Lexical and Syntactic Influences on Children’s Acquisition of Verb Argument Structure: Comparing Typical Children and Children with Autism Spectrum Disorder

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1. Introduction

Levin (2013) describes ‘argument structure’ as an intricate interaction of syntax and semantics, referring to “linguistic phenomena that involve the [syntactic] realization of a lexical item’s arguments.” Allen (2015) highlights how “arguments can be identified in two ways: in terms of syntactic roles with respect to the verb such as Subject and Object, and in terms of semantic roles in relation to the verb such as Agent (entity that instigates an action) and Patient (entity that undergoes an action). [Thus], Argument structure is the specification of the number and types of arguments required for a verb in that structure to be well-formed.” (p. 271). Children’s acquisition of verb argument structure (VAS), then, necessarily requires both syntactic and semantic knowledge. They must have knowledge of the canonical meanings of specific syntactic frames; e.g., that transitive frames signal causative meanings (Goldberg, 1995; Levin, 1993), and they must also learn the syntactic constraints of specific verbs; e.g., that bring is obligatorily transitive, come is obligatorily intransitive, and move can appear in both frames or constructions (Naigles et al., 1993; Pinker, 1989).

Naigles and colleagues have proposed that children’s VAS acquisition is a multi-step process, with the syntactic component dominating during toddlerhood and the lexical component more strongly in evidence during later preschool and school age as children settle on stable meanings for individual verbs (Naigles, Fowler & Helm, 1995; Naigles, 2002; Leischner et al., 2017). This developmental pattern has been observed in studies using the Noah’s Ark paradigm, in which children are asked to enact ungrammatical sentences (i.e., sentences in which the verbs are placed in frames inconsistent with their argument structures); across a
number of languages, younger children’s enactments are more influenced by the frame while older children’s enactments are more influenced by the semantics of individual verbs (Naigles et al., 1993, 1992; Göksun et al., 2008; Leischner et al., 2017). However, none of these studies has directly tested the degree to which older children’s increasing compliance with the verb is most closely related to their overall lexical vs. grammatical development. In the current study, we test this proposal in two ways. First, we assess the VAS acquisition of 5-year-old typically developing (TD) children, and investigate the relationship of their VAS level to their lexical, morphological, and syntactic knowledge. Second, we also assess the VAS acquisition of 6-year-old children with Autism Spectrum Disorder (ASD); these children frequently present with delayed language (Naigles & Chin, 2015), and thus they may demonstrate earlier, more syntactically-based levels of VAS acquisition.

There is now ample evidence that two-year-old English-learning children use the syntactic frames in which verbs are placed to extend and/or make conjectures about the meanings of those verbs—what has been called, Syntactic Bootstrapping (Gleitman, 1990). For example, Bowerman (1982) observed more than 30 years ago that children as young as 33 months of age (incorrectly) produce intransitive verbs in transitive frames such as

(1) I’m just gonna fall this on her

to express causative extensions (cause-to-fall) of those verbs. Moreover, toddlers who see both causative (2-argument) and noncausative (1-argument) events and hear a single novel verb will map that verb onto the causative event if the verb is presented in a transitive frame (e.g., The duck is gorping the bunny), whereas if the verb is presented in an intransitive frame (e.g., The duck and the bunny are gorping), they are more likely to map the verb onto the noncausative event (Naigles, 1990; Noble et al., 2011). Furthermore, toddlers as young as 20 months of age distinguish novel verbs in transitive frames from those in intransitive frames, preferring to map the former onto 2-person events even when the verbs-in-frames are heard before the events are shown (Yuan & Fisher, 2009; Yuan et al., 2012). Thus, a general understanding of at least some canonical mappings between verb meanings and sentence frames seems to be in place sometime around age two.

Successful acquisition of VASs can be observed as children stop producing the spontaneous overgeneralizations noted above; typically, this occurs between four and eight years of age (Pinker, 1989). Experimentally, children increasingly reject these ungrammatical sentences as possible sentences of English during this period; these rejections appear to be primarily lexically based for two reasons. First, rejections are verb- and frequency-dependent, with ungrammatical sentences including high-frequency verbs such as come and go being rejected developmentally earlier than those including lower-frequency verbs such as fall and stay. In addition, rejections are also driven by verb semantics, with directed-motion intransitive verbs being accepted in transitive frames later than emotion-
producing intransitive verbs (Ambridge et al., 2008; Ambridge et al., 2012; Allen, 2015).

We can see this developmental shift within the same paradigm via the Noah’s Ark task (Naigles et al., 1992; 1993), wherein children are asked to enact, rather than judge, ungrammatical sentences such as

(2) *The zebra brings

(3) *The zebra goes the lion.

In particular, 2- and 3-year-olds’ enactments—and those of children with Down syndrome who are syntactically at the 2-year-old level—are primarily Frame Compliant, such that they adjust the verbs to fit the canonical meanings of the frames (Naigles et al., 1993, 1995). Thus, these children usually enact (2) as the zebra moving alone (intransitive frame $\rightarrow$ noncausative meaning), and (3) as the zebra making the lion go (transitive frame $\rightarrow$ causative meaning). In contrast, children aged 5-12 years enact these sentences in increasingly Verb Compliant ways; for example, 5-year-olds consistently add a direct object/patient to their enactments of (2), and 9-year-olds consistently make the zebra go to or with the lion during their enactments of (3) (Naigles et al., 1992; Leischner et al., 2017). Thus, these children adjust the frames to fit what they now know are the stable semantics of each verb. Furthermore, Verb Compliance emerges in a frame-by-frame and verb-by-verb fashion, such that sentences like (2) are enacted Verb Compliantly by younger children than sentences like (3), and intransitive verbs like come and go are enacted Verb Compliantly by younger children than fall and stay (Naigles et al., 1992; Leischner et al., 2017).

In the current paper, we use the Noah’s Ark task to perform two more direct tests of the proposal that early VAS acquisition relies on syntactic knowledge whereas later VAS acquisition relies on lexical knowledge. First, we assess the VAS acquisition of 5-year-old typically developing (TD) children, and investigate the degree to which their level of Verb Compliance is correlated with their lexical, morphological, or syntactic knowledge as assessed independently by a standardized language test. We predict that children who enact more ungrammatical sentences Verb Compliantly will be more advanced in terms of their lexical knowledge, but will not vary systematically in grammatical knowledge.

Second, we also assess the VAS acquisition of 6-year-old children with Autism Spectrum Disorder (ASD). The lexical and grammatical ‘status’ of verbal children with ASD is the topic of considerable controversy, with some researchers reporting that grammar is relatively spared in this population, that grammatical development proceeds similarly to TD children, but that advanced lexical knowledge is impaired (Tager-Flusberg, 1996; Potrzeba et al., 2015; Naigles et al., 2011; Naigles & Tek, 2017). Other researchers have found that children with ASD who are vocabulary-matched to TD children nonetheless produce language that is less advanced grammatically (Eigsti et al., 2007), and perform less
proficiently on grammatical tasks (Eigsti & Bennetto, 2009; Ambridge et al., 2015; Goodwin et al., 2015). Still others have suggested that one subgroup of children with ASD presents with typical grammatical and lexical development whereas another shows specifically syntactic deficits (Kjelgaard & Tager-Flusberg, 2006; Tuller et al., 2017; Wittke et al., 2017; see Naigles & Chin, 2015 for more discussion).

Children with ASD thus have the potential to inform the current proposal concerning VAS acquisition in a number of ways. First, to the extent that their language development is generally delayed (Naigles & Chin, 2015), they may demonstrate developmentally earlier, more syntactically-based levels of VAS acquisition. Thus, when given ungrammatical sentences, they may provide more Frame Compliant enactments than their TD peers (Ambridge et al., 2015). Second, whereas the typical developmental pattern of VAS acquisition is verb-dependent, with Verb Compliance emerging earlier for some verbs than others, the developmental pattern for children with ASD may be less clearly verb-specific. This pattern might be consistent with impairments in lexical semantics. Third, if children with ASD are acquiring VAS in ways similar to TD children, then their VAS performance should likewise correlate with their lexical development. In contrast, if their VAS acquisition is delayed, then their performance might still be more closely related to their levels of syntactic knowledge.

2. Methods
2.1. Participants

As part of an ongoing longitudinal study investigating language acquisition in young children with ASD (see Naigles & Fein, 2017, for an overview), we recruited 16 children diagnosed with ASD and 28 TD children. All children were monolingual English learners. There were zero girls in the ASD group and six in the TD group. Children in the ASD group had been previously diagnosed with Autistic Disorder or Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS) by physicians or psychologists, and their diagnosis was confirmed with the Autism Diagnostic Observation Schedule (ADOS; Lord et al. 1999) before the start of the study, and again when the current data were collected. The ASD group was recruited through treatment facilities and schools in the Northeastern U.S. The children in the TD group were recruited from a database of children in the UConn Child Language Lab. Children in the TD group were administered the ADOS, and none had elevated scores either at recruitment or when the current data were collected (see Table 1). The full TD and ASD groups were matched at recruitment on expressive language, which was measured by the raw scores of the Expressive Language Scale of Mullen Scales of Early Learning; however, by the current data collection, the TD group’s scores were significantly higher than those of the ASD group. Still, the verbal and nonverbal scores of the ASD group were within the normal range. Descriptive statistics for the current sample can be found in Table 1.
Table 1. Descriptive statistics for TD and ASD groups

<table>
<thead>
<tr>
<th>Measure</th>
<th>TD</th>
<th>ASD</th>
<th>t-value, p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>5.6 (.35)</td>
<td>6.37 (.61)</td>
<td>t=-4.6, p &lt; .001</td>
</tr>
<tr>
<td>TACL-V</td>
<td>37.1 (4.28)</td>
<td>34.0 (5.27)</td>
<td>t=2.12, p = .039</td>
</tr>
<tr>
<td>TACL-Gm</td>
<td>31.8 (5.97)</td>
<td>21.43 (10.91)</td>
<td>t=3.51, p = .002</td>
</tr>
<tr>
<td>TACL-Es</td>
<td>29.85 (7.14)</td>
<td>19.25 (10.72)</td>
<td>t=3.53, p = .002</td>
</tr>
<tr>
<td>TACL-Q</td>
<td>121.21 (10.93)</td>
<td>90.5 (23.56)</td>
<td>t=4.92, p &lt; .001</td>
</tr>
<tr>
<td>DAS</td>
<td>107.67 (12.74)</td>
<td>90.4 (22.77)</td>
<td>t=3.2, p = .003</td>
</tr>
<tr>
<td>ADOS-G</td>
<td>1.53 (1.89)</td>
<td>14.0 (7.87)</td>
<td>t=-6.2, p&lt;.001</td>
</tr>
</tbody>
</table>

Note: TACL = Test of Auditory Comprehension of Language-3rd edition (Carrow-Woolfolk, 1999); V=vocabulary subscale raw score; Gm = Grammatical morpheme subscale raw score, Es = Elaborated sentences subscale, raw score; Q = composite quotient standard score. DAS = Differential Abilities Scale (Elliot, 1990) standard score. ADOS-G = Autism Diagnostic Observation Schedule-Generic (Lord, Rutter, DiLavore, & Risi, 2002)

2.2. Materials

A wooden Noah’s Ark set and a stage were provided for the children’s enactments. Children heard 20 sentences, half of which were transitive (NVN) and half of which were intransitive (NV). Each contained one of the following verbs: move, drop, come, go, fall, stay, bring, take, push, and put. Thus, 12 of the sentences were grammatical and eight were ungrammatical (*The zebra goes the lion, *The elephant brings). The test sentences were pseudo-randomized such that there were (a) no more than two sentences in a row containing the same verb, (b) no more than two ungrammatical sentences in a row, and (c) no more than two sentences with the same frame following each other. Two grammatical pretest sentences were provided (e.g., The chicken rides the camel); for these sentences, children were explicitly encouraged to move the animals across the stage.

2.3. Procedure

Children first were asked to name the animals; if some animal was given an unanticipated name (e.g., zebra instead of tiger), then the child’s label was used for all sentences that included that animal. The sentences were then presented one by one, and children were asked to enact each one using whichever animals(s) they needed. Questions concerning sentences (e.g., “Brings what?”) were responded with “Whatever you want.” All enactments were routinely praised. Enactments were filmed for later coding.
2.4. Coding

Each action performed by the participants was described and coded using an inventory of action and coding descriptions adopted from Naigles (1988). The coders described each enactment for a) the kind of movement according to the presented verb (e.g., fall = downward movement, bring = carrying, pushing etc. movement), b) the involved animals, c) which animal was the agent of the action and which the patient, if more than one animal were involved, and d) how many hands the participant used to enact the sentence. Grammatical and ungrammatical sentences were coded as illustrated below:

(4) Grammatical Sentences
(i) NVN (e.g., The horse brings the chicken). In order to count the enactment as correct, the horse had to be the agent of a causative action; for example, if the chicken was seated on the horse’s back or held next to the horse in the same hand.
(ii) NV (e.g., The tiger comes). For correct enactments, the child had to move the named animal (i.e., the tiger) by itself in the appropriate direction.

(5) Ungrammatical Sentences
(i) NVN (e.g., *The sheep goes the horse). Enactments of these sentences were coded as causative when the participant enacted the originally noncausative verb meaning in a causative manner, for example, by the sheep pushing or carrying the horse or both animals being picked up simultaneously and moved by the child in one hand. In contrast, if the participant moved just one toy animal by itself, or if the sheep and the horse moved independently from each other by using separate hands, the enactment was coded as non-causative.
(ii) NV (e.g., *The zebra brings). Enactments of these sentences were coded as non-causative when the zebra was moved alone. In contrast, if the participant made the zebra push or carry another animal, or the sentence was completed verbally (e.g., “brings what?/the lion?”) the enactment was coded as causative.

Enactments of grammatical sentences were coded as correct or incorrect. Enactments of ungrammatical sentences were further coded as Frame Compliant, Verb Compliant, or Other (see Naigles et al., 1993 for more details). Frame Compliant enactments included causative enactments of *NVN sentences and noncausative enactments of *NV sentences. Verb Compliant enactments included noncausative enactments of *NVN sentences and causative enactments of *NV sentences. Enactments involving the incorrect toy animals or movements were coded as Other.

Enactment descriptions and coding as correct or incorrect, and as causative or noncausative, were performed by four undergraduates in the UConn Child Language Lab, including the 2nd author, who then checked all descriptions by reviewing the videos. Disagreements were resolved by joint reviewing and discussion. Coding as Frame Compliant and Verb Compliant was performed by the authors in consultation.
3. Results

3.1. Grammatical sentences

All children in this dataset enacted the grammatical sentences correctly at least 75% of the time. The groups did not differ in their percentage of correct enactments (TD: 91.39% (6.7); ASD: 88.0% (9.2), p > .2).

3.2. Ungrammatical sentences

3.2.1. How consistently did the frames change the children’s enactments?

Our first question concerned whether the children showed sensitivity to the novel frames in which these familiar verbs were presented. That is, did they enact the intransitive verbs in transitive frames (*NVN) causatively more frequently than they had enacted these same verbs in their canonical intransitive frames (NV)? Similarly, did they enact the transitive verbs in intransitive frames (*NV) causatively less frequently than they had enacted these same verbs in their canonical transitive frames (NVN)? The data are presented in Table 2. Two-way repeated measures ANOVAs (2 (frame) X 2 (group)) were performed for the intransitive and transitive verbs separately. As Table 2 shows, the children enacted the intransitive verbs in *NVN frames causatively (i.e., Frame Compliantly) more frequently than they enacted these verbs in NV frames ($F(1,42) = 111.052, p < .001, \eta^2=.726$). There was no main effect nor interaction with group. In contrast, the children enacted the transitive verbs in *NV frames causatively at equivalent rates to their enactments of these verbs in NVN frames ($Fs(1,42) < 1.5, ns$), again with no main effect or interaction with group.

Table 2. Mean Percent Causative Enactments by verb type, frame, and group

<table>
<thead>
<tr>
<th>Verb type</th>
<th>TD</th>
<th>ASD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intransitive verbs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NV Frame</td>
<td>3.57 (8.9)</td>
<td>3.13 (8.5)</td>
</tr>
<tr>
<td>*NVN Frame</td>
<td>47.04 (29.26)</td>
<td>60.94 (28.03)</td>
</tr>
<tr>
<td>Transitive Verbs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*NV Frame</td>
<td>73.50 (31.04)</td>
<td>80.75 (21.65)</td>
</tr>
<tr>
<td>NVN Frame</td>
<td>81.25 (18.79)</td>
<td>76.56 (21.34)</td>
</tr>
</tbody>
</table>

3.2.2. How consistently did the children repair the ungrammatical sentences?

Our second question concerned the degree to which the children enacted the sentences Verb Compliantly; i.e., repairing the ungrammatical sentences so that
their enactments were consistent with the semantics of the verbs. As Figure 1 shows, the children repaired the ungrammatical intransitive sentences (*NV: The zebra brings) more frequently than the ungrammatical transitive sentences (*NVN: The zebra goes the lion). A two-way repeated measures ANOVA (2(frame) X 2(group)) yielded a main effect of frame (F(1,42) = 22.945, p < .001, \(\eta^2 = .353\)), but no main effect or interaction with group.

![Figure 1. Mean Percent Verb Compliance by Frame and Group]

### 3.3.3. Did the degree of Verb Compliance vary by verb?

Recall that Naigles et al. (1992) reported that some verbs elicited Verb Compliance developmentally earlier than other verbs. In particular, *come* and *go* in the NVN frame were generally enacted Verb Compliantly more frequently than *fall* and *stay* in that frame. Because we hypothesized that children with ASD might not show the same verb effects, we compared the groups’ percent of Verb Compliance for *come* and *go*, averaged together, versus *fall* and *stay*, averaged together. As presented in Figure 2, the data indicate that the children in this study showed the same pattern, albeit somewhat more strongly in the TD group. A two-way repeated measures ANOVA (2(verbtype) X 2 (group)) yielded a significant effect of verbtype (\(F(1,42) = 13.16, p = .001, \eta^2 = .239\)), and a significant effect of group (\(F(1,42) = 4.11, p = .049, \eta^2 = .089\)), but no significant interaction (\(p = .143\)). Exploratory paired-sample t-tests revealed that for the TD group, Verb Compliance was higher for *come/go* than *fall/stay* (\(t(27) = 4.277, p < .001\)); however, this comparison was not significant for the ASD group (\(t(15) = 1.32, p = .206\)). Moreover, independent-sample t-tests revealed that the groups differed in their enactments of *come* and *go* (\(t(42) = 2.61, p = .013\), but not *fall* and *stay* (\(t < 1\)).
3.3.4. Which language components correlated with Verb Compliance?

To assess which standardized language components were related to children’s degree of Verb Compliance, we conducted correlational analyses for each group separately. We included only the percent Verb Compliant scores for the ungrammatical transitives (*The zebra goes the lion) because these elicited more variance in each group. For the TD group, as predicted, Percent Verb Compliance correlated significantly and positively with TACL-vocabulary score ($r(28) = .373$, $p = .05$). Thus, children who repaired these sentences more frequently also had higher vocabulary scores; see Figure 3. No other correlations with standardized test scores reached significance. For the ASD group, percent Verb Compliance correlated significantly and negatively only with the TACL-elaborated sentences score ($r(16) = -.535$, $p = .033$). In this group, then, children who repaired the sentences less had higher elaborated sentences score; see Figure 4. To put it another way, children who followed the frame when enacting these sentences (i.e., were more Frame Compliant) also performed better with the elaborated sentences items on the TACL.
Figure 3. Relationship between TD children’s percent verb compliance and TACL vocabulary score

Figure 4. Relationship between children with ASD’s percent verb compliance and TACL Elaborated Sentences score

4. Discussion

This study investigated the correlates and attributes of VAS acquisition of 5-year-old TD children and 6-year-old children with ASD. Participating in the
Noah’s Ark enactment-of-ungrammatical-sentences task, these TD children replicated the performance of the 5-year-olds in Naigles et al. (1992), in that they demonstrated more Verb Compliance with the transitive verbs than with the intransitive verbs, and more with come/go than fall/stay. Moreover, consistent with our first prediction, the TD children’s degree of Verb Compliance correlated positively with their overall vocabulary levels, but not with their grammatical levels.

These findings support our proposal that later VAS acquisition is primarily lexically driven, in two ways. First, as others have found, verbs that were higher in frequency elicited Verb Compliance from more children than verbs that were lower in frequency; the conjecture is that hearing these verbs more frequently in their conventional frames enabled children to resist accepting and interpreting them in unattested frames, at an earlier age (Ambridge et al., 2008; Naigles et al., 1992). Second, children with higher overall vocabularies were the ones who enacted the sentences Verb Compliantly more frequently; here, the conjecture is that more advanced overall vocabulary is a marker of more advanced specific verb knowledge, such as that related to VAS. Thus, the developmental pattern of VAS acquisition observed here is consistent with those ‘Noah’s Ark’ studies published previously, with children school age and older increasingly showing effects of verb-specific knowledge. This developmental pattern is also consistent with findings from other paradigms such as structural priming, where children show primarily syntactic effects whereas adults show influences from both lexical and syntactic content (e.g., Rowland et al., 2012).

The children with ASD performed similarly to the TD children in several ways, including their overall degree of Verb Compliance, and their demonstration of more consistent Verb Compliance for transitive verbs than for intransitive ones. These findings seem to be at odds with our second prediction, that the children with ASD, especially because their overall language levels were below those of the TD children, would enact the sentences similarly to younger TD children; i.e., more frequent Frame Compliance. However, closer scrutiny of the enactments of the ungrammatical intransitives, such as (3), revealed some subtle group differences. While both groups enacted come and go Verb Compliantly numerically more frequently than fall and stay, this verb type effect was actually significant only for the TD group; moreover, the TD group enacted come and go themselves Verb Compliantly more consistently than the ASD group did (Figure 2). Thus, we have some indication that the TD children were somewhat more advanced in VAS acquisition than the children with ASD.

Most strikingly, though, the children with ASD’s VAS performance showed a different relationship to their overall language level: For the ASD group, more consistent Verb Compliance correlated negatively with elaborated syntax levels on the TACL-R. Put another way, children who performed Frame Compliantly more frequently, enacting ‘the lion falls the chicken’ as the lion makes the chicken fall, were the ones with more advanced syntactic knowledge. From one perspective, an association of syntactic knowledge and Frame Compliance makes sense, because enacting a sentence Frame Compliantly means the child is
choosing to focus on the meaning of the syntactic frame; e.g., a causative meaning for transitive frames. An association of the TACL-elaborated syntax subscale and Frame Compliance thus supports Naigles et al.’s claim (1992; 1993) that Frame Compliance involves syntactic knowledge.

However, this association in verbal 6-year-olds with ASD may appear perplexing. That is, higher scores on the elaborated sentences subscale of the TACL-R are taken to indicate children who have more complex syntax knowledge, yet Frame Compliance has been found to instantiate developmentally earlier manifestations of VAS (Naigles et al., 1992, 1993; Leischner et al., 2017). Indeed, the children with ASD in our study averaged lower age-equivalent scores on elaborated syntax (5.05 years) than lexicon (6.48 years). But what the Frame Compliant-Syntax relationship suggests is that children with ASD with relatively more advanced syntactic knowledge do not necessarily deploy this component of language towards their further acquisition of VAS. These results are thus inconsistent with Ambridge et al.’s (2015) interpretation of their own findings, which were similar to ours: that children with ASD were less consistent than TD children in rejecting ungrammatical sentences. Ambridge et al. (2015) argued that this group effect reflected a grammatical deficit in ASD; however, if this were the case, then children with ASD’s more consistent Verb Compliance in the current study should have been associated with more advanced syntax.

Moreover, it is important to reiterate that the children with ASD did show progress with VAS acquisition, with respect to transitive verbs such as bring, take, push, and put: When these verbs appeared in intransitive sentences, the children repaired them, enacting the verbs causatively, as consistently as the TD group. It is possible that this level of Verb Compliance/VAS acquisition reflects the children with ASD’s lexical knowledge, as their age equivalents on this subscale of the TACL (6.48 years) were on par with those of the TD group. However, probably because both groups of children performed so consistently with these verbs, no correlations with either general lexical or syntactic knowledge reached significance. Future investigations might assess these relationships in younger and/or less linguistically advanced children.

References


