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Specifying Event Reference in Verb Learning

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1. Introduction

To identify the meaning of a verb, young language learners benefit from the linguistic context in which it appears. For example, verb argument structure (i.e., the structural relations between a verb and its arguments, and more specifically the NPs or DPs appearing with it) can be a powerful cue to meaning, even for very young children, allowing them to discern a verb's broad semantic category (e.g., Arunachalam & Waxman, 2010; Arunachalam et al., 2013; Fisher, 1996, 2002; Hirsh-Pasek et al., 1996; Landau & Gleitman, 1988; Naigles, 1990; Naigles & Kako, 1993; Noble, Rowland, & Pine, 2011; Yuan & Fisher, 2009).

In a now well-established paradigm, Naigles (1990) and Naigles & Kako (1993) presented children with novel verbs (e.g., *gorp*) in either a Transitive frame (e.g., *John is gorping Mary*), Intransitive frame (e.g., *John and Mary are gorping*), or a Frameless condition (Naigles & Kako only) (*Look! Gorping!*), accompanied by a scene in which two event participants simultaneously interacted with each other (for example, one forces the other to bend over), and also engaged in an individual event (each makes arm gestures). During the test phase, participants were presented with a forced choice between the two previously-conflated events: a scene representing a Causative event (participant 1 forcing participant 2 to bend over) and a Synchronous event (participant and participant 2 both making arm gestures), and asked to *Find gorping!*

These studies demonstrated that the transitive frame exerts a special influence on children's mapping of verb form to meaning – pulling children's attention towards a causative scene – and more generally that young children use syntactic information to constrain verb meaning. This pattern in turn reveals that young children are aware of the semantics associated with syntactic structures: specifically, that transitive frame corresponds to a causative scene, because the noun (or DP) preceding the verb in subject position should be mapped to an agentive role (the participant performing the causative action), and the noun

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following the verb in object position should be mapped to a patient role (the participant upon which the causative action is performed).

However, while children's understanding of the syntax-semantics linking in the transitive frame seems clear, their understanding of the syntax-semantics correspondence associated with other structures is less clear. As we noted above, intransitive frames involving conjoined subjects are often used as a comparison condition for the transitive, since they sentences identify the same event participants in the same order, but do not imply a causation relationship between them, given the semantic roles assigned to participants in their respective argument positions (i.e., in this frame, both are agents). Given the two choices during the test phase in the paradigm described above (two actors engaged in a causative event vs. two actors engaged in individual, synchronous events), children *do not* consistently prefer synchronous events as the referent for novel intransitive verbs (Arunachalam & Waxman, 2010; Hirsh-Pasek et al., 1996; Naigles & Kako, 1993; Noble et al., 2011). Thus, when presented with a transitive frame and a choice between a Causative event and Synchronous events, children are pulled away from the Synchronous scene toward the Causative one, but when presented with an intransitive frame, they do not exhibit a preference – or else do not pattern any differently than in the Frameless condition.

It may be that children fail to map the conjoined-subject intransitive frame to synchronous events because their ability to understand this structure is still developing (Gertner & Fisher, 2012; Noble et al., 2011). Younger children resort to strategies for interpreting the sentence, such as tracking the number and order of nouns. This would mean that at least sometimes, they might map the first noun onto the Agent role and the second onto the Patient role (Chang et al., 2006; Gertner & Fisher, 2012; Yuan & Fisher, 2009; Yuan et al., 2012), which is perhaps why they failed to show a strong preference for mapping novel verbs in intransitive frames to Synchronous scenes.

However, Arunachalam & Waxman (2010) have entertained an alternate position: namely, that children's performance reflects the underspecified semantics associated with the conjoined frame, not a lack of linguistic knowledge. That is, the intransitive frame is compatible with multiple interpretations, and the linguistic information provided in the experimental context does not provide children with enough information to identify the intended interpretation.

In the current research, we elaborate on this hypothesis and offer new experimental evidence in support of it. We posit that the intransitive frame is underinformative in two ways. First, it is compatible with a range of verb meanings, which may be organized taxonomically. Given a scene with two participants interacting, a novel verb appearing in an intransitive frame might refer to general actions, such as 'playing', 'behaving nicely', or 'moving', or to a more specific action subsumed by one of these labels, such as 'waving', 'spinning', and so forth. Both kinds of meanings and their real-world event counterparts are frequent and familiar, and are not implausible given the two

possible referents seen at test. If children pursue a more general kind of meaning at the higher taxonomic level, they will likely find both candidate scenes to be suitable referents at test, thus explaining their chance performance in the intransitive condition in such studies.

Second, the intransitive frame is ambiguous as to whether the event is predicated of the entire *group* of participants or of *each* of the event participants mentioned in the conjoined subject individually. This is known as a ‘collective/distributive’ ambiguity in the semantics literature on plurality (see, for example, Landman, 1996; Link, 1983, 1987). In a sentence such as *John and Mary are gorping* or *The girls are gorping*, the subject – whether it is conjoined DPs or NPs, or a single phrase headed by a determiner – denotes a plurality of individuals, or a group. This plurality has an internal structure, which may be represented by a semi-lattice structure or set membership. This allows the plurality to have atomic subparts (the individuals, and combinations of them, if there are more than two), and the whole itself.

The predicate *are gorping* can apply, then, at multiple levels.¹ In the case where the verb (or predicate) targets the entire group or plurality, the collective reading is favored. In this case, the favored interpretation may be one in which the two participants are working together to pursue a common goal or collectively engaged in an activity, in which case the singular causative event may be the favored referent. When the verb targets the individuals, the distributive reading is favored (because the predicate distributes over the individual event participants). In this case, the better referent for the verb is the scene with multiple and synchronous events, since each of the event participants is performing the same action.

Supporting evidence that the intransitive frame is underinformative comes from an experiment conducted with adults by Sheline, Waxman, and Arunachalam (2013). Adults were shown the same stimuli used by Arunachalam and Waxman (2010), in which 2-year-olds heard novel verbs in transitive or conjoined-subject intransitive sentences. At test, in addition to choosing between causative and synchronous referents for the novel verbs, they were also asked to rate their confidence that they had chosen the correct referent, as well as what they thought the novel verb meant. If the intransitive frame signals a non-causative referent, or synchronous event referent (by virtue of a universally encoded syntax-semantics link between argument structure and semantic role and/or probabilistic interpretation), then adults should be aware of this correlation and choose the Synchronous scene as the better match for the intransitive frame, and provide possible interpretations that corresponded to the meaning represented.

Not surprisingly and not unlike the two-year-olds, adults preferred the

¹ There are some predicates which are restricted from applying at either the higher or lower level, but we will leave that issue aside and only concern ourselves with predicates that can target either level (so-called ‘mixed predicates’), and therefore render the sentence ambiguous.

causative scene as a referent for novel verbs in the transitive frame. However, they were at chance in choosing between the causative and synchronous referents for the verb in the conjoined subject intransitive frame. Further, adults were significantly more confident in the transitive than intransitive condition. In addition, adults often provided a translation corresponding to the intended one ('spinning'), while those who had heard the verb in the intransitive frame provided a variety of definitions. In addition to the target interpretation ('wave'), participants provided other meanings, such as 'play', 'do something together', or 'could be anything'.

In the current work, we (a) replicated this pattern from adults on a broader scale, providing further support for our hypothesis that the intransitive frame is underinformative, and (b) asked whether presenting additional lexical information could provide the requisite semantic information that would allow participants to overcome this underinformativity and map novel intransitive verbs to synchronous events. Specifically, we investigated adverbial modification as a source of the requisite semantic support.

Precedence for adverbial modifiers playing a role in word learning comes from two complementary sources. First, Syrett (2007) and Syrett and Lidz (2010) demonstrated that 30-month-olds can recruit the semantics of adverbial modifiers such as *very* and *completely* to identify the denotation of novel gradable adjectives, and do not demonstrate the same pattern of performance with a bare adjective, or an adjective modified by a novel adverb. *Completely* encodes a selectional restriction that the adjective that it modifies must have a maximal endpoint, while *very* indicates deviation from a standard. Children appear to be tuned in to this lexical semantic information and make use of it in a word learning experiment.

In recent work (Syrett, Arunachalam, & Waxman, 2013), we also found that certain adverbial modifiers support verb learning. In a forced choice task similar to those reported above, two-year-olds recruited the frequent manner-of-motion adverb *slowly* to deduce that a novel word had a motion verb interpretation. The difference between the verb frame appearing in that experiment and the ones reported above is that in Syrett et al. (2013), pronouns appeared in place of the full lexical nouns, which were displaced in the preceding sentence. Without the adverb, young children were at chance. Evidence that they were using the lexical semantics of this adverb to map form to meaning comes from the fact that a vague, manner-of-motion adverb (*nicely*) and a contextually-bounded adverb of even greater lexical frequency (*right now*) did not produce the same effect. We argued that *slowly* led children to focus their attention on the manner of motion represented in the event, and that this provided them with the needed semantic boost to acquire the motion verb.

Given the promise of using adverbial modifiers in the word learning experiments demonstrated in these previous lines of work, and the replicable finding that children – and even adults – remain at chance when presented with a novel verb in an intransitive frame and the choice between a Causative event and Synchronous events, we chose to investigate whether the presence of an

adverbial modifier with the requisite lexical semantics could make a similar contribution in this context, and focus children's attention on the relevant construal of a visual scene.

For this purpose, we targeted *together*, which (under one interpretation) signals that two events (or eventualities) denoted by a VP share spatial proximity and temporal contiguity (Lasnik, 1998). For example, *The boy and the girl are gorging together* may give rise to the interpretation that each of them is gorging, and that these actions are coordinated in space and time. (There is also a salient 'collective' reading, which is often the preferred reading of *together*, but this reading is not supported in either test event. Consequently, we focus on the 'distributive' or synchronous reading.)

Indeed, recent work by Syrett et al. (2011) and Syrett and Musolino (2013) has shown that by at least four years of age, children are sensitive to this aspect of the meaning of *together* and know that *together* can be used to describe events with the kind of spatiotemporal contiguity depicted in synchronous event scenes. Not only do they accept sentences with a plural numerical subject (e.g., *Two boys*) and a predicate modified by *together* (e.g., *Two boys pushed a car together*) in both collective and distributive (i.e., non-causative, synchronous event) contexts, but they cease to accept such sentences in the distributive context when the actions no longer share a temporal link. In their rejections to a puppet, some children even provided explanations appealing to the fact that the events took place *separately*, or that one pushed his car, and *then* the other pushed his car (or whatever event transpired).

On the basis of this evidence, we predicted that sentences with a conjoined-subject (which also denotes a plurality) and a verb appearing in an intransitive frame with a post-VP *together* could lead participants to map novel verbs to synchronous scenes in which two event participants engage in spatiotemporally coordinated actions.

To preview our results, we first replicated previous work in that when presented with the conjoined-subject intransitive sentence without *together*, both 2.5-year-old children and adults were at chance in choosing between causative and synchronous event referents for novel verbs. However, the addition of *together* led both groups to prefer synchronous event referents. These findings therefore support the hypothesis that the intransitive frame is semantically underinformative in the context in which it has been presented in these verb learning experiments, and that chance-level performance results from lack of access to information that could disambiguate the sentence, rather than a lack of linguistic knowledge of structural relations or a syntax-semantics mapping. As our target adverb *together* fills this disambiguating role, our findings add to the mounting evidence that the lexical semantics of adverbial modifiers can be recruited by young children when learning the meaning of words.

2. Method

Participants. Native English-speaking adults (N = 30; 15 in each condition)

and children (N = 45; 26 in the *Together* condition, 19 in the Control condition) participated. Data were excluded from an additional three children who did not cooperate or did not point correctly during the warm-up trials. Participants were recruited from the Central NJ, and Boston, MA, areas. Because previous work suggests that children do not map conjoined-subject intransitive sentences to synchronous events until approximately age 40 months (Noble et al. 2011), we focused on children near this threshold, at a mean age of 37.9 months (range: 28.0 to 47.0 months), dividing each condition into an younger and older group (37 months or less, and 38 months or greater). Adults were tested in the Rutgers University Laboratory for Developmental Language Studies. Children were tested either in preschools in the areas indicated above or in the Boston University Child Language Lab in Boston, MA.




Materials. We adapted a design used successfully to study children's mapping of transitive and intransitive sentences to causative and synchronous events (Arunachalam & Waxman, 2010; Yuan & Fisher, 2009), focusing on their performance with the conjoined-subject intransitive frame. Children and adults heard novel verbs in videotaped conversations between two female actors, in which the novel verb appeared in conjoined-subject intransitive sentences with and without *together*, depending on the condition (e.g., *The boy and the girl lorped (together)*). They then saw two test scenes side-by-side: one depicting two actors engaged in Synchronous, spatiotemporally coordinated actions, and the other depicting a Causative event. The percentage of participants' points to the target, Synchronous scene in response to the test query, "Where's *lorping*?" served as the dependent measure.

The videotaped conversations and scenes of actors performing the test events were all recorded using a Sony digital camera in a quiet, enclosed laboratory space. They were then edited using iMovie, with factors such as length, lighting, and relative salience controlled for. The auditory stimuli used at test were recorded by a female native speaker of American English in a sound-attenuated booth using a child-directed speech register. The sentences were synchronized with the stimuli to create the sequences in Table 1.

Procedure. Videos were presented to participants on a computer monitor. We asked participants to indicate their choice of scenes by pointing. This measure has been used successfully in a number of studies with children of this age. We first presented the children with two warm-up trials, which were designed to encourage pointing to one side of the screen. Two video clips of Sesame Street characters were presented side-by-side on the screen, and the experimenter asked the participant to point to a scene described with a linguistic prompt – once to a particular character (e.g., Big Bird vs. Elmo), and once to a particular action (e.g., dancing vs. eating). On warm-up trials only, the experimenter demonstrated the correct response if the child pointed incorrectly. Adults were told that they would watch a video designed for children, and were not shown the warm-up pointing trials, because piloting indicated that it was

unnecessary. The warm-up was followed by four trials, each involving a novel verb. Each trial had the same structure. There were two phases: Dialogue and Test, as indicated in Table 1.

Table 1. Sample trial (one of four)

	Dialogue Phase	Test Phase
		 Synchronous  Causative
<i>Together Condition</i>	A: Guess what? B: What? A: The boy and her sister lorped <u>together</u> . B: Really? The boy and her sister lorped <u>together</u> ? A: Mmhmm. And the girl and the lady are going to lorp <u>together</u> . B: Oh yes, the girl and the lady are going to lorp <u>together</u> .	Look! Where's lorping?
<i>Control Condition</i>	A: Guess what? B: What? A: The boy and her sister lorped. B: Really? The boy and her sister lorped? A: Mmhmm. And the girl and the lady are going to lorp. B: Oh yes, the girl and the lady are going to lorp.	

Dialogue Phase. At the beginning of each trial, participants viewed a videotaped scene of two women having a conversation, in which they each used a novel verb in conjoined-subject intransitive sentences either with or without *together*. Participants were exposed to the novel verb in the intransitive frame eight times, four times by each actor. Each dialogue consisted of two six-sentence clips (the one presented in Table 1 and another similar clip preceding it), averaging 34 s.

Test phase. Children then saw two test scenes simultaneously, side-by-side. Both scenes depicted the same two participants (e.g., two women), and two different types of scenes: (1) two actors engaged in Synchronous, spatiotemporally coordinated actions (e.g., two girls bending up and down), and (2) two actors engaged in a Causative event (e.g., one girl pulling another girl's hands, causing her to bend over).

There were four such trials, each involving a different novel verb and two

different actions pitted against each other. The event participants differed on each trial. Two trials involved two human actors, and two trials involved one human actor and one inanimate object. On animate-inanimate trials, the animate participant was always the agent of the causative action (e.g., a girl opened a box).

The test phase (15 seconds) began with a brief inspection period, during which children heard, “Look! Wow!” This period allowed them to inspect the test scenes. The scenes then disappeared, and they heard the test query, e.g., “Where’s lörping?” (Crucially, this test query provided no syntactic information at this point to indicate its meaning.) The test scenes then reappeared in their original locations, the test query repeated, and the child was asked to make a selection by pointing. Adults circled their response (Left/Right).

The experimenter encouraged the child to point if he or she was reluctant to do so (e.g., “Can you show me?”), but did not provide any linguistic cues that could help the child determine the verb’s meaning. Neutral encouraging feedback (e.g., “Good pointing!”) was given, regardless of which scene the child pointed to.

Coding and Analysis. In the lab, pointing responses were recorded by two trained coders, blind to study hypotheses. One coder was seated next to the child and elicited pointing; the other watched the procedure, but did not participate. In the preschools, one or two experimenters blind to the hypothesis ran the study, and recorded responses on a response sheet. Coders agreed on all trials. Adults run in the lab recorded their own responses in a booklet, and were not allowed to review or change their responses after they had been recorded.

Predictions. We predicted that if *together* can direct learners’ attention to spatiotemporally coordinated events, then only those participants in the *Together* condition should prefer the Synchronous scene at test compared to those in the Control condition, who would perform at chance level.

3. Results

The results are presented in Figure 1 below. As predicted, in the Control condition, all participants performed at chance; adults selected the synchronous scene 50.0% of the time, and children did so 52.6% of the time. However, in the *Together* condition, both groups performed significantly above chance. Adults chose the Synchronous scene 81.7% of the time (compared to chance, $t(15) = 5.6$, $p < .001$), and children 66.3% of the time (compared to chance, $t(19) = 2.8$, $p < .02$).

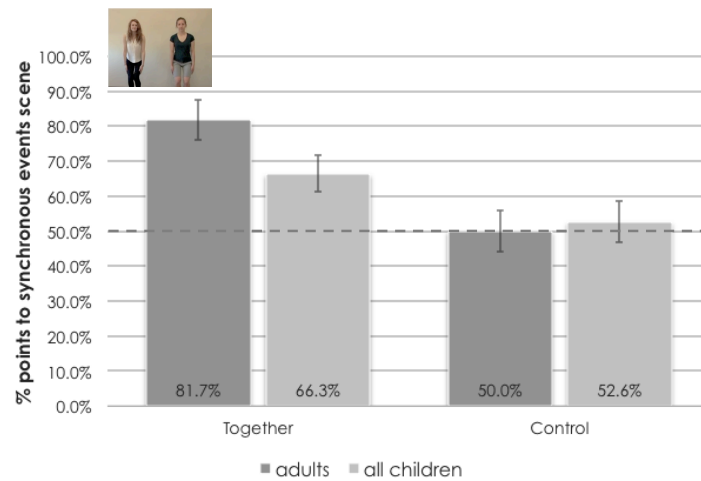


Figure 1. Percentage of pointing responses directed to the Synchronous (target) scene, grouped by linguistic condition and age (adults and children)

Although both children and adults were at chance in choosing between Synchronous and Causative referents for novel verbs appearing in conjoined-subject intransitive frames without *together*, the addition of the semantically informative adverbial modifier *together* boosted their performance, directing them to the scene depicting spatiotemporal coordination between two actors. This same pattern of results also holds for the younger and older groups of children, as shown in Figure 2 (all $ps < .05$ for the *Together* condition).

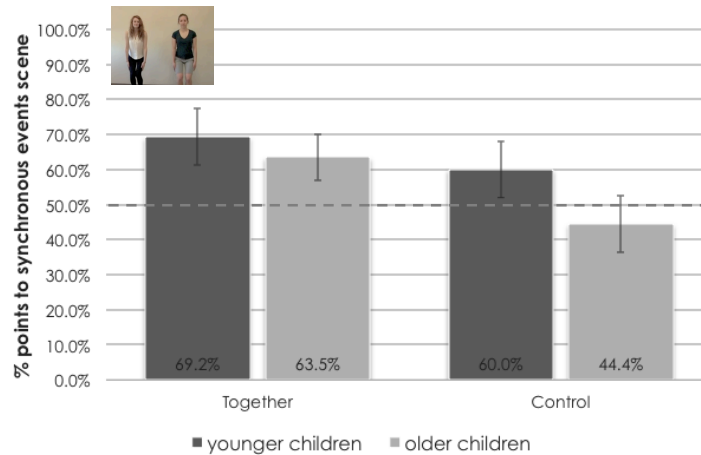


Figure 2. Percentage of pointing responses directed to the Synchronous (target) scene, grouped by linguistic condition and age (younger and older children)

4. General Discussion

In this study, we asked whether the addition of the adverbial modifier *together* could direct participants' attention toward a Synchronous scene, allowing them to map a novel verb appearing in an intransitive frame onto a non-causative, spatiotemporally coordinated events meaning. We provided an affirmative answer to this question. Our findings therefore provide a solution to the well-documented mapping problem with the conjoined-subject intransitive frame: the intransitive frame itself is underinformative, and learners require additional lexical semantic information to resolve the ambiguity inherent to the frame. Whereas the transitive frame may signal causativity, the intransitive frame does not necessarily signal a non-causative meaning – even to adults.

These results also cast previous research on acquisition of novel verbs in the conjoined-subject intransitive frame in a new light. The fact that adults and children behaved similarly in the Control condition calls into question the hypotheses that other scholars have raised about why the conjoined-subject intransitive is difficult for young children. One such hypothesis is that children have not yet acquired the conjoined-subject intransitive. In support of this hypothesis, Noble et al. (2011) provide evidence that 2.5-year-olds do not prefer synchronous events as referents for conjoined-subject intransitives, but by age 3;4, they do. While we, too, found that they do not prefer the synchronous events scene when presented with the verb in the intransitive frame, we also found that adults also lacked such a preference. Such a pattern cannot be explained by a lack of linguistic knowledge. We instead propose that children are behaving like adults in finding many kinds of eventualities, including both Causative and Synchronous actions, to be candidate referents for verbs appearing in conjoined-subject intransitive frames.

However, it still remains to be explained why Noble et al. (2011) found that older children (3;4 and up) *did* prefer the synchronous scenes as referents for the conjoined-subject intransitive verb, and we found *adults* show no preference for synchronous referents for these verbs. Noble et al. (2011) did not test adults, but we suspect that the reason for the discrepancy may be that we presented the syntactic information *before* the event, in dialogues, while Noble et al. presented the syntactic information *simultaneously* with the visual scenes. The former type of presentation requires the learner to posit some kind of representation based on the linguistic information alone, while the latter allows the learner to find the best possible referent given the choices at hand. In at least some word learning situations that include some ambiguity, learners may assign a meaning, despite not having sufficient evidence to do so unequivocally (Trueswell et al., 2013), and this may be what learners are doing in the current study.

Recent work by Pozzan et al. (2012) has suggested that participants may posit a joint activity interpretation (i.e., prefer the causative scene) for the conjoined-subject intransitive when that interpretation is plausible, and specifically, when the two event participants are animate. The reasoning is that *John and Mary are blinking* is likely to describe a joint activity such as fighting,

dancing, or playing, while *John and the box are blinking* is not likely to describe such an action. Pozzan et al. might have predicted that participants in our study would prefer the causative scene on animate-animate trials and the synchronous scene on animate-inanimate trials, when the joint activity interpretation is essentially blocked. In fact, in our study, both child and adult participants behaved similarly in the Control condition, preferring the Synchronous scene for one trial and preferring the Causative scene in another. Moreover, both children and adults preferred the synchronous scene on all trials in the *Together* condition. Why individual trials might elicit different performance, and what aspects of the scene *together* is drawing participants' attention to in order to pull them towards the non-causative scene are questions we wish to entertain in future research.

One final point bears mention. Note that we are not claiming that *together* will promote acquisition of intransitive verbs in all cases. The semantics of *together* highlight one particular interpretation, given the visual scenes we presented to the participants in this experimental context. Given two different test scenes, for example, one depicting a causative event and the other depicting an event in which two actors each perform different actions at different times, we might predict that the addition of *together* would lead participants to choose the causative scene, exactly the opposite of our outcome. This is a reflection of the fact that the semantic contribution of *together* is interpreted within the particular context at hand. Because *together* is compatible with multiple interpretations, the extralinguistic or linguistic context serves to identify which potential meaning is favored over the others. Rather than minimizing the importance of our findings, we believe that this point highlights children's linguistic competence: children are able to interpret sentences – even sentences containing words they do not know – by combining their knowledge of syntactic structure, the syntax-semantics mapping, lexical semantics, and the extralinguistic discourse context. The more information they have, the more successful they are at deducing the meaning of the words they are learning.

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