THE ROLE OF SYNTACTIC AND DISCOURSE INFORMATION IN VERB LEARNING

BY

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ABSTRACT

Children use syntax in verb learning; this is syntactic bootstrapping (Gleitman, 1990; Naigles, 1990). This dissertation proposal investigates two research questions about syntactic bootstrapping: 1) how syntactic bootstrapping could begin, and 2) how syntactic bootstrapping could work despite noisy input due to argument omission. The first three sets of experiments (Chapters 2) showed that 15- to 19-month-old infants use the number of nouns in a sentence to differentiate novel transitive and intransitive verbs. The results confirm a key prediction of structure-mapping account (Fisher, 1996) suggesting that syntactic bootstrapping might begin with an unlearned bias to assign each noun in the sentence to a core participant-role in conceptual representations of events. Experiments 4 and 5 (Chapter 3) showed that Korean-learning 2-year-old children exploit distributional and discourse information to find true number of arguments of a new verb despite pervasive argument omission. Finally, Chapter 4 (Experiment 6, 7 and 8) asked whether a bias to discourse continuity could aid children's verb interpretation even in English that allows noun omission only in restricted situations. The results showed that English-learning children also could use discourse continuity to interpret verbs with missing subjects. Taken together, the results of these studies support the conclusion that the inherent one-to-one mapping bias can guide children's verb learning even in noisy input in any language, with children's expectation for discourse continuity.

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CHAPTER 1

INTRODUCTION

Learning verb is a hard task. Verbs typically have relatively abstract meanings and often focus on different perspectives on events (e.g., Clark, 1990; Levin, & Rappaport-Hovav, 2005). To illustrate, imagine a toddler playing a game with her mother, taking turns putting animal-shaped puzzle pieces on a board. The child can use many strategies to understand what the mother says. For example, the child might learn the word "giraffe" when the mother points to or looks at the giraffe-shaped piece, and says, "Look! This is a giraffe!" These ostensive cues from event scenes help children to learn new words (e.g., Baldwin, 1995; Behne, Carpenter, & Tomasello, 2005; Csibra, 2010). However, not all words are easy to grasp from such observations – aspects of verb meanings in particular are hard to learn based only on observing events (Gillette, Gleitman, Gleitman, & Lederer, 1999; Gleitman et al., 2005; Snedeker & Gleitman, 2004). Going back to the play situation, the mother can describe a scene in multiple ways, saying, "You put this here" or "This goes here," focusing on different aspects of or perspectives on the event. This suggests that children need more information than the observed events themselves in order to learn verb meanings.

Another source of information comes from language itself. The syntactic bootstrapping theory proposes that syntax guides children's sentence interpretation and verb learning (e.g., Gleitman, 1990). This is possible because there are systematic relationships between verb syntax and verb meaning. For example, transitive verbs such as "put" license two noun-phrase (NP) arguments and describe events involving two core participants, whereas intransitive verbs such as "go" license one NP argument and describe events involving one core participant. Evidence

for syntactic bootstrapping comes from many experiments showing that young children assign different interpretations to novel verbs presented in different sentence structures (e.g., Arunachalam & Waxman, 2010; Arunachalam, Escovar, Hansen, & Waxman, 2013; Fisher, 1996; Fisher, Hall, Rakowitz, & Gleitmann, 1994; Lidz, Gleitman, & Gleitman, 2003; Naigles, 1990, 1996; Naigles & Kako, 1993; Yuan, Fisher, & Snedeker, 2012). For example, Naigles (1990) showed that 2-year-olds who heard a novel verb presented in transitive sentences ("The duck is gorping the bunny!") interpreted the verb as referring to a causal action component of a complex scene, whereas those who heard the novel verb presented in intransitive sentences ("The duck and the bunny are gorping!") did not.

How does syntactic bootstrapping work? The primary goals of this dissertation are to investigate 1) how syntactic bootstrapping could begin even before children learn much about the grammar of their native language, and 2) how syntactic bootstrapping could work despite noisy input, in particular when some of a verb's arguments are missing from the surface structure of the sentence. In Section 1.1, I discuss two different proposed accounts of the origins of syntactic bootstrapping – the structure-mapping account and a construction-based learning account. Experiments presented in Chapter 2 test some of the core predictions of the structure-mapping account. In Section 1.2, I discuss a serious challenge to syntactic bootstrapping, posed by argument-dropping languages. Experiments presented in Chapter 3 asked whether Korean children could learn verbs despite pervasive argument omission, by gathering evidence across adjacent sentences in a coherent discourse. Section 1.3 discusses the generality of the role of discourse in verb learning. Experiments presented in Chapter 4 asked whether discourse information also helps children learning English, a language that allows noun omission only in much more restricted contexts.

1.1 The origins of syntactic bootstrapping

How do children begin to use syntax to guide verb interpretation? There are two different accounts of the developmental origins of syntactic bootstrapping; the structure-mapping account (e.g., Fisher, 1996; Fisher, Gertner, Scott, & Yuan, 2010; Lidz, Gleitman, & Gleitman, 2003; Yuan, Fisher, & Snedeker, 2012) and the construction-based learning account (e.g., Casenhiser & Goldberg, 2006; Tomasello, 2003). Proponents of both accounts generally agree that children aged 2 to 5 years old can exploit the links between verb syntax and meaning in verb learning. However, the two accounts have very different perspectives on the origins of the syntax-semantics links that guide children's verb learning. The structure-mapping account assumes that even young children start with an innate bias that allows them to use the set of nouns in a sentence in verb interpretation. In contrast, the construction-based account assumes that children gradually build abstract constructions from experience with a particular language. Thus, the two accounts differ in the hypothesized beginning point of children's use of syntax in verb learning.

1.1.1 Structure-mapping account

According to the structure-mapping account, syntactic bootstrapping begins with an unlearned bias toward one-to-one mapping between nouns in sentences and participant roles in conceptual representations (e.g., Fisher, 1996; Fisher, Gertner, Scott, & Yuan, 2010; Lidz, Gleitman, & Gleitman, 2003; Yuan, Fisher, & Snedeker, 2012). The structure-mapping account assumes that young children represent sentences abstractly in terms of their number of nouns, and represent events abstractly in terms of their number of core participants. Given these structured representations, and equipped with the proposed one-to-one mapping bias, children find the number of nouns in a sentence inherently meaningful. In this way, even young children

can infer that a verb that combines with two nouns implies two participant roles, whereas a verb that combines with one noun implies one participant role.

The structure-mapping account predicts that the number of nouns in a sentence should guide early verb learning. As soon as children can identify some nouns and represent them as parts of a larger sentence structure, they should assign different interpretations to transitive and intransitive verbs, essentially by counting the nouns. Even 15-month-old infants appear to possess these abilities. By 14 months, infants can use distributional information to identify nouns as such (e.g., "This is a blicket!"; Booth & Waxman 2009), and 14- to 15-month-old infants can understand sentences including multiple familiar words (e.g., Hirsh-Pasek & Golinkoff, 1996; Seidl, Hollich, & Jusczyk, 2003). Therefore, the structure-mapping account must predict that 15-month-old infants, at the onset of multi-word sentence comprehension, should be able to use the number of nouns in a sentence to interpret novel transitive and intransitive verbs differently.

1.1.2 Construction-based account

According to the construction-based account, children start by learning about the syntactic behavior and meanings of verbs without an innate mapping bias linking syntax and meaning (e.g., Tomasello, 2000, 2003). A core claim of the construction-based account is that children learn all their linguistic generalizations from experience, without any linguistic constraints on how syntax and meaning will line up. The account suggests that children learn that transitive verbs refer to two-participant events in much the same way as they learn about the English past tense, essentially as an arbitrary fact about the particular language being learned. On this account, children's initial representations of the language input are concrete representations reflecting the details of particular expressions in particular contexts. All generalizations are

based on evidence, gradually formed by abstracting across many sentence-meaning pairs, and across many partly-abstract representations of the usage of particular words.

To illustrate, imagine that a child hears a sentence "John is hugging Mary", given the observed scene. On the construction-based account, the child might represent the sentence describing the particular event involving two participants. As the child accumulate experience, she notes that transitive verbs such as "kiss", "hug", "tickle", and "kick", tend to appear in two-noun sentences and refer to two-participant events. She might also realize that intransitive verbs such as "walk," "run," and "jump," tend to appear in one-noun sentences and refer to one-participant event. As a result, the child learns that verbs share similarities in both their meanings and their syntactic structures. By comparing many lexically-specific structure-meaning pairs, children gradually construct abstract constructions, such as a transitive construction for English.

Once children have built a language-specific transitive construction, they can use this construction to interpret new verbs. The construction-based account predicts the slow emergence of abstract constructions because the links between syntax and semantics that 2- to 5-year-olds ultimately use to learn new verbs are constructed from experience with a particular language, based on considerable context-dependent verb-by-verb learning.

In sum, the structure-mapping account and the construction-based account make different predictions about at what age children should be able to exploit syntax to interpret new verbs. The structure-mapping account suggests that young children have an unlearned bias between nouns in sentences and participant roles in event. Thus, the account predicts that even infants can use the number of nouns in a sentence to interpret verb meanings, as soon as they start multi-word sentence comprehension. Even 15-month-old infants satisfy these prerequisites (e.g., Hirsh-Pasek & Golinkoff, 1996; Seidl, Hollich, & Jusczyk, 2003). Thus, the structure-mapping account

predicts that even 15-month-old can use a simple sentence structural cue, the number of nouns in a sentence, to learn new verbs. Conversely, it is hard for the construction-based account to explain such young children's use syntactic-structure cues in verb learning.

The experiments in Chapters 2 tested this prediction of the structure-mapping account by asking whether 15-month-old infants could use the set of nouns in a sentence to interpret a new verb. We adapted the task from recent experiments by Yuan, Fisher, and Senedeker (2012), which showed that even 21- and 19-month-olds can assign different interpretations to a novel verb presented in a transitive sentence with two nouns (e.g., "He's gorping him") or in an intransitive sentence with one noun (e.g., "He's gorping"). In addition, Chapter 2 also eliminated an alternative hypothesis that children under 2 might succeed in using verb transitivity to interpret new verbs in part because language-specific case marked pronouns (He and him) were used. In order to rule out this alternative, we asked whether 19-month-olds could interpret the set of nouns as meaningful, even without language-specific case-marked pronouns (e.g., "It's kradding it" versus "It's kradding"). Positive evidence in these experiments supports the proposal of the structure-mapping account: that infants may have unlearned syntax-semantics links, such as the relationship between the set of nouns in the sentence and the semantic predicate-argument structure of a verb.

1.2 A substantial challenge to syntactic bootstrapping theory

As discussed above, prior research on syntactic bootstrapping has focused on the number of nouns as useful information in verb learning, due to the non-arbitrary nature of the relationship between syntactic and semantic argument structure. The structure-mapping account suggests that children start the mapping between syntax and semantics simply by assuming each

noun is a distinct NP argument (Fisher, 1996; Lidz, Gleitman, & Gleitman, 2003; Naigles, 1990; Yuan, Fisher, & Snedeker, 2012). However, what if the relationships information between the number of NP arguments expressed in sentences containing each verb and the participant-roles involved in the verb's meaning is markedly unreliable? Languages that allow frequent argument omission present a serious challenge to syntactic bootstrapping. For example, in Korean, one example of an argument-dropping language, sentence 1) has both arguments, and sentence 2) through 4) omit one or the other or both arguments, but all four sentences are fully grammatical as long as the referents of the omitted NP arguments are clear in the discourse context.

1) Na thakca mil-koiss-e (I table push-PROG-DECL, "I'm pushing the table")

2) Na Ø mil-koiss-e (I push-PROG-DECL, "I'm pushing")

3) Ø Thakca mil-koiss-e (table push-PROG-DECL, "pushing the table")

4) Ø Ø Mil-koiss-e (push-PROG-DECL, "pushing")

In an analysis of child-directed Korean, only 13.4 to 23% (varying across different mother-child corpora) of transitive clauses expressed two overt arguments (Clancy, 2009). A similar dearth of overt arguments was found in child-directed speech in many other languages, including Mandarin Chinese, Hindi, and Japanese (e.g., Lee & Naigles, 2005; Narasimhan, Budwig, & Murty, 2005; Rispoli, 1995). If the overt number of nouns is typically fewer than the verb's true underlying argument number, then the number of nouns in individual sentences provides little reliable information about verb meaning. The experiments in Chapter 3 investigated how syntactic bootstrapping might work in argument-dropping languages, by testing Korean-learning 2-year-olds. We and others have proposed two possible routes that might help children learning argument-dropping languages to overcome the challenge in verb learning posed

by pervasive argument omission – one is distributional learning and the other is discourse continuity (e.g., Bowerman & Brown, 2008; Jin et al., 2012, 2014).

1.2.1 Distributional learning

One way that children learning argument-dropping languages might overcome the noise in the input is by considering distributional facts about verbs across many sentences containing each verb. Even though arguments are frequently omitted, the input language data, taken together, almost certainly would still permit a probabilistic distinction between transitive and intransitive verbs. For example, transitive verbs are presumably more likely to occur with two overt nouns than are intransitive verbs, despite the frequency of argument omission. Thus, children might gather data about the argument-taking properties of each verb, by learning distributional facts across many sentences containing the same verb (Fisher & Gleitman, 2002; Naigles, 2002).

Language-specific cues also probabilistically differentiate transitive and intransitive verbs, and may help the learner to separate these as two classes of verbs that occur in different distributional contexts. For example, in Mandarin, which has a Subject-Verb-Object word order, transitive verbs are more likely than intransitive verbs to appear with a post-verbal noun phrase (Lee & Naigles, 2005). In Japanese and Korean, which have a Subject-Object-Verb word order, the same word-order distinction would not be available, but transitive verbs are more likely than intransitive verbs to appear with (optional) accusative case-markers denoting sentence objects (e.g., Kim, 2008; Matsuo et al., 2012). In principle, children could estimate the correct argument structure of each verb by keeping track of the overall probabilistic pattern of occurrences of noun-phrases with each verb across many utterances, perhaps boosted by various language-

specific cues that might help children to separate transitive from intransitive verbs as distinct classes.

However, it remains unclear whether this kind of probabilistic information is sufficient to guide early verb learning. Young children's input might not contain enough distributional evidence to differentiate verbs by transitivity. In an analysis of child-directed Hindi, for example, only 17 of the most frequent 29 transitive verbs in input appear with both arguments (Narasimhan et al., 2005). In child-directed Japanese, only 9.9 % of transitive utterances appeared with an accusative case marker. Given the paucity of overt arguments in the input, children learning argument-dropping languages might have to wait for quite a while for the required evidence that a particular transitive verb has more arguments than an intransitive verb.

1.2.2 Discourse continuity

Another promising information source comes from discourse structure. Argument omission is linguistically constrained – arguments can be omitted only when their referents are clear in the discourse and pragmatic context (e.g., Allen, 2000; Clancy, 1996; Narasimhan et al., 2005). Thus, even though a verb may appear with fewer than its full set of arguments in an individual sentence, some missing arguments may be recoverable from the linguistic discourse context, perhaps even by a naïve listener.

For example, Clancy (1996) reported that in a Korean adult-child interaction involving a board and plastic shapes that adhered to it, the adult speaker combined the verb pwuthita 'stick_on' with all of its typical arguments, but did so only one at a time, across multiple utterances within the discourse. For instance, on different speaking turns the adult said "acwumma-ka pwuthi-l-kka? (aunt-NOM stick-IRRL-Q? "Shall auntie stick?") (specifying the

subject of the verb); “yo-ke pwuthi-e. (this-thing stick-IE, “Stick this!”) (specifying the object); “kekita pwuthi-e?(there stick-IE, “Stick (it) there!”) (specifying location). Viewed in isolation, such sentences exemplify the problem of noise from argument omission. It is easy to imagine, however, that at least some of these sentences might not be so mysterious if viewed in their local discourse context. For example, suppose the adult says “Shall Auntie stick?” immediately after bringing a plastic zebra to the child’s attention, either by establishing joint attention by pointing and eye gaze, or by linguistic mention (e.g., “What about this?”). If children consider discourse continuity when interpreting sentences, they might sometimes be able to recover missing arguments that were focused in scenes or overtly mentioned across multiple sentences in discourse. Korean-learning preschoolers can link the omitted subject of a familiar verb with the subject established in previous discourse (Song, Choi, & Kim, 2008). Perhaps, Korean children might gain an accurate estimate of an unknown verb’s argument number despite noise in the input, by relying on their discourse continuity bias.

The experiments in Chapter 3 investigated how Korean 2-year-olds learn verb transitivity when the number of nouns in individual sentences does not provide a reliable cue for verb syntax and meaning. We show that children can use s use syntactic bootstrapping with noisy data, and the first to show reliance on discourse continuity in syntactic bootstrapping. In two experiments, we asked whether children could use probabilistic syntactic evidence in verb learning from noisy surface input; and also ask whether a coherent discourse could allow children to recover a missing argument even when given no straightforward evidence for transitivity, such as two-noun sentences. To do so, we adapted the dialogue-training method by Yuan and Fisher (2009), and designed our Korean dialogues to have novel-verb sentences with missing nouns, as in (5).

(5) A: minswu-nun mwe-ha-ko iss-e?

(Minswu-Top what-do-Prog-Q?, "*What's Minswu doing*?")

B: koyangi philkhi-ko iss-e!

(Cat pilk-Prog-Decl, "*Is cat pilking*!").

or

B: Minswu philkhi-ko iss-e.

(Minswu pilk-Prog-Decl, "*Minswu is pilking*!").

If Korean children can recover the omitted subject argument from the prior discourse, they should be able to infer that the novel verb (pilk) is transitive, in part because the novel-verb sentence containing only one noun introduces a new topic (the cat) without mentioning the prominent discourse topic (Minswu). Positive evidence in these experiments would highlight the significant role of a bias to discourse continuity in children's verb interpretation.

1.3 The generality of a discourse-continuity bias

As discussed above, an expectation for discourse continuity might aid children learning argument-dropping languages, allowing them to integrate across sentences in a connected discourse in order to find missing arguments in individual utterances. At issue is whether the discourse-continuity bias in verb learning is a language-specific learned strategy or a language-general mechanism that allows children learning any language to gather information across discourse.

English places strong restrictions on noun omission, and as a result, noun omission is much rarer in English than in Korean, or in other argument-dropping languages such as Japanese or Mandarin. For example, Tardif et al. reported that 35% of English child-directed sentences

had null subjects, and almost all of these null subjects were found in imperative sentences. Korean differs markedly: In two child-directed corpora, Clancy (2009) found that 77 to 87% of transitive sentences had fewer than two overt arguments. Although these numbers are not directly comparable because the two studies used different measures, they make clear the very large difference in the provision of overt arguments in Korean vs. English input; similar estimates are derived from corpora of other argument-dropping languages, as noted earlier. Given this large difference, one might argue that Korean-learners would learn, as a language-specific strategy, to seek a verb's arguments in the prior discourse, because verbs do not reliably display their syntactic arguments in individual sentences. In contrast, English-leaners do not need to learn to do so, because each verb's arguments are much more reliably present. Therefore, the striking cross-linguistic difference in the overt display of verbal arguments can be exploited to help us understand the developmental origins of the Korean-learners' sensitivity to discourse structure in verb learning. If English-learners can exploit discourse information in much the same way to determine the number of arguments licensed by a novel verb, even though English input does not force them to learn to use this procedure, then we would conclude that a more general expectation of discourse continuity, which might be available in any language, provides linguistic support for verb learning.

Do English-learning children have a general expectation of discourse continuity that adjacent sentences in a discourse are related to each other? By age 2 to 3, English-learning children show sensitivity to discourse continuity. Children use discourse structure to interpret ambiguous pronouns, linking them with the referent made most prominent in preceding sentences (e.g., Hartshorne, Nappa, & Snedeker, 2014; Pyykkönen, Matthews, & Järvikivi, 2010; Song & Fisher, 2005, 2007). Even 15- to 18-month-olds can link a pronoun to a previously

mentioned referent, in simple contexts in which only one referent has been recently mentioned (Ganea & Saylor, 2007; Lidz, Waxman, & Friedman, 2003), and preschoolers can use the local discourse context to infer the referent of a novel noun (Horowitz & Frank, 2015). All of these findings suggest that English-learning children expect sentences in a discourse to share referential connections. This general expectation of discourse coherence, in turn, might allow children learning any language to recover the missing arguments of verbs.

The experiments in Chapter 4 investigated whether English-learning toddlers, like their Korean counterparts, could exploit an expectation of discourse continuity to learn verb transitivity from null-subject transitive sentences. These experiments presented English-learning children with dialogues similar to those created for the Korean studies reported in Chapter 3 (e.g., A: "What's Grandma doing?", B: Transitive: "Pilking the cat!"; Intransitive: "She's pilking!"). In order to isolate the role of discourse continuity from language-specific cues for verb transitivity, such as the presence of a post-verbal noun (which suggests that "pilking the cat" is a transitive sentence by virtue of the SVO word order of English), we also manipulated the coherence of the local discourse. Positive evidence in these experiments would suggest that a general expectation of discourse continuity guides children's verb interpretation despite noisy input in any language.

In summary, in eight experiments, this dissertation explored how syntactic bootstrapping begins and how it could work in noisy input characterized by argument omission. The results of these studies support the conclusion that the proposed one-to-one mapping bias can guide children's verb learning even in noisy input in any language, with the support of a coherent discourse.

CHAPTER 2

EARLY EVIDENCE FOR SYNTACTIC BOOTSTRAPPING:

15- AND 19-MONTH-OLDS USE SENTENCE STRUCTURE IN VERB LEARNING

Infant language-learners receive input consisting of word sequences paired with world scenes. Based on these data, they start learning to understand sentences well before age two, and ultimately build a lexicon and grammar that support broad generalization across words and contexts. Accounts of how they do so necessarily begin with the extra-linguistic world: The true novice, not yet knowing the words or the syntax, must try to link input sentences with aspects of the accompanying scenes. Top-down knowledge derived from the scene then 'supervises' word and syntax learning, investing words and their combinations with meaning. Views of language acquisition of all theoretical stamps thus assume that knowledge of word and sentence meaning drives syntax acquisition (e.g., Pinker, 1989; Tomasello, 2003).

However, aspects of verb meanings in particular challenge the assumption that children can recover word and sentence meanings based only on understanding scenes, and thus in turn challenge our theories of syntax acquisition (Gleitman et al., 2005). Verbs do not simply label events; rather, they denote abstract construals of them. To illustrate, pairs of verbs such as *feed* and *eat*, *give* and *receive*, take different perspectives on the same events. Scene feedback thus provides equivocal evidence for verb and sentence meaning (Gillette et al., 1999).

The syntactic bootstrapping theory proposes that children use knowledge of syntax itself to decode sentence and verb meanings (e.g., Gleitman et al., 2005). Syntactic bootstrapping relies on tight links between verb syntax and meaning (Fisher et al., 1991; Levin & Rappaport-Hovav, 2005; Pinker, 1989). Part of the meaning of a verb is a semantic predicate-argument

structure specifying the number and type of participant roles that the verb's meaning implies. This semantic structure partly determines the syntactic structures licensed by the verb. For example, verbs entailing one participant role take intransitive frames, with one noun phrase (NP) argument ("It fell"); verbs entailing two participant roles take transitive frames, with two NP arguments ("I dropped it"). Toddlers use these links, assigning different meanings to verbs in different syntactic structures (Arunachalam & Waxman, 2010; Fisher, 1996; Naigles, 1990, 1996; Yuan & Fisher, 2009; Yuan et al., 2012). For example, Naigles (1990) showed that 2-year-olds who heard a novel transitive verb ("The duck is gorping the bunny!") looked longer at an event in which the duck acted on the bunny than at one in which the duck and bunny both acted independently, while those who heard a novel intransitive verb ("The duck and the bunny are gorping!") did not.

The present work asks how syntactic bootstrapping begins. That is, (1) when do children begin to use links between syntax and semantics to guide their verb interpretation, and (2) by what mechanisms does this ability develop? Below we consider two broad hypotheses concerning this issue; a structure-mapping account (e.g., Fisher, 1996, 2000; Lidz, Gleitman, & Gleitman, 2003) and a construction-based account learning (e.g., Abbot-Smith, Lieven, & Tomasello, 2008, Tomasello, 2003).

Structure-mapping account

Fisher and colleagues have proposed a structure-mapping account on which syntactic bootstrapping originates in an unlearned bias toward one-to-one mapping between nouns in sentences and semantic arguments of predicate terms (e.g., Fisher et al., 2010, Yuan, Fisher, & Snedeker, 2012). This represents (roughly) the theta-criterion of linguistic theory (Chomsky, 1981). This bias allows children to find the number of nouns in a sentence inherently

meaningful. The structure-mapping account assumes that young children represent sentences abstractly in terms of their number of nouns, and create structured conceptual representations of events that make explicit their number of core participants. Given these representations, armed with the proposed one-to-one mapping bias, children infer that a verb that licenses two nouns implies two participant roles, whereas a verb that licenses one noun implies one role.

This account makes a strong prediction about the development of syntactic bootstrapping: Given the proposed one-to-one mapping bias, infants should use the number of nouns to differentiate transitive from intransitive verbs *as soon as* they identify some nouns, and represent them as parts of a larger sentence.

Construction-based learning account

The construction-based learning account suggests that children start by learning about the relationships between sentence structure and meaning based on concrete representations of the usage of particular words in particular contexts, without innate constraints on possible relations between syntax and meaning (e.g., Tomasello, 2003). According to this account, children gradually distill representations of highly abstract constructions such as the transitive structure (with its associated two-participant causal semantics) as they accumulate structure-meaning pairs for multiple verbs from their input. To do so, children abstract away from the specifics of individual verbs' meanings and sentence contexts, by comparing individual instances of sentence-scene pairs (e.g., Abbot-Smith & Tomasello, 2006, Abbot-Smith et al., 2008).

To illustrate, consider a situation in which a child hears a sentence containing a novel verb, such as "He's kradding him!" According to the construction-based learning account, understanding this transitive sentence would depend very directly on the child's previous experience with other words in similar structures. If the child has only learned a small number of

verb-specific sentence-meaning pairs, her current construction should not yet be abstract enough to guide interpretation of the novel verb. The child still needs to store more sentence-scene pairs in order to detect the similarities across these input pairs in both sentence form and meaning. Each of these pairs must be stored in a verb-by-verb fashion. For example, upon hearing a sentence such as "Mary kissed the baby" in a relevant scene, the child initially represents the semantic role of "Mary" as a "kisser" and that of "the baby" as a "kissee." As many such lexically-specific relations sentence structures and observed scene are added, the child's memory for sentences and scenes gradually begins to reflect the fact that many verbs such as "hug" and "hit" share similar features in meaning and sentence form: They describe events involving two participant roles, and reliably position nouns referring to agents before the verb and nouns referring to patients after the verb. Once such a language-specific transitive construction has emerged, the child can use it to guide verb learning.

The construction-based learning account predicts that an abstract construction emerges slowly in development because the learner must await the emergence of patterns across multiple lexical items, and these patterns must emerge without language-specific constraints on what dimensions of similarity are important. For these reasons, a reliable verb-general transitive construction is typically predicted not to emerge until beyond the second birthday (e.g., Tomasello, 2000). This prediction has been used to account for phenomena such as that children under about age 3 do not readily extend new verbs to new sentence frames in production (e.g., Brooks & Tomasello, 1999; Tomasello & Brooks, 1998; Olguin & Tomasello, 1993).

Thus the two accounts we have described yield strikingly different predictions about the timing, relative to other developmental milestones, of children's use of sentence structure in verb interpretation. The structure-mapping account predicts that children should assign different

interpretations to transitive and intransitive verbs, essentially by counting the nouns in sentences containing them, as soon as they can identify some nouns and represent them as parts of a larger sentence structure. In contrast, the construction-based account predicts that children under age 2 do not yet have built abstract representations that eventually would allow them to tell apart novel transitive versus intransitive verbs.

Building on prior work by Yuan et al. (2012), the present research was designed to test this core prediction of the structure-mapping account. Yuan et al. tested 21- and 19-month-old infants in a syntactic bootstrapping task. In their experiments, 19-month-olds saw two side-by-side events: a two-participant causal event and a one-participant event. Children heard a novel verb presented in simple transitive ("He's gorping him!") or intransitive sentences ("He's gorping!"). Children who heard a transitive verb looked longer at the two-participant event than did those who heard an intransitive verb. These data showed that syntax begins to guide verb interpretation well before age two.

Yuan et al. (2012) tested the youngest infants to date in a syntactic bootstrapping task, 19-month-olds; but they leave untested the core prediction that children should be able to use the set of nouns as soon as they can do multi-word sentence comprehension at all. A strong test of the predictions of the structure-mapping account required us to test younger infants, at the onset of multi-word sentence comprehension.

It is hard to fit evidence that children under age 2 can do syntactic bootstrapping into the current version of the construction-based account. However, it is easy to imagine the revised versions of the construction-based account could account for Yuan et al. (2012)'s findings. For example, the revised version could propose that 19-month-old infants already could have adequate sentence-scene evidence in the input to permit the abstraction and generalization of

language-specific constructions. Early productive vocabularies contain few verbs (e.g., Fenson et al., 1994; Golinkoff & Hirsh-Pasek, 2008), but comprehension data suggest that 10-month-olds attach some meaning to a few non-object words such as "eat" or "hug", "uh-oh" or "hi" (Bergeloson & Swingley, 2013), and infants between 12 and 18 months of age understand a number of action verbs (e.g., Golinkoff, Hirsh-Pasek, Cauley, & Gordon, 1987; Huttenlocher, Smiley, & Charney, 1983; Naigles & Hoff, 2006).

Here, we tested younger infants, 15-month-olds, at the onset of the multiword sentence comprehension alternatives in order to provide a stronger test of the structure-mapping account. Several considerations suggest that 15-month-olds satisfy the prerequisites of structure mapping. First, foundational work on syntax-guided word learning in infancy shows that by 14 months, infants treat new nouns (e.g., "This is a blicket"), not just any new word ("This is blickish"), as referring to object kinds (Booth & Waxman, 2009; Waxman & Booth, 2001). Thus by 14 months, infants can use distributional information to identify nouns as such, distinct from other grammatical categories. Second, 14- to 15-month-olds understand multi-word sentences under some circumstances (Hirsh-Pasek & Golinkoff, 1996; Seidl et al., 2003). For example, Seidl et al. showed infants an event in which a book hit some keys. Infants then saw the book and keys side-by-side and heard either "Where are the keys?" or "What hit the keys?". Infants tended to look at the keys if they heard the first of these sentences, but at the book if they heard the second. These two reports document the earliest signs of multiword sentence comprehension that we know of: 14- to 15-month-olds, but not younger, can identify multiple familiar words per sentence, at least under some conditions, and integrate their meanings to interpret the sentence. Younger infants may typically fail to understand multiple familiar words per sentence, limited by inefficient word recognition: Though even 6- to 7-month-olds understand some nouns, at 14

months infants show a substantial improvement in the speed and accuracy of word comprehension (Bergelson & Swingley, 2012, 2013). This improvement may result from growing knowledge of the distributional contexts of known words, and in turn give infants a chance to identify multiple familiar words per sentence.

Another revised version of the construction-based account could argue that that 21- and 19-month-olds succeeded in Yuan et al.'s (2012) experiments in part because the test sentences provided additional language-specific morphological markers of transitivity (see discussion in Yuan et al., 2012). The novel-verb test sentences in the previous study included case-marked pronouns, comparing transitive sentences such as "He's gorping him!" or "She's stiping her!" to intransitive sentences such as "He's gorping!" or "She's stiping!". As Yuan et al. pointed out in their discussion, the use of case-marked pronouns might have provided distributional information about sentence meaning, because *he* and *she* are subject noun phrases, thus typically agents, whereas *him* and *her* are usually not subject noun phrases, and thus typically refer to non-agent semantic roles (although *her* can be used in subject position as a possessive in sentences such as "Her shoes are shiny" and both *him* and *her* can be used in subject position in embedded clauses such as "You saw her crying"). The presence of accusative case-marked pronouns (*him, her*) could also have provided distributional cues to identify a verb as transitive, because they often appear in direct object position (e.g., Ibbotson & Tomasello, 2009).

Relevant to this possibility, a recent study with older preschoolers reported evidence that accusative case-marked pronouns helped children to interpret transitive sentences containing novel verbs (Ibbotson, Theakston, Lieven, & Tomasello, 2011). In this study, 34-month-olds first watched a series of animated scenes that introduced the actions and novel verbs (e.g., "Look! Tamming!"). Later in test, children saw two cartoon pictures depicting the action and the

outcome of the novel causal events that they previously watched, but the scenes involved new cartoon characters. The two events within a pair showed the same causal action enacted by the same two characters differing in gender or animacy, but the roles of the characters were reversed. For example, one pair of pictures showed a girl acting on a boy versus a boy acting on a girl; another pair showed a girl acting on a chair versus an animated chair acting on a girl. For present purposes, the relevant result is that 34-month-olds chose the matching event reliably more often than expected by chance when given a transitive sentence either with ("She is tamming him" or "He is tamming her") or without ("She is tamming it" or "It is tamming her") accusative case-marked pronouns. However, they chose more accurately when the sentence contained two case-marked pronouns rather than one, suggesting that the accusative case-marked pronouns provided additional information about syntactic structure for children just under three years of age. In principle, accusative case-marked pronouns could also help 19-month-olds to differentiate transitive from intransitive verbs.

The present research addressed the two alternative interpretations discussed above. The first possibility that 19-month-olds already have learned enough verbs to learn a partial estimate of the transitive construction requires us to test younger infants who are just at the onset of multi-word sentence comprehension. In Experiment 1 and 2, we asked whether 15-month-old infants could use the number of nouns to tell apart transitive verbs from intransitive verbs. This is the youngest age at which infants have been shown to be able to understand sentences with multiple familiar words (e.g., Hirsh-Pasek & Golinkoff, 1996; Seidl et al., 2003): we know of no evidence that infants younger than 14-15 months understand multi-word phrases. By testing 15-month-olds, we thus tested a core prediction of the structure-mapping account that *as soon as* infants

identify some nouns as such, and have some ability to understand multi-word sentences, they should succeed in a simple syntactic bootstrapping task.

The second possibility that children could use case-marked pronouns to interpret verb transitivity requires us to test transitive sentences without accusative case-marked pronouns. To do so, we used the pronoun "it," which retains the same morphological form in subject and object position. In Experiment 3, we asked whether 19-month-old infants would assign appropriately different interpretations to novel verbs in transitive ("It's lorping it!") and intransitive ("It's lorping!") sentences, despite the absence of case-marking. By eliminating case-marked pronouns, we thus tested the prediction of the structure-mapping account that the number of nouns in a sentence guide young learners' verb interpretation as an inherently meaningful cue, even without the aid of prior language-specific learning about morphology.

In sum, the present research explored when and how the syntactic bootstrapping begins, by testing key predictions of our structure-mapping account.

Experiment 1

In Experiment 1 we adapted the task of Yuan et al. (2012), simplifying the events and procedure for younger infants. In the critical novel-verb test item, 15-month-olds saw two animated events side by side: a two-participant caused-motion event (one box repeatedly bumped another box, causing it to move), and a one-participant action event (a ball jumped up and down; see Figure 1). These events were accompanied by a novel verb in Transitive ("He's kradding him!") or Intransitive ("He's kradding!") sentences, or by Neutral audio with no novel verb (e.g., "Which one do you like?") to assess infants' baseline visual preferences between the two events.

Via structure-mapping, infants in the transitive condition should note the presence of two nouns in their test sentence, infer that the verb's meaning involves two participant roles, and therefore look longer at the two-participant event than would those in the intransitive or neutral conditions. Infants in the intransitive condition should note the presence of one noun in their test sentence, and infer that the verb's meaning involves one participant role. Notice the intransitive verb could refer either to the one-participant action event or to a component of the two-participant caused-motion event (Fernandes et al., 2006; Yuan et al., 2012); note that this is a case of the ambiguity in real-world scenes with which we began. Thus, as in previous work, we predicted no systematic preference for either event in the intransitive condition, relative to the neutral condition.

Method

Participants

Thirty-six 15-month-olds (M = 15.5 months, range 14.0–17.0; 18 girls) participated; all were carried full-term, and heard 85% English or more. None had a history of hearing problems. Two additional infants were excluded due to parental interference (1), or because the infant looked away 100% of the time during one of the two novel-verb preview trials (1; see Procedure below). Infants' receptive vocabularies, measured by the short form of the MacArthur CDI (Level I; Fenson et al., 2000), ranged from 4 to 65, with a median of 18. Twelve infants each were assigned to the Transitive, Intransitive, and Neutral conditions.

Apparatus

Infants sat on a parent's lap in a dimly lit room, about four feet from a 50" TV screen. Soundtracks were presented from the television's speakers. A central camera concealed beneath the television screen recorded infants' faces. Parents were instructed to close their eyes.

Materials and procedure

The procedure included a monologue phase, two familiar-word practice items, and one novel-verb test item. See Figure 1.

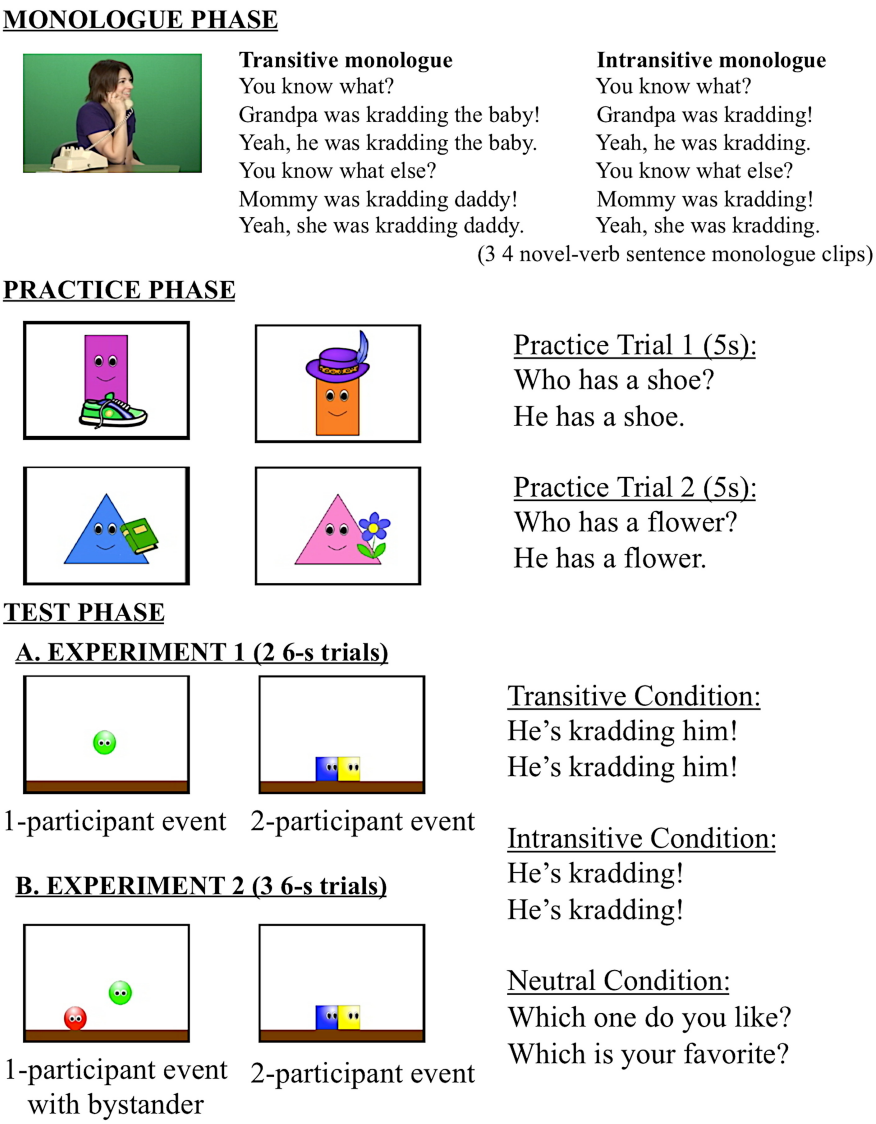

Figure 1. Stimulus events for Experiments 1 and 2 (15-month-olds). During the Monologue phase, infants watched a video in which a woman spoke on the telephone, using a novel verb in either Transitive or Intransitive sentences. Two practice items followed, involving the familiar verb "have." In these practice items, infants were prompted first to look at the one who "has a shoe", and then to find the one "has a flower". Finally, in the single novel-verb test item, infants saw a two-participant event in which a box repeatedly bumped another box, causing it to move, and a one-participant event in which a ball jumped up and down. These two events were accompanied by the novel verb in Transitive ("He's kradding him!"), Intransitive ("He's kradding!"), or Neutral ("Which one do you like") audio. In Experiment 1 only one figure was visible in the 1-participant event, whereas in Experiment 2, an immobile bystander was added to the 1-participant event. In the practice and test items, the two videos in each pair were previewed alone first and then shown together as shown here; see text for a description of this procedure.

As in Yuan et al. (2012), the experiment started with the monologue phase where infants saw videos of a woman talking on the phone, using the invented verb *krad* in sentences. Infants in the transitive condition heard the verb in transitive sentences (e.g., "Grandpa is gonna krad the baby."), and those in the intransitive condition heard it in intransitive sentences ("Grandpa is gonna krad."); half of the infants in the neutral condition heard transitive monologues, and half heard intransitive monologues. The monologues served to pre-familiarize infants with the novel verb and its syntactic contexts, easing processing of the test sentences to be presented later in the task.

All nouns in the monologue sentences had animate referents; these included proper names, pronouns, and common nouns (e.g., *baby*, *boy*). Infants saw three monologue video clips, each 24.7 to 31.7 s long, and each containing 4 novel-verb sentences. The novel verb appeared in multiple morphological forms across the monologue clips (e.g., *is kradding, kradded, is gonna krad, was kradding*). The monologue video clips were separated by 6-s intervals, each comprising a 1-s silent blank-screen interval, a 4-s presentation of a drawing of a smiling sun accompanied by a laughing-baby soundtrack, and another 1-s silent blank-screen interval. The monologue videos and sun image appeared centered on the TV screen.

Next, after a 5-s blank-screen interval in which infants heard "Now let's watch this!," two practice items followed, both involving the familiar verb *have*. Infants saw still pictures of geometric characters (e.g., a colorful rectangle with eyes and a mouth; see Figure 1) with familiar objects (e.g., a book or a hat). The practice items served to familiarize infants with the task, teaching them that one image matched the soundtrack on each trial.

The first practice item showed one rectangular character with a shoe, and another rectangular character in another color with a hat. Each picture was previewed alone (5s) on the

left or right side of the screen, in counterbalanced order and separated by a 4-s blank-screen interval, accompanied by descriptive audio (e.g., “He has a shoe!,” then “He has a hat!”). Next, during another 4-s blank-screen interval, infants heard “Who has a shoe?”; then infants saw the two pictures side by side (5s) in their previewed positions, and heard “Who has a shoe? He has a shoe”. After a 4-s blank-screen interval, the second practice item was presented in the same manner. This item showed different-colored triangular characters, one with a book and one with a flower; infants were prompted to find the character with the flower.

Finally, following a 4-s blank-screen interval, the novel-verb test item was presented. The 6-s animated events included a two-participant causal event (a blue box repeatedly bumped a yellow box, causing it to move) and a one-participant action (a green ball repeatedly jumped up and down). Both events were previewed alone in counterbalanced order, separated by a 4-s blank-screen interval, accompanied by neutral audio (e.g., “Watch this.”). Next, during a 9-s blank-screen interval, infants heard two test sentences appropriate for their condition (e.g., Transitive: “He’s gonna krad him! He’s gonna krad him!,” Intransitive: “He’s gonna krad! He’s gonna krad!,” Neutral: “Which one do you like? Find your favorite!”). Both events then played simultaneously (6s) while the infants heard two more test sentences (Transitive: “He’s kradding him! He’s kradding him!,” Intransitive: “He’s kradding! He’s kradding!,” Neutral: “Which one do you like? Which is your favorite?”). Next, during a 6-s interval, infants heard another test sentence and a prompt (e.g., Transitive: “He kradded him. Find kradding!,” Intransitive: “He kradded. Find kradding!,” Neutral: “Did you find it? That was fun!”). Both test events then appeared again, accompanied by one more test sentence and a prompt.

The left/right position of the test events was counterbalanced with dialogue and test condition.

Coding and analysis

We coded where infants looked (left, right, away) during the two 6-s trials of the novel-verb test item, frame by frame from silent video. Reliability was assessed for 9 randomly selected infants (25% of the data); primary and reliability coders agreed on 96% of video frames. Individual test trials were treated as missing if the infant looked away for more than half of the 6-s trial (1 trial).

A preliminary analysis of time spent looking away, averaged across the two 6-s test trials, revealed no effect of sentence condition ($F < 1$), suggesting that infants in all conditions tended to look away about equally, and briefly (transitive: $M = 0.60$ s, $SD = 0.38$; intransitive: $M = 0.68$ s, $SD = 0.50$; neutral: $M = 0.58$ s, $SD = 0.45$). Given the uniformity of time spent looking away, we conducted our main analyses on a single measure, looking time to the two-participant event as a proportion of total time spent looking at either test event, averaged across the two 6-s test trials. Preliminary analyses of the test data revealed no interactions involving sentence condition and gender, whether infants' performance in the practice trials[1] was above or below the median, or whether infants' receptive vocabulary was above or below the median (Fs < 2.4, ps > .11). The data were therefore collapsed over these factors.

Results and Discussion

As shown in Figure 2a, the 15-month-old infants' looking preferences varied across conditions. An analysis of variance (ANOVA) revealed a significant effect of sentence condition on looking time to the two-participant event, $F(2, 33) = 3.672$, $p = .036$. Planned comparisons revealed that infants in the transitive condition ($M = .56$, $SD = .16$) looked reliably longer at the two-participant event than did those in the intransitive condition ($M = .40$, $SD = .16$), $t(22) =$

[1] The median of infants' target preference in the practice trials was 0.50.

2.401, $p = .025$. Looking preferences in the neutral condition ($M = .55$, $SD = .16$) did not differ from the transitive condition, $t < 1$, but unlike in previous studies (Arunachalam & Waxman, 2010; Yuan et al., 2012), the neutral condition differed reliably from the intransitive condition, $t(22) = 2.395$, $p = .032$. The difference between the intransitive and neutral conditions was unexpected; this prompted us to replicate Experiment 1, to determine whether this unexpected pattern would be reproduced, as well as to confirm the key difference between the transitive and intransitive conditions.

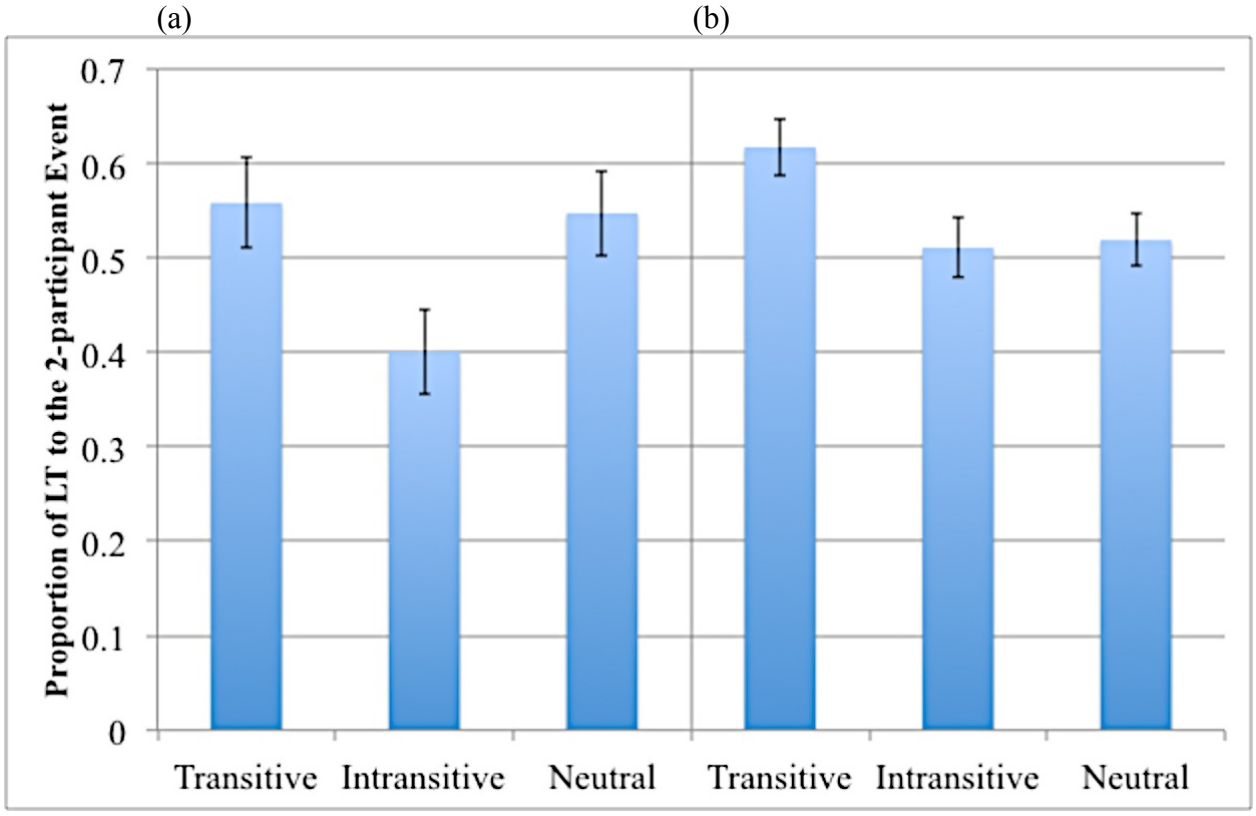

Figure 2. Mean (se) proportion looking time to the two-participant event, Experiment 1 (a) and the replication of Experiment 1 (b) (15-month-olds).

Replication

We tested 36 additional 15-month-olds (13.9–16.7 months, *M* =14.9 months, 18 girls) from the same population described above. An additional 3 infants were tested but excluded because they cried (2), or did not complete the experiment (1). The included infants' receptive vocabularies ranged from 3 to 87 with a median of 18.5. Twelve infants were assigned to each of the three conditions.

The procedure and materials were identical to those described above. Reliability was assessed for 9 randomly selected infants (25% of the data); primary and reliability coders agreed on 96% of video frames. Individual test trials were dropped if the infant looked away for more than half of the 6-s trial (3 trials). Preliminary analyses again revealed no effect of sentence condition on look-away times in the test item ($F < 1$), suggesting that infants in all conditions tended to look away about equally, and briefly (transitive: $M = 0.57$ s, $SD = 0.47$; intransitive: $M = 0.68$ s, $SD = 0.80$; neutral: $M = 0.64$ s, $SD = 0.41$). Given the uniformity of time spent looking away, as in the main experiment, we conducted our main analyses on a single measure, looking time to the two-participant event as a proportion of total time spent looking at either test event, averaged across the two 6-s test trials. Preliminary analyses of the test data revealed no interactions involving sentence condition and gender, whether infants' performance in the practice trials was above or below the median[2], or whether infants' receptive vocabulary was above or below the median (Fs < 1.5, ps > .25). Therefore, we again analyzed looking time to the two-participant event as a proportion of total time spent looking at either test event.

As Figure 2b shows, the 15-month-olds' looking preferences varied as predicted across sentence conditions. An ANOVA revealed a main effect of sentence condition, $F(2, 33) = 3.968$,

[2] The median of infants' target preference in the practice trials was 0.50.

p = .029. The data from this replication experiment confirmed the key effect of transitivity in the main experiment, but did not replicate the unexpected difference between the intransitive and neutral conditions. Infants in the transitive condition looked reliably longer at the two-participant event (M = .62, SD = .10) than did those in the intransitive condition (M = .51, SD = .11), $t(22)$ = 2.456, p = .022, and the neutral condition (M = .52, SD = .10), $t(22)$ = 2.398, p = .025. The intransitive and neutral conditions did not differ, $t(22) < 1$.

In Experiment 1 and its replication, 15-month-olds assigned different interpretations to transitive and intransitive sentences containing unknown verbs. Infants who heard the novel verb in transitive sentences ("He's kradding him!") looked longer at the two-participant event than did those who had heard the novel verb in intransitive sentences ("He's kradding!").

The results in the neutral condition were less stable. In the main experiment, looking preferences in the neutral condition resembled those in the transitive condition, and differed from those in the intransitive condition. However, the replication data did not confirm this unexpected result; as we shall see below, Experiment 2 also did not reproduce this unexpected result.

The striking difference between the transitive and intransitive conditions yields powerful evidence for a key prediction of the structure-mapping account. Even 15-month-old infants, near the start of multi-word sentence comprehension, use sentence structure clues to differentiate transitive and intransitive sentences containing unknown verbs.

Experiment 2

As predicted by the structure-mapping account, the 15-month-olds in Experiment 1 assigned different interpretations to novel verbs in simple transitive vs. intransitive sentences. On our account, this inference results from a one-to-one mapping bias that prompts infants to align

each noun in a stimulus sentence with a core participant role in a structured conceptual representation of one of the stimulus events. An alternative interpretation, however, is that the effects of sentence structure in Experiment 1 reflected an even simpler tendency to match the number of nouns in the sentence with the number of characters visible in the test videos. In Experiment 2, we sought both to replicate the findings of Experiment 1 and to rule out this alternative interpretation.

To do so, we adopted the 'bystander' manipulation of Yuan et al. (2012), adding a second character (a bystander) to the one-participant test event (Figure 1). As a result, both test events showed two characters, but only the two-participant test event showed the two characters involved in a coherent interaction. If infants succeeded in Experiment 1 simply by matching nouns with visible characters on the screen, then in Experiment 2 we should find no differences between the two critical sentence conditions. On this alternative interpretation, neither transitive nor intransitive sentences should direct infants' attention selectively to one of the two stimulus events, because both events contained the same number of characters. In contrast, if infants succeeded in Experiment 1 by mapping each noun onto a core participant role in a coherent conceptual representation of the stimulus events, then we should replicate the key findings of Experiment 1. Infants in the transitive condition should interpret their sentence as referring to a two-participant relational event, and thus look longer at the two-participant event than do infants in the intransitive condition.

Method

Participants

Thirty-six native English-learning 15-month-olds (M = 15.5 months, range 14.0–17.0; 19 girls) participated; all were born full-term. None had hearing problems. Three additional infants

were excluded because they did not complete the experiment. Infants' receptive vocabularies, measured as in Experiment 1, ranged from 5 to 65, with a median of 25. Twelve infants each were assigned to the Transitive, Intransitive, and Neutral conditions.

Materials and procedure

The materials and procedure were as in Experiment 1 with two exceptions. First, a second character, a ball-shaped character in a different color, was introduced into the one-participant test event (see the bottom row of Figure 1). This bystander simply stood immobile as the other character jumped. Second, a bystander was introduced to all practice-item pictures (not shown in Figure 1), to reduce the novelty of the bystander in the test item. For example, a second rectangular character without an additional object stood beside the one with a shoe, and another beside the one with a hat, in the first practice item.

Coding and analysis

Coding and analysis were carried out as in Experiment 1. Individual test trials were dropped if the child looked away for more than 50% of the trial (4 trials). Reliability was assessed for 9 infants; coders agreed on 96% of video frames. Look-away times in the test trials again did not vary with sentence condition ($F < 2$, $p > .17$), suggesting that infants in all conditions tended to look away about equally, and briefly (transitive: $M = 0.42$ s, $SD = 0.33$; intransitive: $M = 0.42$ s, $SD = 0.17$; neutral: $M = 0.62$ s, $SD = 0.32$). We therefore again took as our main measure infants' looking times at the two-participant event, as a proportion of time spent looking at either event, averaged across the two 6-s test trials.

Preliminary analyses of the test data revealed no interactions involving sentence condition and gender, whether infants' target preference in the practice trials was above or below the median[3], or whether infants' vocabulary was above or below the median (Fs < 1.2, ps > .32).

Results and Discussion

As Figure 3 shows, infants' looking patterns again varied with sentence condition. An ANOVA revealed a significant effect of sentence condition on looking time to the two-participant event, $F(2, 33) = 6.533$, $p = .004$. Planned comparisons showed that infants in the transitive condition looked reliably longer at the two-participant event ($M = .58$, $SD = .18$) than did those in the intransitive ($M = .37$, $SD = .19$), $t(22) = 2.806$, $p = .01$, or the neutral condition ($M = .32$, $SD = .19$), $t(22) = 3.399$, $p = .003$. The intransitive and neutral conditions did not differ, $t(22) < 1$.

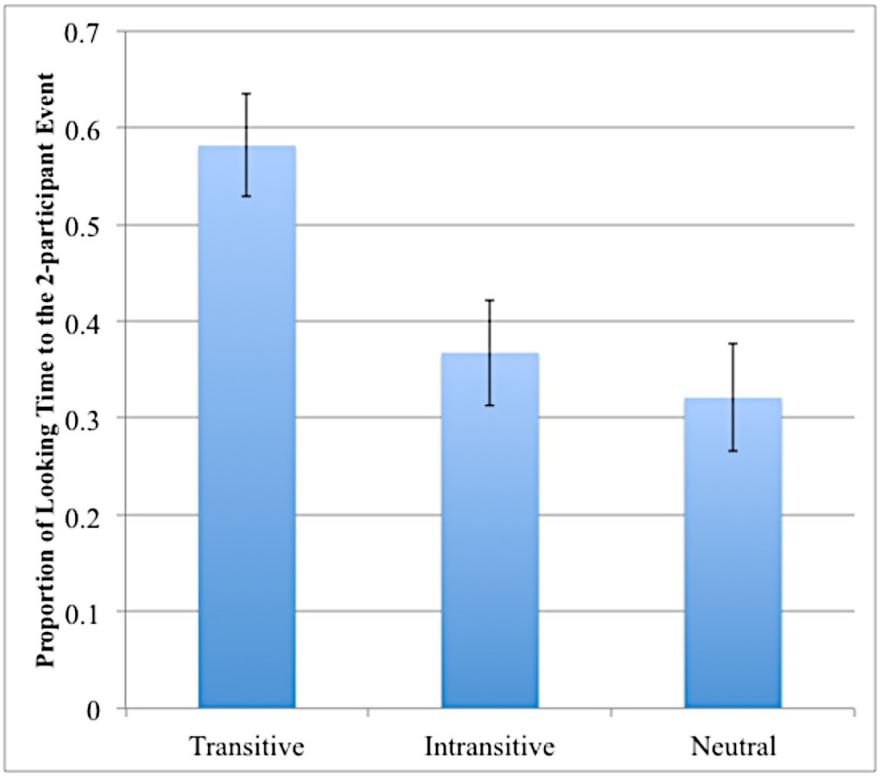

Figure 3. Mean (se) proportion looking time to the two-participant event, Experiment 2 (15-month-olds).

[3] The median of infants' target preference in the practice trials was 0.53.

Experiment 2 replicated and extended the findings of Experiment 1. Fifteen-month-olds again assigned different interpretations to novel transitive and intransitive verbs. Those who heard the verb in transitive sentences looked longer at the two-participant event than did those who heard intransitive sentences or neutral audio. In Experiment 2, this pattern held even in the bystander case, when both test events depicted the same number of characters. This tells us that 15-month-olds who heard transitive sentences looked longer at the two-participant event not simply because it showed two characters, one for each noun, but because it showed a coherent two-participant event, with one participant role for each noun.

This confirms a key prediction of the structure-mapping account: infants at the earliest point of multi-word sentence comprehension can differentiate transitive and intransitive verbs via a mapping bias between nouns in sentences and participant roles in events. This finding is important because it reveals the dependence of syntactic bootstrapping on structured conceptual representations of events (see Fisher, Gleitman & Gleitman, 1991; Landau & Gleitman, 1985).

Experiment 3

Experiment 1 and 2 showed that 15-month-old infants could use the number of nouns to differentiate novel transitive and intransitive verbs. These results are consistent with the prediction of the structure mapping account, that the set of nouns is inherently meaningful in early verb interpretation. However, most of the syntactic bootstrapping experiments testing children under age two, including Experiments 1 and 2, included case-marked pronouns, such as *him* or *her* (e.g., Yuan et al., 2012). Such case-marked pronouns could provide additional lexical cues to the grammatical roles of noun phrases (subject or object), and therefore, permit the child to infer the grammatical roles of these nouns directly (subject vs. object), supplementing the

number of nouns information. This inference depends on language-specific learning. For example in Japanese, children must learn that postnominal case markers convey agent–patient role information. Japanese-learning 2-year-old children benefit from case markers when they interpret transitive sentences containing novel verbs (i.e. morphosyntactic bootstrapping, Göksun, Küntay, & Naigles 2008; Matsuo et al., 2012). In a study by Matsuo and her colleagues, Japanese 2-year-olds were more likely to assign a causal meaning to a novel verb in a two-noun transitive sentence when the nouns were marked with case markers (e.g., Ahiru-san-*ga* usage-san-*o* neket-teru-yo, duck-Mr-NOM rabbit-Mr-ACC Verb-PROG-PROG, 'The bunny is gorping the duck') than when they were not (e.g., Ahiru-san usage-san neket-teru-yo). Similarly, Korean-learning 2-year-olds interpreted one-noun novel-verb sentences with an accusative case marker as more transitive compared to one-noun sentences with a nominated case marker (Lee, Kim & Song, 2013), together suggesting that case-markers or cased-marked pronouns could help children confirm the structure.

In Experiment 3, we asked whether English-learning toddlers could use the number of nouns as an indicator for verb meaning, even without the aid of language-specific case-marked pronouns. The structure-mapping account proposes that the number of nouns in sentences is inherently meaningful to children; therefore, noun number itself should be a sufficient cue to differentiate transitive from intransitive sentences, once infants can identify nouns as such, as parts of a larger sentence. The goal of Experiment 3 was to test the structure-mapping account, by asking whether 19-month-olds could use the number of nouns to differentiate transitive from intransitive verbs, without additional information from case-marked pronouns.

To do so, we used only the pronoun *it* in the test sentences. Unlike the personal pronouns used in Yuan et al.'s (2012) experiments and in Experiments 1 and 2, "it" retains the same

morphological form in subject and object position. *It* can appear as a subject pronoun, as in "It fell" or "It scared me", or as an object pronoun, as in "I saw it". Thus the mere presence of the word *it* in a sentence tells the listener nothing about whether the verb in that sentence is transitive or intransitive. If 19-month-olds are sensitive to the number of nouns, they should assign appropriately different interpretations to novel verbs in transitive ("It's lorping it!") and intransitive ("It's lorping!") sentences, despite the absence of case-marking. This manipulation allowed the two test sentences to have the same pronoun, but differ only in the number of nouns. We chose *it* not only for the object, but also for the subject position, partly to rule out another potential alternative that children could take advantage of pronouns contrasting in animacy (e.g., He's [verb]-ing it) compared to the case without it (e.g., "The dog's tamming the chair.") (Childers & Tomasello, 2001).

Here, we tested 19-month-olds rather than 15-month-olds, because of the anticipated difficulty in processing sentences (*It's lorping it*) that would be quite rare in natural language input. Analyses of English child-directed speech show that active transitive sentences very frequently have a pronoun in subject position, but not so much in the direct object position (e.g., Cameron-Faulkner et al., 2003; Laakso & Smith, 2007). Cameron-Faulkner et al. looked at the argument realization of a set of highly frequent transitive and intransitive verbs and found that parents use the inanimate pronoun it much less frequently as the subject of transitive sentences than of a subject of intransitive sentences: only 5% the tokens of the transitive verbs had 'it' as sentence subjects. Thus, the "It's verbing it" sentence form chosen for Experiment 3 is likely to be very infrequent in the input, which in turn would impede 15-month-old infants' sentence processing in the task.

Method

Participants

Forty-eight native English-learning 19-month-olds (*M* = 19.0 months, range 18.2–20.0; 24 girls) participated; all were born full-term, and none had hearing problems. Three additional infants were excluded due to crying (1), inattentiveness (1; looking at the test events for < 50% in two out of three test trials; see Procedures below), or because the infant did not complete the experiment (1). The median productive vocabulary, measured using the short form of the MacArthur-Bates Communicative Development Inventory (CDI) Level II (Fenson et al., 2000), was 17 (range = 0-66). Parents reported that 21 of the infants did "not yet" combine words in production, 19 did so "sometimes," and 8 "often." Sixteen infants were assigned to the Transitive, Intransitive, and Neutral conditions.

Materials and procedure

The materials and procedure were similar to those of Experiment 1 and 2 with one key difference: while watching the novel-verb test events, infants heard a novel verb (*lorp*) presented in test sentences with the pronoun *it* rather than *he* and *him* (Transitive: "It's lorping it!," Intransitive: "It's lorping!").

As before, Experiment 3 began with a monologue phase. The monologues in Experiment 3 contained no case-marked pronouns, but introduced *it* as a sentence subject. Infants watched a video showing a woman talking on the telephone (Figure 4.), using the novel verb in transitive ("The cat lorped the bunny! Yeah, it lorped the bunny!") or intransitive sentences ("The cat lorped! Yeah, it lorped!"). We reasoned that pre-exposure to *it* in subject position might help offset any sentence-processing difficulties posed by the rarity of *it* as a sentence subject, for transitive verbs in particular (e.g., Cameron-Faulkner et al., 2003).

Figure 4. Sequence of events within Experiment 3 (19-month-olds). In Experiment 3, a pronoun unmarked for case (it) was used in the test sentences, instead of the personal pronouns he and him. In the test item, infants watched a two-participant event and a one-participant bystander event. These two events were accompanied by the novel verb in transitive ("It's lorping it!"), intransitive ("It's lorping!"), or Neutral (What's happening?) audio.

A single practice item followed, involving the familiar verb *have*: one image showed a tall box with a shoe; the other showed another box with a hat, as shown in Figure 4. The procedure of practice trials were similar to that of Experiment 1 and 2, except that Experiment 3 had only one pair of practice item and asked infants to look at each of the two images in turn (Experiment 1 and 2 had two practice pairs and on asked infants to look at one of the two images in two different pairs). The two images were first previewed one at a time for 5s, separated by a 3s blank-screen interval; each event preview was accompanied by a soundtrack labeling the

object that the character held (e.g., “It has a shoe!” “It has a hat!”). Next, during a 3s blank-screen interval, the infants were prompted to look at the shoe event (“Who has a shoe?”). The two events then played simultaneously (5s), accompanied by sentences that matched the shoe event (“Who has a shoe? It has a shoe.”). During another 3s blank- screen interval, infants were prompted to look at the hat event (“Who has a hat?”). Next, the event pair was presented again in a second 6s trial, in which the accompanying audio matched the hat event (“Who has a hat? It has a hat.”).

Finally, the single novel-verb test item involved the same 2-participant event and bystander 1-participant event described in Experiment 2. The test item was structured as in Experiments 1 and 2, except that infants received three 6-s trials rather than two; the third trial was provided to give infants more time to process the unusual sentences.

Coding and analysis

Coding and analysis were carried out as in Experiment 1 and 2. Individual test trials were dropped if the child looked away for more than 50% of the trial (8 trials). Reliability was assessed for 12 infants; coders agreed on 96% of video frames. Look-away times in the test trials again did not vary with sentence condition ($F < 1$), suggesting that infants in all conditions tended to look away about equally, and briefly (transitive: $M = 0.41$ s, $SD = 0.42$; intransitive: $M = 0.57$ s, $SD = 0.35$; neutral: $M = 0.50$ s, $SD = 0.46$); we therefore analyzed a single measure, infants’ looking times at the two-participant event as a proportion of time spent looking at either event, averaged across the three 6-s test trials.

Preliminary analyses of the test data revealed no interactions involving sentence condition and gender, whether infants’ target preference in the practice trials was above or below

the median[4], whether infants' vocabulary was above or below the median, or whether infants combined words in production or not (*F*s < 1).

Results and Discussion

As Figure 5 shows, infants' looking patterns again varied with sentence condition. An ANOVA revealed a significant effect of sentence condition on looking time to the two-participant event, $F(2, 45) = 3.938$, $p = .027$. Planned comparisons showed that infants in the transitive condition looked reliably longer at the two-participant event ($M = .56$, $SD = .09$) than did those in the intransitive ($M = .46$, $SD = .14$), $t(30) = 2.569$, $p = .015$, or the neutral conditions ($M = .45$, $SD = .14$), $t(30) = 2.591$, $p = .015$. The intransitive and neutral conditions did not differ, $t(30) < 1$.

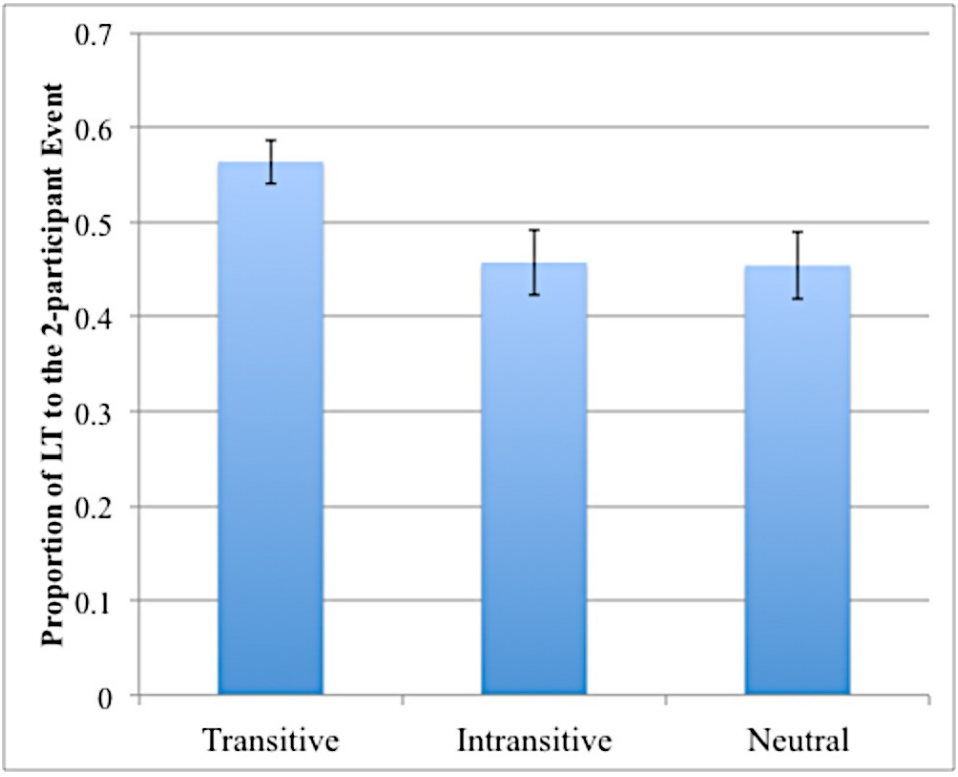

Figure 5. Mean (se) proportion looking time to the two-participant event, Experiments 3 (19-month-olds).

[4] The median of infants' target preference in the practice trials was .49.

In Experiment 3, we replicated and extended key results of previous experiments by Yuan, Fisher, and Snedeker (2012), showing that 19-month-old infants use the number of noun phrase to interpret novel verbs. Infants who heard the verb in transitive sentences looked longer at the two-participant event than did those who heard intransitive sentences or neutral audio. Crucially, this success held despite the absence of language-specific case-marking cues to transitivity. This finding yields strong evidence for the structure-mapping account: 19-month-olds use the structure of a sentence to guide interpretation of a novel verb, even without useful information from case-marked pronouns.

Importantly, 19-month-olds succeeded in this task even with fairly unusual examples of transitive sentences. Transitive sentences in a [It-Verb-it] frame are infrequent in English input sentences: As noted earlier, only 5 % of uses of frequent transitive verbs in English child-directed speech have the inanimate subject pronoun (e.g., Cameron-Faulkner et al., 2003).

In sum, the findings in Experiment 3 support the structure-mapping account: 19-month-old infants differentiate transitive and intransitive sentences by counting even case-unmarked pronouns that do not signal the verb's transitivity.

General Discussion

The experiments reported in this chapter set out to test key predictions of the structure-mapping account. In Experiments 1 and 2, 15-month-old infants used sentence-structure cues to interpret novel transitive and intransitive verbs. Infants who heard a novel verb in simple two-noun transitive sentences ("He's kradding him!") looked longer at a two-participant event as opposed to a one-participant event than did those who heard the novel verb in one-noun intransitive sentences ("He's kradding!"). They did so even when the one-participant event

included a second character, a bystander not engaged in any obvious relationship with the other character. These results are just what we would predict on the structure-mapping account. They suggest that 15-month-olds assigned a relational meaning to a novel transitive verb, and did so by aligning each noun in a sentence with a core participant role in a coherent conceptual representation of an event. In Experiment 3, 19-month-old infants succeeded in a similar task with sentences without language-specific evidence for transitivity due to case-marked pronouns. Infants who heard a novel verb in two-noun transitive sentences ("It's lorping it!") looked longer at a two-participant event as opposed to a one-participant event than did those who heard the novel verb in one-noun intransitive sentences ("It's lorping!"). These findings extend what we know about the origins of syntactic bootstrapping, and about early sentence interpretation, in three main ways.

First, these data confirm that children use sentence structure to guide verb learning well before two years of age (e.g., Arunachalam et al. 2013; Yuan et al., 2012), and provide striking new evidence of the early onset of syntactic bootstrapping in infancy. We argued in the Introduction that our account of the origins of syntactic bootstrapping required us to test 15-month-olds. On the structure-mapping account, infants are innately biased to map each noun in a sentence onto a distinct participant role in a structured conceptual representation of an event. If so, then infants should find simple aspects of sentence structure inherently meaningful, as soon as they can identify some nouns as such, and can identify multiple words per sentence. We reviewed evidence that by 14 to 15 months of age, infants possess these prerequisite skills. The current evidence that 15-month-olds assigned different interpretations to novel transitive and intransitive verbs thus provides strong evidence for a key prediction of the structure-mapping

account. Simple aspects of syntactic structure guide sentence comprehension from early in the second year of life, at or near the onset of multi-word sentence comprehension.

Second, the present results provide new evidence that children can understand multi-word sentences early in the second year. As far as we know, only two prior published reports demonstrate such early prowess (Hirsh-Pasek & Golinkoff, 1996; Seidl et al., 2003). Success in the present experiments, as in the two previous reports, required infants to identify multiple words per sentence (in our case, the two familiar nouns in the transitive-condition sentences) and to integrate them in understanding the sentence; these data thus confirm that multi-word sentence comprehension becomes possible, at least under some circumstances, by 14 to 15 months of age. Moreover, the task in Experiments 1 and 2 required 15-month-olds to identify two function words in the transitive test sentences, the pronouns *he* and *him*, and to do so despite the presence of a novel word. This ability should give toddlers access to powerful new constraints on word-learning, allowing them to use what they know about the meanings of other words in the sentence to guide learning of new words. Older children, 23-month-olds can use function words to identify the grammatical category of a novel word (e.g. "il poune par là" / "it's pooning there" vs. "un poune est là"/ "a poon is here"), and infer its meaning (e.g., Bernal, Lidz, Millotte, & Christophe, 2007).

Third, our results rule out the alternative possibility that syntactic bootstrapping in children under age 2 depends on the presence of case-marked pronouns, at least for 19-month-olds. The 19-month-olds' success in our task is not trivial. Even older children, 2.5-year-olds, showed difficulty in act-out tasks of transitive sentence comprehension with *it* in subject rather than object position (e.g., Childers & Tomasello, 2001). Transitive sentences with the pronoun *it* as subjects are not common. Indeed, the pronoun *it* appears more often as a subject in intransitive

sentences than in transitive sentences (e.g., Cameron-Faulkner et al., 2003; Laakso & Smith, 2007). In Cameron-Faulkner et al., the inanimate pronoun *it* appears as a subject in about 5% of utterances of frequent transitive verbs in child-directed speech, whereas 14% of frequent intransitive-verb sentences contained *it* as sentence subjects.

Mintz (2003) reported "It___the" as a "frequent frame" where pairs of words that frequently co-occur with one word position intervening in the same order, categorizing the intervening word together. However, not all intervening words in this frame were verbs: in fact, "It___the" frame was more frequent as prepositions (e.g., "It's under the…") than verbs. The verbs occurred with "It___the" were low-frequency verbs in the corpora, occurring once or twice in the sample. These all suggest that 19-month-old infants used the noun number information without firm probabilistic cues from pronouns for transitive verb category.

However, other possibilities must be considered before we can take these data as direct evidence for the innate one-to-one mapping bias that is at the heart of the structure-mapping account. An alternative possibility is that infants used the familiar words in our test sentences as arbitrary distributional cues, to identify the novel verb as a member of a previously-learned category of words. For example, the frame "He___ him" could occur often enough in the input to become a frequent frame of a kind that provides useful data about grammatical categories (Mintz, 2003). Such frames have no inherent meaning, but become meaningful by virtue of their association with a set of words whose meanings are already known (e.g., Lany & Saffran, 2010; Maratsos & Chalkley, 1980). Infants might identify such distributional cues in the stimulus sentences, use them to put the new verb in a category of known verbs that share the same distributional contexts, and then interpret the new verb as having a meaning characteristic of the known verbs in that class (e.g., *hug, kiss, eat*). There is ample evidence that infants make such

category-mediated inferences in interpreting new words, using function words to distinguish novel nouns from other words (e.g., “This is a blicket” vs. “This is blickish”; Waxman & Booth, 2001), and proper names from count nouns (e.g., “It’s an X” vs. “It’s named X”; Hall & Lavin, 2004).

Could such learned categories alone explain our data, without appeal to an innate one-to-one mapping bias? A learned-category explanation implies an account of the origins of syntactic bootstrapping that relies on early abstract syntactic and semantic categories (needed for success in our task), but not on innate links between syntax and meaning. On such an account, all links between syntax and meaning would be learned. A firm answer to this question would take us beyond what is now known about early word knowledge and early distributional learning. As noted in the introduction, infants 12 to 18 months old do understand some transitive and intransitive action verbs (Hirsh-Pasek & Golinkoff, 1996; Huttenlocher, Smiley, & Charney, 1983), and 10- to 13-month-olds distinguish the referents of a few common verbs such as *kiss* vs. *dance* or *eat* vs. *hug* (Bergelson & Swingley, 2013). Moreover, 12-month-olds have learned some of the distributional contexts of native-language verbs, and can use them to predict in which new linguistic contexts a novel word should appear (e.g., *to lonk it* → *you lonk the*; Mintz, 2006; but see Höhle et al., 2004). Further research will be needed to determine whether infants could use this nascent verb semantic and distributional knowledge to build categories that would support success in our task, prompting 15-month-olds to interpret a novel transitive but not intransitive verb as referring to a coherent two-participant relation.

Still, several considerations cause us to prefer the structure-mapping account over an account that includes no innate links between syntax and semantics. For example, the sensible syntactic-semantic patterns that characterize the inventions of Home Signers (e.g., Goldin-

Meadow, 2005) suggest that certain non-arbitrary links between syntax and semantics may not need to be learned from language experience, even if they could be (see Yuan et al., 2012, for discussion). In addition, a learned-category account provides no solution to the learning problem with which we began—how verbs' abstract semantic structures are learned in the first place. As just noted, 10- to 13-month-olds can link some verbs with appropriate events (Bergelson & Swingley, 2013). But verb meanings do not simply label events; they represent particular perspectives on them, foregrounding the roles of varying subsets of event participants. To illustrate, a parent encouraging an infant to put a block in a shape sorter might say "Let's put that one here," or "That one goes here." These two sentences take different perspectives on the same caused-motion event, reflecting the different semantic structures of the verbs put and go. Via syntactic bootstrapping, syntactic evidence informs learners about each verb's abstract perspective on events, including its number of participant-roles. This is the semantic structure knowledge infants needed to succeed in our task, and is just what we and others have argued is not readily available in observations of scenes alone (e.g., Fisher, 1996; Gleitman et al., 2005).

The present results provide the first evidence that even 15-month-old infants use sentence structure cues to interpret new transitive versus intransitive verbs. This extends what we know about the development of syntactic bootstrapping, and confirms a key prediction of the structure-mapping account: Infants use syntax to interpret verbs from the start of multi-word sentence comprehension.

CHAPTER 3

COUNTING THE (MISSING) NOUNS: SYNTACTIC BOOTSTRAPPING IN KOREAN

The syntactic bootstrapping theory proposes that syntax guides children's verb learning (e.g., Gleitman, 1990). This is possible because languages universally have systematic relationship between verb syntax and verb meaning. For example, transitive verbs such as "put" license two noun-phrase (NP) arguments and describe events involving two core participants, whereas intransitive verbs such as "go" license one NP argument and describe construals of events that focus on one core participant. Syntactic bootstrapping has been argued to be an essential part of the language learning procedure. The scene input does not contain reliable information about the abstract relational meanings of verbs, and syntactic structures themselves contribute meaning to verbs and sentences (Gleitman et al., 2005). Evidence for syntactic bootstrapping comes from many experiments showing that young children assign different interpretations to novel verbs presented in different sentence structures (e.g., Arunachalam & Waxman, 2010; Arunachalam et al., 2013; Fisher, 1996; Fisher et al., 1994; Lidz, Gleitman, & Gleitman, 2004; Naigles, 1990, 1996; Naigles & Kako, 1993; Yuan, Fisher, & Snedeker, 2012).

Accounts of syntactic bootstrapping have focused on the number of noun-phrase arguments as information about verb predicate-argument semantics (e.g., Lidz et al., 2003; Yuan, et al., 2012). Our account of the origins of syntactic bootstrapping, the structure-mapping account (e.g., Fisher, 1996) proposes that the number of noun phrases in a sentence is inherently meaningful to children. A key assumption of this account is that children have an unlearned bias to link each NP argument with a core participant role in their conceptual representation of an event.

Consistent with the predictions of the structure mapping account, a recent study found that even children under two years of age assigned appropriately different meanings to novel verbs presented in transitive versus intransitive, when the number of nouns in the sentences was informative (Yuan et al., 2012). In this study, 21- and 19-month-olds heard a novel verb in two-noun transitive ("He's blicking him"), or one-noun intransitive sentences ("He's blicking"), while viewing two simultaneous events. One event involved two participants, and the other involved one participant (or one participant and a bystander). Children hearing a transitive verb looked reliably longer at the two-participant event than did those hearing an intransitive verb, suggesting that the number of nouns in sentences guides very young children's verb interpretation. Chapter 2 reported experiments in which this key finding was extended to 15-month-olds, showing that even infants at the very start of multi-word sentence comprehension can use the set of nouns in the sentence to interpret new transitive versus intransitive verbs.

Most of the evidence for syntactic bootstrapping, however, comes from studies conducted with English-learning children (I will discuss some important exceptions below). This raises questions about the universality of syntactic bootstrapping, because English has properties that might make syntactic bootstrapping especially helpful. In English, arguments are mostly expressed in sentences as overt noun-phrases. Although sentence subjects can be dropped in English (e.g., Schmerling, 1973), subject omission occurs only in limited contexts (e.g., Haegeman & Ihsane, 1999; Oh, 2006; Weir, 2012). In contrast, many languages, such as Hindi, Japanese, Korean, Mandarin, and Turkish, permit very pervasive noun argument omission as a grammatical option, whenever an argument is recoverable from the discourse context. Therefore, the number of overt nouns in an individual sentence is a far less reliable cue for a verb's

semantic predicate-argument structure in argument-dropping languages than in languages that allow less argument dropping.

For example, in describing a two-participant event (e.g., someone breaks a camera) in Korean, it is fully grammatical to omit overt mention of the subject or object noun-phrase, or both, as shown in (1). Given speaker A's question in the imagined exchange shown in (1), speaker B may respond with any of the options shown in (1b-d), with varying sets of missing arguments. All are completely acceptable, because the referents of both the subject and object in the answer (Speaker B and the camera) have been established as topics in A's question. This example makes clear the difference in argument dropping between English and Korean. In English, a response like (a) would be appropriate, but none of the others would be; instead of these omitted-argument options, Speaker B would need to say "I broke it", using overt pronouns to mark the verb's arguments despite their discourse-given status.

(1) A: khameyla etiesse? neka ecey khameyla ss-ess-canh-a
camera where be-Q? you-NOM yesterday camera use-PAST-CONF-DECL
'Where is the camera? You used the camera yesterday, right?"

B: (a) nay-ka khameyla mangkattuly-ess-e (SOV)
'I broke the camera.'

(b) nay-ka mangkattuly-ess-e (SV)
'I broke Ø.'

(c) khameyla mangkattuly-ess-e (OV)
'Ø broke the camera.'

(d) mangkattuly-ess-e (V)
'Ø broke Ø.'

Argument-dropping, in the relevant languages, is very common in the style of speech addressed to children. Existing corpus data in several languages establish the ubiquity of argument-dropping in speech to children. For example, Rispoli (1995) found that only about 11% of transitive sentences had two overt noun phrase arguments in child-directed Japanese. The majority of transitive sentences had only one overt noun phrase argument (58%) or even no overt arguments (32%), and overt arguments were usually not case-marked. Similarly high rates of argument-dropping have been reported for child-directed speech in another analysis of Japanese (Matsuo et al., 2012), and analyses of Korean (Clancy, 2009) and Hindi (Narasimhan et al., 2005).

Given the scarcity of overt noun arguments (even in speech to children), argument-dropping languages pose a serious challenge to syntactic bootstrapping, perhaps especially to the structure-mapping account. The structure-mapping account holds that the set of nouns in the sentence is inherently meaningful for young children learning any language, and therefore provides a crucial bootstrap for learning verbs, and for learning the significance of language-specific syntactic cues such as case markers or word order (e.g., Fisher, 1996; Yuan et al., 2012). However, *overt* evidence about the number of NP arguments in each sentence appears not to be equally available to learners of different languages. If children often encounter verbs accompanied by none or only a subset of their arguments, how can they use syntactic structures to make good inferences about the verbs' meanings (e.g., Allen, 2008; Bowerman & Brown, 2008; Clancy, 1996; Göksun et al., 2008; Matsuo et al., 2012; Lee & Naigles, 2005, 2008; Narasimhan et al., 2005; Rispoli, 1995)?

Here we asked how children learning argument-dropping languages overcome this ambiguity in the linguistic input and learn the meaning of verbs, by testing Korean-learning

children. Korean makes a good test case because, as noted above, it permits pervasive argument-dropping. In Korean, which has a subject-object-verb (SOV) word order, subject and object noun-phrases are often omitted, as shown above in (1), and as attested in corpus studies of Korean child-directed speech (Clancy, 2009). Korean has postpositional case markers that, once learned, can preserve overt information about grammatical relations in sentences with some of their arguments missing. For example, in (2) the subject NP is marked with the nominative marker -*ka*[5], and the object with the accusative marker -*ul*. However, as noted above, these case markers are also omitted more often than not in casual speech (Lee, 2006; No, 2009), including speech to children.

(2) a. Susie-ka kong-ul cha-ss-ta. (SOV)
Susie-NOM ball-ACC kick-PAST-DECL
'Susie kicked the ball.'

b. Susie-ka cha-ss-ta. (SV)
'Susie kicked ∅.'

c. Kong-ul cha-ss-ta. (OV)
'∅ kicked the ball.'

We propose that there are at least two mechanisms that may allow children to infer the number of nouns for each verb even in argument-dropping languages such as Korean: probabilistic distributional learning and reliance on discourse structure. Although as we shall see these two proposed routes rely on different kinds of information, both assume that children obtain information about a verb's arguments not only from an individual sentence, but from multiple sentences.

[5] There are two forms of both the nominative ([ka], [i]) and accusative markers ([ul], [lul]) in Korean. The choice of each form depends on the phonetic features of the last syllable of the preceding noun.

First, probabilistic distributional learning offers one promising route whereby Korean children could discover the true number of NP arguments for each verb. Although individual sentences can be ambiguous due to pervasive noun omission, multiple utterances together yield probabilistic data about a verb's transitivity (e.g., Fisher & Gleitman, 2002; Lee & Naigles, 2005). At least two different kinds of probabilistic information can be gathered across many sentences--(a) the number of nouns per sentence each verb occurs with, and (b) language-specific cues such as case-markers that each verb may occur with, with some probability.

Even in an argument-dropping language, suppose we estimate that 10% or more of transitive sentences still appear with 2 overt NP arguments (e.g., Clancy, 2009; Matsuo et al., 2012; Rispoli, 1995). If so, then transitive and intransitive verbs will still tend to have probabilistically different distributional profiles with respect to noun number information. For example, transitive verbs will be more likely than intransitive verbs to appear with two overt noun phrases (e.g., Kim, 2008; Matsuo et al., 2012). In principle, children might estimate the NP number for each verb by keeping track of the probabilistic pattern of occurrences of noun-phrases with that verb across many utterances (Fisher & Gleitman, 2002). Prior research with children learning argument-dropping languages has shown that they can use noun-phrase number information in verb interpretation, just like their English-speaking counterparts (e.g., Göksun et al., 2008; Lee, Kim, & Song, 2013; Lee & Naigles, 2008; Lidz et al., 2003; Yuan et al., 2007). Thus if a child learning an argument-dropping language discovers the true NP number of a verb despite noisy input, then she should be able to use that estimate to assign appropriate interpretations to the verb. This procedure might work well for relatively frequent verbs, those that children might hear many times a day, therefore getting many chances to estimate its NP number reliably. Less frequent verbs might pose a problem for this procedure, alone however: If

only sparse data are available for a particular verb, it may take children a very long time to obtain a robust estimate of its number of NP arguments (Narasimhan et al., 2005).

Language-specific cues also can provide probabilistic information about a verb's transitivity, once their significance is learned. For example, in the case of Mandarin Chinese, which has an SVO order, transitive verbs are more likely to be followed by a post-verbal noun-phrase than are intransitive verbs (40% vs. 17%; Lee & Naigles, 2005). This is a language-specific word-order cue that would not be found in verb-final languages such as Korean or Japanese. In these languages, however, different cues might be available: optional accusative case markers can provide probabilistic information about verb transitivity. For example, an analysis of Japanese child-directed speech revealed that accusative case markers appeared in 9.9% of utterances with transitive verbs (Matsuo et al., 2012). Once children acquire knowledge about these case-markers, they can rely on this information to interpret verb meanings even when the number of noun information is not available (e.g., Göksun et al., 2008; Matsuo et al., 2012; Lee, Kim, & Song, 2013). Such language-specific indicators of transitivity could lessen the need to observe each verb with its full set of NP arguments; instead, once the significance of word-order or case-marking is learned from even a small set of verbs that do happen to appear with multiple NP arguments, the markers can be used, in turn, to help interpret verbs that have not yet appeared with their full set of NP arguments.

The distributional learning route proposed here, by which children might detect a verb's true NP numbers from noisy input (boosted by language-specific cues such as accusative case markers), would not be a trivial achievement for learners. Children would need to detect cues that have very low probabilities in the input, and treat them as important evidence rather than anomalies. As noted above, in an analysis of Korean child-directed speech (Clancy, 2009), only

13.4 to 23% of transitive clauses express overt two arguments. Accusative case markers appear in only 9.9% of transitive sentences in Japanese child-directed speech (Matsuo et al., 2011), and 19% of Korean adult-directed speech (Kim, 2008). Although distributional learning is presumed to be a powerful learning mechanism at multiple levels of language acquisition (e.g., Gerken et al., 2005; Lany & Saffran, 2010; Maye et al., 2002; Mintz et al., 2002), much of the experimental work on distributional learning has tested children in brief experiments with near all-or-none probabilities. Thus, it remains an open question whether the learning that we can document in short-term experiments, based on very strong distributional evidence, can scale up to longer-term learning from low probability events.

Recent experiments in another domain, however, suggest that infants and toddlers can interpret a small sample of events as meaningful when appropriate, based on comparisons to a base-rate estimate for a population (e.g., Gweon, et al., 2010; Kushnir, Xu, & Wellman, 2010; Ma & Xu, 2011; Voloumanos & Werker, 2009; Xu & Denison 2009). For example, in Kushinir et al., one group of 20-month-olds first saw inside a box containing a biased population of toys, 82% toy frogs and 18% toy ducks; another group saw a box containing 18% frogs and 82% ducks. The experimenter looked inside the box and picked out five frogs in a row. In a later test, toddlers systematically gave the experimenter a new frog rather than a new duck if the original box had contained 18% frogs, but not if it had contained 82% frogs; this result suggests that the toddlers interpreted the experimenter's sample with respect to the base-rate availability of frogs. A systematic choice of frogs where frogs were rare was interpreted as indicating a preference; the same sample where frogs were common was taken as uninformative. Perhaps children make similar inferences in the case of learning verb syntax. If children estimate the overall base-rate of argument provision vs. omission in their input language (e.g., see Valian, 1991), they may draw

strong inferences about a verb's transitivity when they encounter even a few cases of a verb occurring with two overt nouns.

Even so, one could argue that the distributional learner will face serious data sparseness problems in estimating the transitivity of each individual verb. In a reasonable sample of a child's input, some verbs may never occur with their true number of arguments at all. Narasimhan et al. (2005) made just this argument for Hindi. In an analysis of argument omission patterns in Hindi speech to children, 7% of the tokens of the 29 most frequent transitive verbs occurred with two noun arguments. However, this probabilistic information was not evenly distributed across verbs: Only 17 of the 29 verbs appeared with two noun arguments in this sample, ranging from 2 to 33% of the time; the other 12 transitive verbs never occurred with two overt noun arguments. The sample could be enlarged, of course, but it seems clear that where arguments are often missing, children may not get a chance to observe some transitive verbs' true argument number.

Combing multiple distributional facts about the same verb might help. As mentioned above, the number of nouns, but also language-specific cues (which must be learned) could jointly provide probabilistic information about verb transitivity. These two kinds of cues might complement each other, increasing the likelihood of identifying the transitivity of each verb. To illustrate, suppose a Korean-speaking child identifies some verbs as transitive by encountering those verbs with two overt arguments. The child might also note that these transitive verbs tend to occur with accusative case markers. Once the child detects the arbitrary relationship between verb transitivity (or the corresponding verb meanings) and accusative case markers, she can rely on accusative case markers to identify a new verb's syntax and meaning, even when that verb is missing some of its arguments.

In sum, even in argument-dropping languages, transitive verbs have different distributional profiles. Transitive verbs will be more likely to appear with two overt NPs than intransitive verbs, and will tend to occur with accusative case markers. Although the probabilities of these cues are still low, if Korean children can make a meaningful inference from low probability evidence, they may arrive at a verb's true argument number.

A second information source, sensitivity to discourse context, may allow Korean children to discover the true number of arguments for each verb (e.g., Allen, 2008; Bowerman & Brown, 2008; Clancy, 1996; Narasimhan et al., 2005). Arguments are not omitted arbitrarily. Instead, each utterance's place in a larger discourse determines whether and how arguments are overtly expressed. In argument-dropping languages, arguments are omitted only when their referents are clearly established in the discourse context (e.g., Clancy, 2009). Thus, even though any individual sentence may not include all the arguments of its main verb, the missing arguments will typically have been mentioned in prior sentences, or made prominent in the discourse context in other ways (e.g., Bowerman & Brown, 2008). For example, Clancy (1996) found that in a Korean adult-child interaction involving a magnetic picture-board game, all of the arguments of a verb meaning 'stick_on' (*pwuthita*) were overtly displayed across multiple utterances within a coherent discourse, as in "Shall auntie stick (it)?", "Stick this", and "Stick (it) there". As one might predict for Korean, all three arguments never occurred in a single sentence within this interaction; however, across multiple sentences the child received evidence that this verb could occur with a subject (*Auntie*), a direct object (*this*), and a location (*there*).

Discourse prominence can be established by numerous linguistic and nonlinguistic means (e.g., Allen, 2008; Akhtar, Carpenter, & Tomasello, 1996; Baldwin, 1991, 1993; Hughes & Allen, 2015; Frank, Tenenbaum, & Fernald, 2013), but here our focus will be on the creation of a

linguistic discourse topic, a referent that is repeatedly and prominently mentioned across adjacent sentences. We propose that an expectation for discourse continuity could help children identify argument structure across nearby sentences, as shown in the 'stick_on' (*pwuthita*) example above. For example, suppose Korean children hear a conversation about "Mom", leading up to the question, "What's Mom doing?" (*Mom what doing*, in Korean word order). If they assume that a felicitous answer to this question is likely to include the topic "Mom," then they might correctly infer that an argument is in an answer such as "*Ø* pilking the cat!" (*Ø cat pilking*, in Korean word order).

Can Korean children use discourse information in verb learning to help overcome the ambiguity posed by pervasive argument omission? In order to do so, they must be sensitive to the prominence of referents in the discourse. Analyses of children's speech suggest that children do show early sensitivity to many aspects of the discourse context. In production, young children have a surprisingly reasonable view of what needs to be expressed versus omitted in accordance with each referent's place in the larger discourse (e.g., Allen, 2000; Clancy, 1997; Guerriero, Oshima-Takane, & Kuriyama, 2006; Huang, 2011; Narasimhan et al., 2005; Skarabela, 2007). For example, 20- to 22-month-old Korean-speaking toddlers are more likely to omit a noun phrase when its referent is given rather than new to the discourse (Clancy, 1997). Narasimhan and her colleagues (2005) reported similar findings with Hindi-speaking toddlers. Taken together, these data provide powerful evidence for children's sensitivity to discourse pressures that affect referential choice.

Comprehension data also show young children's sensitivity to discourse continuity. One-year-old infants link ambiguous verbal referents with previously mentioned referents (e.g., "I really want to find *my puppy*!"; "Can you get *it* for me?"; in Ganea & Salor, 2007; also see Lidz

et al., 2003). Similarly, 2- to 3-year-old children link ambiguous pronouns with referents made prominent in prior sentences (Song & Fisher, 2005, 2007). For example, in Song and Fisher (2005), one character in each story was established as more prominent than another because it was mentioned first and appeared as sentence subject (e.g., "See the alligator and tiger. On a sunny day, the alligator wanted to play outside. So he went to the tiger's yard"). Children as young as 2.5 years old interpreted an ambiguous pronoun in the subsequent test sentence (e.g., "And what did *he* find? Look *he* found a bucket!") as referring to the character established as more prominent in the story. Overall, prior research suggests substantial evidence of children's understanding of discourse continuity (e.g., Hartshorne, Nappa, & Snedeker, 2014; Horowitz & Frank, 2015; Pyykkönen, Matthews, & Järvikivi, 2010).

Can Korean children consult the prior discourse even when there is no overt pronoun? In order to recover missing arguments from the prior discourse in question-answer pairs such as our example above (*What's Mom doing? Pilking the cat!*), children must consider discourse information without encountering overt pronouns. Pronouns provide an overt word to cue the search for an antecedent in the discourse context, whereas missing arguments do not provide such an anchor point. Recent work by Song, Choi and Kim (2008) has shown that Korean children as young as 4 can link the omitted subject of a familiar verb with the subject established in previous context sentences. As in the previous English study (Song & Fisher, 2005, 2007), children heard stories that introduce one character (the bear) as more prominent than the other (the pig) in discourse (e.g., an English gloss: "There were a bear and a pig. One day, the bear wanted to play outside. The bear went to the playground with the pig."). Children correctly chose the target character (the bear) when they received a null-subject test sentence (e.g., "Now, what does Ø have?"). These results suggest that Korean-learning preschoolers can exploit an

expectation of discourse continuity to link the omitted argument of a familiar verb with a previously established discourse topic. Given this evidence of young children's sensitivity to discourse structure, we speculated that children might have a strong enough expectation of discourse continuity to anticipate the missing argument of an unknown verb.

In sum, here we propose two routes that Korean children could depend on in learning verbs despite frequent argument omission—distributional learning and an expectation of discourse continuity. Despite noisy data, probabilistic differences in NP-number between transitive and intransitive verbs, boosted by learned, language-specific correlates of transitivity, may permit children to distinguish transitive and intransitive verbs based on their distributional properties. Discourse structure may also increase linguistic support for verb learning by letting learners collect evidence for argument structure across nearby sentences, prompted by an expectation of discourse continuity.

The present study asked whether Korean 2-year-old children can learn new verbs from realistically noisy data, when provided with discourse support. The design was a version of the dialogue-and-test method introduced in earlier work (Messenger, Yuan, & Fisher, in press; Scott & Fisher, 2009; Yuan & Fisher, 2009). Yuan and Fisher (2009), for example, showed that English-learning 29-month-old children learned whether an unknown verb was transitive or intransitive by listening to sentences in a dialogue, with no accompanying referential scenes. However, the dialogues presented by Yuan and Fisher provided all-or-none data about verb transitivity. Transitive verbs occurred 100% of the time in 2-noun transitive sentences (e.g., "Anna blicked the baby!") and intransitive verbs occurred 100% of the time in 1-noun intransitive sentences (e.g., "Anna blicked!"). Children later heard the verb in isolation (e.g., "Find blicking!"); those who had heard the verb in transitive sentences in the dialogues looked

longer at a two-participant (as opposed to a solo action) event than did those who had heard it in intransitive sentences, suggesting that children can gather and use a verb's syntactic history, rather than only its current syntactic context, to interpret a new verb. In the present study, we examined if children can gather this kind of data on transitivity even when the nouns are often missing.

In Experiment 4, we designed our Korean dialogues to contain realistically noisy distributional evidence about transitivity, based on a corpus analysis of Korean child-directed speech (Clancy, 2009). Children watched videos showing two women conversing about unseen events, using the novel verb *thomita* either in transitive sentences or intransitive sentences, as sketched in the top part of Figure 6. Crucially, only a few of the novel-verb sentences in the transitive dialogues contained two overt noun phrases; the rest contained only one noun or a bare verb. Accusative case-markers were also left out more often than not. In contrast, noun phrases were omitted only rarely in the corresponding intransitive dialogues. As a result, the transitive and intransitive dialogues had similar average numbers of overt NPs per sentence: about one NP argument per sentence, on average.

To establish strong expectations about discourse continuity, in both dialogues the unknown verb was introduced in the answer to a question (as in "What's Mom doing?" Intransitive: "Mom is pilking!", Transitive: "Pilking the cat!"; see Figure 6). In the transitive dialogue, the answer mentioned a new referent, and typically did not overtly mention the topic referent from the question. In the intransitive dialogue, the answer always overtly mentioned the topic referent, and introduced no additional new referents. In this way, because an apparent answer to a direct question did not mention the topic asked about, we reasoned that the transitive dialogue might bias children to search for the antecedent of a missing argument in the discourse,

whereas the intransitive dialogue did not cue such a search. The unknown verb was repeated in subsequent sentences, allowing the two talkers to ratify the answer to the question.

Later, in novel-verb test trials, all children viewed two simultaneously-presented test events, shown in the bottom panel of Figure 6. The two-participant causal event showed one girl swinging another girl's leg. The one-participant event showed two people enacting the same one-participant action, arm-circling. During these event- phases, the verb was presented in a syntactically uninformative context ("Find thomming!").

If Korean children can (1) recover transitivity from probabilistic rather than absolute distributional information and (2) make use of discourse continuity to recover missing arguments, then they should be able to discern the true number of arguments of the novel verb. If so, then as in the previous experiments, children who heard the verb in transitive dialogues should look longer at a two-participant event than should those who had heard it in intransitive dialogues.

We also included control conditions in which children heard the same dialogues, but heard a different verb when the test events were presented ("Find mwupping!"). Since the children in these control conditions had not encountered the novel verb *mwuppita* in the previously-heard dialogues, they should treat the dialogues as irrelevant to the test trials. Therefore we should see no effect of dialogue exposure in the different-verb control condition.

Experiment 5 was designed to probe the role of discourse structure in our task. Positive results in Experiment 4 could result from the overt evidence for transitivity provided in the dialogues. The transitive dialogues did contain a few uses of the new verb in 2-NP sentences, or with accusative case markers; in principle, even a few such sentences might suffice to establish the verb as transitive. To isolate the contribution of discourse structure, we eliminated the direct

distributional evidence for transitivity provided in Experiment 4, leaving only discourse information to guide verb interpretation. In Experiment 5, the transitive dialogues included no sentences with two overt nouns, and no accusative case markers. Even without these distributional cues to transitivity, however, the question-answer exchange shown in Figure 7(A) still might suggest that an argument is missing. If this discourse information is sufficient for Korean children to attribute a missing argument to a novel verb, then children who heard the verb in transitive dialogues should still look longer at a two-participant event than should those who had heard it in intransitive dialogues in the experimental conditions, but not in the control conditions.

Experiment 4

Method

Participants

Sixty-four 2-year-olds (M = 30.8 months; range 25.6-35.9; 31 girls) participated; all were recruited from Seoul, Korea, and surrounding areas, and were acquiring Korean as their native language. Another 10 children were tested but excluded, 3 because they did not complete the experiment, 1 because he was overly fussy, 1 because she looked away more than half of the time in two of the three test trials, 1 because of sibling interference, and 4 because of experimenter error. Children's productive vocabulary was measured using the short form of the Korean CDI (Macarthur-Bates CDI-K, Pae et al., 2006). One parent did not complete the vocabulary checklist. Vocabulary scores ranged from 4-128 with a median of 103[6]. Sixteen children were randomly assigned to each of the four combinations of the dialogue (transitive, intransitive) and test-verb (same-verb, different-verb) groups.

[6] The average vocabulary score of 30- to 32-month-olds is 84.56 (*SD* = 31.5) (Pae et al., 2008).

Apparatus

Children sat on a parent's lap in a dimly-lit room, 3.6 feet away from a 42-inch wide-screen television. In the test phase, two test events were presented on the large screen. Each image was 8.9" tall and 13.2" wide, aligned with the left and right edges of the screen and separated by 7.1 inches of black space. In the dialogue phase, a single video, 18.3" tall and 27.6" wide, was displayed in the center of the screen. Soundtracks were played from two speakers located at the left and right bottom of the TV. A camera hidden beneath the center of the television recorded children's eye-movements. Parents were instructed to remain silent and neutral and to close their eyes during the experiment.

Materials and Procedure

Stimulus materials were color videos of two women conversing and of people performing actions. Test events were shown in synchronized pairs and accompanied by a soundtrack recorded by a female native Korean speaker.

The procedure consisted of three phases: dialogue, practice, and test (see Figure 6). In the dialogue phase, the novel verb *thomita* was introduced. Children first encountered the verb in four dialogue video-clips (each 19.4-22.9 s), separated by 3-s intervals. Each dialogue clip presented 3 sentences containing the novel verb. Children in the transitive condition thus heard a total of 12 transitive sentences, whereas those in the intransitive condition heard 12 intransitive sentences; half of the children in the different-verb condition heard each dialogue.

(A) Dialogue phase

Transitive Dialogue
A: 민수는 뭐하고 있어?
minswu-nun mwe-ha-ko-iss-e
Minsu-TOP what-do-PROG-Q
'What is Minsu doing?'

B: 고양이를 토미고 있어.
koyangi-lul thomi-koiss-e
cat-ACC thomi-PROG-DECL
'(Minsu) is thomming the cat.'

A: 정말? 토미고 있다고?
cengmal? thomi-koiss-tako?
really thomi-PROG-Q
'Really? Is (Minsu) thomming (the cat)?'

B: 응 민수 고양이 토미고 있어.
ung minswu koyangi thomi-koiss-e
yes Minsu cat thomi-PROG-DECL
'Yes, Minsu is thomming the cat.'
..... (12 novel-verb sentences total)

Intransitive Dialogue
A: 민수는 뭐하고 있어?
minswu-nun mwe-ha-ko-iss-e?
Minsu-TOP what-do-PROG-Q
'What is Minsu doing?'

B: 민수 토미고 있어.
minswu thomi-koiss-e
Minsu thomi-PROG-DECL
'Minsu is thomming.'

A: 정말? 토미고 있다고?
cengmal? thomi-koiss-tako?
really thomi-PROG-Q
'Really? Is (Minsu) thomming?'

B: 응 민수 토미고 있어.
ung minswu thomi-koiss-e
yes Minsu thomi-PROG-DECL
'Yes, Minsu is thomming.'
..... (12 novel-verb sentences total)

(B) Test phase

Familiar-verb practice trials

Practice 1:
누가 신발을 가지고 있어? 이모가 신발을 가지고 있어.
nwuka sinpal-ul kaci-koiss-e? imo-ka sinpal-ul kaci-koiss-e.
who shoe-ACC have-PROG-Q, aunt-NOM shoe-ACC have-PROG-DECL
'Who has a shoe? Aunt has a shoe.'

Practice 2:
누가 모자를 가지고 있어? 이모가 모자를 가지고 있어
nwuka moca-lul kaci-koiss-e? imo-ka moca-lul kaci-koiss-e.
who hat-ACC have-PROG-Q
'Who has a hat? Aunt has a hat.'

Novel-verb test trials

2-participant event

1-participant event

Same-verb condition:
토미고 있다! 토미는 거 찾아봐!
Thomi-koiss-ta! Thomi-koiss-nun ke chaca-pw-a!
thomi-PROG-DECL thomi-Conn thing find-try-SentEnder
'Is thomming! Find thomming!'

Different-verb condition:
무삐고 있다! 무삐는 거 찾아봐!
mwuppi-koiss-ta! mwuppi-koiss-nun ke chaca-pw-a!
mwuppi-PROG-DECL mwuppi-Conn thing find-try-SentEnder
'Is mwupping! Find mwupping!'

Figure 6. Sample dialogue phase and test item of Experiment 4.

Arguments were frequently omitted in the transitive but not in the intransitive dialogue; thus the transitive and intransitive included similar average numbers of overt nouns per sentence (transitive: 1 noun per sentence, intransitive: 0.91). The distribution of nouns in the transitive

dialogue roughly matched the distribution found in a previous corpus study (Clancy, 2009). The Transitive dialogue comprised 3 (25%) 2-noun sentences, 5 (41.6%) 1-noun sentences, 3 (25%) bare-verb sentences and 1 (8.3%) bare-noun sentence (this bare-noun sentence was part of the evidence for transitivity, as it hosted an accusative case marker). Four of the transitive sentences (33%; 3 1-noun sentences, 1 bare-noun sentence) included an accusative case-marker. The Intransitive dialogue comprised 11 (91.6%) 1-noun sentences, and 1 (8.3%) bare-verb sentence.

In the transitive dialogue, nouns were omitted only when the referent had already been mentioned in the previous utterance. For example, speaker A asked "minswu-nun mwe-ha-koiss-e? (Minswu-TOP what-do-PROG-Q, 'What is Minsu doing?')" and speaker B responded "Ø koyangi-lul thomi-koiss-e (Ø cat-ACC thomi-PROG-DECL**,** 'thomming the cat')". All nouns in the dialogues had animate referents.

After a 7s interval, a single practice item followed, involving the familiar verb *kacita* (have). Two 6s video events were presented: One showed a woman holding a shoe, and the other a woman holding a hat. The actors tilted the objects gently. Each event was previewed alone on one screen, in counterbalanced order, separated by a 3s blank-screen interval, accompanied by audio labeling the object (e.g., "imo-ka sinpal-ul kaci-koiss-e! (aunt[7]-NOM shoe-ACC have-PROG-DECL, 'Aunt has a shoe!')"). Next, during a 4s blank-screen interval, children were prompted to look at the shoe event ("nwuka sinpal-ul kaci-koiss-e? (who shoe-ACC have-PROG-Q, 'Who has a shoe?')"). Both events then played simultaneously, while children heard "nwuka sinpal-ul kaci-koiss-e? imo-ka sinpal-ul kaci-koiss-e. (who shoe-ACC have-PROG-Q, aunt-NOM shoe-ACC have-PROG-DECL; 'Who has a shoe? Aunt has a shoe.')." During another 4s blank-screen interval, children were prompted to look at the hat event ("nwuka moca-

[7] In child-directed speech in Korean, 'aunt' usually refers to any adult female, not necessarily a relative. We used this term here because third-person pronouns are very rare in spoken Korean.

lul kaci-koiss-e? (who hat-ACC have-PROG-Q, 'Who has a hat?')"). The events were then presented again, while children heard "nwuka moca-lul kaci-ko iss-e? imo-ka moca-lul kaci-ko iss-e (who hat-ACC have-PROG-Q, aunt-NOM hat-ACC have-PROG-DECL, 'Who has a hat? Aunt has a hat.')".

Next, children received a test phase in which a novel verb was presented in a syntactically uninformative context. During a 7s blank-screen interval following the practice phase children in the same-verb groups heard, "wuwa pw-a pw-a! Thomi-koiss-ta. Thomi-nun-ke chaca-pw-a!" (wow see-SentEnder see-SentEnder, thomi-PROG-DECL, thomi-CONN-thing find-try-SentEnder, 'Wow, look! Is thomming! Find thomming!'). The children then saw a pair of 8s videos: one showed a two-participant caused action (one girl swinging another girl's leg), and the other showed two people enacting the same one-participant action (two girls making arm-circles). These events were accompanied by the novel verb in isolation (e.g. "Thomi-nun-ke chaca-pw-a!" (thomi-CONN-thing find-try-SentEnder, 'Find thomming!'). The pair of videos was presented three times, separated by a 6s interval. These three 8s trials tested children's interpretations of the novel verb. The different-verb groups received the same dialogues and the same test trials as the same-verb groups, except that the novel-verb test events contained the verb *mwuppita* instead of *thomita* (e.g., "Find mwupping!").

Coding

We coded where children looked (left, right, away) during the test trials, frame-by-frame from silent video. Data for an individual test trial were treated as missing if the child looked away for more than half of that trial (6 trials total). Reliability was assessed for 16 children by a second coder. The first and second coders agreed on the children's direction of gaze for 98.1% of coded video frames.

The amount of time children spent looking away from the two video screens, averaged across the three test trials, was analyzed by means of a 2 X 2 ANOVA with dialogue (transitive or intransitive) and test verb conditions (same-verb or different-verb) as between-subjects factors. No effect was significant, all *F*s < 2, suggesting that the children in the two experimental and two control groups tended to look away about equally during the test trials (same-verb: transitive *M* = 0.70 s, *SD* = .51, intransitive *M* = 0.55 s, *SD* = .51; different-verb: transitive *M* = 0.59 s, *SD* = .34, intransitive *M* = .54, *SD* = .34). Given the uniformity of time spent looking away, we conducted our analyses on a single measure: the proportion of time spent looking at the two-participant event, out of total time spent looking at either the two- or the one-participant test event, averaged across the three test trials.

Preliminary analyses of children's looking time performance in the test trials revealed no significant interactions of dialogue and test-verb with sex or with whether the child's vocabulary or performance in the practice trials[8] was above or below the median (*F*s < 3.2, *p*s > .08)[9]. The data were therefore collapsed across these factors.

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[8] The median of children's target preference in the practice trials was .57.

[9] There was a marginal 3-way interaction of dialogue and test-verb with whether children's vocabulary was above or below the median (median vocabulary score: high-vocabulary group = 116.5, low-vocabulary group = 83), $F(1, 55) = 3.162$, $p = .081$. This marginal interaction appears to reflect an unexpected difference between the high- and low-vocabulary groups in the different-verb control condition, not in the same-verb condition. In the same-verb condition, both high- and low-vocabulary children showed the predicted looking time pattern: those who heard transitive dialogues looked longer at the two-participant event than did those who heard intransitive dialogues [High-vocabulary group: Transitive (*n* = 6): *M* = .49, *SD* = .13; Intransitive (*n* = 8): *M* = .43, *SD* = .11; Low-vocabulary group: Transitive (*n* = 10): *M* = .57, *SD* = .12; Intransitive (*n* = 7), *M* = .45, *SD* = .12]. In the different-verb control condition, children in the high-vocabulary group showed a looking-time pattern similar to that found in the same-verb condition (Transitive (*n* = 7): *M* = .51, *SD* = .20; Intransitive (*n* = 9): *M* = .45, *SD* = .13), but children in the low-vocabulary group showed the reverse pattern (Transitive (*n* = 9): *M* = .41, *SD* = .13; Intransitive (*n* = 7): *M* = .54, *SD* = .14). Such an interaction, if replicated across studies, might suggest that the high-vocabulary children expected the dialogue and test portions of the same task to be related to each other, and so they showed a systematic dialogue effect even though in the different-verb condition where the verb from the dialogues was not presented at test. However, this unexpected pattern in the different-verb control condition was not found in Experiment 5, which had very similar materials and procedures, and a similar vocabulary range.

Results and Discussion

Table 1 shows the mean proportion of looking time to the two-participant event, out of the total time spent looking at either test event, averaged across the three test trials, separately by dialogue and test-verb condition. As predicted, dialogue type affected looking preferences in the test trials, but did so only for children in the same-verb condition. A 2 (dialogue: transitive, intransitive) by 2 (test-verb: same-verb, different-verb) ANOVA revealed an interaction of dialogue and test-verb condition, F (1, 60) = 4.073, p = .048. In the same-verb condition, children who heard transitive dialogues looked reliably longer at the two-participant event, as opposed to the one-participant event, than did children who heard intransitive dialogues, t(30) = 2.554, p = .016. This dialogue effect disappeared in the different-verb condition. Children in the different-verb condition looked about equally at the two-participant event regardless of whether they had heard transitive or intransitive dialogues, $t < 1$. The absence of an effect of dialogue in the different-verb condition suggests that children used the presentation of the verb in the test trial as a cue to retrieve what they knew about this verb. When the verb in the test trials was entirely new, the information from the dialogue was treated as irrelevant.

Table 1. Mean (SD) proportion of looking time to the two-participant event, averaged across the three 8 s test trials, separately by dialogue and test-verb condition, Experiment 4.

Test verb	Dialogue	Average
Same-verb	Transitive	.54 (.12)
	Intransitive	.43 (.12)
Different-verb	Transitive	.46 (.17)
	Intransitive	.49 (.14)

The findings of Experiment 4 suggest that Korean children benefitted from very noisy data about verb transitivity, at least when the local discourse also provided some evidence for argument omission. Children who heard the transitive dialogues treated the novel verb as a transitive verb, even though only a few sentences containing the verb expressed two overt nouns, and only a few contained an accusative case maker. The discourse structure of each dialogue might have provided an aid to the children in dealing with this sparse data about verb transitivity, because arguments were omitted only when their referents were clearly established as topics in preceding sentences. These findings therefore show that Korean children successfully learned verb transitivity despite noisy evidence, when both distributional and discourse structure evidence are present in the input.

Experiment 5

In Experiment 4, Korean 2-year-olds learned a new verb's transitivity despite frequent argument omission, when a coherent discourse supported the recovery of the omitted nouns. Experiment 5 sought to replicate this key result and addressed one important remaining question: How substantial a role did discourse structure play in children's success in our task? In Experiment 5, we asked whether Korean 2-year-olds could exploit discourse information to distinguish novel transitive from intransitive verbs, without encountering any direct distributional evidence of verb transitivity. To isolate the contribution of discourse cues, we presented a new verb in dialogues in which it never appeared with either two overt NPs or an accusative case-marker, but still maintained the question-answer discourse structure that implies a missing argument (Figure 7).

As in Experiment 4, children first heard transitive or intransitive dialogues with a novel verb. Each dialogue included 16 novel-verb sentences, all with one overt NP. The dialogue phase was lengthened (from 12 critical sentences in each to 16 in Experiment 4) because we removed the overt distributional evidence about transitivity provided in Experiment 4, and therefore reasoned that more dialogue sentences might be needed to permit children to distinguish the transitive from the intransitive verbs. Our manipulation in Experiment 5 involved the discourse context: An English gloss is "What's Grandma doing?", answered by "Grandma is thomming" in the intransitive, versus "Thomming the puppy" in the transitive dialogues. Given Korean word-order (SOV), these answers had the same constituent order, but differed in whether they invoked the discourse-prominent referent, or a new referent. If toddlers expected the answer to the question to include Grandma, "Thomming the puppy", but not "Grandma is thomming", should be interpreted as transitive.

Method

Participants

Forty-eight 2-year-olds (*M* = 30.7 months; range 27.1-35.7; 24 girls) participated; all were recruited from Seoul, Korea, and surrounding areas, and were acquiring Korean as their native language. Another 7 children were tested but excluded, 1 because she did not complete the experiment, 3 because they looked away more than half of the time in two of the three test trials, 1 because of sibling interference, and 2 because of experimenter errors. Children's productive vocabulary was measured using the Korean CDI (Macarthur-Bates CDI-K, Pae et al., 2006). Two parents did not complete the vocabulary test. Vocabulary scores ranged from 31-128 with a median of 103. Twelve children were randomly assigned to each of the four combinations of the dialogue (transitive, intransitive) and test-verb (same-verb, different-verb) groups.

Apparatus

In Experiment 5, the dialogue and the test phases were shown in two separate sessions separated by a brief break, to avoid over-taxing children's attention despite the somewhat longer dialogue phase. In both sessions, children sat on a parent's lap in the same dimly-lit room. In the dialogue phase, children watched a pre-recorded dialogue video on a 15.6-inch laptop, placed in front of the 42" TV. Soundtracks were played from 2 external speakers connected to the laptop. A camera placed behind the child recorded the session. An experimenter sitting to the right of the child watched the dialogue phase along with the child. The practice and test phases were displayed on the 42-inch TV, as in Experiment 4. A camera hidden beneath the center of the television recorded children's eye-movements. Throughout the experiment, parents were instructed to remain silent and neutral and to close their eyes.

Materials and Procedure

The materials and procedure of Experiment 5 were similar to those of Experiment 4, with several changes. The main difference was in the dialogue phase. First, all novel-verb sentences in both the transitive and the intransitive dialogues contained exactly one overt NP (Figure 7). Second, the transitive dialogue did not include any accusative case markers. Thus, in contrast to the dialogues of Experiment 4, the transitive dialogue in Experiment 5 provides no within-sentence distributional evidence that the new verb was transitive.

In the dialogue phase, children heard either the transitive or intransitive dialogues with the novel verb *thomita*. Both dialogues included 16 novel-verb sentences distributed over 8 dialogue clips (each 19.4 – 24.9 s). Each dialogue clip included 2 sentences containing the novel verb, preceded by several sentences that established the discourse topic.

(A) Dialogue phase

Transitive Dialogue

A: 너 어제 할머니 봤어? 할머니 어디에 있었어?
Ne ecey halmeni pw-ass-e? halmeni eti-ey iss-ess-e?
You yesterday grandma see-Past-Q? Grandma where-Loc be-Past-Q
'Have you seen grandma yesterday? Where was grandma?'

B: 할머니 공원에 있었어.
Halmeni kongwen-ey iss-ess-e.
Grandma park-Loc be-Past-Decl
'Grandma was at the park'

A: 아 그래? 할머니 공원에서 뭐하고 있었어?
A kulay? Halmeni kongwen-eyse mwe-ha-ko issess-e?
Ah Yes Grandma park-Loc what-do-Past Prog-Q
'Oh yeah? What was grandma doing at the park?'

B: 강아지 토미고 있었어.
Kangaci thomi-ko issess-e.
Puppy thomi-Past Prog-Decl
'Was thomming the puppy.'

A: 진짜? 강아지 토미고 있었다고? 재밌었겠다.
Cincca? Kangaci thomi-ko issess-tako? Caymi-ssess-keyss-ta.
Really? Puppy thomi-Past Prog-Quote Fun-exist-Past-Fut-Decl
'Really? Thomming the puppy? Sounds fun!'

(…16 novel verb sentences total)

Intransitive Dialogue

A: 너 어제 할머니 봤어? 할머니 어디에 있었어?
Ne ecey halmeni pw-ass-e? halmeni eti-ey iss-ess-e?
You yesterday grandma see-Past-Q? Grandma where-Loc be-Past-Q
'Have you seen grandma yesterday? Where was grandma?'

B: 할머니 공원에 있었어.
Halmeni kongwen-ey iss-ess-e.
Grandma park-Loc be-Past-Decl
'Grandma was at the park'

A: 아 그래? 할머니 공원에서 뭐하고 있었어?
A kulay? Halmeni kongwen-eyse mwe-ha-ko issess-e?
Ah Yes Grandma park-Loc what-do-Past Prog-Q
'Oh yeah? What was grandma doing at the park?'

B: 할머니 토미고 있었어.
Halmeni thomi-ko issess-e.
Grandma thomi-Past Prog-Decl
'Grandma was thomming.'

A: 진짜? 할머니가 토미고 있었다고? 재밌었겠다.
Cincca? Halmeni-ka thomi-ko issess-tako? Caymi-ssess-keyss-ta.
Really? Grandma-Nom thomi-Past pros-Quote Fun-exist-Past-Fut-Decl
'Really? Grandma was thomming? Sounds fun!'

(…16 novel verb sentences total)

(B) Test phase

Familiar-verb practice trials

Practice 1:
그리고 있다! 그리고 있는 거 찾아봐!
Kuli-ko iss-ta! kuli-ko iss-nun ke chaca-pw-a!
draw-Prog-Decl draw-Prog-Conn thing find-try-SentEnder
'Is drawing! Find drawing!'

Practice 2:
마시고 있다! 마시고 있는 거 찾아봐!
Masi-ko iss-ta! Masi-ko iss-nun ke chaca-pw-a!
drink-Prog-Decl drink-Prog-Conn thing find-try-SentEnder
'Is drinking! Find drinking!'

Novel-verb test trials

2-participant event 1-participant event

Same-verb Experimental condition:
토미고 있다! 토미고 있는 거 찾아봐!
Thomi-koiss-ta! Thomi-koiss-nun ke chaca-pw-a!
thomi-PROG-DECL thomi-Prog-Conn thing find-try-SentEnder
'Is thomming! Find thomming!'

Different-verb Control condition:
무삐고 있다! 무삐고 있는 거 찾아봐!
mwuppi-koiss-ta! mwuppi-koiss-nun ke chaca-pw-a!
mwuppi-PROG-DECL mwuppi-Prog-Conn thing find-try-SentEnder
'Is mwupping! Find mwupping!'

Figure 7. Sample dialogue phase and test item of Experiment 5.

Each dialogue started with a conversation that set up a strong topic. For example, speaker A asked “ne ecey halmeni pw-ass-e? halmeni eti-ey iss-ess-e? (you yesterday grandmother see-PAST-Q? Grandma where-LOC be-PAST-Q?, ‘Have you seen grandma yesterday? Where was grandma?’) and speaker B responded “halmeni kongwen-ey iss-ess-e. (grandma park-LOC be-PAST-DECL, ‘Grandma was at the park.’). Then, speaker A asked “halmeni kongwen-eyse mwe-ha-ko issess-e? (grandma park-Loc what-do-PAST PROG-Q, ‘What was grandma doing at the park?’). In the transitive dialogue, speaker B responded “Ø kangaci thomi-ko issess-e.” (Ø puppy thomi-PAST PROG-DECL, ‘Ø was thomming the puppy.’). Finally, speaker A ratified and repeated speaker B’s answer, saying “cincca? Ø kangaci thomi-ko issess-tako? (really? puppy thomi-PAST PROG-QUOTE?, ‘Really? Ø was thomming the puppy?). All nouns in the dialogue had animate referents.

The intransitive dialogue was similar except that no additional referent (e.g., the puppy) was introduced to the discourse in the answer to the question. Instead, speaker B answered “halmeni thomi-ko issess-e.” (Grandma thomi-PAST PROG-DECL, ‘Grandma was thomming’). Speaker A’s ratification of this answer once again mentioned the topic, “cincca? halmeni-ka thomi-ko issess-tako? (really? grandma-NOM thomi-PAST PROG-QUOTE?, ‘Really? Grandma was thomming?’). This second novel-verb sentence in each intransitive dialogue clip (speaker A’s ratification of the answer) included a nominative case marker (-ka, -i). We added the nominative markers to avoid a possible referential ambiguity due to excessive repetition of overt nouns in adjacent sentences, comparable to the repeated-name penalty reported for English (e.g., Gordon, Grosz, & Gilliom, 1993). In natural conversation, a speaker of Korean would typically omit such strongly given information (e.g., Grandma) in the answer to the preceding question (e.g., ‘What is Grandma doing?’). Given referents were not omitted in our intransitive dialogues,

allowing us to match the number of overt nouns that combined with the novel verb across the transitive and the intransitive dialogues. By adding a nominative marker in the second intransitive sentence of each dialogue, we sought to minimize the possibility of any misinterpretation that might result from the slight unnaturalness of the repeated nouns. Note that the nominative case marker does not mark the novel verb as intransitive, as both transitive and intransitive verbs can occur with nominative-marked subject NPs. One corpus study suggests that intransitive verbs are somewhat more likely to occur with nominative markers (28%) than are transitive verbs (16%) (Kim, 2008), suggesting that the nominative marker provided at best a very subtle cue to intransitivity in our intransitive dialogues.

In the dialogue phase, children watched the video appropriate for their condition on the screen of a laptop computer. The child sat on parent's lap, and a female experimenter sat to the right of the child, about 20 inches away. The experimenter showed 7 of the 8 dialogue clips to the child on the laptop. After each clip, the experimenter paused the video, and after every second dialogue she repeated the last novel verb sentence of that clip. For example, the experimenter said "cal pw-ass-e? kangaci thomi-ko issess-tay." (well see-PAST-Q? puppy thomi-PAST PROG-QUOTE, 'Did you see it? Ø was thomming the puppy.'). The purpose of the experimenter's repetition was to make the task more interesting for children and also to facilitate children's later recognition of the new verb by presenting the new word in live speech. After repeating the last novel-verb sentence, the experimenter gave children a sticker and praised them for watching the video.

After the dialogue phase, the child and parent went out to the waiting room for approximately 1 to 2 minutes, while the test video was set up on the large TV. They then came back to the testing room and sat in front of the TV, just as in Experiment 4. Children first

watched one additional new dialogue clip as a reminder. Next, children received two practice items involving familiar verbs (*draw*, *drink*), followed by the single novel-verb test item (Figure 7). The first familiar verb was *draw*; the target event showed a woman drawing, and the distracter event showed another women eating. During a 7s blank-screen interval, children heard "Pw-a pw-a! kuli-ko iss-ta! kuli-ko iss-nun-ke chaca-pw-a" (see-SentEnder see-SentEnder draw-PROG-DECL draw-PROG-CONN-thing find-try-SentEnder,'Watch! Is drawing! Find drawing.') Next, the two 8s videos played simultaneously. Children heard the familiar verb three times as this event-pair played (e.g., "Find drawing!"). Children heard the verb again during a 6s blank-screen interval ("Did you find it? Where's drawing?"), then saw a second presentation of the 8s event-pair, again with three repetitions of the target verb. This procedure was repeated with the second familiar verb ("Find drinking!"); in this case the target event showed a woman drinking, and the distracter event showed another woman washing a dish. These items familiarized them with the wording of the isolated-verb prompts used in the test trials ("Find verb-ing!").

Finally, the novel-verb test item was presented, following the procedure described for the practice items. The materials and procedure of the test item were as in Experiment 4. Children in the same-verb condition heard the novel verb from the dialogues ("Find thomming!"), whereas children in the different-verb condition heard another novel verb ("Find mwupping!") in three 8s trials.

The left/right position of the test events was counterbalanced with dialogue and test condition.

Coding

Coding and analysis were carried out as in Experiment 4. Individual test trials were dropped if a child looked away for more than 50% of the 8s trial (9 trials total). Reliability was

assessed for 12 children. The first and second coders agreed on the children's direction of gaze for 96% of coded video frames. Looking-times to the two-participant event, the one-participant event, and away were averaged across the three test trials. The amount of time children spent looking away from the two video screens, averaged across the three test trials, was analyzed by means of a 2 X 2 ANOVA with dialogue (transitive or intransitive) and test-verb conditions (same-verb or different-verb) as between-subjects factors. This analysis revealed no reliable main effect of dialogue condition or interaction of dialogue and test conditions (Fs < 2, ps > .18), but a significant effect of test condition ($F(1, 44) = 6.826$, $p = .012$). Children in the different-verb condition looked away slightly but significantly longer ($M = 1.07$s, $SD = .67$) than did children who in same-verb condition ($M = .64$s, $SD = .47$). Although this difference was not found in Experiment 4, we speculated that children in the different-verb condition could have looked away more than children in the same-verb condition because the different-verb condition is less constraining given the referential contexts provided at test. Given this difference in look-away times between the two test-verb conditions, we conducted our main analyses on the raw looking-times to the two- and to the one-participant event rather than on a single measure of looking-time to one event as a proportion of looking-time to either event (see Yuan & Fisher, 2009, for a similar approach). Analyses based on a proportion of two-participant event out of total looking time at either event revealed the same pattern of significant effects as the analyses reported below.

Preliminary analyses of test-trial performance revealed no interactions of dialogue and test-verb with sex or with whether the child's vocabulary or performance in the practice trials[10] was above or below the median, all Fs < 1. These factors were not examined further.

[10] The median of children's target preference in the practice trials was .58.

Results and Discussion

As noted above, the unpredicted difference in look-away times between the same-verb and the different-verb conditions led us to analyze raw looking-times to the two- and one-participant events.

Table 2 shows mean looking times to the two-participant and to the one-participant event, averaged across the three 8-s test trials. As predicted, dialogue type affected looking preferences in the test trials, but did so only for children in the same-verb condition. Children who heard transitive dialogues looked longer at the two-participant event and less at the one-participant event than did those who heard intransitive dialogues, but this pattern appeared only within the same-verb condition.

Table 2: Mean (SD) looking-time (seconds) to the two-participant event, one-participant event, and away, averaged across the three 8-s trials of the novel-verb test item, Experiment 5.

Test Condition	Dialogue	Two-participant event	One-participant event	Away
Same-verb	Transitive	4.02 (.68)	3.50 (.54)	.48 (.37)
	Intransitive	2.84 (1.41)	4.36 (1.26)	.81 (.51)
Different-verb	Transitive	3.46 (1.21)	3.53 (1.09)	1.02 (.70)
	Intransitive	3.84 (.96)	3.03 (.92)	1.13 (.66)

A 2 (Dialogue: Transitive, Intransitive) by 2 (Test-verb: Same-verb, Different-verb) ANOVA was conducted separately for each dependent measure. Analyses of looking-times to the two-participant event revealed a significant interaction of dialogue and test-verb condition,

$F(1, 44) = 6.059$, $p = .018$. Similarly, analyses of looking-times to the one-participant event revealed a significant interaction of dialogue and test-verb condition, $F(1, 44) = 5.579$, $p = .023$. As Table 2 shows, in the same-verb condition only, children who heard transitive dialogues looked reliably longer at the two-participant event than did those who heard intransitive dialogues, $t(15.891) = 2.611$, $p = .019$[11]; the children who heard transitive dialogue looked reliably less at the one-participant event than did those who heard intransitive dialogues, $t(14.883) = 2.150$, $p = .048$. In the different-verb condition, dialogue did not affect children's looking times to either the two-participant or the one-participant event, ts < 1.3, ps > .23.

Experiment 5 replicated and extended the findings of Experiment 4. Korean learning 2-year-olds exploited the discourse context to learn verb transitivity despite frequent argument omission. Crucially, they learned that a new verb was transitive even when they never encountered that verb with two overt NPs in an individual sentence, or with an accusative case marker. In essence, when the preceding question made one referent very prominent, they assumed this referent must be part of the answer, and thus interpreted a 1-NP sentence response as transitive if it mentioned only a different referent rather than re-mentioning the topic of the question.

General Discussion

The syntactic bootstrapping hypothesis suggests that children use information about sentence structure to learn verb meanings (Gleitman, 1990). Evidence for syntactic bootstrapping

[11] The Levene's Test for Equality of Variances was significant both for the analyses of two-participant looking time, $p = .030$ and those of one-participant looking time, $p = .033$. Thus, equal variances could not be assumed for the transitive and intransitive groups. We speculate that the variance of the intransitive condition could be larger than that of the transitive condition, because the intransitive condition is less referentially constraining. We corrected this violation by using the unpooled estimate for the error term in the t-test, and adjusting the degree of freedom.

comes from many studies showing that the set of nouns in a sentence guides children's verb interpretation (e.g., Arunachalam & Waxman, 2010; Lidz et al., 2003; Gertner & Fisher, 2012; Yuan & Fisher, 2009; Yuan et al., 2012). This is possible because the number of noun phrases in a sentence is a probabilistic reflection of the number of syntactic arguments licensed by the verb, which in turn reflects the verb's number of semantic argument-roles. However, argument-dropping languages present a serious challenge to syntactic bootstrapping, because the number of nouns in individual sentences provides a strikingly weaker cue to the predicate-argument structure of its verb. The current studies investigated how syntactic bootstrapping could work in Korean, a language that allows pervasive argument omission.

In two experiments, Korean 2-year-olds learned about a verb's transitivity despite pervasive argument omission, when the discourse context also suggested that there was an omitted argument. In Experiment 4, children treated a new verb as transitive, and therefore as likely to refer to a two-participant event at test, even though that verb only appeared a few times with 2 overt NPs or accusative case markers, at least when there was strong discourse support for a missing argument. In Experiment 5, children could tell novel transitive from intransitive verbs even when all direct within-sentence evidence for verb transitivity was eliminated. That is, they learned that a new verb was transitive, even though it never appeared with two NP arguments or an accusative case marker, if the local discourse structure suggested that an argument was missing. These data suggest that the expectation for discourse continuity between a question and its answer was strong enough to guide Korean children's learning of verb syntactic and semantic structures, allowing them gather the full set of a new verb's arguments across multiple related sentences. These findings provide new evidence for the cross-linguistic power of syntactic bootstrapping: Argument omission may not pose such a challenge to syntactic bootstrapping

after all, if children can use discourse constraints to recover the omitted arguments of unknown verbs.

How could the preceding discourse be used to infer a missing argument? Here we outline a possible mechanism by which young children might use discourse cues to recover missing arguments. Consider a child learning Korean who hears a one-noun sentence such as "thomming the cat" ("cat thomming" in Korean SOV word order), like the ones in our dialogues. This sentence would be represented simply as a one-noun sentence in the child's sentence representation. Armed with the simple one-to-one mapping bias proposed by the structure-mapping bias (e.g., Fisher, 1996; Fisher, Gertner, Scott, & Yuan, 2010; Lidz et al., 2003), the child should map this one-noun sentence onto a conceptual representation of relevant events that focuses on one participant's role; that is, they could interpret the sentence as predicating something about the cat. However, we must consider the child's conceptual representation of the possible referent world, not as a snapshot of events, but as an evolving *situation model* that the child updates with information about the referents introduced into the discourse, and what has been said about them (Ganea et al., 2007; Grosz & Sidner, 1986; Johnson-Laird, 1983). Each sentence in a connected discourse alters the situation model, thereby affecting the interpretation of the next sentence. If our one-noun novel-verb sentence follows a question about a different referent, such as "What's Grandma doing?," as it did in our transitive dialogues, this question should highlight its referent's role in the evolving situation model. This, in turn, might bias the child to attend to aspects of the imagined situation that include Grandma (because of the preceding question) as well as the cat (because of the current sentence). In this case, the child might assign a two-participant interpretation to the target sentence "thomming the cat," on the assumption that the previous topic (Grandma) is still relevant. If this two-participant

interpretation of the one-noun sentence is compelling enough, the child might conclude that the one-noun sentence was syntactically transitive via the same one-to-one mapping bias that drives syntactic bootstrapping, based on an expectation of discourse continuity.

Where might this expectation of discourse continuity come from? Might children learn it from experience, or might they approach language learning with a general expectation that sentences within a connected discourse are likely to be connected? One possibility is that Korean children might learn to seek the syntactic arguments of verbs in the prior discourse because Korean input does not reliably display verbs' argument. If so, we could predict that children learning languages with fewer argument omissions, such as English, might not show the same kind of discourse-continuity bias in similar tasks, because English input contains much more reliable information about verbs' arguments.

On the other hand, there is considerable evidence that children learning every language must – and do – assume that adjacent sentences are likely to be related in meaning. All language use comes in connected discourse, and child-directed speech tends to be of heightened coherence, with considerable overlap in reference across utterances (e.g., Frank, Tenenbaum, & Fernald, 2013; Hoff, 2010). Even in child-directed speech, the disappearance of full NPs and their replacement by pronouns (e.g., Clark & Haviland, 1977; Fisher & Tokura, 1995; Rohde & Frank, 2014) is more characteristic of adjacent sentences within a topical discourse segment than is repetition of the same nouns. This suggests that any expectation of topic continuity would have to be gathered via a representation that included the inferred referents of the words, in a situation. Such a representation might allow children to note that topics are often continued – one reference to a kitty might be followed by others that could often be linked to the original at least in part through indications of continuity other than repeated use of 'kitty' (e.g., "There's a kitty." "Do

you see him?"), perhaps including comments on properties of the original referent (e.g., "There's his tail"). English-learning 2- to 3-year-olds can link ambiguous pronouns of a familiar-verb sentence with prominent referents in discourse (e.g., Song & Fisher, 2005, 2007; Pyykkönen, Matthews, & Järvikivi, 2010), and even 1-year-olds can do so when only one referent has been prominently mentioned (e.g., Ganea & Saylor, 2007; Lidz et al., 2003). This suggests that young comprehenders do expect adjacent sentences to be related to each other, and thus they interpret each sentence in light of previous comments. It remains an open question whether the same general expectation of discourse continuity that guides pronoun interpretation in English-learning toddlers could support the recovery of missing arguments in Korean. This is because pronouns provide an overt signal (an ambiguous word) to guide the search for a suitable referent in the prior discourse. Therefore, languages with less argument omission, such as English, provide a good comparison case to examine whether a general expectation of discourse continuity could help children recover the omitted arguments of verbs. The following Chapter 4 (Experiment 6, 7, and 8) asks whether English-learning children have the same kind of bias as Korean children do in similar tasks.

The present study focused on isolating discourse-structure cues to verb syntax, rather than on exploring the use of probabilistic distributional learning. Although we found that Korean children used discourse context in novel verb interpretation even when we eliminated potentially useful within-sentence distributional information such as (occasional) sentences with two overt NPs or accusative case markers, we would strongly predict that this kind of distributional information would help Korean children to estimate each verb's true number of arguments. Another possible kind of distributional information that might tend to pattern differently relative to transitive and intransitive verbs is noun animacy. In our dialogues, we used only animate

nouns in order to control noun animacy across conditions. However, the subject NPs all referred to humans (e.g., *Grandma, Mom, Minswu*), whereas some of the object NPs in the transitive dialogues referred to non-human inanimates or humans of reduced autonomy (e.g., *cat, dog, baby*). Thus, there could be a subtle cue that our transitive dialogues tended to include less animate nouns than the intransitive dialogues did. It is universal that referents of subject NPs are generally animate, whereas those of object NPs tend to be lower on an animacy scale (e.g., Aissen 2003; Croft, 1990; Hopper & Thomson, 1980). Moreover, Korean is one of the languages that are relatively less tolerant of inanimate subjects than others such as English, especially for action verbs (e.g., Kim, 2000). For example, it is not permissible to have inanimate subjects in Korean sentences as shown in (3).

(3) * cangnankami yekilo kanta (The toy goes here)

* chayki chayksang wiey nohta (The book lies on the table)

Instead, a better way to say the above sentences in Korean would be to use a transitive structure with a missing subject (e.g., (You) put the toy here) or to use transitive verbs marked with passive suffixes (e.g., The book is put on the table (by someone)). Given the tendency for sentence subjects to be higher in animacy than objects, transitive sentences should be generally more likely to occur with inanimate nouns than intransitive sentences in Korean. English-learning 2-year-olds are sensitive to distributional information about noun animacy, and can use it to infer the meaning of a novel transitivity-alternating verb (Scott & Fisher, 2009). If Korean children could keep track of the distribution of animate versus inanimate nouns relative to verbs, then this feature of our dialogues might have provided probabilistic information about verb transitivity. Future research can investigate whether a combination of multiple kinds of

information including noun animacy may help younger children tell apart transitive from intransitive verbs.

In sum, the present findings provide new evidence about how children figure out which verbs are transitive and which are intransitive, in argument-dropping languages. Korean 2-year-old children can distinguish novel transitive versus intransitive verbs based on exceedingly noisy evidence about verb transitivity. We suggested that probabilistic distributional learning and sensitivity to the discourse context could both reduce the ambiguity in the input caused by pervasive argument omission in Korean. The present results suggest that an expectation of discourse continuity itself is sufficient to guide Korean children's verb interpretation even when useful within-sentence distributional information and morphology is unavailable. Discourse constraints helped children recover omitted arguments for unknown verbs. In this way, children can learn to represent the true number of each verb's arguments, even when the surface of individual sentence is unhelpful. Therefore, with the support of linguistic context, syntactic bootstrapping can guide children's verb learning even in argument-dropping languages.

CHAPTER 4

USING DISCOURSE CONTINUITY TO LEARN VERBS IN ENGLISH

The syntactic bootstrapping hypothesis (e.g., Landau & Gleitman, 1985) holds that children exploit systematic links between syntactic structure and verb meaning, in addition to their extralinguistic experiences. Syntactic structure provides a powerful shortcut to early verb learning by reducing the ambiguity of interpretations allowed by the extralinguistc scene alone (e.g., Gleitman et al., 2005). One scene can be described in multiple ways. For example, a speaker might comment on the same scene using a sentence such as "Mom tickled the baby" or "The baby giggled", depending on the speaker's focus and perspective. Sentence structure can guide interpretation because verbs that occur in similar sentence structures have similar meanings. For example, verbs that describe meanings involving two participant roles tend to occur in transitive sentences with two noun-phrase arguments ("Mom tickled the baby") whereas verbs that describe meanings involving one-participant role tend to be intransitive, with one argument (e.g., "The baby giggled.").

As the syntactic bootstrapping hypothesis predicts, young children use these systematic relationships between structure and meaning in novel verb interpretation (e.g., Arunachalam & Waxman, 2010; Fisher, 2002; Naigles, 1990; Naigles & Kako, 1993; Yuan & Fisher, 2009). To illustrate, Yuan, Fisher and Snedeker (2012) showed that even 19-month-olds use sentence structure to make inferences about a verb's meaning by counting the number of nouns in a sentence. Children watched two simultaneous events: one depicted a two-participant event and the other depicted a one-participant action. While viewing these events, children heard a novel verb in a simple transitive sentence (e.g., He's gorping him) or an intransitive sentence (e.g.,

He's gorping). Children who heard the verb used in a transitive sentence looked longer at a two-participant event than did children who heard the verb used in the intransitive sentence. The findings support a structure-mapping account of the origins of syntactic bootstrapping, on which partial representations of sentence structure guide early sentence interpretation (Fisher, 1996; Fisher et al., 2010; Lidz et al., 2003). This account proposes that syntactic bootstrapping begins with an innate bias toward one-to-one mapping between nouns and participant roles. A strong prediction of this account is that young children can use the number of nouns in a sentence to interpret a verb's argument structure.

Note that in order to succeed in structure mapping, children must be able to identify the correct number of syntactic arguments in a sentence. Although the relationship between the number of noun phrases in sentences and the number of arguments is not arbitrary, noun phrases in a sentence and arguments of the verb are certainly not the same thing. Therefore, the number of nouns provides at best *probabilistic* evidence for the argument structure of verbs.

First, sentences can contain more noun phrases than there are arguments of the main verb. For example, in a sentence "The duck and the bunny are jumping", the two noun phrases are not two individual arguments, but are conjoined as a single argument of the verb. In the sentence "I am running at the park", the phrase "at the park" is not an argument of run, but an optional adverbial adjunct that modifies the circumstances of the action or state expressed by the verb. Such non-argument noun phrases in sentences create noise in the relations between noun numbers and argument numbers.

As a result, the structure-mapping account predicts 'telltale' errors in early sentence interpretation, when the number of nouns in a sentence provides misleading information about the verb's true number of arguments (Gertner & Fisher, 2012). A simple strategy that counts the

number of nouns should lead young children to make mistakes in interpreting sentences with adjunct NPs. Accordingly, Gertner and Fisher found that 21-month-olds mistakenly interpreted a two-noun conjoined-subject intransitive sentence (e.g., "The girl and the boy are gorping!") as a transitive sentence conveying agent-patient role information.

Second, as I discussed in Chapter 3, arguments can be missing. This issue has been largely raised from a cross-linguistic perspective: in many languages, noun phrases are omitted if they can be recovered from the discourse context (e.g., Allen, 2008; Clancy, 1993, 2003; Li & Thompson, 1981; Matsuo et al., 2012; Narasimhan, Budwig & Murty, 2005; Rispoli, 1995). For example, Clancy (2009) reported that only 13.4 to 23% of transitive sentences occurred with two overt NP arguments in two samples of mother-to-child speech in Korean. Thus, the number of noun phrases in the surface structure of individual sentences is not a reliable cue for verb argument-structure in argument-dropping languages. Although children learning argument-dropping languages also possess the one-to-one mapping bias between nouns and participant roles (e.g., Göksun, Küntay, & Naigles, 2008; Lee, Kim, & Song, 2013; Lidz et al., 2003; Yuan et al., 2007), severe argument omission in those languages questions about the real-world usefulness of the bias in children's learning.

Prior research has focused on language-specific cues that can help learners overcome the erroneous signal from the number of nouns in argument-dropping languages (e.g., Göksun, Küntay, & Naigles, 2008; Lee, Kim, & Song, 2013; Lidz, Gleitman, & Gleitman, 2003; Lee & Naigles, 2005; Matsuo et al., 2012). In Mandarin, an SVO language that permits argument omission, a post-verbal noun phrase is still a useful cue to identify transitive verbs. Thus, even a null-subject Mandarin sentence (e.g., "Ø kàn diànshì", watch television, 'Ø watch television') could be interpreted as a transitive, if the learner has already learned the word order of the

language. Other language-specific devices, such as case-markers that denote the grammatical role of noun phrases, would be particularly helpful in verb-final languages, which do not offer word-order cues to differentiate subject from object NPs. For example, a null-subject Korean sentence (e.g., "Ø television-ul pota", television-ACC watch, 'Ø watch television') could be interpreted as a transitive sentence, if the leaner has already learned that the accusative case marker marks direct objects. Consistent with this prediction, for example, Korean 24-month-old children can identify a null-subject transitive sentence containing a novel verb as referring to a two-participant event, when the overt object is marked with an accusative case marker (e.g., "twayci-lul lwuti-ko iss-e", pig-ACC lwuti-PROG-DECL, 'Ø is lwutting the pig'; Lee, Kim, & Song, 2013). Thus, language-specific learned cues can help children deal with the problem of missing arguments in verb interpretation.

In a recent study (Chapter 3), we suggested that an expectation of discourse continuity could provide another useful support for children's verb learning despite very noisy input caused by argument omission (Jin et al., 2014). We predicted that discourse information should be helpful because argument omission is strongly governed by the discourse context: even in argument-dropping languages, arguments can be omitted only when their referents are clearly established in the discourse (e.g., Allen, 2008; Clancy, 1993, 2003, 2009; Narasimhan et al., 2005). In Experiment 5, Korean 2-year-old children first heard transitive or intransitive dialogues with a novel verb. Each dialogue included 16 novel-verb sentences, all with one overt NP. The manipulation involved the discourse context, as shown in example (1): After introducing and establishing a topic (e.g., *Grandma*) in several introductory sentences, speaker A asks about that topic's actions (e.g., an English gloss is *What's Grandma doing*?), and speaker B responds with a one-noun sentence containing a novel verb, introducing a new referent (e.g., *Thomming the*

puppy) in the transitive condition, but keeping the topic referent (e.g., *Grandma is thomming*) in the intransitive condition. Given the SOV word order of Korean, both of these one-noun answers had the same constituent order (noun-verb), but they differed in whether they again invoked the discourse-prominent referent (in the intransitive condition), or a new referent (in the transitive condition). None of the novel-verb transitive sentences contained an accusative case marker that could provide language-specific morphological evidence for the novel verb's transitivity.

(1)

<Transitive>

…

A: "**halmeni** mwe-ha-ko iss-e?"
grandma what-do- PROG-Q?
'What's **Grandma** doing?'

B: "**kangaci** thomi-ko iss-e"
puppy thom-PROG-DECL
'Is thomming **the puppy**.'

<Intransitive>

…

A: "**halmeni** mwe-ha-ko iss-e?"
grandma what-do- PROG-Q?
'What's **Grandma** doing?'

B: "**halmeni** thomi-ko iss-e"
grandma thom-PROG-DECL
'**Grandma** is thomming.'

Next, in a single novel-verb test item, children saw two simultaneously-presented events, a two-participant action and a one-participant action simultaneously enacted by two people, accompanied by the novel verb in isolation (e.g., an English gloss is "Find thomming"). Children who had heard the test verb in transitive dialogues looked reliably longer at the two-participant event than did those who had heard it in intransitive dialogues, suggesting that Korean toddlers exploit the discourse context to recover a missing argument, and therefore to successfully learn the transitivity of a novel verb despite systematically dropped arguments. The findings provided

the crucial turning point in our understanding of the role of linguistic context in syntactic bootstrapping.

Here, we probe the universality of a discourse-continuity bias in children's verb learning, by testing English-learners. Possibly, Korean children in the previous study (Jin et al., 2014) might be prompted to learn to seek each verb's arguments in the prior discourse continuity by the high frequency of argument omission in their language. If so, their English-learning counterparts should not show the same sensitivity to discourse continuity. Another possibility, however, is that the previous finding reflects a quite general bias to expect referential continuity in connected discourse. Discourse coherence is a key feature in the retrieval of referents in any language (e.g., Ariel, 1990; Clark, 1996; Gundel, Hedberg, & Zacharski, 1993; Prince, 1992). If so, an expectation of discourse continuity should support children's language acquisition in any language (e.g., Frank et al., 2013; Horowitz & Frank, 2015), and might permit learners of any language to help determine how many arguments a novel verb licenses despite occasional argument dropping or other sources of noise in the input.

In English, about 65% of sentences of child-directed speech have overt subjects (Tardif, Shatz, & Naigles, 1997), and objects cannot be omitted. This may seem like a very low rate of subject provision for a language without argument dropping, but the vast majority of omitted subjects in English occur in imperatives (e.g., "Put that down!"). The subjects of declaratives or questions are present much more often than not. In contrast, in Korean, only 13.4 to 23% (varying across different mother-child corpora) of transitive sentences have two overt arguments (Clancy, 2009). This substantial difference in argument provision between English and Korean allowed us to probe the developmental origins of Korean children's use of discourse evidence in verb learning, as shown in Chapter 3.

One possibility is that Korean children learn from their language experience that verbs do not display their syntactic arguments reliably, and therefore that they must often seek the syntactic arguments of verbs in the prior discourse. If this language-specific learning about verbs is the source of the Korean-learning children's success in the experiments reported in Chapter 3, then English-learning children should not show the same pattern. Arguments are much more reliably present in English sentences, and therefore English-learners do not have the same language-specific reason to learn to seek verbs' arguments in the prior discourse.

Another possibility, however, is that Korean children's use of discourse context in verb learning resulted, not from learning about how verbs work in Korean sentences, but from a much more general expectation of discourse continuity. Children learning any language might expect adjacent sentences in a conversation or narrative to share referents. Given this general expectation, children would routinely use their understanding of the prior discourse to help them identify the content and meaning of each sentence. Under some circumstances, this expectation might be strong enough to permit children to infer that an argument is missing. An expectation of discourse continuity might result from the general relatedness across sentences in language use (e.g., Ariel, 1990; Clark, 1996), continuity in the goals of human actions more generally (e.g., Woodward, 1998), or could be an innate expectation, either linguistic or much more general. If English-learners can use discourse context to identify a novel verb's arguments, this would suggest that the use of discourse context to guide the learning of verb syntax follows from a general expectation of discourse continuity, perhaps universally available to children, rather than a language-specific learned strategy.

There is reason to suppose that children might have a language-general expectation of discourse continuity. All language use comes in connected discourse, and arguments are

pronominalized, shortened, or omitted when their referents are given rather than new in the discourse context (e.g, Prince, 1981), with a difference in their choice of pronouns or omitted arguments in the relevant languages. This feature that the discourse governs the disappearance of full noun phrases and their replacement by pronouns is also found in child-directed speech (e.g., Clark & Haviland, 1977; Fisher & Tokura, 1995; Rohde & Frank, 2014). Comprehension data suggest that English-learning children are sensitive to discourse continuity in pronoun comprehension (e.g., Ganea & Saylor, 2007; Hartshorne, Nappa, & Snedeker, 2014; Horowitz & Frank, 2015; Lidz et al., 2003; Pyykkönen, Matthews, & Järvikivi, 2010). For example, English-learning 2- to 3-year-old children link ambiguous pronouns with referents made prominent in prior sentences (e.g., "See the alligator and tiger. On a sunny day, the alligator wanted to play outside. So he went to the tiger's yard" "And what did *he* find? Look *he* found a bucket!", Song & Fisher, 2005, 2007). Thus, English-learning children have an expectation about discourse continuity that might be a general expectation, but this would not be learned as a way to recover the underlying syntactic arguments of verbs because argument omission is not pervasive in English.

In the present research, we investigated whether discourse bias that Korean children use in verb learning (Jin et al., 2014) also helps English learners identify transitive versus intransitive verbs. We again adapted the dialogue-training method by Yuan and Fisher (2009) to do so. To study the recovery of missing arguments in English, we must identify a context in which it is relatively natural for arguments to be missing. One possibility would be to use imperative sentences, which in English almost always have omitted subjects. However, using imperatives would reduce the usefulness of our cross-linguistic comparison. The subjects of imperatives are typically omitted in English, and therefore English-learning children might learn that the

imperative construction, complete with its interactional and morphological properties, is a special case in which a subject is omitted. Instead, we elected to use a question and answer context very similar to that employed in the Korean experiments.

Answers to questions provide a context in which null-subject sentences are found even in languages such as English, Danish, Dutch, and German that normally do not permit argument omission as a grammatical option (e.g., Haegeman, 1990, Schmerling, 1973). When asked a direct question, we sometimes respond with an answer lacking a subject, as in "What's Mom doing?" "Washing the car." These English null-subject sentences are typically described as due to the phonological reduction of weak elements at the left edge of the sentence (e.g., Bromberg & Wexler, 1995; Haegeman, 1990; Haegeman & Ihsane, 1999; Rizzi, 1994, Weir, 2012); accordingly, it is not simply the subject noun-phrase that is deleted (e.g., the answer "Is washing the car" is ungrammatical in English; thus the auxiliary verb is deleted along with the subject). However, this left-edge deletion occurs only in casual speech, and only in strongly supportive discourse contexts (e.g., Oh, 2005, 2006; Scott, 2013; White, 2013). In child-directed speech, caregivers drop sentence subjects in about 35% of all utterances, mostly in imperatives (Tardif, Shatz, & Naigles, 1997). In addition, fragments are often used in child-directed speech, for example, "Want a cookie?", "Want her over here?", (e.g., Broen, 1972; Cameron-Faulkner, Lieven, & Tomasello, 2003). Interestingly, these fragments tend to occur as answers to questions or parents' additions to their own prior sentences, discourse contexts in which such fragments are pragmatically appropriate (e.g., A: "Where do you want the doll?" B: "Want her over here?"). Thus, like Korean, English also drops nouns that could be recovered from the discourse context. Though this happens much more rarely in English – and therefore English and Korean make a good contrast to test the cross-linguistic generality of children's use of discourse structure to

recover the argument structure of a novel verb – these considerations at least show that there are contexts in English in which it would sound relatively natural to drop a subject argument.

Second, however, arguments can be misidentified. Words are often reduced in speech when they are predictable: the more predictable or redundant words are in their discourse context, the less time and effort speakers put into their articulation (e.g., Fisher & Tokura 1995; Fowler & Housum, 1987; Gahl & Garnsey 2004; Hunnicutt, 1985; Jurafsky et al. 2001; Lieberman, 1963; Samuel & Troicki, 1998; Pate 2013). As a result, listeners have difficulty in identifying individual words surreptitiously isolated from continuous speech (e.g., Pollack & Pickett, 1963). Child-directed speech can cause even greater difficulty in such tasks, because child-directed speech tends to be more repetitive and redundant (e.g., Bard & Anderson, 1983, 1994). Thus, children learning any language might need to consider how a word has been previously mentioned in the linguistic context in order to identify the word based on a noisy speech stream. Adults use linguistic context to identify words (e.g., Morton & Long, 1976), and they also adjust for the history of conversation with a particular addressee (e.g., Brown-Schmidt, 2009; Metzing & Brennan, 2003; Brennan & Clark, 1996; Isaacs & Clark, 1987). These considerations suggest a striking conclusion about the nature of young children's intake of linguistic experience. Until children learn how to use linguistic knowledge and discourse context to interpret words and sentences (Fernald & Hurtado, 2006; Lew-Williams & Fernald, 2007), young children might often fail to identify many words in connected speech. An expectation of discourse continuity could help children to identify arguments that would be unintelligible without discourse support.

In sum, even in English that allows less noun omission, individual sentences provide imperfect information about the syntactic argument-structure of verbs, because (a) subjects can still be dropped under some circumstances, and (b) arguments can be unidentifiable due to

acoustic reduction. In both cases, discourse information could be helpful in identifying missing or unidentifiable arguments for the same reasons discourse context is helpful in argument dropping languages, because arguments are missing or less intelligible when their referents are predictable based on the discourse-pragmatic context. Thus, an expectation of discourse continuity still could give an advantage in English-leaners' sentence comprehension. English-learning children viewed dialogue materials similar to those of the Korean study reported in Experiment 5, in which a new verb appeared in intransitive sentences, or transitive sentences with missing subjects. These subject omissions were always appropriate in the discourse context, because the omitted subjects' referents were already prominent discourse topics.

In Experiment 6, English-learning 3-year-olds first heard either transitive or intransitive dialogues involving a new verb (*pilk*). The verb occurred with exactly one overt NP per sentence both in transitive and intransitive dialogues. Our manipulation involved the discourse context: the question "What's he doing?" was answered by "Pilking the cat" in the transitive dialogues, but by "He's pilking" in the intransitive dialogues. Later, in the novel-verb test item, children viewed two events used by Yuan and her colleagues (2012): a two-participant caused-motion event and an event involving a one-participant action and a bystander (Figure 8). Children in the same-verb experimental condition heard the target verb from the preceding dialogues in isolation ("Find pilking!"), whereas those in different-verb control heard a different novel verb ("Find gorping!"). If children use discourse expectations to fill in a verb's arguments, those who heard transitive dialogues should identify their novel verb as transitive, even though it only appeared in one-noun sentences, and thus look longer at the two-participant event than those who heard intransitive dialogues. This effect should disappear in the control condition, because children had no prior knowledge of the novel verb presented in the test item.

In Experiment 7, we probed the role of discourse coherence in Experiment 6. In addition to the discourse support provided in the dialogues, English word order and verb morphology could provide useful information to identify the novel verb in "Pilking the cat" but not in "He's pilking" as transitive. English-speaking adults might identify these as transitive and intransitive sentences, respectively, based simply on these language-specific cues. In principle, 3-year-olds could do the same, and if so positive results in Experiment 6 might reflect only syntactic and morphological cues local to each novel-verb sentence. However, these cues are far from perfect. English verbs do not typically appear sentence-initially, and forms ending in *-ing* can appear as nouns, adjectives, or adverbs (e.g., *lightning, human being, a frightening story, swimming is fun*; of course, some of these are verbs, but are not used as verbs, with arguments, in these contexts). Therefore, we speculated that young children might not find it easy to identify the novel items as verbs at all in the elliptical sentences provided in the transitive dialogues, and therefore might be unable to learn about their transitivity via listening, without strong discourse support for argument omission.

To isolate the role of discourse continuity in our task, we manipulated the coherence of the dialogue discourse. In Experiment 7, 3-year-old children heard the transitive dialogue sentences of Experiment 6, presented in either a coherent or a scrambled order. In the coherent-dialogue condition, children received the transitive dialogue sentences in the same order as in Experiment 6. In the scrambled-dialogue condition, the same audio- and video-recorded sentences were reordered to eliminate discourse support for omitted subjects (See Figure 10). Later in the novel-verb test item, children viewed two events: a two-participant causal event in which one woman caused a seated woman to bend forward and back by pushing and pulling on her shoulders, and a one-participant action event in which two women each raised and lowered

their arms as in jumping-jacks (Figure 10). If discourse support helps children to identify transitive verbs even in null-subject sentences, then in the coherent-dialogue condition, children who heard transitive dialogues should look longer at the two-participant event than those who heard intransitive dialogues; this effect should disappear in the scrambled-dialogue condition.

In Experiment 8, we tested younger children, 2-year-olds, to examine whether English-learning children also show sensitivity to discourse continuity at an age similar to their Korean-learning counterparts in the earlier experiments (Jin et al., 2014). In Experiment 8, children heard either coherent or scrambled dialogues. We speculated that young children might have greater than older children difficulty identifying a sentence-initial word as a verb (e.g., in "Pilking the baby!"), because this sentence position is typical only for verbs in imperative sentences. To lessen the unnaturalness of this word order in English, we added artificial noise in front of the novel verb sentences (Transitive: "(noise) Pilking the baby", Intransitive: "(noise)" He's pilking") on the dialogue videos. If the ability to seek missing elements from discourse is language-general, toddlers learning English also should succeed in this task.

Experiment 6

Method

Participants

Sixty-four 3-year-olds (M = 41.7 months, range 37.1–46.0; 32 girls) participated; all were learning English as their first language. None had a history of hearing problems or speech delay. Two additional children were excluded due to experimenter error (1), or refusal to participant (1) Children's productive vocabularies, measured using the MacArthur Bates CDI (Level III; Fenson et al., 2007), ranged from 4 to 100 (median = 90). Children were randomly assigned to one of the

four combinations of dialogue (transitive, intransitive) and test (same-verb, different-verb) conditions.

Apparatus

Children sat on a parent's lap in a dimly-lit room, about four feet from a 50" television. Soundtracks were presented from the television's internal speakers. A central camera concealed just beneath the television screen recorded children's faces while they watched. White curtains to the left and right blocked the child's view of the testing room. Parents wore opaque glasses.

Materials and Procedure

The experiment began with a dialogue phase, in which the novel verb *pilk* was presented in 10 sentences distributed across five video-clips showing conversations between two female English speakers (Figure 8). Dialogue video-clips were 22.8 to 29.5 s long. Each dialogue video-clip was presented as a large video image centered on the television screen. Children in the transitive condition heard the novel verb only in transitive sentences with missing subjects (e.g., "Pilking the cat"); those in the intransitive condition heard it only in intransitive sentences with overt subjects ("He's pilking"). This manipulation allowed the two dialogue conditions to contain the same number of NPs in every novel-verb sentence. As in the previous Korean study (Chapter 3, Jin et al., 2014), the two novel-verb sentences in each dialogue always followed several sentences in which one character was repeatedly mentioned (e.g., "I'm looking for Mom, have you seen her?" "Yes, I just saw Mom. She's in the playground."), leading up to a question about that character's actions ("What's she doing?"). At this point in the dialogue, the novel-verb sentence was introduced as an answer to this question: In the transitive condition, children heard a transitive sentence with an omitted subject (e.g., "Pilking the baby"), whereas in the intransitive condition they heard an intransitive sentence with a pronoun subject (e.g., "She's

pilking."). All nouns in the dialogue sentences referred to animates. A short filler item was introduced during the dialogue phase to keep children's attention: After the third dialogue clip, children saw a smiling sun picture (5s) accompanied by audio of a baby laughing, separated from the preceding and following dialogue clips by a 1s blank-screen interval.

Next, in the practice item, children saw synchronized pairs of videos showing people performing actions, with soundtracks recorded by a female native English speaker (Figure 8). Each event-pair consisted of two video windows presented side by side, vertically centered and widely separated on the television screen. The test phase included two practice items involving familiar verbs (*wash, sweep*), followed by one more dialogue clip and the novel-verb item.

The first familiar verb was *wash*; the target event showed a woman washing a dish in a dishpan, and the distracter event showed a woman drawing on a large pad of paper. First, during a 7s blank-screen interval, children heard "Now let's watch this! Hey watch! Washing! Find washing!" Next, two 8s videos played simultaneously. Children heard the familiar verb three times as this event-pair played (e.g., "Find washing!"). Children heard the verb again during a 6s blank-screen interval ("Did you find it? Where's washing?), then again saw the 8s event-pair, while hearing three more repetitions of the target verb. This procedure was repeated with the second familiar verb ("Find sweeping!"). In the second practice pair, the target event showed a woman sweeping, and the distractor event showed a woman cooking (pretending to stir something in a pan). These items familiarized children with the task, informing them that one video matched the soundtrack on each trial, and also familiarized them with the wording of the isolated-verb prompts used in the test trials ("Find verb-ing!").

After 4 practice trials, one more dialogue clip containing two novel-verb sentences was presented. As shown in Figure 8, this final dialogue clip described events involving male

participants in the past tense (e.g., "What was he doing?" "Pilking the boy!" or "Billy was pilking!"), to avoid leading children to treat the dialogue sentences as referring directly to the upcoming test events.

Figure 8. Sample dialogue and test item for Experiment 6 (3-year-olds).

Finally, children received the novel-verb test item. Children in the same-verb condition heard the novel verb from the dialogues ("Find pilking!"), whereas children in the different-verb condition heard another novel verb ("Find gorping!"). The test events were adapted from Yuan et al. (2012). The 8s test events included a two-participant causal event (one woman rotated another on a tall swivel chair) and a one-participant event with a bystander (one woman bounced on a gym ball, while another stood idly by). Both test videos depicted two people; but only the two-participant causal event depicted a coherent event involving two participant-roles. Children first received previews of the test events, presented one at a time for 6s each[12]. Each preview was accompanied by neutral audio (e.g., "What's happening? Look here!"). Next, during a 7s blank-screen interval, children heard the test verb appropriate for their condition twice in isolation (e.g., "Now look, pilking (gorping)! Find pilking (gorping)!" The two 8s test events were then presented simultaneously while children heard three more repetitions of their test verb (e.g., "Where's pilking (gorping)? Find pilking (gorping)! See? Where's pilking (gorping)?"). In the subsequent 6s blank-screen interval, children heard one more test verb and a prompt (e.g., "Can you find it? Where's pilking (gorping)?"). This sequence was repeated for two more test trials.

The left/right position of the test events was counterbalanced with the order of the test-event previews, and with dialogue and test conditions.

Coding

We coded where children looked during the three 8s test trials (left, right, away), frame by frame from silent video. A second coder re-coded 25% of the data (16 children); the two coders agreed on 96% of video frames.

The time spent looking away from the stimulus videos during the test trial was analyzed by a 2 by 2 analysis of variance (ANOVA) with dialogue (transitive, intransitive) and test

[12] The previews were briefer than the test events in order to help keep the task short.

conditions (same-verb, different-verb) as between-subjects factors. No effect was significant ($p > .066$)[13], suggesting that children in all dialogue and test conditions looked away about equally during the test trials (same-verb, transitive: $M = .62$ s, $SD = .53$; same-verb, intransitive: $M = 0.50$ s, $SD = .51$; different-verb, transitive: $M = .71$ s, $SD = .51$; different-verb, intransitive: $M = 0.39$ s, $SD = .31$). Given the uniformity of time spent looking away, we conducted our main analyses on a single measure, looking time to the caused-motion event as a proportion of total time spent looking at either test event, averaged across the three trials of the novel-verb test item. Analyses based on raw looking times to the two-participant or to the one-participant event revealed the same pattern of significant effects as the analyses reported below.

Preliminary analyses of children's looking-preference in the test trials revealed no interactions of dialogue and test condition with sex or with whether the child's vocabulary or performance in the practice trials[14] was above or below the median, all Fs < 1. Thus, the data were collapsed across these factors in subsequent analyses.

Results and discussion

As shown in Figure 9, 3-year-olds' preference for the two-participant event varied with sentence condition: Those who previously heard the novel verb in transitive dialogues looked longer at the two-participant event than did those who heard it in intransitive dialogues. Crucially, this dialogue effect appeared only in the same-verb condition, in which children heard at test the same verb previously encountered in the dialogues. Children's looking times in the different-verb condition did not differ depending on whether they had heard transitive or intransitive dialogues. A 2X2 ANOVA with the between-subjects factors dialogue (transitive,

[13] The main effect of training sentence was marginally significant, $F(1, 60) = 3.468$, $p = .067$. Overall, children who heard transitive dialogue ($M = .67$ s, $SD = .51$) looked away more than children who heard intransitive dialogue ($M = .45$ s, $SD = .42$).

[14] The median of children's target preference in the practice trials was .64.

intransitive) and test condition (same-verb, different-verb) confirmed a significant interaction of these two factors, $F(1, 60) = 8.512$, $p = .005$.

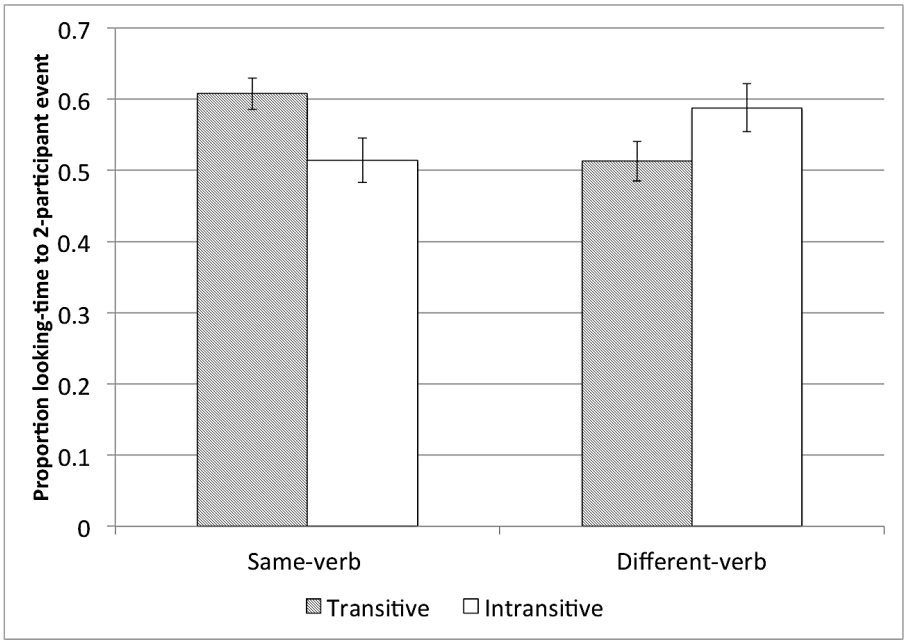

Figure 9. Mean (se) proportion looking-time to the two-participant causal event, by dialogue type and test sentence condition (3-year-olds, Experiment 6).

Planned comparison revealed that in the same-verb condition, children who heard transitive dialogues looked significantly longer at the two participant event as opposed to the one participant event ($M = .61$, $SD = .09$), than did those who heard intransitive dialogues ($M = .51$, $SD = .12$), $t(30) = 2.445$, $p = .021$. In contrast, in the different-verb condition, children who heard transitive dialogues ($M = .51$, $SD = .11$) did not differ significantly from those who heard intransitive dialogues ($M = .59$, $SD = .13$), $t(30) = 1.733$, $p = .093$[15]. Thus, as predicted, children who heard transitive dialogues looked longer at the two-participant event upon hearing the same verb again ("Find pilking!") than did children who heard the intransitive dialogues, but this

[15] Indeed, children in the different-verb condition tended to show the opposite looking pattern from those in the same-verb condition. It is hard to interpret this unpredicted difference in the different-verb, because the different-verb control condition is less constraining and thus may be somewhat noisier than the same-verb condition.

dialogue effect disappeared in the different-verb condition ("Find gorping!").

The findings from Experiment 6 suggest that, like Korean-learners, English-learning 3-year-olds readily interpreted a novel verb presented in null-subject transitive sentences as referring to a two-participant event, even though the verb occurred with only one overt NP, at least when these sentences were presented in a supportive discourse context. When a preceding question highlighted one referent prominent, children might have treated this referent as part of the answer, thus interpreting a 1-NP sentence as transitive.

Alternatively, language-specific grammatical and morphological cues could have provided sufficient information for our English-leaners to identify the transitivity of the novel verbs. The transitive sentences with null subjects in Experiment 6 (e.g., "Pilking the boy!" vs. "He's pilking!") provided category-level word-order cues to transitivity. Transitive verbs precede NPs whereas intransitive verbs tend to follow nominative pronouns. The [Verb-ing the] frame could also serve as a strong probabilistic cue to transitivity. In Experiment 7, we addressed this issue and further probed the role of discourse expectations in English-learning children.

Experiment 7

The findings from Experiment 6 suggest that English-learning 3-year-old children can correctly identify a novel transitive verb when given transitive sentences with omitted subjects (e.g., "Pilking the boy!"), with the support of a coherent discourse. However, in addition to discourse context, English word order or morphological cues could contribute to children's interpretation of null-subject transitive sentences. In Experiment 7, we replicated the key findings of Experiment 6 and further explored the role of discourse continuity. To do so, we compared the coherent dialogues of Experiment 6 with scrambled dialogues in which the same

video- and audio-recorded sentences were reordered (Figure 10). Thus, children who heard the scrambled dialogues received the same sentences as those who heard the coherent dialogues, except that omitted subjects were not previously mentioned as prominent in discourse. If children's success in Experiment 6 depended only on their detection of aspects of English word order and morphology local to the novel-verb sentences (e.g., the fact that 'pilking' ended in–*ing*, and that it preceded a noun phrase), then children should assign appropriately different interpretations to the transitive and intransitive verbs in Experiment 7, regardless of whether they hear scrambled or coherent dialogues. In contrast, if an expectation of discourse continuity aided children's interpretation of transitive sentences with missing subjects, then only children who hear the novel verb sentences in a supportive discourse context in the coherent dialogues should succeed in this task. .

Method

Participant

Ninety-six 3-year-olds (*M* = 40.0 months, range 37.0–45.9; 49 girls) participated; all were healthy, and were learning English as their first language. None had a history of hearing problems or speech delay. Four additional children were excluded because they looked away for 50% of the single test trial (3), or because the parent ended the task (1). Children's productive vocabularies, measured using the MacArthur Bates CDI (Level III; Fenson et al., 2007), ranged from 10 to 115 (median = 81). Children were randomly assigned to one of the four combinations of discourse (coherent, scrambled) and sentence (transitive, intransitive) conditions.

Materials and Procedure

Experiment 7 was similar to Experiment 6, with several modifications of the materials and procedure (Figure 10). In the coherent-discourse condition, children first watched the same

transitive or intransitive dialogue videos as in Experiment 6. Experiment 7 did not have a reminder dialogue clip in between the practice and test items; the last dialogue clip was presented along with the other dialogue clips before children received the familiar-verb practice trials. This change allowed a longer delay between the final dialogue and the novel-verb test item, in order to confirm the robustness of the dialogue effects. Following the dialogue phase, children received the same practice items involving familiar verbs (*washing, sweeping*) as in Experiment 6. Finally, in the critical test item, the interpretation of the novel verb 'pilking' was tested in in a manner similar to Experiment 6. In Experiment 7, a new pair of test events was used; a two-participant event showed one woman causing another to bend forward and back by pushing and pulling on her shoulders and a one-participant event showed two women moving their arms in synchrony. We used these events for Experiment 7 and Experiment 8. We switched to them because the bystander events used in Experiment 6 had a relatively high baseline level of looks to the two-participant event. This suggests the one-participant bystander event was relatively uninteresting in this context. The one-participant events enacted by two people are more duo events are more perceptually salient (Naigles & Kako, 1993). Therefore, they reduce the baseline tendency of children to look at the two-participant event regardless of what sentence they hear. Children received a single test trial. The 3-year-olds in current study are relatively older in the dialogue-training method. Therefore, we used a single test trial to provide a more sensitive measurement for older children's retrieval of what they knew about this verb in case children inconsistently look around the events after they complete their decision.

The materials and procedure of the scrambled-discourse condition were similar to those of the coherent-discourse condition except that the videos were edited to change the order, and therefore the discourse coherence, of the dialogue sentences. In creating the scrambled dialogues,

the goal was to eliminate discourse evidence for omitted subjects. To do so, the sentences were reordered within each dialogue clip, such that the two novel-verb sentences were uttered at the start of each dialogue clip (e.g., transitive: A: “Pilking the baby!”, B: “Pilking the baby?”, intransitive: A: “She’s pilking!”, B: “She’s pilking?”), without any prior sentences to introduce a possible referent for a null subject. The rest of the dialogue sentences then followed; these sentences were presented in the same order as in the original dialogue videos, to avoid extended incoherence that might cause children to lose interest in the scrambled dialogues. Thus after the novel verb sentences, children in the scrambled dialogue conditions heard the same sequence, as in the following example: A: “I’m looking for Mom. Have you seen her?”, B: “Yes, I just saw Mom”, A: “What’s she doing?”, B: “She’s in the playground."

To reorder the sentences, we first edited the coherent dialogue video, sentence-by-sentence, into short clips (1.7-4.17 s long). Next, each single-sentence video clip was cropped so that the video showed only the talker, not the listener. This was done to eliminate unnatural visual transitions in the video that resulted from re-ordering naturally recorded video dialogues. Then, the resulting 45 single-sentence video-clips were edited into a sequence with each sentence-long clip taken from the same dialogue separated from the next by a 10 frame (333ms) interval. These single-talker clips appeared in the center of the video screen. In Experiment 6, each dialogue clip ended with a scene where the two talkers laughed together; here, we kept the laughing part for the end of each dialogue clip and two talkers appeared together as in Experiment 6, to signal the boundaries of the dialogues. As much as possible given the constraints of editing the original videos, each sentence video clip retained the same length of pause following the sentence that it had in the original video; thus the length of the entire dialogue phase in the scrambled-dialogue condition (2 min 42.6 s) was similar to that of the

coherent dialogues (2 min 43.6 s).

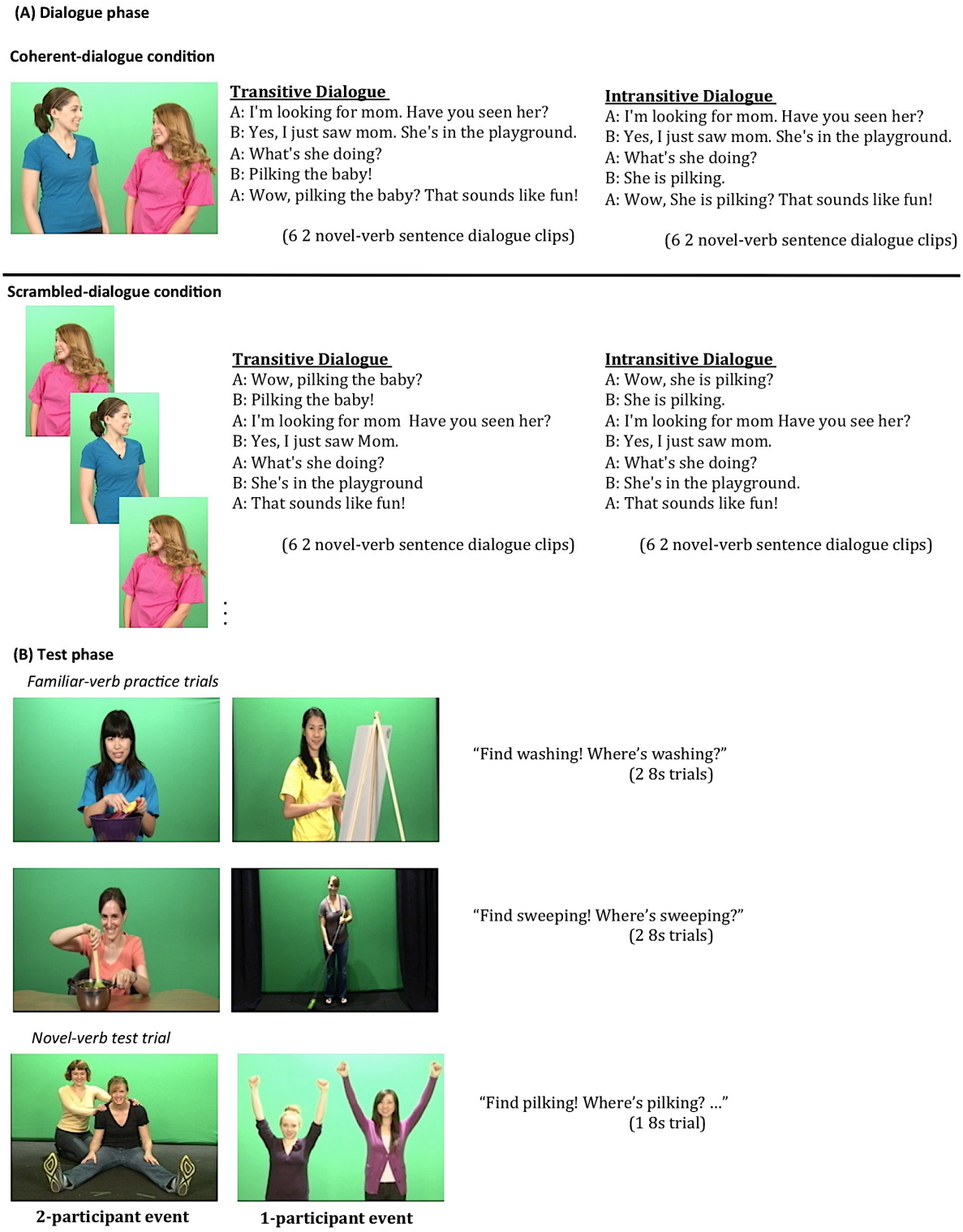

Figure 10. Sample dialogue and test-item for Experiment 7 (3-year-olds) and Experiment 8 (2-year-olds).

In sum, the coherent and scrambled dialogues offered the same within-sentence syntactic cues, and introduced the same number of referents per sequence of sentences taken from the same source dialogue. Therefore, differences across conditions will suggest that toddlers are more likely to identify the null-subject sentences (e.g., "Pilking the baby!") as transitive if they appear in a supportive discourse context.

Coding

Coding was conducted as in Experiment 6. A second coder re-coded 35% of the data (34 children); the two coders agreed on 96% of video frames. The amount of time children spent looking away from the two video screens, averaged across the three test trials, was analyzed by a 2 X 2 ANOVA with discourse (coherent or scrambled dialogues) and sentence condition (transitive vs. intransitive dialogues) as between-subjects factors. This analysis revealed no reliable main effect of discourse condition or significant interaction of discourse and sentence conditions (Fs < 2.3, ps > .13), but a significant effect of sentence condition ($F(1, 92) = 7.361$, $p < .01$). Children in the intransitive condition looked away slightly but significantly longer ($M = .41$ s, $SD = .49$) than did children who in transitive condition ($M = .20$ s, $SD = .23$). Given this difference in look-away times between the two sentence conditions, as in Experiment 5 in Chapter 2, we conducted our main analyses on the raw looking-times to the two- and to the one-participant event rather than on a single measure of looking-time to one event as a proportion of looking-time to either event (see also Yuan & Fisher, 2009, for a similar approach).

Preliminary analyses were conducted as in Experiment 6. The analyses of children's test-trial performance revealed no interactions of discourse and sentence condition with sex, whether children's performance in the practice trials[16] or their vocabulary level was above or below the

[16] The median of children's target preference in the practice trials was .63.

median (Fs < 3.1, ps > .08)[17]. Thus, the data were collapsed across these factors in subsequent analyses.

Results and Discussion

As noted above, the unpredicted difference in look-away times between the transitive and the intransitive conditions led us to analyze raw looking-times to the two- and one- participant events. Table 3 shows mean looking times (in seconds) to the two-participant and to the one-participant event, during the single 8-s test trial. As predicted, dialogue sentence type affected looking preferences in the test trials, but did so only for children in the coherent-dialogue condition. Children who heard transitive dialogues looked longer at the two-participant event and less at the one-participant event than did those who heard intransitive dialogues, but this pattern appeared only within the coherent-dialogue condition.

A 2 (Discourse: Coherent, Scrambled) by 2 (Sentence: Transitive, Intransitive) ANOVA was conducted separately for each dependent measure. Analyses of looking-times to the two-participant event revealed a significant interaction of discourse and sentence condition, $F(1, 92)$

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[17] There was a marginal 3-way interaction of dialogue and test-verb with sex for children's looking times to one-participant event, $F(1, 88) = 3.080$, $p = .083$. This marginal interaction appears to reflect an unexpected difference between the boys and the girls in the scrambled-dialogue condition, not in the coherent-dialogue condition. In the coherent-dialogue condition, both boys and girls showed the predicted looking time pattern: those who heard transitive dialogues tended to look less at the one-participant event than did those who heard intransitive dialogues [Boys: Transitive (n = 12): M = 3.26 s, SD = .91, Intransitive (n = 12): M = 3.72 s, SD = .73; Girls: Transitive (n = 12): M = 3.24 s, SD = 1.52, Intransitive (n = 12): M = 4.20 s, SD = 1.79]. In the scrambled-dialogue condition, the boys showed a looking-time pattern similar to that found in the coherent-dialogue condition (Transitive (n = 12): M = 3.46 s, SD = .94; Intransitive (n = 11): M = 3.96 s, SD = 1.31), but the girls showed the reverse pattern (Transitive (n = 11): M = 3.97 s, SD = 1.21; Intransitive (n = 13): M = 3.21 s, SD = 1.11). The interaction was smaller for children's looking time to two-participant event, $F(1, 88) = 2.465$, $p = .12$. Such an interaction, if replicated across studies, might suggest that the boys expected the dialogue and test portions of the same task to be related to each other, and so they showed a systematic dialogue effect even though in the scramble-dialogue condition where children received word-order and morphological information about the verb's transitivity. The interaction was not found in Experiment 8 where we tested younger children, 2-year-olds, using the similar dialogues and test item.

= 4.517, p = .036. Similarly, analyses of looking-times to the one-participant event revealed a marginally significant interaction of discourse and sentence condition, $F(1, 92) = 2.975$, p = .088.

Table 3: Mean (SD) looking-time (seconds) to the two-participant event, one-participant event, and away, in the 8-s trial of the novel-verb test item, Experiment 7.

Dialogue Condition	Sentence	Two-participant event	One-participant event	Away
Coherent-dialogue	Transitive	4.56 (1.28)	3.25 (1.23)	.19 (.28)
	Intransitive	3.52 (1.41)	3.96 (1.36)	.52 (.55)
Scrambled-dialogue	Transitive	4.08 (1.08)	3.72 (1.10)	.20 (.16)
	Intransitive	4.15 (1.30)	3.55 (1.24)	.30 (.41)

As Table 3 shows, in the coherent-discourse condition only, children who heard transitive dialogues looked reliably longer at the two-participant event than did those who heard intransitive dialogues, $t(46) = 2.665$, p = .011; the children who heard transitive dialogue tended to look less at the one-participant event than did those who heard intransitive dialogues, though the difference in this measure was not significant, $t(46) = 1.894$, p = .065. In contrast, in the scrambled-dialogue condition, children looked about equally at the two events regardless of the transitivity of the novel-verb sentences in the dialogues, ts < 1.

These results suggest that children assigned appropriately different meanings to null-subject transitive sentences versus intransitive sentences only when the discourse context cued children to expect a missing (or reduced) subject. Although English word-order and morphological cues signaled the transitivity of the null-subject sentences (e.g., “Pilking the

baby"), children did not successfully interpret those sentences as transitive without discourse support.

In sum, Experiment 7 replicated and extended the findings of Experiment 6. English-learning 3-year-old children used an expectation for discourse continuity to infer the missing subjects of transitive sentences. This suggests that children's use of discourse expectancy in verb interpretation is language-general: A coherent discourse context helps children identify a verb's true number of arguments when subjects are missing, not only in Korean, an argument-dropping language (Jin et al., 2014), but also in English, a language that permits only rarer noun omission.

The transitive sentences (e.g., "Pilking the cat!") provided categorical-level word order and morphological cues that could have been used to identify the verb's transitivity. As noted above, we assume adult English speakers would be able to identify "pilking the baby" sentence as transitive, even without discourse support, using their mature knowledge of English grammar and expert sentence-processing ability. However, 3-year-old children needed a discourse context providing linguistic support for omitted subjects in order to identify the null-subject sentences as transitive.

This might seem surprising. English-learning 3-year-olds certainly know the word order of transitive sentences, and can use the affix *–ing* to identify an unknown word as a verb (Akhtar & Tomasello, 1997; Brown, 1957; Gertner, Fisher, & Eisengart, 2006; Slobin & Bever, 1982). For example, Brown (1957) showed that 3- and 4-year-olds assigned action meanings to novel words presented as verbs (*sibbing*), as opposed to as nouns (*a sib* or *some sib*). Given such findings, why would the 3-year-olds in Experiment 7 not readily identify *pilking* as a verb, and then use their knowledge of English word order to identify *Pilking the cat* as transitive? One possibility is that children did identify *pilking* as a verb, but were unable to achieve a stable parse

of the entire sentence, with its unusual verb-initial structure, and therefore failed to identify the new verb as transitive. Another possibility, however, is that it was difficult to identify *pilking* as a verb in the transitive dialogues, given its unvarying gerund form and its unusual sentence-initial position. As noted earlier, *-ing* is not an unambiguous cue to the verb category; hearing the same verb stem in multiple morphological contexts would make its identification as a verb more certain. (In fact, in Brown's classic study, children did hear the novel verbs in two forms, *to sib* and *sibbing*.) The present results suggest that, when a new word's local context makes it difficult to identify its grammatical properties – a verb's transitivity, or perhaps even whether the new word is a verb –, the discourse context can help. In the coherent transitive dialogues, the novel-verb sentences were presented in answer to a question that followed the clear establishment of one character as a topic (e.g., *What's she doing?*); this context was designed to strongly suggest that an acceptable answer would include reference to the character whose actions were queried. In this context, 3-year-olds found it easier to determine that the answer *Pilking the baby* contained a transitive verb.

Experiment 8

Experiment 6 and 7 showed that English-learning 3-year-olds, like the Korean children in Experiments 4 and 5, were able to consult the discourse to identify the transitivity of novel verbs in noisy input. These data are consistent with the hypothesis that children may universally rely on an expectation of discourse continuity to identify the structure and meaning of sentences. However, a critical remaining question is whether this ability appears with similar developmental timing across languages. The English-learning children in Experiments 6 and 7 were about a year older than the Korean-learning children in the previous similar experiments (Jin et al., 2014). It

might be that English-learning children would start to use discourse continuity in verb learning later than Korean-learning children, because the English input more reliably includes overt noun phrases for each verb argument, and therefore English learning children are not as strongly prompted by their language experience to expect arguments to be missing altogether. Alternatively, English-learning children could develop the ability to rely on discourse continuity approximately as early as do their Korean-learning counterparts. Experiment 8 examines whether the discourse-continuity bias in verb interpretation occurs at a similar age across languages, by testing English-learning 2-year-olds' use of discourse continuity in verb interpretation.

Method

Participant

Sixty-four 2-year-olds (*M* = 32.6 months, range 30.0-36.0 months, 32 girls) participated; all were learning English as their first language. Four additional children were excluded because they did not complete the experiment. Children's productive vocabularies, measured using the MacArthur Bates CDI (Level III; Fenson et al., 2007), ranged from 1 to 101 (median = 59). Children were randomly assigned to one of the four combinations of discourse (coherent, scrambled) and sentence (transitive, intransitive) conditions.

We also tested 30 additional 3-year-olds (*M* = 42.0 months, range 36.2-47.9 months, 15 girls), in order to replicate, with the revised materials of Experiment 8 (see below), 3-year-old's success in the coherent dialogue conditions as shown in Experiments 6 and 7. The 3-year-olds' productive vocabularies, measured using the MacArthur Bates CDI (Level III; Fenson et al., 2007), ranged from 33 to 101 (median = 82.5). The 3-year-old children were randomly assigned to one of the two coherent sentence (transitive, intransitive) conditions.

Materials and Procedure

The materials and procedure of Experiment 8 are similar to those used in Experiment 7, with a few changes to make the study more suitable for younger children. Pilot data with 2-year-olds (n = 23) in the same-verb condition of Experiment 6 suggested that younger children might have difficulty processing sentences with dropped subjects, even with the aid of a coherent discourse. The coherent dialogues as presented in Experiment 6 (transitive, intransitive) did not affect 2-year-olds' looking preferences at test in this pilot study.

We speculated that younger children's difficulty might be due to the sheer surface unnaturalness of sentences (spoken clearly and slowly in child-directed speech) that began with a verb and that were not imperatives. The position of each word, relative both to sentence boundaries and to other words, provides distributional evidence for grammatical category Children, like adults, use sentence context to identify the grammatical categories of words (e.g., Gómez & Gerken, 1999; Gómez & Lakusta, 2004; Mintz, 2002). As noted earlier, the majority of omitted subjects in English are imperative sentences (Tardif et al., 1997). As a result, a verb in the *-ing* form such as "Pilking" occurs only rarely in sentence-initial position in English. In order to help young children rise above this unnaturalness, which might hamper their identification of the novel word as a verb, we added pink acoustic noise immediately before all novel-verb sentences in the dialogues. We did so by rough analogy to the literature on phoneme restoration, the perception of a word as complete despite a missing phoneme. Adults and children are better at restoring a missing sound in speech if the missing sound is replaced with noise such as a cough or a tone than when it is replaced with silence (e.g., Newman, 2004; Warren, 1970). We speculated that a brief noise immediately preceding the novel-verb sentences would help to mask the unnaturalness of the novel-verb sentences in the transitive dialogues in particular. Therefore a

10 frame (333ms) noise was added immediately before the onset of the novel-verb sentences in both dialogues. Thus, in the transitive dialogues, the noise was presented at the position where the missing subject would normally appear (e.g., "(noise) pilking the baby!"); in the intransitive dialogues, the noise was presented before the overt sentence subject (e.g., "(noise) She's pilking!"). These noise segments were inserted into the soundtrack of the dialogue videos, and were aligned with visual noise that disrupted the video track itself; the video noise was created in video-editing software, and was included to mask the fact that the speaker's mouth movements suggested she was not speaking during the interval of the noise. Audio-video noise was added in the same way, and at the same positions relative to the same recorded sentences, to the coherent and the scrambled dialogues described in Experiment 7.

Before beginning the experiment, an experimenter first asked children to repeat the novel verb in a gerund form (e.g., "Today, we're going to watch a fun movie about pilking. Can you say pilking?"). This was added to help young children recognize the form of the novel verb, by presenting the word in live speech. Twenty-five of the 64 2-year-olds and 23 of the 30 3-year-olds repeated the novel word. Next, the experimenter told children that the TV was not working well that day, in order to explain the noise in the video. The experimenter said, for example, "This TV is really old. When I watched a movie yesterday, it was not working well. I'm not sure whether it'll work well this time. Let's try!" The experimenter then went behind a curtain and started the stimuli video.

At the beginning of the video, children first watched a 37.2 s filler animation clip with music (retrieved from the internet). The audio and video noise occurred twice during this filler animation; this was done to familiarize children with the noise before they heard it before the critical sentences. Six additional instances of audio-video noise were added to the dialogue

videos, between non-critical sentences that did not contain the novel verb, for the same purpose. Other than this addition, the dialogue phase played just as in the previous experiment.

After the dialogue phase, the experimenter emerged from behind the curtain and told children that she needed to fix the TV. For example she said, "This TV is so old! Wait, I think I know how to fix this. I'm going to fix the connection to the TV!", pretended to check the back of the TV, said "Yay! I fixed it! It should be fine now. Let's watch the rest of the movie!", and went back behind the curtain to start the rest of the video.

At this point, children received the same familiar-verb practice and novel-verb test items presented in Experiment 7. No further audio or video noise was presented during these items.

Coding

Coding was conducted as in Experiment 6 and 7. A second coder re-coded 27% of the data (25 children); the two coders agreed on 97% of video frames. The amount of time the 2-year-old children spent looking away from the two video screens during the single test trial was analyzed by a 2 by 2 ANOVA with discourse (coherent or scrambled dialogues) and sentence condition (transitive vs. intransitive dialogues) as between-subjects factors. No effect was significant (Fs < 2.2, ps > .14), suggesting that the 2-year-olds in all discourse and test conditions looked away about equally during the test trial (coherent, transitive: M = .18 s, SD = .12; coherent, intransitive: M = 0.21 s, SD = .13; scrambled, transitive: M = .28 s, SD = .29; scrambled, intransitive: M = 0.25 s, SD = .25). The 3-year-olds' time spent looking away was analyzed by a one-way ANOVA with sentence condition (transitive vs. intransitive dialogues) as a between-subject factor. Again, no effect was significant (F < 2.7, p > .12), suggesting that the 3-year-old children in the two sentence conditions looked away about equally during the test trial (coherent, transitive: M = .52 s, SD = .69; coherent, intransitive: M = 0.21 s, SD = .24). Given the

uniformity of time spent looking away, we conducted our main analyses on a single measure, looking time to the two-participant event as a proportion of total time spent looking at either test event, during the novel-verb test item.

Preliminary analyses of 2-year-olds' test-trial performance revealed no interactions of discourse and test condition with sex, whether children's performance in the practice trials[18] or their vocabulary level was above or below the median (Fs < 1.4, ps $> .25$). The corresponding analyses of the 3-year-olds' revealed no interactions of sentence condition with sex, whether children's performance in the practice trials [19]or their vocabulary level was above or below the median (Fs < 1.2, ps $> .28$). Thus, the data were collapsed across these factors in subsequent analyses.

Results and Discussion

Figure 11 shows data for the 3-year-olds' and the 2-year-olds' mean proportion of time spent looking at the two-participant event, out of total looking-time to either test event.

First, note in Figure 11 that we replicated 3-year-olds' performance in coherent-dialogue condition of Experiment 6 and 7, using the dialogue materials with added audio-video noise. As in Experiments 6 and 7, 3-year-old children who heard coherent transitive dialogues looked longer at the two-participant event as opposed to the one participant event ($M = .62$, $SD = .13$), than did children who heard coherent intransitive dialogues ($M = .51$, $SD = .14$), $t(28) = 2.066$, $p = .048$. Thus the noise additions did not disrupt the 3-year-olds' ability to identify the transitivity of the novel verbs, with discourse support.

[18] The median of 2-year-old children's target preference in the practice trials was .61.
[19] The median of 3-year-old children's target preference in the practice trials was .65.

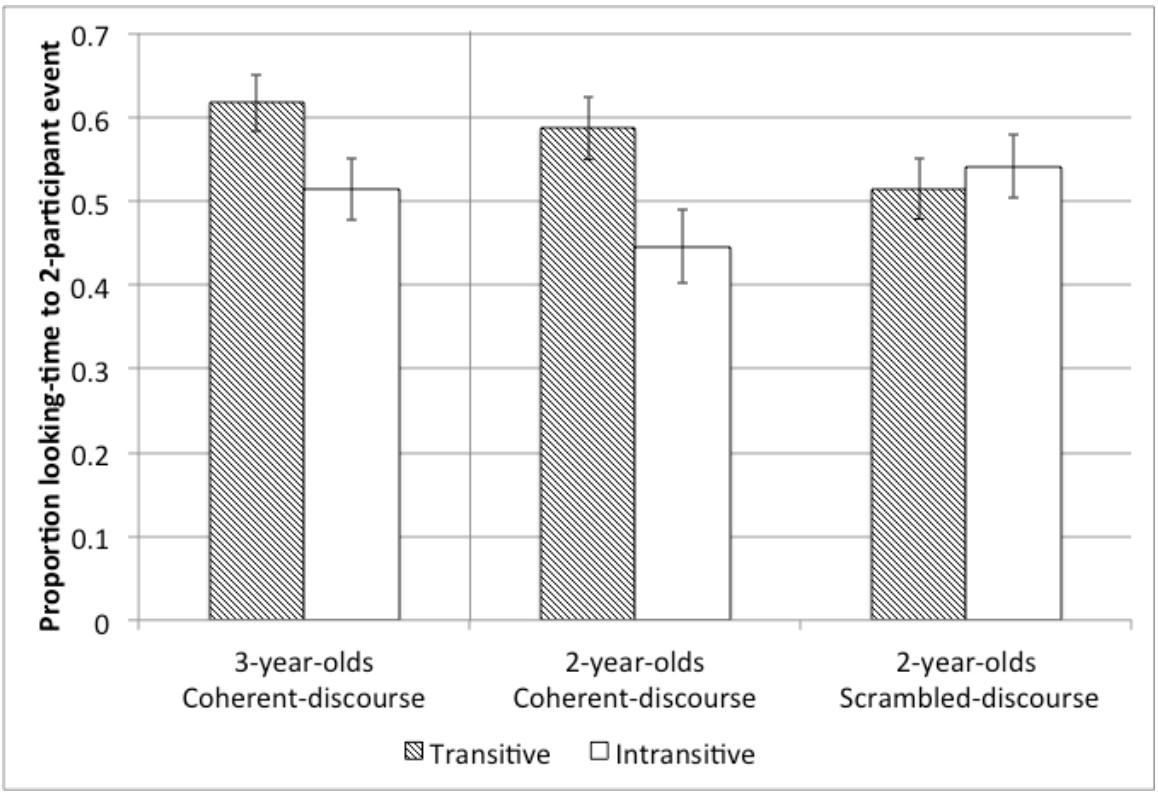

Figure 11. Mean (se) proportion looking-time to the two-participant causal event (2- and 3-year-olds, Experiment 8).

For younger children, 2-year-olds, a 2 (discourse: coherent, scrambled) by 2 (sentence: transitive, intransitive) revealed an interaction of discourse and sentence condition, $F(1, 60) = 4.693$, $p = .034$. 2-year-old children who heard coherent transitive dialogues looked longer at the two-participant event as opposed to the one participant event ($M = .59$, $SD = .15$), than did children who heard coherent intransitive dialogues ($M = .45$, $SD = .18$), $t(30) = 2.457$, $p = .02$. In contrast, in the scrambled-dialogue condition, the looking preferences of children who heard transitive dialogues ($M = .51$, $SD = .14$) did not differ significantly from those who heard intransitive dialogues ($M = .54$, $SD = .15$), $t < 1$. Analyses of two-participant looking-times revealed a significant effect of dialogue, and a significant interaction of dialogue and test condition. Thus, dialogue type affected looking preferences in the test trial, but did so only for

children in the coherent-discourse condition.

Further results

The results of Experiments 7 and 8 suggest that English-learning 2- and 3-year-olds can use the discourse context to help them analyze sentences with missing subjects, and therefore identify the transitivity of a novel verb. Key evidence for this interpretation is that children in the scrambled-dialogue conditions, in both experiments, yielded no systematic effect of dialogue on looking times at test. Apparently, without discourse support, children had trouble identifying a sentence such as "Pilking the baby" as a sentence containing a transitive verb.

However, an alternative interpretation is that, for children in the scrambled-dialogue condition, the structure of the video materials presented during the dialogue might have disrupted children's processing of the critical sentences. In the coherent-dialogue condition, the dialogues were presented as multiple continuous conversations between two talkers, both visible in the video frame. In contrast, in the scrambled-dialogue condition, individual sentences of the coherent dialogues were cropped, reordered, and presented sentence-by-sentence with a brief blank screen interval intervening between all adjacent sentences. This method of creating the scrambled dialogues was intended to avoid creating unnatural discourse transitions between the re-ordered sentences, which might disrupt sentence processing. However, it might be that children were distracted by the cropped presentation of the scrambled dialogues, and therefore found it more difficult to comprehend the sentences in that condition.

To rule out this alternative interpretation, we tested an additional 24 2-year-old children (29.9-35.9 months, $M = 31.2$, 15 girls) with a new cropped-coherent dialogue condition. In the cropped-coherent condition, the same individual-sentence clips that were used to create the scrambled condition of Experiment 8 were re-arranged and played in their original order. As in

the scrambled condition, these clips were cropped to show only the active talker, and were presented one at a time on the center of the screen, with adjacent sentences separated by 10-frame intervals. Data collection is still ongoing, to attain a planned sample of 32. However, the preliminary data are promising.

Figure 12 shows preliminary data for the 2-year-olds' mean proportion of time spent looking at the two-participant event, out of total looking-time to either test event, for children in the cropped-coherent-discourse condition. As in the coherent-dialogue condition of the main experiment, 2-year-old children who heard transitive dialogues (n = 12, M = .61, SD = .08) tended to look longer at the two-participant event, as opposed to the one participant event, than did children who heard coherent intransitive dialogues (n = 12, M = .45, SD = .26), t(12.959) = 2.037, p =.063[20].

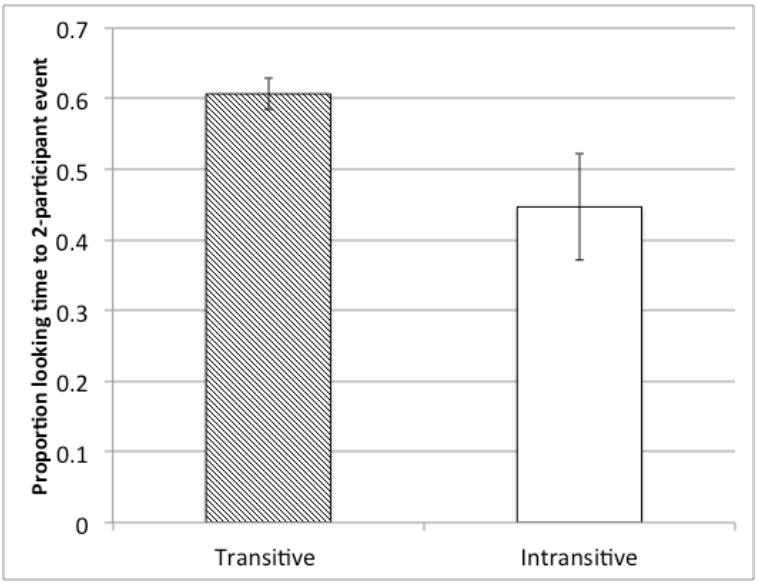

Figure 12. Mean (se) proportion looking-time to the two-participant causal event in the cropped-coherent discourse condition (2-year-olds).

[20] The Levene's Test for Equality of Variances was significant, p = .009. Thus, equal variances could not be assumed for the transitive and intransitive groups. We speculate that the variance of the intransitive condition could be larger than that of the transitive condition, because the intransitive condition is less referentially constraining. We corrected this violation by using the unpooled estimate for the error term in the t-test, and adjusting the degree of freedom.

These preliminary results help to support our interpretation of the findings from Experiments 6, 7, and 8, that English-learning toddlers can exploit discourse continuity to correctly identify a novel verb's transitivity despite null-subject transitive sentences. The 2-year-olds tested in Experiment 8, as well as in the follow-up study from which we report preliminary results, are similar in age to the Korean-learning children whom we have previously shown can readily use discourse continuity to help them identify the syntactic structures of novel verbs (Jin et al., 2014). These results suggest an intriguing conclusion, that children learning any language will find the discourse context useful in learning verb syntax despite noise in the data. We began by noting a serious problem for syntactic bootstrapping, the unreliable relationship between the number of overt noun-phrases that the child might identify in individual sentences, and the true number of syntactic arguments licensed by the verbs in those sentences. A coherent discourse context helps young leaners to use the recent conversational history to fill in missing arguments, thus supporting their learning of the transitivity of each verb.

General Discussion

In Chapter 3, we found that Korean-learning 2-year-old children can use discourse information to assign different interpretations to novel transitive and intransitive verbs despite pervasive omission of arguments. These findings provided compelling evidence for the usefulness of syntactic bootstrapping in argument-dropping languages: children identify each verb's true argument structures by relying on their expectations for discourse continuity. Here, we explored the universality of children's discourse-continuity bias by testing English-learning children. We predicted that discourse information should help children's verb learning and sentence interpretation in any language, if the bias comes from a general expectation of discourse continuity that might be universally available to children.

In three experiments, English-learning 2- and 3-year-olds identified the transitivity of a new verb presented in null-subject transitive sentences. They did so only when the discourse context cued children to expect a missing subject (e.g., "What's Grandma doing?" "Pilking the baby!"). Thus, an expectation of discourse continuity facilitates verb learning by helping young learners collect evidence for verb argument-structure across nearby sentences.

The null-subject sentences in the transitive dialogues ("Pilking the baby") did provide within-sentence word order and morphological cues that might have been sufficient for children to identify the verb as transitive. However, these cues did not provide enough information for the 2- and 3-year-old children to identify our null-subject sentences as transitive, without discourse support. One might assume that, as children acquire more linguistic knowledge, they might be able to succeed with only these sparse morphosyntactic cues even without support from discourse structure. Future research with older children can investigate when children's grammatical knowledge provides enough support in interpretation of null-subject sentences.

One important remaining question is how discourse information might prompt such modifications of input sentences. Not all adjacent sentences, even ones within a coherent discourse, share arguments. For example, a question similar to the ones in our dialogues, "What's Mom doing?," might be answered by a sentence that includes the focused referent from the question, as in "(She's) talking on the phone." However, one might also respond with a sentence such as "Grandma's on the phone." This sentence would answer the question perfectly well, but via a bridging inference (e.g., Clark, 1996), rather than by direct argument overlap between question and answer. Too strongly assuming that any answer must include (as a syntactic and semantic part of the sentence) the key referent from the question might lead to errors, if children attempt to force an extra argument into a sentence that is not missing anything. How could

children decide which sentences they want to combine, to estimate the intended argument structure of each sentence in connected discourse?

Two kinds of information could guide this decision. First, the meaning of the preceding sentence, and its fit with what is known about the target sentence, should matter. In our dialogues, the questions all referred to actions, as in “What’s Grandma doing?”. The action meaning of the question then might make it easier to interpret an incomplete answer such as “Pilking the cat”, with its action-appropriate progressive verb morphology, as containing a verb referring to an action, and therefore a direct answer to the question. The same novel-verb sentence might be interpreted differently in a different discourse setting in which the prior sentence does not ask *which action* the discourse topic is doing, but asks about something else, as in “What’s Grandma reading?.”; in this case, the response “Pilking the cat” would receive no semantic support for interpretation as an action verb.

Second, and relatedly, grammatical features that link the target sentence to its discourse context could help. In our dialogues, both the question and answer matched in tense and aspect ("What’s Mom doing?" or "What was Mom doing?" "Pilking the cat!"). Even a young child’s tendency to assume that adjacent sentences share arguments might be decreased, if the target and preceding sentences differed in their grammatical features. For example, if the target sentence “Pilking the cat” were preceded by the question “What did Grandma do?,” it might be more difficult for children to identify the verb in the target sentence as transitive. In future research, we hope to explore interactions between discourse structure and both the semantic and syntactic cues in the target sentence, to explore how young children use the discourse context to help identify the intended syntactic structure of each sentence.

CHAPTER 5

CONCLUSIONS

Previous research on early verb learning has shown that children assign different meanings to novel verbs presented in different sentence structures, providing support for the syntactic bootstrapping theory (e.g., Arunachalam & Waxman, 2010; Arunachalam et al., 2013; Fisher, 1996; Fisher et al., 1994; Lidz, Gleitman, & Gleitman, 2004; Naigles, 1990, 1996; Naigles & Kako, 1993; Yuan, Fisher, & Snedeker, 2012). The project addressed two main questions about syntactic bootstrapping. The first question is how syntactic bootstrapping could begin in infancy, even before infants have leaned much about the syntax of their native language. The second question is how syntactic bootstrapping could work despite noisy input caused by missing or misidentified arguments.

Chapter 2 investigated the origins of syntactic bootstrapping. We have adopted the structure-mapping account as the working hypothesis for our research. On this account, syntactic bootstrapping begins with an unlearned mapping bias between nouns in sentences and participant roles in events. Results showed that even 15-month-olds could use the number of nouns in sentences in interpreting novel transitive and intransitive verbs. This is the first evidence that infants at this age use sentence structure to learn verb meanings. We argued that the early age of this result is important because no evidence that we are aware of shows that infants younger than this age can do multi-word sentence comprehension. Thus, our findings strongly support the structure-mapping account, which proposes that a bias for one-to-one mapping between nouns in sentences and participant-roles events is innate. Once infants can identify some nouns and represent them as part of a sentence, they can use sentence structural information to assign verb meanings. Chapter 2 also found that slightly older infants, 19-month-olds, could use the number

of nouns, even without additional information from case-marked pronouns. Together, these findings suggest that syntactic bootstrapping begins with an inherent bias in early infancy, without much learning of language-specific syntactic knowledge.

Chapter 3 investigated how syntactic bootstrapping works in argument-dropping languages. Prior experimental research on syntactic bootstrapping has largely focused on highly informative linguistic contexts, in which each verb's arguments are all overtly displayed in the surface structure of the sentence. However, frequent argument omission in many languages challenges the syntactic bootstrapping theory, because children learning those languages often encounter a verb with only some of its true arguments. We asked whether Korean-learning children could use discourse information to collect a verb's arguments across nearby sentences in a coherent discourse. Results showed that Korean 2-year-old children could identify a verb as transitive even when the verb rarely occurred with two nouns, or even when it never occurred with two nouns. To do so, children consulted the discourse context, which provided useful linguistic support for the recovery of missing nouns. These findings provide important evidence about the mechanisms of syntactic bootstrapping in realistically noisy input. They suggest that children's representations of individual sentences, which in turn were used to help assign a meaning to the verb, can be affected by the linguistic discourse context. Argument-dropping languages might not pose a serious challenge to the syntactic bootstrapping theory after all, if children can recover missing arguments from discourse.

Chapter 4 investigated the universality of the discourse-continuity bias. The motivation for these studies was to discover whether Korean children's use of discourse information to fill in the arguments of a verb depended on a universal expectation of discourse continuity across sentences, or rather depended on learning this expectation with regard to verb syntax in

particular. Because in Korean, verbs' arguments are missing more often than not, one might propose that as children learn the meanings of verbs, they learn that the arguments of those verbs are rarely present in a single sentence, but must be sought out in a representation of the prior discourse context. We therefore tested children learning English, a language in which argument dropping is much less common. English makes a useful contrast to Korean because whereas in Korean, arguments are missing more often than not, in English arguments are present more often than not. Thus, unlike Korean, English does not force children to learn to seek a verb's arguments in the prior discourse, because English displays much more reliable information about each verb's arguments. We reasoned that if English-learners can use discourse context to identify a novel verb's arguments as Korean-learners do, then we would have evidence that the use of discourse continuity in verb learning follows from a more general expectation of discourse continuity, which is perhaps available in any language. Results from Chapter 4 suggest that English-learning 2- to 3-year-old children can rely on an expectation of discourse continuity to draw appropriate inferences about a transitive verb that occurred without its full set of arguments. These findings suggest that the discourse bias may be language-universal: an expectation of referential continuity across sentences in a connected discourse allows children to integrate across nearby sentences in a discourse to gather a verb's intended arguments.

In summary, the findings in this project provide additional evidence for syntactic bootstrapping. Syntactic bootstrapping starts with an innate structure-mapping bias linking nouns and participant-roles. This bias enables even infants at the onset of multi-word sentence comprehension to use the set of overt noun-phrases to interpret transitive and intransitive verbs in sentences, as shown in Chapter 2. However, the experiments reported in Chapters 3 and 4 suggest that children are not helpless when nouns are missing. Both in English and in Korean,

the child's representation of each sentence depends not only on the words in that sentence, but its place in the larger discourse structure. When the preceding context strongly suggests that a topic referent might be part of the next sentence, children can identify a verb as transitive, based on hearing it used in sentences, even when they never encounter it in a sentence containing two nouns. In this way, children's discourse continuity bias increases the linguistic support for learning verb syntactic and semantic structure.

Our findings suggest that children can use discourse information to find a verb's true argument structure, by pooling arguments across sentences within a coherent discourse. One interesting question for future research is how children decide which sentences they want to combine in this way. Even within a coherent discourse, not all adjacent sentences share arguments. For example, the question "What's Mom doing?" could be answered not only by a sentence that share referents, as in "(She's) talking on the phone," but also in a sentence that is linked to the question by pragmatic inference, as in "Grandma's on the phone." A simple bias to combine the current sentence with any prominently established topic would lead to errors when the nearby sentences do not share arguments. How can children avoid such errors and appropriately integrate suitable sentences in discourse?

In the general discussion of Chapter 4, we speculated that at least two kinds of information might guide children's decisions about which sentences in the discourse they want to integrate to infer that a verb has a missing argument. First, the meaning of the context sentence, and its fit with what the child knows about the target sentence, could matter. The question "What's Mom doing?" implies an answer describing an action; this semantic constraint may help children to identify a novel-verb sentence "(She's) pilking the cat!" as a transitive sentence containing a novel progressive-marked verb, appropriate for describing an action. However, a

different question, such as “What’s Mom reading?,” implies a different answer (a description of her reading matter, perhaps the name of a book); these different semantic constraints might not allow children interpret the answer “Pilking the cat!” as a sentence with an action verb. Second, and relatedly, the overlap in the grammatical features of the adjacent sentences might matter. The question “What’s Mom doing?” and the answer “(She’s) pilking the cat!” match in verb tense and aspect morphology. This congruency in verb morphology might encourage children to treat the two sentences as related. In contrast, children might be less likely to link two sentences that do not match in verb morphology, for example, “What’s Mom doing?” and “Pilked the cat!” We hope to explore this possibility in future experiments.

This dissertation provided evidence that 1) young children at the onset of multiword sentence comprehension can use number of noun information to interpret verb transitivity and 2) older children can exploit discourse information to recover missing arguments. One interesting question for future research might be whether discourse support can help younger children gather useful data about verb syntax from listening experience, even before they are very skilled at multi-word sentence comprehension, and thus perhaps even earlier than shown in Experiments 1 and 2. For example, infants' interpretation of the two-noun transitive sentence “Grandma is pilking the cat!” could be facilitated when the sentence follows a sentence that already introduces one of the arguments, as in “What’s Grandma doing?” or “What’s up with the cat?” If young children have early sensitivity to discourse continuity, a preceding question could help their verb interpretation, possibly by representing one of the two arguments in situation model before they have to process the new verb and the two nouns. In future research, we hope to test this possibility by providing discourse information to younger children and investigating whether

discourse information impair their multiword sentence comprehension, thus supporting their learning of verb transitivity.

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