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Brief article

From semantics to syntax and back again: Argument structure in the third year of life

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Abstract

An essential part of the human capacity for language is the ability to link conceptual or semantic representations with syntactic representations. On the basis of data from spontaneous production, Tomasello (2000) suggested that young children acquire such links on a verb-by-verb basis, with little in the way of a general understanding of linguistic argument structure. Here, we suggest that a receptive understanding of argument structure—including principles linking syntax and conceptual/semantic structure—appears earlier. In a forced-choice pointing task we have shown that toddlers in the third year of life can map a single scene (involving a novel causative action paired with a novel verb) onto two distinct syntactic frames (transitive and intransitive). This suggests that even before toddlers begin generalizing argument structure in their own speech, they have some representation of conceptual/semantic categories, syntactic categories, and a system that links the two.

Keywords: Verb learning; Word learning; Toddlers; Children; Syntax; Semantics; Argument structure

1. Introduction

Learning a language requires learners to acquire not just a set of arbitrary sound-meaning correspondences (words) and a set of rules for combining words into larger units

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(e.g., sentences), but also a systematic means of connecting surface syntactic forms to semantic–conceptual representations. Although, it would be logically possible for a language to express the participants of an event in a unique way for each verb in the language, no human language appears to do so. One never finds, for instance, a language that represents entities that lift things, entities that move things, and entities that throw things in three distinct syntactic positions. Rather, regular relationships link semantic or conceptual roles to syntactic renderings. For example, (in active declarative sentences) causal participants like lifters, movers, and throwers, which all instantiate a common semantic or conceptual role such as AGENT are canonically — in active declarative — sentences expressed as grammatical Subjects, a syntactic notion that may be marked by word order (e.g., in English, Subjects occur pre-verbally), by morphology (e.g., nominative case in Latin), or some combination of the two.

Such systematic relationships, known as "linking rules" (or linking principles), allow languages to relate a small set of abstract semantic/conceptual roles to an even smaller set of grammatical functions, and as such play a crucial role in the productivity of natural language (Dowty, 1991; Jackendoff, 1983; Pinker, 1989). For example, in English, linking principles make it possible to use exactly the same words in a different order to represent two different events (e.g. *The magician noticed the assistant* vs. *The assistant noticed the magician*), or use two different syntactic strings to describe a single event (e.g. *The magician noticed the assistant* vs. *The assistant was noticed by the magician*).

It is generally agreed that children have some grasp of such principles by the fifth year of life (Akhtar and Tomasello, 1997; Fisher, Hall, Rakowitz, & Gleitman, 1994; Gropen, Pinker, Hollander, & Goldberg, 1991), but the capacities of younger children remain uncertain. Evidence from spontaneous speech shows that children's earliest verb-use closely parallels what they have heard: two- and three-year-olds rarely use familiar or novel verbs in unattested, but semantically appropriate, frames (Olguin and Tomasello, 1993; Pine, Lieven, & Rowland, 1998; Tomasello, 1992; Tomasello, Akhtar, Dodson, & Rekau, 1997). Moreover, younger children do not appear to know the significance of surface syntactic cues such as word order. In contrast to four- and five-year-olds, they do poorly in tasks where the only cue to grammatical function is word order (Akhtar and Tomasello, 1997), and they are also quite willing to accept word-order configurations that are inconsistent with the target language (Abbot-Smith, Lieven, & Tomasello, 2004; Akhtar, 1999). These limitations have been interpreted as suggesting that two- and three-year-olds' knowledge of argument structure is "item-specific", rather than "abstract and verb-general" (Tomasello, 2000).[1]

However, several comprehension and priming-style elicitation studies make it clear that two-year-olds possess at least some rudimentary knowledge of argument structure. For example, toddlers prefer to match novel transitive sentences with scenes depicting two participants interacting through a single action, rather than with scenes with the same two participants simultaneously and independently performing the same action (Bavin and

[1] A variation on this interpretation is Childers and Tomasello's (2001) suggestion that children's "early linguistic constructions [are built] around certain specific lexical or morphological items and patterns, perhaps especially around particular pronoun configurations."

Growcott, 1999; Fisher, 2002; Hirsh-Pasek, Golinkoff, & Naigles, 1996; Naigles, 1990). Similarly, toddlers trained extensively on transitive sentences with familiar verbs could extend this frame to nonce verbs (Abbot-Smith et al., 2004; Childers and Tomasello, 2001). Nonetheless, such studies could be interpreted as showing that toddlers know only the *number* of arguments represented by a transitive verb—and not the nature of those arguments (Tomasello and Abbot-Smith, 2002). The crux of argument structure is the ways in which syntactic notions such as post-verbal position relate to semantic notions such as Undergoer. Might toddlers possess "only a weak verb-general representation of the transitive construction that includes information about its basically causative meaning, but not information about how the two different participants (actor, undergoer) are syntactically marked," as Tomasello and Abbot-Smith (2002) suggest?

Aiming to address this issue more directly, Fisher (2000) asked whether children could use word order to decide between two perspectives of the same novel transitive action (e.g., does the sentence *The Bunny is blicking the Duck around* correspond to a scene wherein the Bunny was the Agent and the Duck the Patient, or a comparison scene in which the roles were reversed?). However, prepositional phrases (*around*, *up, and down*) could have provided additional pragmatic information that alone could suffice for success on the task. A related conference report by Naigles, Bavin, and Smith (2002) asked whether children could generalize *between* syntactic frames (e.g., from transitive *You're krazzing the ball* to intransitive *The ball is krazzing* or vice versa), but the method in that study forced children to compare two distinct *actions* with each other—rather than two perspectives on a single event or two argument structures from a single verb. Consequently, the results may have had more to do with learning the core meaning of the verb (i.e. identifying *krazzing* versus *lorping*) than with argument structure per se.

The situation with intransitives is also somewhat problematic. For example, in order to balance the number of characters mentioned (and observed), Bavin and Growcott (1999) used intransitives with prepositional phrases, and the prepositional phrases (not required by intransitive syntax) could have been confusing to children. More importantly, to our knowledge, no previous study has ever addressed the critical question of whether toddlers know anything about *which* semantic roles are appropriate for the single argument of intransitive verbs.

In short, Tomasello's challenge has remained unanswered. Primarily because of methodological concerns, no study has provided unambiguous evidence that children have the abstract categories necessary to systematically link semantics to syntax independently of pragmatic information.

To address this question— whether children can link conceptual/semantic representations to syntactic representations in a general way, rather than relying on simpler pragmatic strategies (e.g., putting phrases referring to animate entities before the verb, Dodson and Tomasello, 1998)—we designed a task that trades on the fact that languages can describe a single scene in more than one way using a single verb in different syntactic frames. For example, depending on factors such as focus, emphasis, or style, one might choose to describe a scene in which a black-hatted tuxedo-wearer causes a leotarded apprentice to spin with either the transitive sentence, *The magician spun the assistant* or the intransitive sentence, *The assistant spun* (among other possibilities) but not, say, either, *The assistant spun the magician* or *The magician spun*. These sentences—which describe

instances of *caused-action* events—typically involve one participant acting in some manner so as to cause a second participant to perform an action, and, as illustrated, these complex events can be described either by transitive or intransitive sentences. Crucially, caused-action events of the sort used in this study are composed of two (sub-) events, a causal event and a caused event, each with a distinct AGENT participant. As such, they preclude children from using animacy as a cue to interpretation.[2] Additionally, by not giving syntactic cues to argument structure in a "neutral" condition, we gave children the freedom to make mappings as they choose. Finally, to address the Childers and Tomasello's (2001) suggestion that children's early constructions might be limited to "particular pronoun configurations," we used proper names rather than pronouns. In short, careful use of caused-action events allows us to address three questions in parallel: whether children make use of abstract categories in mapping sentences to events, whether they do so in a way consistent with the constraints on natural language, and whether they can use such linguistic knowledge in a generalizable way (even when pragmatic information alone would not suffice).

2. Method

2.1. Participants

Thirty-one 28-month-olds (range: 27–30) and seventeen 34-month-olds (range: 33–35), overall mean 30.6 months, were included in the final sample. An additional 48 children were tested, but excluded due to fussing out (21), failure to reach training criteria (14), picking only one side (11), inattention (1), and prematurity (1).

2.2. Stimuli

Visual stimuli were prepared on a Power Macintosh G4 using Flash 5.0 software. A female American-English speaker recorded auditory stimuli in child-directed speech which were matched for pitch and amplitude using SoundEdit Pro16.

2.2.1. Characters

Two novel characters, *Bunny* and *Greenbean*, were presented as stuffed toys, as still images, and in animations.

2.2.2. Novel actions

Two novel caused-action events were devised such that they were easily demonstrated, ecologically natural, and not naturally expressed by any existing English verb. In one action, one character pulls the other character's arms behind its back (Fig. 1, Top); arms

[2] For maximal precision, we refer to the role Tomasello and Abbot-Smith (among others) described as the Actor or AGENT as the AGENT of the Causal Action. We also distinguish between animate participants who play a passive role in a causative event described as Patient or Undergoer (as in Fisher, 2002, or Tomasello, 2000) and participants who play an active role as AGENT of the Caused Action.

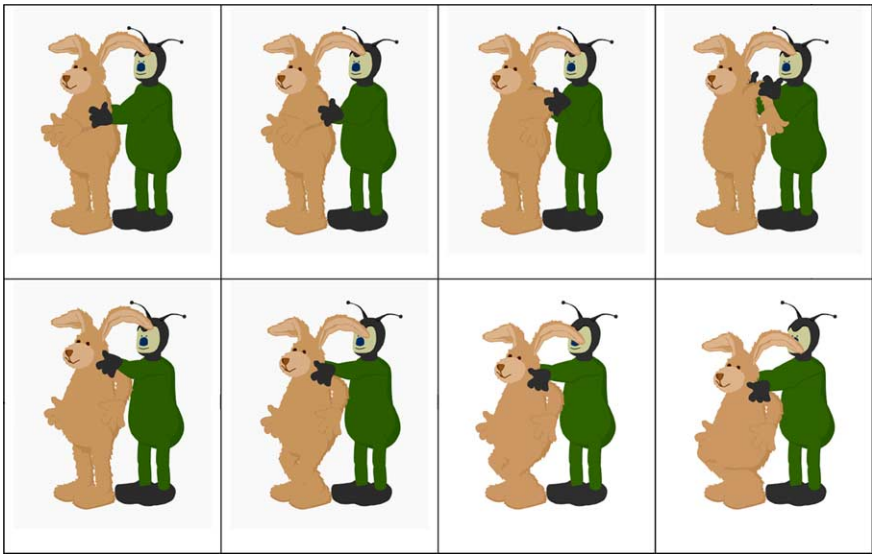

Fig. 1. Novel actions: Greenbean pulls Bunny's arms behind his back (top panel contains 4 stills excerpted from movie). Greenbean presses down on Bunny's shoulders, thereby forcing him to squat (bottom panel).

then return to forward position. In the second action, one character presses down on the other character's shoulders, forcing its knees to buckle (Fig. 1, Bottom); knee-buckled character then returns to standing position.

2.2.3. Sentences

In training, novel verbs *dack* and *koom* were presented either as gerundivals ("Neutral," in order to test generalization to novel verbs absent of syntactic cues to argument structure) or with Intransitive syntax.[3] In the test, we used Intransitive and Transitive syntax. (See Table 1 for an example using *dack*.)

2.2.4. Reward clips

A 5-min children's cartoon was divided into a series of clips and accompanied by music.

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[3] We did not train children on the transitive, as pilot studies with adult participants revealed that once adults were exposed to a transitive form (*x is dacking y*), there was a strong tendency to interpret test sentences that we intended as intransitive (*x is dacking*) as referring to the Agent of the *Causal Action*—in stark contrast to what would be expected normatively. One possibility under investigation is that—primed with initial exposure to transitives—participants may have treated Subject-Verb test sentences not as ordinary intransitives but as something like an underlying transitive with an omitted Object (Goldberg, 2001). Until this adult departure from normative syntax is better understood, similar tests with children seem premature.

Table 1
Experimental conditions

	Training		Test		
Experimental conditions	Training condition	Training	Screen A image	Sentences (prefaced by *touch where or find where)*	Screen B image
Generalizing from unspecified (neutral) argument structure	Gerundival	*Look, docking* 		*Bunny is docking Greenbean.* [A] *Greenbean is docking Bunny.* [B]	
		Watch, docking 		*Bunny is docking.* [B] *Greenbean is docking.* [A]	
Generalization between argument structures	Intransitive	*Look, Bunny is docking* 		*Bunny is docking Greenbean.* [A] *Greenbean is docking Bunny.* [B]	
Control		*Watch, Bunny is docking* 		*Bunny is docking.* [B] *Greenbean is docking.* [A]	

2.3. Procedure

Using a two-alternative-forced-choice procedure, children were asked to decide which of two displays—each showing the same characters engaged in the same action, but with roles reversed—was a better match for an unfamiliar use of a novel verb.

Children, tested individually in a 20–25 min videotaped session, were randomly assigned either to neutral or intransitive training and tested (again by random assignment) either in intransitive or transitive syntax. This between-subject design resulted in four conditions, with 12 children per condition.

The procedure had five distinct stages, designed to be as engaging and child-friendly as possible.

2.3.1. Stage 1: Modeling

In a reception room, two experimenters made the child comfortable through free play and then introduced the child and parent to the Bunny and Greenbean toys through

structured play, repeating each character's name several times. Introducing the idea of "watching some silly things," the experimenters and parent took turns demonstrating the two novel events, with the adults serving as the AGENT of the Causal Action and Bunny as the AGENT of the Caused Action. The experimenters took turns providing the appropriate linguistic description (e.g., Look, *Bunny is dacking* or *Look, Dacking*) for a total of 9 tokens for each action.

2.3.2. Stage 2: The robot

Next, the child was brought to another room and was introduced to the "Robot" character constructed of brightly painted foam-board with two 17" computer-monitor "eyes" (used to present visual stimuli). The child sat facing Robot with monitors at eye-level and within reach. The parent sat behind the child. One experimenter sat behind the child. This experimenter interacted directly with the child, provided feedback in the training phase, and compliance-directed social reinforcement. (The other experimenter remotely controlled Robot, via PsyScope 1.2.5 on a Power Macintosh G4).

2.3.3. Stage 3: The animations

Children saw animated movies for each novel caused-action with Bunny continuing to perform as the AGENT of the Caused Action, but now with Greenbean as the AGENT of the Causal Action. Three pre-recorded exemplars of the matching training sentence were played when the child was attending to the display.

2.3.4. Stage 4: Learning "Robot's Game"

In this stage, children learned to play Robot's game by matching familiar sentences that describe states rather than events (e.g., *Greenbean is standing*) to one of two static images, one in which Bunny was sitting and Greenbean was standing and the other in which Bunny was standing and Greenbean was sitting. Children were taught to touch or point to the screen that matched. Feedback (a computer-generated "thank-you" sound) was supplied only for correct responses; the displays persisted through an incorrect response and the experimenter directed the child to try again. Children who could not provide three consecutive unaided correct responses in a maximum of 12 trials were excluded from the final sample.

2.3.5. Stage 5: Testing

Children were asked to match transitive sentences (e.g., *Bunny is kooming Greenbean*) or intransitive sentences (e.g., *Greenbean is kooming*) to one of a pair of animated displays. For each trial, one screen displayed Greenbean as the AGENT of the Caused Action, and Bunny as the AGENT of the Causal Action and the other screen displayed the same action with the roles reversed (i.e., Bunny → AGENT of the Caused Action and Greenbean → AGENT of the Causal Action; see Table 1 & Fig. 2). Each child experienced a different subset of six of the eight possible trials. As such, the design was not completely balanced within each child, but every child was exposed to each character, verb, and side of correct response an equal number of times.

Fig. 2. Sample test trial: During test trials, children saw two scenes depicting the same action, but with reversed roles. Children heard an utterance and were asked to choose the scene that matched. Since agents canonically map onto Subject position in transitive sentences, the transitive test utterance with Bunny as the grammatical Subject ("*Find where Bunny is dacking Greenbean*") should pick out the left panel of Fig. 2, wherein Bunny is the AGENT of the Causal Action. In contrast, causal actions cannot naturally be described by means of an *intransitive* utterance in English. In the intransitive test utterance with Bunny in Subject position ("*Find where Bunny is dacking*"), the correct response should be to pick out the right panel, in which Bunny buckles at the knees (and not the left panel in which Bunny performs the causal pushing down action).

Regardless of what the child chose, Robot responded with its special sound and the experimenter provided performance-neutral social reinforcement.

2.4. Scoring

2.4.1. The transitive test condition

An English-speaking child who has mastered the relevant linking principles should match the transitive sentence *Bunny is dacking Greenbean* to the animation where Bunny is pushing on Greenbean's shoulders, causing Greenbean to buckle at the knees (Screen A Image in samples given in Table 1), because in this novel transitive causative sentence, *Bunny* is in Subject position, and therefore can only describe a scene in which Bunny is the AGENT of the Causal Action. Conversely, the child should match *Greenbean is dacking Bunny* to the animation where the reverse is true (Screen B Image). (A child who had not discovered that word order is significant in English, or thought mistakenly that any animate participant could be a Subject would be at chance, as would any child who thought that any AGENT could be a Subject).

2.4.2. The intransitive test condition

Given the same pair of images, and the *intransitive* sentence *Bunny is dacking*, a English-speaking child who has mastered the relevant linking principles should prefer the animation where Bunny is the AGENT of the Caused Action (Table 1, Screen B) and not the scene where Bunny is the AGENT of the Causal Action since the grammatical Subject of an English intransitive can refer to an entity who is the AGENT of an event but cannot refer to an entity who is both the AGENT of an event and the external cause of an event (Levin and Rappaport, 1995).

3. Results

Children's performance was calculated as the proportion of correct responses across the six test trials (0 = no correct responses; 1 = all correct responses). Children who performed two SD above or below the overall mean were excluded from subsequent analyses (this excluded two children, one in the NEU-TRN and one in the INT-INT conditions).

An omnibus 2 (response side: left or right) × 2 (character: Bunny or Greenbean) × 2 (gender: male or female) × 2 (age: 28-months-old or 34-months-old) × 4 (experimental condition: Intransitive → Intransitive, Intransitive → Transitive, Neutral → Intransitive, or Neutral → Transitive) ANOVA, with time to reach criterion as a covariate, revealed no significant effects of response side, character, gender, age, time to criterion, or experimental condition, with no interactions (all Ps > .05).

In order to examine children's ability to generalize more carefully, we examined whether children chose the correct response more frequently than predicted by chance alone. Indeed, across all experimental conditions, children's overall performance was significantly above chance ($M = .696$, SD = .209, $t(45) = 6.356$, $P < .001$). Planned comparisons testing each of the four experimental conditions against chance revealed that children performed above chance in every condition (INT–INT ($M = .727$, SD = .171, $t(10) = 4.40$, $P = .001$)); INT–TRN ($M = .639$, SD = .211, $t(11) = 2.278$, $P = .044$)); NEU–INT ($M = .750$, SD = .219; $t(11) = 3.95$, $P = .002$)); NEU–TRN ($M = .667$, SD = .236, $t(10) = 2.35$, $P = .041$).

4. Discussion

Tomasello and Abbot-Smith (2002) argued that only if young children had "a full-blown representation of the transitive construction" they will be able to "connect the preverbal position with the actor… and the post-verbal position with the undergoer… in a transitive utterance." We suggest that this is precisely what the toddlers in the transitive generalization condition in our task have done. We have shown children can similarly connect the Subject position in an intransitive sentence to the best candidate AGENT.

In both cases, transitive and intransitive, children were able to match novel sentences to scenes showing the same action and the same participants, but with the roles interchanged, suggesting some genuine knowledge of linking principles. To correctly interpret novel verbs in syntactic frames new to those verbs, children must possess abstract categories such as AGENT, be able to identify which participants in the novel scenes conform to this category, and know something about linking relations (e.g., that in English, AGENTS of Causal Actions are typically referred to by the pre-verbal noun-phrase of transitive sentences). Children may be conservative in production, but our results show that absent other information, toddlers can use linking principles in comprehension. Furthermore, inasmuch as both Bunny and Greenbean were expressed with proper names rather than pronouns, our results speak against the notion that early "constructions" are limited to particular pronoun configurations.

Our results, which converge on with those of Gertner and Fisher (in press), challenge both the Verb-Island hypothesis (Tomasello, 1992, 2000) and the weaker notion that

toddler's knowledge of argument structure is limited to a "weak verb-general transitive schema" (Abbot-Smith, Lieven, & Tomasello, 2004).

Success with the intransitive, observed here for the first time, is arguably even more telling than in the transitive. In the intransitive test condition, neither display has the canonical number of arguments for an intransitive. Instead, it would appear that the only way in which a child could succeed in this condition is by having some generalizable way of relating intransitive syntax to semantic representation. Moreover, to the extent that this inference may be under-constrained by direct linguistic evidence, generalization from neutral to intransitive may require children to know (implicitly) not just what is logically possible but what is humanly possible. To our knowledge, although many languages express AGENTS of Caused Actions as Subjects in intransitives, no human language represents AGENTS of Causal Actions as Subjects in intransitives (without extraneous processes such as noun incorporation). Our findings could thus be taken as evidence that children have at least some implicit knowledge of this sort, suggesting the intriguing possibility that the ultimate range of possible linguistic variation may stem in part from children's judgments about what links are and are not natural.

While the abilities observed here are impressive, they are by no means sufficient for full mastery of argument structure. For example, there is no evidence that children of this age are aware of the language-particular criteria (semantic, morpho-phonological, or otherwise) that define subclasses of verbs that do or do not alternate in idiosyncratic ways (e.g. *donate* versus *give;* Pinker, 1989). The present findings suggest that children approach such challenges with the roots of argument structure already in hand.

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