participant random slopes for argument type were included. The code for these models is also in Appendix 1. Participants who heard full NP arguments during learning showed an effect of argument type at test ($z=3.576$, $p<.001$), indicating that they were worse at comprehending the novel structure with pronominal arguments (53.5% correct) than with full NP arguments (70.1% correct). Participants who heard pronominal patients during learning did not show an effect of argument type at test ($z=-0.841$, $p=0.4$). This indicates that there was not evidence of a difference in their comprehension of the novel structure when the patient was a full NP or a pronoun. No other interactions were statistically significant. Due to the sample size and the lack of a priori directional hypotheses, these analyses are more exploratory than confirmatory. The formulae for all statistical models used in these analyses are in Appendix 1.

Discussion

This study asked how children's experience with verb diversity and argument type affected their learning of a novel argument structure. We parametrically manipulated the number of nonce verb types that children experienced in the novel structure, as well as whether they heard full NPs or pronouns in the patient role. Then, we tested children's ability to comprehend the novel structure with familiar nonce verbs or new nonce verbs, as well as with pronouns or full NPs. The results provide no evidence that verb diversity during training and verb familiarity at test affect children's ability to comprehend the structure. However, they suggest that experience with pronouns in the novel argument structure leads to better comprehension and generalization of the structure. Specifically, children who had learned the structure with pronouns showed successful comprehension when tested with pronominal patients or with full NP patients, while children who had not previously heard pronouns in the structure did not differ from chance when tested with pronouns, but were above chance performance when tested with full NP patients.

These findings do not strongly support an account in which lexical diversity supports learning of a novel argument structure. There was no evidence of an effect of verb type diversity on children's ability to comprehend the new argument structure at test, and children who heard lower argument diversity during learning did *better* on test trials than those who learned with diverse arguments. This indicates that, at least in this paradigm, reduced lexical diversity does not hinder children's learning. This is somewhat surprising given previous evidence that lexical diversity impacts argument structure learning (Casenhiser & Goldberg, 2005; Conwell, et al., 2011; Hadley, et al., 2017; Wonnacott, et al., 2012; Yang, 2016). However, one difference between this study and both natural language and some previous novel structure learning paradigms is that this study used an even distribution of tokens of each lexical type during the

learning phase. Prior work suggesting that the frequency of lexical types impacts argument structure acquisition primarily considers distributions that are also skewed in terms of type frequency (Boyd & Goldberg, 2012; Casenhiser & Goldberg, 2005). The findings presented here may indicate that increasing lexical type frequency while decreasing lexical diversity overall does not impact learning if each word type is used an equal number of times. Rather, effects of lexical type frequency on argument structure learning may only been seen when a single high frequency word co-occurs with a diverse set of lower frequency items, as in the prior work by Goldberg and colleagues (but see Wonnacott, et al., 2012, for evidence of better learning with diverse verbs in the absence of skew).

Because pronouns are a closed class, use of pronominal arguments reduces the lexical variability in an argument structure, as compared to the use of NP arguments with lexical heads. If lexical variability plays a critical role in supporting argument structure acquisition (e.g., Conwell, et al., 2011; Hadley, et al., 2017; Yang, 2016), we would expect to have seen a learning and generalization disadvantage for children who heard the novel argument structure with only pronominal patients. These children were exposed to reduced lexical variability, and so should have been less able to generalize to new words. However, we saw the opposite. Children who were familiarized to the novel structure with full NP arguments in both agent and patient positions showed lower overall performance and less generalization than children who were familiarized to the structure with pronominal patients. One possible explanation for this pattern is that children in the pronoun learning conditions had more practice interpreting the pronouns in this context, and so were better able to do so during testing. Although the pronouns used in this study were gendered, the animals in the scenes were not depicted with any kind of canonical gender cues. To determine which character was the referent of the pronoun, children needed to

use an elimination process (i.e., the animal that was not mentioned by name was the referent of the pronoun). If this process was particularly challenging to children, then those children with experience hearing pronouns in the study could perform better with pronouns at test simply because they had more practice. Although this possibility cannot be ruled out with the current data, it could be tested in future studies. However, it is the case that the data presented here do not support the claim that pronominal arguments inhibit or reduce structure generalization, which was a hypothesis under consideration.

These findings do support the idea that pronominal arguments may play a unique role in argument structure learning. Although children who learned the structure with full NP arguments as both agent and patient were able to comprehend the structure with new NP arguments, they performed at chance when the patient was a pronoun. However, children who learned the structure with pronominal patients successfully comprehended the structure with either pronominal or full NP patients. This is consistent with an account by which pronouns provide case information that supports thematic role assignment during learning. Prior work by Childers & Tomasello (2001) showed that young children were more likely to generalize new verbs to a familiar argument structure when trained with pronouns. In those generalizations, children used pronominal arguments, which Childers & Tomasello interpreted as consistent with a slot-and-frame grammar. Because children in the present study who learned the structure with pronouns had no difficulty with full NP arguments and novel verbs, these results are not consistent with a frame-based grammar. A frame-based grammar would require at least some lexical overlap. The results of both this study and Childers & Tomasello (2001), as well as those of Casenhiser & Goldberg (2005), suggest that high frequency lexical items that are repeated across uses may support children's argument structure learning by facilitating comparison. This could support

generalization by analogy, perhaps through a process like structural alignment (Markman & Gentner, 1993).

The results of the present study, taken together with the results from Childers & Tomasello (2001) and with research showing that children can access case information on pronouns (Ibbotson, et al., 2010), also support the idea that pronouns may facilitate thematic role assignment, which in turn assists with argument structure learning. Furthermore, in Syntactic Bootstrapping research, studies of toddlers' ability to use argument structure to interpret a novel verb often use pronominal arguments (e.g., Yuan, et al., 2012), which is consistent with an account by which pronouns can support thematic role assignment. One difference between the study presented here and some previous studies looking at pronoun use in argument structure acquisition is that this study only presented accusative pronouns. Children's ability to use pronouns to extract case information may be affected by the diversity of cases in which pronouns occur. This is an important issue for future research. Likewise, future work should investigate whether similar benefits of pronoun exposure during learning are found with pronouns that do not provide case information, which would refute the claim that case marking is the critical contribution of pronominal arguments.

This study shows that preschool-aged children can learn a novel argument structure and extend it to new verbs and arguments. It further demonstrates that children whose exposure to the novel argument structure contains pronominal arguments are able to comprehend the structure with both pronouns and full NP arguments. These results, taken together with previous research, demonstrate that pronouns may facilitate the acquisition of argument structure in English by providing critical information about thematic roles and supporting comparison across utterances.

References

- Ambridge, B., Kidd, E., Rowland, C. F. & Theakston, A. L. (2015). The ubiquity of frequency effects in first language acquisition. *Journal of Child Language*, 42, 239-273.
- Arunachalam, S. (2017). Preschoolers' acquisition of novel verbs in the double object dative. *Cognitive Science*, 41, 831-854.
- Bates, D., Maechler, M., Bolker, B.M. & Walker, S. (2015). Fitting linear mixed-effects models using lme4. ArXiv e-print, retrieved from <http://arxiv.org/abs/1406.5823>
- Boyd, J. K. & Goldberg, A. E. (2012). Young children fail to fully generalize a novel argument structure construction when exposed to the same input as older learners. *Journal of Child Language*, 39, 457-481.
- Braine, M. D. S. (1976). Children's first word combinations. *Monographs of the Society for Research in Child Development*, 41.
- Bresnan, J. & Nikitina T. (2009). The gradience of the dative alternation. In L. Uyechi & L. H. Wee (Eds.), *Reality, exploration and discovery: Pattern interaction in language and life*. Stanford, CA: CSLI Publications.
- Campbell, A. & Tomasello, M. (2001). The acquisition of English dative constructions. *Applied Linguistics*, 22, 253-267.
- Casenhiser, D. & Goldberg, A. E. (2005). Fast mapping between a phrasal form and meaning. *Developmental Science*, 8, 500-508.
- Childers, J. B. & Tomasello, M. (2001). The role of pronouns in young children's acquisition of the English transitive construction. *Developmental Psychology*, 37, 739-748.
- Conwell, E. (2019). The effects of the pronoun *me* on dative comprehension. *Journal of Child Language*, 46, 1127-1141.

- Conwell, E. & Demuth, K. (2007). Early syntactic productivity: Evidence from dative shift. *Cognition*, 103, 163-179.
- Conwell, E., O'Donnell, T. J. & Snedeker, J. (2011). Frozen chunks and generalized representations: The case of the English dative alternation. In N. Danis, K. Mesh & H. Sung (Eds.), *Proceedings of the 35th Annual Boston University Conference on Language Development*. Somerville, MA: Cascadilla Press.
- De Marneffe, M.-C., Grimm, S., Arnon, I., Kirby, S. & Bresnan, J. (2012). A statistical model of the grammatical choices in child production of dative sentences. *Language and Cognitive Processes*, 27, 25-61.
- Goldberg, A. E., Casenhiser, D. M. & Sethuraman, N. (2004). Learning argument structure generalizations. *Cognitive Linguistics*, 15, 289-316.
- Hadley, P. A., Rispoli, M., Holt, J. K., Papastratakos, T., Hsu, N., Kubalanza, M., & McKenna, M. M. (2017). Input subject diversity enhances early grammatical growth: Evidence from a parent-implemented intervention. *Language Learning and Development*, 13, 64-79.
- Ibbotson, P., Theakston, A., Lieven, E. & Tomasello, M. (2010). The role of pronoun frames in early comprehension of transitive constructions in English. *Language Learning & Development*, 7, 24-39.
- Laasko, A. & Smith, L. B. (2007). Pronouns and verbs in adult speech to children: A corpus analysis. *Journal of Child Language*, 34, 725-763.
- Levin, B. (1993). *English verb classes and alternations: A preliminary investigation*. Chicago, IL: University of Chicago Press.
- Markman, A. & Gentner, D. (1993). Structural alignment during similarity comparisons. *Cognitive Psychology*, 25, 431-467.

- Mintz, T. H. (2003). Frequent frames as a cue to grammatical categories in child-directed speech. *Cognition*, 90, 91-117.
- Naigles, L. R. & Hoff-Ginsberg, E. (1998). Why are some verbs learned before other verbs? Effects of input frequency and structure on children's early verb use. *Journal of Child Language*, 25, 95-120.
- Osgood, C. & Zehler, A. (1981). Acquisition of bi-transitive sentences: Pre-linguistic determinants of language acquisition. *Journal of Child Language*, 8, 367-383.
- Perek, F. & Goldberg, A. E. (2017). Linguistic generalization on the basis of function and constraints on the basis of statistical preemption. *Cognition*, 168, 276-293.
- R Core Team (2015). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Retrieved from <http://www.R-project.org/>.
- Rowland, C. F. & Noble, C. H. (2010). The role of syntactic structure in children's sentence comprehension: Evidence from the dative. *Language Learning and Development*, 7, 55-75.
- Stephens, N. (2015). Dative constructions and givenness in the speech of four-year-olds. *Linguistics*, 53, 405-442.
- Snyder, W. & Stromswold, K. (1997). The structure and acquisition of the English dative constructions. *Linguistic Inquiry*, 28, 281-317.
- Valian, V. (1991). Syntactic subjects in the early speech of American and Italian children. *Cognition*, 40, 21-81.
- Viau, J. (2007). *Possession and spatial motion in the acquisition of ditransitives*. Unpublished doctoral dissertation. Northwestern University.
- Wonnacott, E. (2011). Balancing generalization and lexical conservatism: An artificial language study with child learners. *Journal of Memory and Language*, 65, 1-14.

- Wonnacott, E., Boyd, J. K., Thomson, J., & Goldberg, A. E. (2012). Input effects on the acquisition of a novel phrasal construction in 5 year olds. *Journal of Memory and Language*, 66,, 458-478.
- Wonnacott, E., Brown, H., & Nation, K. (2017). Skewing the evidence: The effect of input structure on child and adult learning of lexically based patterns in an artificial language. *Journal of Memory and Language*, 95, 36-48.
- Yang, C. D. (2016). *The price of productivity: How children break the rules of language*. Cambridge, MA: MIT Press.
- Yuan, S. & Fisher, C. (2009). “Really? She blicked the baby?” Two-year-olds learn combinatorial facts about verbs by listening. *Psychological Science*, 20, 619-626.
- Yuan, S., Fisher, C. & Snedeker, J. (2012). Counting the nouns: Simple structural cues to verb meaning. *Child Development*, 83, 1382-1399.

Table Captions

Table 1. Example sentence stimuli from the learning phase.

Table 2. Results of the binomial logistic regression. The dependent variable was accuracy (correct/incorrect).

Table 1.

NP Learning Condition	Pronoun Learning Condition
The monkey the cat pilks.	The monkey her pilks.

Table 2.

Effect	Estimate	SE	z-score
<i>Fixed Effects</i>			
Intercept	1.13	0.186	6.083***
Number of Verbs in Learning Phase	0.09	0.182	0.494
Learning Phase Argument Types	-0.384	0.182	-2.105*
Test Phase Verb Familiarity	-0.058	0.074	-0.782
Test Phase Argument Types	0.148	0.113	1.306
Number of Learning Verbs x Learning Argument Type	-0.114	0.182	-0.627
Number of Learning Verbs x Test Verb Familiarity	0.116	0.074	1.553
Number of Learning Verbs x Test Argument Type	0.171	0.105	1.626
Learning Argument Type x Test Verb Familiarity	0.131	0.074	1.752
Learning Argument Type x Test Argument Type	0.362	0.106	3.417***
Test Verb Familiarity x Test Argument Type	-0.035	0.074	-0.465
Number of Learning Verbs x Learning Argument Type x Test Verb Familiarity	-0.048	0.074	-0.637
Number of Learning Verbs x Learning Argument Type x Test Argument Type	0.001	0.105	0.013
Number of Learning Verbs x Test Verb Familiarity x Test Argument Type	-0.03	0.074	-0.409
Learning Argument Type x Test Verb Familiarity x Test Argument Type	-0.08	0.075	-1.07
Number of Learning Verbs x Learning Argument Type x Test Verb Familiarity x Test Argument Type	0.094	0.074	1.263

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure Captions

Figure 1. A frame from a learning trial in which the agent (monkey) causes the patient (cat) to bend backward. The audio for this trial would be *The monkey the cat gofes* or *The monkey her gofes*, depending on the learning condition.

Figure 2. An example test trial in which the agent in each video causes the patient to lie down. The audio for this trial was *The mouse him glorps*, which refers to the video on the left.

Figure 3. Data from test trials on which participants heard verbs they had heard during the learning phase (left panel) and from test trials on which participants heard verbs they had not heard during the learning phase (right panel). The dotted line indicates chance performance.

Figure 1.

Figure 2.

Figure 3.

Appendix

Formula for full statistical model

```
glmer(Accuracy~LearningVerb*LearningArgs*VerbType*ArgType+(ArgType|Participant), data=asl, family=binomial, glmerControl(optimizer="bobyqa"))
```

Formula for model analyzing the effect of argument type on accuracy for participants in the full NP Learning condition

```
glmer(Accuracy~ArgType+(ArgType|Participant), data=asl.nplearners, family=binomial)
```

Formula for model analyzing the effect of argument type on accuracy for participants in the pronoun Learning condition

```
glmer(Accuracy~ArgType+(ArgType|Participant), data=asl.proearners, family=binomial)
```