University of Groningen

Cognitive bias overrides syntactic bootstrapping in novel verb learning

Mills, Annelot; van Hout, Angeliek

Cognitive Bias Overrides Syntactic Bootstrapping in Novel Verb Learning

Annelot Mills and Angeliek van Hout

1. Background

Acquiring novel verb meanings is challenging because events in the world are inherently multi-interpretable (Quine, 1960). Of the many different types of events there are in the world, the class of motion events has been most extensively studied, both in acquisition (e.g. Allen et al., 2007) as well as in typology (e.g., Talmy, 2000). Change-of-state events, on the other hand, have received much less attention. Only few acquisition studies so far have looked at this class of events, aiming to identify lexicalization biases in young learners and determining at what age these become language-specific (Bunger et al., 2016; Papafragou et al., 2002). The present study focuses on change-of-state events and investigates if syntactic structure, specifically, transitivity, plays a role in determining which meaning aspect of such events—manner or result—is encoded in novel verbs. The study is framed in syntactic bootstrapping theory, the idea that meaning can be inferred from syntactic structure (Brown, 1957; Gleitman, 1990; Naigles, 1996). Replicating Wagner's (2010) novel-verb paradigm we ask: does transitivity—the use of a verb in a transitive or intransitive verb frame—affect the lexical encoding of a change-of state event, triggering a preference for a manner or result meaning? We investigate if there are such encoding biases associated with transitivity in Dutch 3-year-olds and English 7-year-olds. Presenting novel verbs used in either a transitive or an intransitive verb frame with novel events that showed both a distinctive manner of action and a distinctive result, we wanted to see if participants had any biases in interpreting the verbs as manner or result verbs.

Transitivity restricts the availability of manner and result interpretations to some extent. In a transitive sentence like (1), the Agent and Patient participants are both explicitly given as subject and direct object, respectively. For multi-interpretable scenes, this verb frame is compatible with a focus either on the Agent's manner of action as directed upon a Patient, or the change of state in the Patient as brought about by an Agent. Thus, when a novel verb like *dax* is used in a transitive frame in (1), it is principally ambiguous: it can lexicalize either a

manner reading, such as *comb,* or a result reading, such as *rip* (in the sample scene in Figure 3 these are the two possible verb meanings).

(1) a. The monster is daxing the chair.
     b. The monster is combing the chair.   Manner
     c. The monster is rippin*g* the chair.   Result

Intransitive sentences, on the other hand, mention only one participant, the Agent or the Patient. Descriptions of novel scenes with a manner and result component using an intransitive verb frame necessarily focus on either the Agent or the Patient, which crucially affects the possible interpretations. If the Agent of the event is expressed as the subject of the sentence, the only possible lexicalization for *dax* is the action that the Agent is engaged in: a manner interpretation, (2). On the other hand, if the Patient appears as the subject of the sentence, the focus is on what is happening to the Patient, triggering a result reading, (3). The meaning of novel verbs used in an intransitive verb frame is thus more restricted than verbs used in transitive frames; it depends on whether the participant expressed as subject of the sentence is an Agent or a Patient in the event.

(2) a. The monster is daxing.
     b. The monster is combing.   Manner
     c. *The monster is ripping.   Result

(3) a. The chair is daxing.
     b. *The chair is combing.   Manner
     c. The chair is ripping.   Result

The lexical notions of manner and result as possible components of verb meanings can be straightforwardly connected to the semantic distinction of telicity: telic verbs describe events with a natural endpoint or culmination moment (Dowty, 1979; Vendler 1967). Most change-of-state verbs involve a result component and are telic: *open, close, break, blow out, kill, die*. Atelic verbs describe events without any notion of culmination, instead expressing the manner of action: *work, talk, shine, love, push*. Telicity is therefore another way of characterizing verbs and whether or not they include a result component.

In an acquisition study on the link between transitivity and telicity Wagner (2010) used a match-to-sample task. Three-year-old children were shown novel events with a distinctive manner and a distinctive result and heard a novel verb describing this scene, presented in either a transitive frame or an intransitive frame. Their task was to judge whether new scenes matched the sample, where the new scenes either showed the same manner or the same result. The results showed that participants preferred a manner interpretation when the novel verb was presented in an intransitive frame, while a result meaning was favored for novel verbs in a transitive frame. These results suggest that children exploit

transitivity when inferring the meaning of novel verbs in event contexts with a particular manner and a particular result. Wagner concludes that this link between transitivity and telicity is yet another reflex of syntactic bootstrapping as a learnability meachnism.

However, as Wagner herself points out, "(a)lthough transitivity is an important syntactic reflex of telicity, it is neither necessary nor sufficient for predicting a telicity value; it is therefore a weak cue for telicity semantics" (Wagner, 2010:1354). Given the range of interpretations for both transitive and intransitive verbs in (1)-(3), it is actually highly surprising that the meaning biases that were found linked transitives with a result reading, and intransitives with a manner reading. In fact, in the English syntax-semantics mapping system there do not seem to be any such specific associations between telicity and transitivity. There are transitive verbs that are telic (*destroy, damage, construct*) and others that are atelic (*push, carry, love*), and also intransitive verbs can be telic (*die, open, close)* or atelic (*sleep, work, talk)*. A novel transitive verb, (1), is therefore compatible both with manner and result readings, as is an intransitive verb, modulo the thematic role of the subject, (2)-(3).

The aim of this paper is to investigate further the alleged link between telicity and transitivity for the class of change-of-state events, thereby evaluating the role of syntactic bootstrapping for learning the meaning of manner and result verbs. Our approach is two-fold. First, an elicitation study investigates how English-speaking adults interpret and describe short animated cartoons with ambiguous scenes with a manner and result component in order to see if such scenes trigger any lexicalization biases. These results also served as stimuli validation for the second study to make sure that the animations were not inherently biased towards manner or result. Second, like Wagner (2010), we investigated whether Dutch and English learners and Dutch adults use transitivity as a cue to determine the meaning of novel verbs for ambiguous scenes. We replicated her novel verb paradigm, adjusting a few methodological issues, the most important of which is that we replaced the match-to-sample task with a forced-choice selection task. Wagner's findings lead us to expect that, when novel verbs are presented in an intransitive sentence frame, a manner interpretation will be preferred, whereas novel verbs presented in a transitive sentence frame will trigger a result reading. Based on the syntax-semantics of English transitive and intransitive sentences as discussed above, however, we do not expect any particular associations between telicity and transitivity.

2. Study 1: Adults' lexicalizations of novel change-of-state scenes

Goal. The primary goal of the first experiment was to validate the stimuli to be used for the second experiment: ambiguous events with two salient subcomponents—manner and result. We needed to check that the animated cartoons that were used in both experiments were not inherently biased towards one or the other subcomponent. In addition, this experiment allows us to see if adults have a lexicalization biases when they describe such ambiguous scenes. In

Talmy's (1985) typology English is classified as a so-called satellite-framed language, which means that English main verbs characteristically encode a manner of motion or action, while meaning components such as path or result are encoded in a satellite to the verb, in English, typically particles, PPs and resultative phrases. Given this typological status, one might expect participants to produce mostly manner verbs in their descriptions.

Participants. 20 English-speaking adults were recruited through Amazon Mechanical Turk. They were paid $1 for their participation in the study.

Stimuli and procedure. Participants were presented with animated cartoons, adopted from Geojo (2015), showing ambiguous events which depicted caused change-of-state events in which a friendly green monster was doing some action on an object causing a salient change in the object. The manner was made salient by showing the monster using a particular instrument and making three or four movements with the instrument directed at the object. Participants were asked to type one action word to describe the events. All items were randomized across participants. Before the start of the experiment there was one training trial, in which the action word was given to familiarize participants with the task. Table 1 lists the descriptions of the eight scenes together with potential matching manner and result verbs.

This method is based on similar methods used by Behrend (1990) and Bunger et al. (2016) with a few improvements: we used animated cartoons instead of still images and participants were asked to provide one word to describe the main event in the scenes instead of full sentences or multiple descriptions. Participants' responses were coded as expressing either manner or result. Manner meanings were defined as verbs that described the action itself without a clear outcome or endpoint (e.g. *comb, combing*), while result meanings included verbs that did describe an outcome or result state of an event (e.g. *breaking*), following the verb classification of Levin and Rappaport Hovav (2005).

Table 1. Description of events and possible MANNER and RESULT matches

Main ambiguous event	MANNER match	RESULT match
Ripping armchair with comb	comb	rip
Cutting bread with knife	saw	cut
Emptying trash with poker	poke	empty
Bending candle with pliers	push	bend
Opening BBQ grill with crowbar	lift	open
Breaking record with bat	hit	break
Flatting sand pile with trowel	push	flatten
Crushing strawberries with hammer	hammer	crush

Results. Figure 1 shows that there were no clear preferences when all responses are taken together, For the individual items, Figure 2 clearly shows item

effects, with some events eliciting a specific bias, either manner or result, and other events with no similar bias. After computing a mean for each item, a chi-square test revealed that the proportion of Result responses differed significantly across items ($\chi(7) = 30.1$, p < 0.0001).
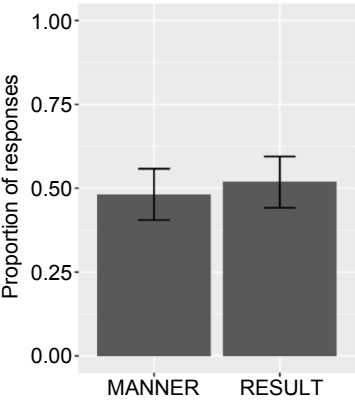

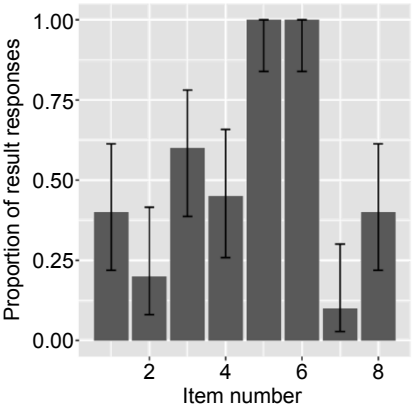**Figure 1. Proportion Manner and Result responses across all eight items**

Figure 2. Proportion Result responses per individual item

Error bars depict a Wilson exact 95% confidence interval.

Discussion. First, there was no evidence for any overall bias one way or the other. Participants were not more manner biased overall, as one might have expected given Talmy's (1985) classification of English as a satellite-framed language where main verbs typically encode manners of action or motion. Second, the stimuli set contained items spanning the entire range with respect to the bias they induce. Thus, as a collection of stimuli, the items were distributed across manner and result meanings and there were also some scenes eliciting both kinds of interpretations, providing a balanced stimuli set for the second experiment.

3. Study 2: Children's interpretation of novel verbs in transitive and intransitive sentences

Goal. The second experiment investigates the role of syntactic bootstrapping in novel verb learning, specifically, the link between transitivity and telicity. The main question is this: do Dutch and English learners use transitivity as a cue to infer the meaning of novel verbs when interpreting ambiguous scenes?

Participants. Two sets of children participated: Dutch 3-year-olds (N = 39, mean age = 47.2 months) and English 7-year-olds (N = 51, mean age = 93.9 months), plus Dutch adults (N= 12) who served as a control group. The Dutch participants were recruited through nursery contacts and at the University of Groningen. The children were tested at a local nursery in Groningen in a separate

room or quiet area of the nursery. The adults were tested in an office at the Faculty of Arts at the University of Groningen. The English children were recruited during public engagement activities at the Oxford University Museum of Natural History in the main area of the museum. Headphones were used to make sure that the English participants could hear the audio. For the English arm of the study ethical approval was obtained through CUREC (project code R50563/RE001).

All participants were randomly assigned to one of the experimental conditions in each language (see Table 2).

Table 2. Overview of number of participants, mean age in months, and the standard deviation of age in each experimental condition

Condition	Language	N	Mean age	SD age
Intransitive	Dutch	20	48	11.6
Transitive	Dutch	19	46.4	10.1
Intransitive	English	28	77	22.2
Transitive	English	23	110.7	28.6
Intransitive	Dutch	6		
Transitive	Dutch	6		

Stimuli and procedure. The test stimuli consisted of short animated cartoons (5 sec.) adopted from Geojo (2015) and audio sentences that described the videos, recorded by a female native speaker of Dutch and a female native speaker of English. The animations were presented on a 13.3 inch MacBook Pro laptop using MATLAB 2015b software. All scenes portrayed an event with an animate agent (a friendly green monster) performing an action on an object using an instrument. These were the same scenes used in Study 1. There were eight trials in total and each trial consisted of a training phase and a test phase. Prior to the experiment there was one training trial that used a familiar verb to ensure that participants understood the task.

Participants were told that they were going to learn new words. During the training phase participants watched ambiguous scenes with a manner and a result component (the agent performing a certain action and an object undergoing a change-of-state), while they heard a novel verb used either in transitive or intransitive sentences. Figure 3 shows one of the sample events with the monster combing (manner) a chair and ripping it (result). Thus, the novel verb could be interpreted as a manner or a result verb. Two sentences were played at the start of the training phase, followed by the animation displayed in the middle of the screen with the ambiguous event and one more sentence describing it. After the sample event was over, two more sentences were played, all of which contained the novel verb in its frame, making for five novel verb uses per trial. Participants had to infer the meaning of the novel verb based on the sample scene and the verb frame. At the end of each trial, there was a test phase in which participants saw two new animations, appearing from left to right on the screen, and subsequently had to

choose which video depicted the meaning of the novel verb. One match item showed the same manner with the monster using the same instrument leading to a different result than the original sample (e.g., crushing a cookie by combing it); the other match item showed the same outcome which came about as the result of a different action, with the monster using a different instrument (e.g., ripping a shirt by hammering on it). All trials were randomized across participants to avoid list effects. The two animations in the test phase always appeared from left to right, but the displayed order of the Manner and Result match was fully randomized across participants. In total, each session lasted about 12 minutes.
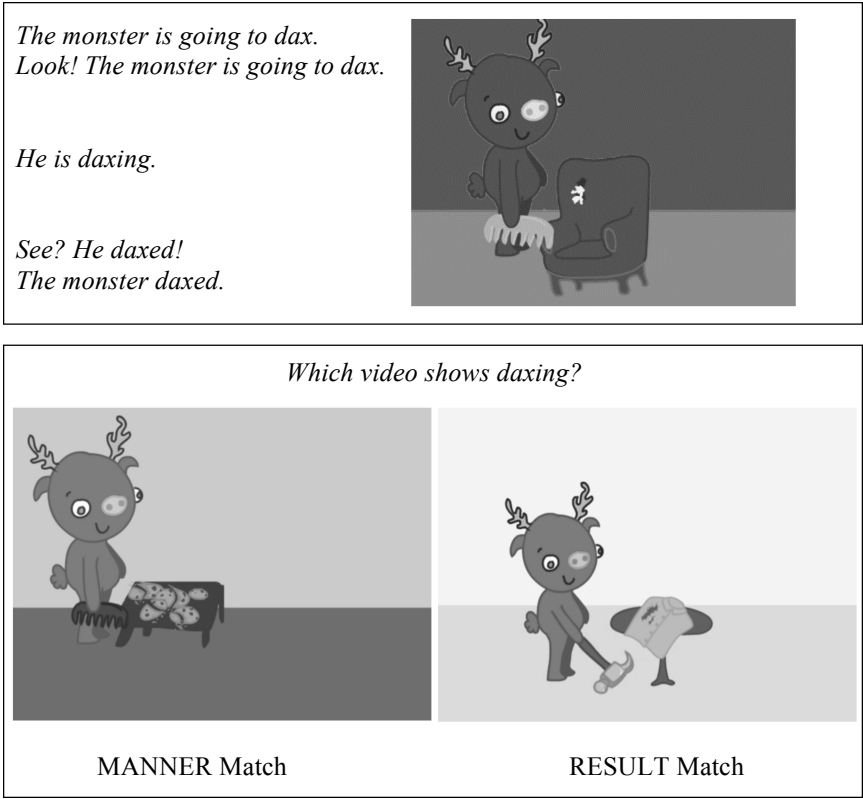

The monster is going to dax.
Look! The monster is going to dax.

He is daxing.

See? He daxed!
The monster daxed.

Which video shows daxing?

MANNER Match   RESULT Match

Figure 3. Trial structure with a sample of the intransitive condition. The top box depicts the training phase; the bottom box shows the test phase.

Our method replicated Wagner's (2010) method, although we made several adjustments. First, we used a forced-choice picture-selection task instead of a match-to-sample task. Our task forced participants to choose, thereby directly probing their preferred interpretation, and avoiding any pattern of overall acceptance or rejection that can arise in a match-to-sample judgment task. Second,

whereas Wagner used the novel verb in a full sentence at test ("*In this movie, did the boy also drack (the X), or did he do something different?*"), we used the novel verb without a sentence frame ("*Which video shows daxing?*"). The frame-neutral question measured how participants generalized the meaning of the novel verb from the sentence frame uses in the training phase, as opposed to providing yet another cue at test by presenting the verb in that same frame again. The frame-neutral question also ensured that the test phases were the same across the two experimental conditions. Third, we used a between-subjects design, while Wagner used a within design. Our participants heard all five instances of novel verbs in all eight items used in one type of sentence frame, never hearing the other frame. Wagner's within-subjects design does not exclude the possibility that the participants' interpretations were somehow affected by noticing a contrast between the two frames across items. A between-subjects design therefore provides a test of the effect of verb frame without this possible confound. Finally, we used eight trials and Wagner only four. All of our trials were causal change-of-state events, whereas Wagner used a variety of novel events: two non-causal directed motion events, one causal change-of-state event and one causal creation event. It cannot be excluded that the effects in Wagner's study were due to certain types of events in her more heterogeneous set of samples. Our exclusive focus on change-of-state events with a homogeneous set of sample events remediated this potential problem.

Predictions. If verb frame plays a role in determining manner versus result readings, it was expected that the intransitive condition would trigger mostly manner readings and the transitive condition result readings (Wagner, 2010). On the other hand, if transitivity is not an informative source for inferring telicity and the manner/result distinction, no preferences were expected for either frame.
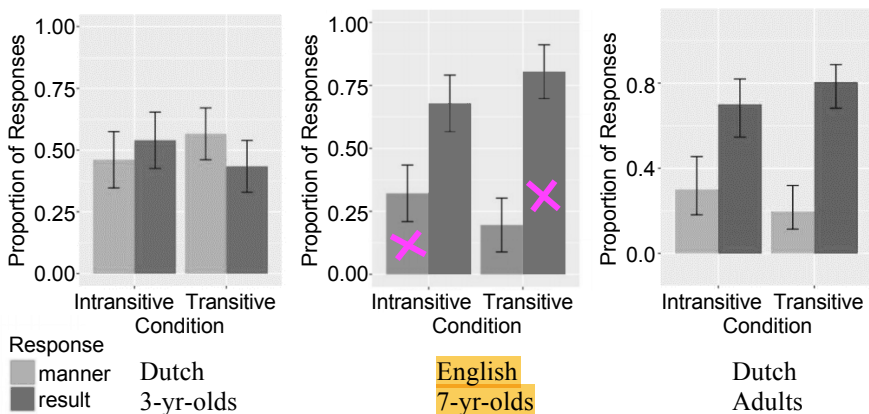

Figure 4. Proportions of manner and result responses in the transitive and intransitive condition for the three groups of participants.

thus, only coded intransitive=>manner and transitive=>result bc those are "correct"

Results. Figure 4 shows the distribution of manner and result choices for all three groups of participants. A two-way repeated-measures ANOVA showed that Dutch adults ($F(1,10) = 5.07$, $p < .05$) and English children ($F(1,49) = 34.8$, $p < .0001$) were strongly result biased. None of the participants was manner biased. Furthermore, a logistic mixed-model revealed no effect of sentence frame; the result bias occurred equally often in both conditions. Moreover, there was a strong positive relationship between age and the degree to which participants were result biased ($b = .03$, $SE = .006$, $p < .0001$).

Discussion. Based on Wagner's (2010) results it was expected that children and adults would interpret novel verbs presented in an intransitive frame with a manner meaning and verbs presented in a transitive frame with a result meaning. Our results do not replicate Wagner's results. Furthermore, on the hypothesis that there is no association between transitivity and telicity (see the discussion of (1)-(3)), it was expected that there would be no biases. This hypothesis is supported for the preschoolers, but not for the 7-year-olds and the adults, as the older children and adults showed a clear result bias.

4. General discussion and conclusions

We discuss three main findings to answer our research question about the relation between transitivity and telicity in syntactic bootstrapping. First, young Dutch children did not show a clear preference, but older English children and Dutch adults were result biased in both conditions. The result bias in our participants is surprising given that both languages are claimed to be manner languages (Talmy, 1985, 2000). Second, the lack of effect of sentence frame is not in line with Wagner (2010). Our results do not support Wagner's application of the syntactic bootstrapping hypothesis, which predicted manner readings for the intransitive frame. Third, seeing the effect of age, we tentatively suggest that the result bias emerges over the course of development. This will need to be confirmed by testing a wider range of ages in each language.

We conclude, contra Wagner, that syntactic bootstrapping does not affect inferences about telic/atelic or manner/result interpretations of novel verbs. We argue that this was not to be expected given that there are no strong links between transitivity and resultativity in the first place, since both transitive and intransitive sentences can refer to resultative and non-resultative events (Borer, 2005; van Hout, 1996). The role of transitivity in syntactic bootstrapping is clear for learning the difference between one and two-argument verbs (Fisher, 1996; Fisher, Gertner, Scott & Yuan, 2010), but not for telicity differences.

Instead, we suggest that a result bias in verb learning arises because learners are intrinsically goal-directed (Carpenter et al., 2005, Gergely et al., 2002), which leads them to represent multi-interpretable scenes in terms of event outcomes, i.e., result, and not manners of actions. Given the unexpected, overall result bias, we hypothesize, *post hoc*, that participants may have been result biased, because humans naturally observe behavior by other agents as goal-directed, and that syntactic bootstrapping cannot always override this cognitive bias.

There is a series of questions that remain before we can answer the question under what circumstances syntactic bootstrapping is at work in the acquisition of manner and result meanings of novel verbs, some of which raise methodological issues, while others question linguistic assumptions. While aiming to replicate Wagner's (2010) study, our study differed from hers on a number of counts. Could the use of the novel verb at test in a certain sentence frame (Wagner's study) or without a frame (our study) have caused the different results? This can be checked by rerunning the experiment with a question form using the novel verb in its frame and see if that changes the results. Furthermore, could the nature of the events in the animations in the two studies have caused the differences? We included only causal change-of-state events, whereas Wagner used a variety of different change-of-state events. Possibly our change-of-state events triggered a result bias. This is not very likely, because there was no overall result bias in the first experiment in which adults described the events. Another methodological point is the question if the different outcomes across studies can be explained by the difference in design: between-subjects (our study) versus within-subjects (Wagner)? Does hearing a contrast in the test sentences in a within-subjects design lead participants somehow to impose a difference between the two types, and if so, is this a more general problem of within designs? Finally, are there particular kinds of events that would elicit a manner interpretation?

On the linguistic side, we wonder if verb frequency plays a role in explaining Wagner's (2010) results, which established an association between transitivity and manner and result interpretations. Possibly, in actual language use, the number of transitive verbs that are telic differs from the number of verbs that are atelic; and similarly for intransitive verbs are telic or atelic. This should be investigated with corpus studies. Could a difference in frequency of use have caused the two patterns in Wagner's study? If so, why would it not affect our results? Finally, and possibly most importantly, the results of this study challenge the typological claim that English, as a satellite-framed language, uses mostly verbs that encode a manner (Talmy, 1985). We did not find any support for manner as a preferred meaning of novel English verbs.

References

Allen, Shanley, Aslı Özyürek, Sotaro Kita, Amanda Brown, Reyhan Furman, Tomoko Ishizuka, & Mihoko Fujii. (2007). Language-specific and universal influences in children's syntactic packaging of manner and path: A comparison of English, Japanese, and Turkish. *Cognition*, 102(1), 16-48.

Behrend, Douglas A. (1990). The development of verb concepts: Children's use of verbs to label familiar and novel events. *Child Development*, 61(3), 681-696.

Borer, Hagit. (2005). *Structuring Sense, Vol II: The Normal Course of Events*. Oxford: Oxford University Press.

Brown, Roger W. (1957). Linguistic determinism and the part of speech. *The Journal of Abnormal and Social Psychology*, 55(1), 1.

Bunger, Ann, Dimitrios Skordos, John C. Trueswell, & Anna Papafragou. (2016). How adults and children encode causative events cross-linguistically: Implications for

language production and attention. *Language, Cognition and Neuroscience*, 31(8), 1-23.

Carpenter, Malinda, Josep Call, & Michael Tomasello. (2005). Twelve-and 18-month-olds copy actions in terms of goals. *Developmental Science*, 8(1), F13-F20.

Dowty, David R. (1979). *Word Meaning and Montague Grammar: The Semantics of Verbs and Times in Generative Semantics and in Montague's PTQ*. Berlin: Springer.

Fisher, Cynthia. (1996). Structural limits on verb mapping: the role of analogy in children's interpretation of sentences. *Cognitive Psychology*, 31:41 – 81.

Fisher, Cynthia, Yael Gertner, Rose M. Scott, & Sylvia Yuan. (2010). Syntactic bootstrapping. *Wiley Interdisciplinary Reviews: Cognitive Science*. doi.org/10.1002/wcs.17

Geojo, Amy C. (2015). *Breaking and Entering: Verb Semantics and Event Structure*. Doctoral dissertation, Harvard University.

Gergely, György, Harold Bekkering, & Ildikó Király. (2002). Developmental psychology: Rational imitation in preverbal infants. *Nature*, 415(6873), 755.

Gleitman, Lila R. (1990). The structural sources of verb meanings. *Language Acquisition*, 1(1), 3-55.

van Hout, Angeliek. (1996). *Event Semantics of Verb Frame Alternations: A case study of Dutch and its acquisition*. Doctoral dissertation, University of Tilburg. Published in 1998 by Garland Publishing, New York.

Lakusta, Laura, Laura Wagner, Kirsten O'Hearn, & Barbara Landau. (2007). Conceptual foundations of spatial language: Evidence for a goal bias in infants. *Language Learning and Development*, 3(3), 179-197.

Naigles, Letitia R. (1996). The use of multiple frames in verb learning via syntactic bootstrapping. *Cognition*, 58(2), 221-251.

Papafragou, Anna, Christine Massey, & Lila R. Gleitman. (2002). Shake, rattle,'n'roll: The representation of motion in language and cognition. *Cognition*, 84(2), 189-219.

Rappaport Hovav, Malka, & Beth Levin. (2010). Reflections on manner/result complementarity. *Syntax, Lexical Semantics, and Event structure*, 21-38.

Talmy, Leonard. (1985). Lexicalization patterns: Semantic structure in lexical forms. *Language typology and syntactic description*, 3(99), 36-149.

Talmy, Leonard. (2000). *Toward a Cognitive Semantics*. Cambridge, Mass: The MIT Press.

Quine, Willard V. (1960). *Word and Object*. Cambridge, Mass: The MIT Press.

Vendler, Zeno. (1967). Causal relations. *The Journal of Philosophy*, 64(21), 704- 713.

Wagner, Laura. (2010). Inferring meaning from syntactic structures in acquisition: The case of transitivity and telicity. *Language and Cognitive Processes*, 25(10), 1354-1379.

Proceedings of the 43rd annual Boston University Conference on Language Development

edited by Megan M. Brown
and Brady Dailey

Cascadilla Press   Somerville, MA   2019

Ordering information