Glossa a journal of general linguistics

Gerard, Juliana, et al. 2018. The acquisition of adjunct control is colored by the task. *Glossa: a journal of general linguistics* 3(1): 75. 1–22, DOI: https://doi.org/10.5334/gjgl.547

RESEARCH

The acquisition of adjunct control is colored by the task

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Previous studies on children's interpretations of PRO in adjunct clauses have found that 4- to 6-year old children exhibit non-adultlike interpretations of adjunct PRO. For sentences with adjunct control, as in *John bumped Mary after PRO tripping on the sidewalk*, these studies have argued that children's knowledge is not adultlike. In this paper, we use a new task to reduce the demands involved in making a response. With this task, we find improved performance for sentences with adjunct control. These results suggest that children's knowledge of adjunct control is adultlike, but has been obscured by the tasks used in previous studies.

Keywords: adjunct control; language acquisition; binding; anaphora; task effects

1 Introduction

Linguistic dependencies present an important problem for language acquisition: how do children learn different types of relations between two non-adjacent elements? As dependencies vary in their structural configurations, children are tasked with identifying which elements form a relation and in which contexts.

For example, a pronoun can have a discourse antecedent, but must be free in its governing category (Chomsky 1981), as in (1). Meanwhile, a reflexive must be bound in its governing category, as in (2).

(1) Bob_1 called yesterday. John_2 said that Bill_3 should draw $\text{him}_{1/*3}$.
(2) Bob_1 called yesterday. John_2 said that Bill_3 should draw $\text{himself}_{*1/*2/3}$.

This learning problem is further complicated by dependencies involving silent material, as in (3). Although verbs typically have subjects, there is no overt subject of *draw* in (3). The only available interpretation is that *John*, the matrix subject, is the one who drew a picture, similar to the interpretation in (4) with a dependency between the matrix subject *John* and the overt pronoun embedded subject. Positing a silent referential element (annotated here as PRO) as the subject of *draw* allows for a similar dependency in (3).

(3) John_1 promised Mary_2 $\text{PRO}_{1/*2}$ to draw a picture.
(4) John_1 promised Mary_2 that $\text{he}_{1/*2}$ would draw a picture.

The dependency in (3) with a silent subject is further motivated by the contrast in (5) and (6). As demonstrated in (2), a reflexive needs a local antecedent. This can be any overt pronoun in the subject position of the embedded clause, as in (5).

(5) a. John$_1$ promised Mary$_2$ that he$_1$ would draw himself$_1$/*herself$_2$.
b. John$_1$ promised Mary$_2$ that she$_2$ could draw herself$_2$/*himself$_1$.

Meanwhile, the reflexive in (6) does not have an overt local antecedent. With a silent pronoun (PRO) in the embedded clause, this pronoun can serve as a local antecedent. Unlike in (5), however, PRO in (6) can only be dependent on the main clause subject (*John*), and not the object (*Mary*):

(6) John$_1$ promised Mary$_2$ PRO$_{1/*2}$ to draw himself$_1$/*herself$_2$.

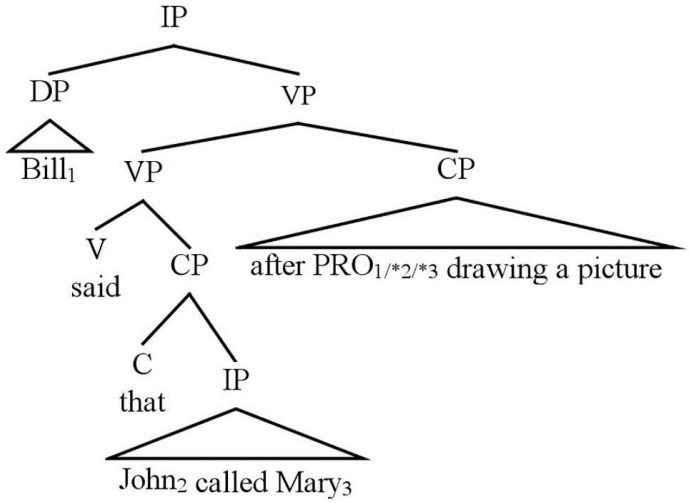
Different dependencies with silent elements involve different configurations, with different types of null content. Thus, a learner must not only detect whether a dependency has a silent element (e.g. from encountering a verb without a subject), but also determine how one silent element differs from any others.

The current study focuses on adjunct control, a syntactic dependency between the matrix subject and the silent subject of a non-finite adjunct clause:

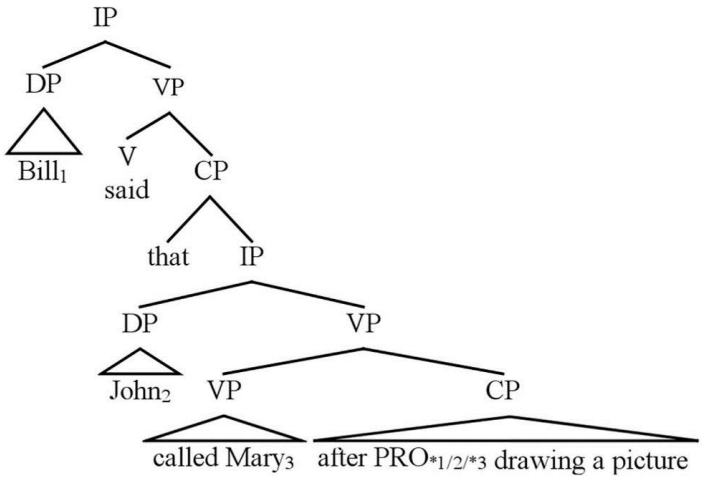
(7) John$_1$ called Mary$_2$ after PRO$_{1/*2}$ drawing a picture.

Like reflexives, adjunct PRO has a locality constraint – it must be bound by the subject of the next highest clause, without skipping clauses.

(8) Bill$_1$ said that [John$_2$ called Mary$_3$] [after PRO$_{1/*2/*3}$ drawing a picture]



(9) Bill$_1$ said that [John$_2$ called Mary$_3$ [after PRO$_{*1/2/*3}$ drawing a picture]]



When the adjunct is attached high, as in (8), the subject of the next highest clause is the subject of the main clause (*Bill*), and *Bill* is interpreted as the one who drew a picture. This structure contrasts with the one in (9), where the adjunct is attached to the embedded clause. With this lower attachment, the subject of the next highest clause is the subject of the embedded clause (*John*), and *John* is interpreted as the one who drew a picture.

Unlike reflexives, adjunct control dependencies involve a silent element, as in (3), raising the question posed above of how children might determine the antecedent of a null element. Indeed, while adults' judgements are generally consistent, many studies have shown children to allow a much wider range of interpretations for adjunct PRO (Goodluck 1981; Hsu, Cairns & Fiengo 1985; McDaniel, Cairns & Hsu 1991; Goodluck & Behne 1992; Cairns et al. 1994; Broihier & Wexler 1995; Goodluck 1998; 2001; Adler 2006). Multiple factors may be involved in the patterns of behavior observed in previous studies on children's acquisition of adjunct control: although children's behavior might be due to non-adultlike knowledge, it may also be a result of task effects or the interaction of adultlike knowledge and non-adultlike general systems. Nevertheless, all accounts to date have assumed that children's behavior is due to an immature grammar. While several accounts have proposed different non-adultlike grammars to account for the behavior observed in previous studies, no one proposal clearly provides a definitive explanation over the others.

In this paper, we discuss the source of children's non-adultlike behavior, and consider how children's behavior may have been influenced in previous studies by extragrammatical factors. Then, we compare children's behavior on two different tasks: a Truth Value Judgment Task (TVJT) similar to the ones in previous studies, and a new task designed to address some concerns with these studies. Although children's accuracy is above chance for the TVJT, their performance improves significantly on the new task, showing that children's errors for adjunct control can vary depending on the task.

1.1 Grammatical accounts of non-adultlike behavior

In previous studies, researchers have consistently observed that 4–6-year-old children allow non-adultlike interpretations for sentences with adjunct control. The central focus, however, has been on describing children's interpretations, and citing their patterns of behavior as evidence for one particular non-adultlike grammar over another.

Under the Variable Attachment account (Goodluck 1981; Hsu et al. 1985; McDaniel & Cairns 1990; McDaniel et al. 1991; Cairns et al. 1994), children's non-adultlike behavior results from misattaching the adjunct to the main clause, with three distinct non-adultlike states that a child might pass through before acquiring the adult grammar:

1. **Free interpretation of adjunct PRO** is explained by attaching the adjunct too high, such that no argument in the main clause binds PRO and requiring a discourse-based interpretation.
2. **Strict object control** is explained by attaching the adjunct too low, such that the object can bind PRO. Strict object control arises as a result, as the controller is the *closest* c-commanding NP of the next highest clause (Chomsky 1981).
3. **Optional subject-object control**, where children allow both a subject and an object interpretation of PRO but reject an external antecedent. For these children, it is proposed that their grammar includes both the adultlike and the low attachment structures, and that their interpretations are dependent upon which of the two structures is accessed at any given time.

For each of these three states, children access a non-adultlike interpretation as a result of misattaching the adjunct clause to the main clause, with transitions between states – including to the adult grammar – triggered by acquiring lexical and semantic information about the complementizers (e.g. *before, after, while*). Thus, all children converge on the adult grammar by virtue of acquiring adultlike knowledge of the relevant complementizers, which is assumed (although not stated explicitly) to include information about their attachment height.

Although the Variable Attachment account does descriptively cover the wide range of interpretations that were observed across studies, Wexler (1992) pointed out various concerns with Variable Attachment and the evidence for it, including small sample sizes to support each grammar type, not enough test items for reliable categorization into a single non-adultlike grammar, and relatedly, the possibility that children who allowed some but not all non-adultlike interpretations would have also allowed other interpretations with a larger number of trials.

Based on this last concern, Wexler (1992) and Broihier and Wexler (1995) argued instead that there is just one non-adultlike grammar for adjunct control, which does not place any syntactic restriction on the interpretation of adjunct PRO. In particular, they proposed following Carlson (1990) that children's non-adultlike behavior results from an inability to represent PRO in temporal adjuncts, forcing children to represent sentences with adjunct control with a nominal construction as in (10), adapted from Broihier & Wexler (1995):

(10) a. adjunct control:
Ernie scratched the witch before [$_S$ PRO drinking a gulp of water].
b. nominal structure:
Ernie scratched the witch before [$_{NP}$ (the) drinking (of) a gulp of water].

In (10b), the adjunct is underspecified for who tripped on the sidewalk, and the subject, object, and sentence-external interpretations are all available in the adult grammar. Under this Nominalization account, children with the non-adultlike grammar assign a similarly underspecified interpretation to sentences with adjunct control, and under appropriate experimental conditions, are predicted to allow any plausible interpretation for the antecedent (Wexler 1992; Broihier & Wexler 1995). Indeed, arguing in support of the Nominalization account, Broihier and Wexler (1995) found that while all children allowed a subject (adultlike) interpretation of adjunct PRO, the same children who allowed an object interpretation in some trials also accepted an external interpretation in other trials. A similar result was later supported by Goodluck (2001).

In addition to the Variable Attachment and Nominalization accounts, it has also been proposed that children employ a strategy of linking adjunct PRO to the main clause agent, rather than the subject (Goodluck 1998; Goodluck & Behne 1992), with an arbitrary interpretation of PRO (PRO_{arb}) that is sensitive to the context. This account predicts a more adultlike pattern of behavior in sentences with an active main clause, where the agent is also the subject, in contrast to the more consistent finding that children accept non-adultlike interpretations even with an active main clause. Non-adultlike behavior is predicted, however, for sentences with a passive main clause, where the agent is not the subject.

In general, children's behavior in previous studies is *consistent* with the above grammatical accounts. However, a number of questions remain regarding the source of children's behavior in previous studies. First, although a pattern of behavior with only two groups of children – one adultlike, and one non-adultlike – as reported in Broihier and Wexler (1995) and Goodluck (2001) is consistent with the nominalization structure in (10b), it is just as consistent with the high attachment structure proposed by the Variable

Attachment account: specifically, both structures predict free (or arbitrary) interpretation of PRO. Thus, while Wexler's (1992) argument against three *distinct* non-adultlike states as proposed in the Variable Attachment hypothesis is likely correct, arbitrary interpretation of PRO is not inconsistent with incorrect attachment altogether.

Second, neither the Nominalization account nor the Variable Attachment account make predictions about the rate at which a non-adultlike interpretation should be accessed in place of the adultlike interpretation. While both the nominal structure in (10b) and the high attachment structure from the Variable Attachment account predict the free interpretation of PRO, in all of the studies to date, children accessed different interpretations at different rates. Although this variation is not inconsistent with either account, no explanation is offered for why, for example, uniform rates for each interpretation of PRO were never observed across all studies – a result that would also have been consistent with these accounts. In sum, any pattern of behavior with non-adultlike interpretations of adjunct control would be consistent with both the nominal and high attachment structures, since neither one places a syntactic restriction on the interpretation of the adjunct subject.

Thus, several questions remain about children's interpretations of adjunct control. In the next section, we consider how extragrammatical factors might influence children's behavior, in particular the role of task effects.

1.2 Task-related factors in previous studies

While the influence of task-specific factors in children's interpretations of adjunct control has been discussed previously (McDaniel & Cairns 1990; McDaniel et al. 1991; Cairns et al. 1994; Broihier & Wexler 1995), the variation observed across tasks does suggest that children's non-adultlike behavior was at least partly task-related. Since the focus to date has been on determining a grammatical source for children's non-adultlike behavior, however, there has been no systematic comparison across tasks to examine extragrammatical factors.

The most commonly used methodology in studies investigating the acquisition of adjunct control has been the Act Out Task (Goodluck 1981; Hsu et al. 1985; McDaniel & Cairns 1990; Goodluck & Behne 1992; Goodluck 1998; 2001), in which children are instructed to act out a test sentence with a set of toys. Necessarily, only one interpretation can be acted out at any one time, which presents a dilemma for children whose grammars make the adjunct subject ambiguous. In adults, a number of factors have been argued to influence the resolution of referential ambiguities, including first mention, recency, and syntactic parallelism (Sanford & Garrod 1981; Givón 1983; Gernsbacher & Hargreaves 1988; Gernsbacher 1989; Ariel 1990; Gordon, Grosz & Gilliom 1993; Gundel, Hedberg & Zacharski 1993; Stevenson, Crawley & Kleinman 1994; Grosz, Weinstein & Joshi 1995; Arnold 1998; 2001; Arnold, Brown-Schmidt & Trueswell 2007; Kehler & Rohde 2013). However, children's sensitivity to these factors is inconsistent at best (Thornton & Wexler 1999; Arnold et al. 2007; Conroy et al. 2009). Importantly, if children do have a nominal structure like in (10b) (repeated below) that allows free reference of PRO, then in an act out task there may be any number of non-syntactic interpretation strategies involved in choosing one antecedent of PRO over another.

(10) b. Ernie scratched the witch before [$_{NP}$ (the) drinking (of) a gulp of water].

It is therefore unclear how to interpret a pattern of behavior with variation both within and across studies in which non-adultlike interpretations were reported for sentences with adjunct control.

To address this concern, McDaniel and colleagues (McDaniel & Cairns 1990; McDaniel et al. 1991; Cairns et al. 1994) added a judgment of reference task. This judgment task is designed to address the limitation of act out tasks in revealing only one interpretation. However, the interview procedure of inquiring about other interpretations after children's initial responses may add an additional pragmatic pressure to accept a wider range of interpretations by implying that in at least some cases, there should be multiple interpretations available. To avoid this type of pragmatic pressure, tasks like the TVJT (Crain & McKee 1985; Crain & Thornton 1998) are designed to probe for different interpretations but with a carefully balanced context.

Two studies to date on the acquisition of adjunct control did use TVJTs, but there are concerns with both of them that motivate some of the methodological choices implemented in the current study. First, Broihier & Wexler (1995) reported results that were consistent with the proposed Nominalization analysis, but with high variability and without eliciting justifications for children's true/false answers. Justifications are a crucial feature of a TVJT, especially in a case with a high proportion of non-adultlike responses where no data are provided from adults.

The most recent study on the acquisition of adjunct control, by Adler (2006) did use a TVJT and did elicit justifications, but did not test for an object control interpretation of PRO, using test sentences with the form:

(11) Donald Duck went to the bank after PRO buying a truck.

Although Adler (2006) reported some non-adultlike behavior due to interpretation of PRO as a sentence-external referent, an adult pattern of behavior for (11) is indistinguishable from one where the only plausible sentence-internal referent of PRO (which in (11) happens to be the main clause subject) is selected over a sentence-external one. Testing whether children have the adult grammar of adjunct control therefore requires a context with the main clause object as a plausible antecedent of PRO.

These concerns suggest that an adequate test of children's interpretation of adjunct control has not yet been conducted. Furthermore, with different ranges of interpretations observed across different studies, it is not clear to what extent children's behavior has been influenced by specific task demands. In the current study, we first reproduce children' non-adultlike interpretations for adjunct control using a design based on previous tasks. We then show that children's accuracy improves significantly with a new task which addresses some concerns from the first design. This difference suggests that extragrammatical processes may be able to account for children's errors. We conclude by discussing how future work can further clarify the relation between the grammatical analysis, the performance system, and the observed behavior.

2 Experiment 1

Experiment 1 was designed to reproduce children's behavior for sentences with adjunct control in previous studies, based on the TVJT designs used by Broihier and Wexler (1995) and Adler (2006). If, as proposed in previous studies, many children do not have adultlike knowledge of adjunct control, then the overall pattern of behavior for children should contrast with the pattern for adults. However, non-adultlike responses are also predicted for children if their behavior is influenced by the task. These patterns are not necessarily predicted to be the same, as it is not clear exactly how the task might have influenced children's behavior. We take children's performance in Experiment 1, therefore, as a baseline for comparison with other tasks.

2.1 Participants

Participants were 34 children (16 males) ages 4;0–5;3 (M = 4;7) who were recruited through the University of Maryland Infant and Child Studies Database or participated at their local preschools; and 20 undergraduate students in introductory Linguistics classes at the University of Maryland, College Park. An additional 11 children were excluded from the final sample for answering too many control sentences incorrectly (6), failure to complete the training portion (2) or inattention (3). Adults received course credit for their participation.

This study was approved by the Institutional Review Board at the University of Maryland, College Park, with written informed consent collected from adult participants and the parents of child participants.

2.2 Design and Materials

We used a TVJT to set up contexts that made both a subject interpretation and an object interpretation of PRO available and relevant (Conroy et al. 2009). Factors were Context (subject-true/object-true, within-subjects), and Age (child/adult, between-subjects) with the truth conditions for Context spelled out in Table 1.

Context either made the subject interpretation of PRO true and the object interpretation false (subject-true) or the subject interpretation false and the object interpretation true (object-true). For a given story, both interpretations were always available, and so a single item appeared in both conditions (subject-true and object-true) in different lists.

Test stories had a format like the following (important events in bold):

(12) a. Dora and Diego are going outside to play in the snow but neither of them has a jacket. Diego wants to get a jacket and asks Dora if she wants one too, but Dora doesn't because she thinks she won't be cold if they play tag. **Diego gets a jacket anyway**, and tries to hide from Dora behind a snowman. Dora sees Diego hide, so **she tags him** and he falls down in the snow. Dora realizes that she's cold now too, and asks Diego if he's cold since he's covered in snow. Diego says he's not since he already had a jacket on, so **Dora gets a jacket too** so she won't be cold anymore either.

b. subject-true: Dora tagged Diego before getting a jacket.
object-true: Dora tagged Diego after getting a jacket.

For the test sentences in (12), the subject control (adult) interpretation is available because Dora got a jacket after the tagging event. At the same time, the object control (non-adult-like) interpretation is also available for both sentences, because Diego got a jacket before the tagging event.

The stories were designed so that a statement about the order of events would be a felicitous description of the story. This was achieved by establishing the possibility of alternate

Table 1: Factors and truth values for Context in Experiment 1.

Context	interpretation	
	PRO = subject (adultlike)	**PRO = object (non-adultlike)**
subject-true	true	false
object-true	false	true

orders throughout the story, making a true statement about an order that was ultimately realized, and a false one about one that was possible at one point in the story, but ultimately unrealized. Additionally, boxes with pictures of the three main events appeared at the end of each story as a reminder of the order in which they had occurred. To make sure children had followed the entire story, they were asked to resummarize the story just before the test sentence to "help the puppet remember" (all children could do this).

Since the difference between the subject and object interpretation of PRO depended on awareness of the temporal order of events in the stories, we included minimally different control items which depended on event ordering, but which had no syntactic control. Instead, the control items had a finite adjunct and an overt subject (which was another item in the story):

(13) Dora hugged Diego before/after the plane landed.
(where Diego has arrived on a plane to meet Dora)

High performance on the control items serves as an indication that children's judgments for the test sentences were indeed based on the order of events, which involved resolving the antecedent of adjunct PRO before judging the event order.

2.3 Procedure

To ensure that children would base their judgments on the temporal order of events in the stories, the training session was designed not just to confirm that children could correctly judge if a puppet's statement was true or false (by indicating that a puppet "got it right"), but also that:

(a) children knew the meanings of *before* and *after*
(b) they could correctly judge the puppet's statements when they included *before* and *after* to describe everyday routines, and the events in two warmup stories

Children received feedback for incorrect responses, and those who judged the puppet to always be correct or to always be incorrect for all training items despite the feedback did not proceed to the test portion. The training items focused exclusively on the ordering of events, to focus children's attention on the relevance of *before* and *after* to the truth value of the test sentences. No features of control were included in the training trials.

Stimuli included 4 easy training items without visuals, 2 training items with visuals similar to the test items, 4 test items, and 3 control items with an overt subject and a finite adjunct. Children were included in the analysis if they answered zero or one control question incorrectly, but were excluded if they answered more than one control question incorrectly.

Two orders were constructed, with two different lists for each order. Truth value of the sentence, whether the sentence contained *before* or *after,* and the correct antecedent of PRO were all counterbalanced across items and lists. In order to balance the salience of both potential antecedents of PRO, the puppet uttered a preamble directly before each test sentence that consisted of a short (one clause) description of the story and contained both names of the potential antecedents of PRO in a conjunct:

(14) Dora and Diego were both playing tag outside, and oh, I know: [test sentence]

The order of mention for the potential antecedents was also counterbalanced across items and lists. Test sentences were all sentences with a structure like in (12), and visual stimuli

were presented to children with the PowerPoint app on an iPad2, and to adults on a 13-inch laptop. Adults were not presented with the four easy training items. Each participant was tested in a single session that lasted from 20 to 25 minutes for the children, and from 10 to 15 minutes for the adults.

2.4 Predictions

For Experiment 1, similar patterns of non-adultlike behavior are predicted for non-adultlike grammars that allow free reference. One assumption that is made with the Truth Value Judgment Task is that children (and adults) will accept a true interpretation if one is available, i.e. the Principle of Charity (Crain & Thornton 1998). A true interpretation is made available in both conditions (the subject interpretation in the subject-true condition, and the object interpretation in the object-true condition); thus, if children's grammars allow free reference of PRO, we expect them to accept the test sentences in both conditions.

However, in practice the Principle of Charity is not always available. If one interpretation is more salient than the other, then assumptions like the Principle of Charity may be overridden. Moreover, children may override a grammatical constraint if the context favors an ungrammatical interpretation (Crain & Thornton 1998; Conroy et al. 2009). Therefore, if any pragmatic pressures are introduced by the context, children may not behave as expected with respect to the Principle of Charity, and they may give responses that are inconsistent with their grammars.

Meanwhile, adults can usually be expected to accommodate a pragmatically biased context and respond without violating grammatical constraints. In particular, even if any task-specific factors do influence children's interpretations, adults should still accept subject-true sentences and reject object-true sentences.

2.5 Justifications

In addition to judging whether a test sentence was true or false, children and adults were asked to justify their answers. Children generally gave justifications to their answers with little prompting, and the vast majority of justifications given cited order of events as the reason for rejection or acceptance.

Justifications were coded as *clear*, *unclear*, or *irrelevant* (Syrett & Lidz 2011). *Irrelevant* justifications were primarily observed when a child was distracted or forgot the test sentence, while *unclear* justifications tended to include all three events in the story, making it unclear which of the characters, if either, had been selected as the antecedent of PRO. *Clear* justifications cited two of the three main events, and made it clear which character had been interpreted as PRO. Examples of *clear* justifications to the test sentences in (12) are given in Table 2.

Of the 80 responses by adults to the test sentences, 78 (98%) were *clear*, and 2 (2%) were *irrelevant*. Of the 134 responses by children, 113 (85%) were *clear* (66 as Diego and 47 as Dora), 18 (13%) were *unclear*, and 3 (2%) were *irrelevant*. Since most of the time

Table 2: Examples of *clear* justifications to the test sentences in (12).

subject-true: Dora tagged Diego before getting a jacket
"Yes, because she was cold *after* she tagged him behind the snowman." (PRO = Dora) "No, because Diego put on a jacket then Dora tagged Diego." (PRO = Diego)
object-true: Dora tagged Diego after getting a jacket
"No, because he should have said Dora tagged Diego *before* she got a jacket." (PRO = Dora) "Yes, because he got a jacket before they played tag." (PRO = Diego)

children gave clear justifications to their answers, including the answers without clear justifications does not significantly affect the data, so all data is included in the analysis.

2.6 Results

Results for Experiment 1 are presented in Figure 1. We used R (R Core Team 2015) and *lme4* (Bates et al. 2015) to perform a mixed-effects logistic regression, with Age and Context as fixed effects (with treatment coding), and subjects and items as random effects. The model revealed a main effect of Context ($\beta = 5.48, Z = 5.57, p < .001$), a main effect of Age ($\beta = 2.64, Z = 3.41, p < .001$), and a significant interaction between Context and Age ($\beta = –4.62, Z = –4.49, p < .001$).

The interaction and main effect of Context are clear from a visual inspection of Figure 1: adults responded as expected, with higher acceptance for subject-true sentences than for object-true sentences ($t(19) = 17.74, p < .001$), with a smaller difference in the same direction for the children ($t(33) = 2.68, p = .01$). However, there was much more variation in the different patterns of responses exhibited by children (Table 3), and the main effect of Age is likely due to this variation.

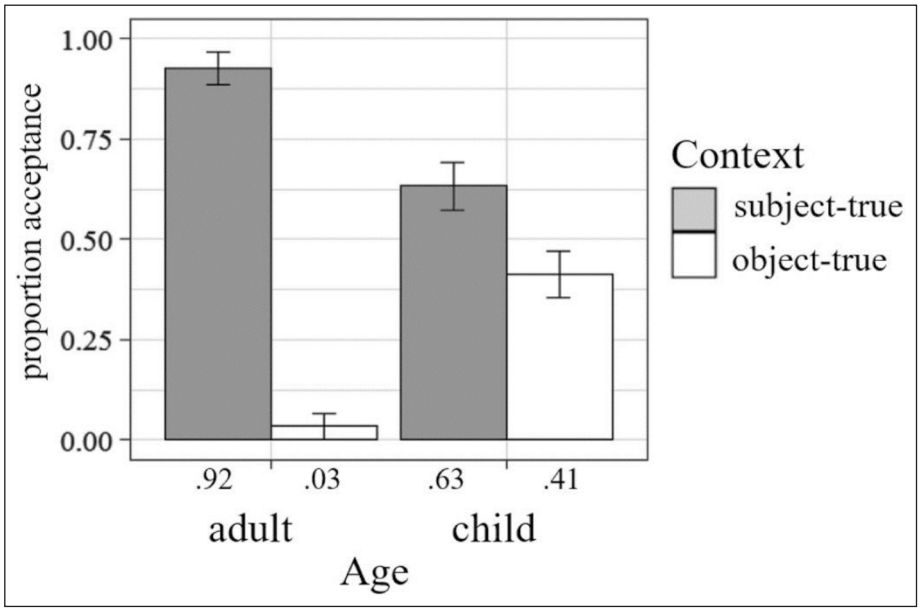


Figure 1: Proportion acceptance of the test sentence by Context and Age in Experiment 1.

Table 3: Distribution of responses in Experiment 1 by number of trials accepted in each condition, children only.

Number of trials accepted in each condition	Number of children
2 subject-true accepted, 0 object-true accepted (strict subject/adult-like)	5
2 subject-true accepted, 1 object-true accepted	6
2 subject-true accepted, 2 object-true accepted (all test trials accepted)	3
1 subject-true accepted, 0 object-true accepted	4
1 subject-true accepted, 1 object-true accepted	10
1 subject-true accepted, 2 object-true accepted	1
0 subject-true accepted, 0 object-true accepted (all test trials rejected)	2
0 subject-true accepted, 1 object-true accepted	2
0 subject-true accepted, 2 object-true accepted (strict object)	1

2.7 Discussion

Although children's behavior in Experiment 1 patterned in the same direction as adults, they gave a much higher number of object control responses, reflected by the interaction between Age and Context. Moreover, children's behavior doesn't clearly resemble any of the patterns that were predicted by previous grammatical accounts based on the Principle of Charity: children's behavior was predicted to be at ceiling in the subject-true condition for a strict subject (adult-like) grammar or at ceiling in the object-true condition for a strict object grammar, or at ceiling for both conditions with a free reference grammar. Instead, acceptance was not at ceiling for either condition, suggesting that other factors may have played a role in determining their responses.

For example, the dependent measure in Experiment 1 was a true/false answer, but reaching that answer for each trial involved various steps. After listening to each story, children needed to evaluate the truth value of the test sentence, based on the order of the events in the story. Determining which events to focus on involved retrieving an antecedent for PRO. Then, after determining which events to judge and in which order (based on the test sentence), children gave a true/false answer (based on the order of the events in the story).

With a true/false answer based on a judgment about event order, the dependent variable in Experiment 1 did not directly reflect children's interpretations of PRO. In general, children's justifications matched their true/false answers, but it is also possible that the cost of holding events in memory interfered with retrieving the antecedent of PRO, or with making a true/false judgment. For example, for the adjunct control test sentences, children may correctly retrieve the antecedent of PRO in their initial parse of the test sentence, but their representation of the antecedent or the event order in the sentence may become degraded due to later processing demands. Alternatively, children may experience difficulty when comparing the order of the events in the test sentence to the order of events in the story. While children's behavior may have been influenced during any of these steps, Experiment 1 is not designed to identify which ones. In Experiment 2 we introduce a new task that reduces the number of steps between the test sentence and the behavioral response, providing a more direct measure of children's interpretations.

3 Experiment 2

Experiment 2 takes three steps to reduce the task demands from Experiment 1. First, to avoid any pragmatic bias for one interpretation over another, the stories were replaced with standalone pictures, with minimal context. If children's responses were influenced by the processing costs associated with holding the events in the sentence in memory to compare with the events in the story, then simplifying the context should result in improved accuracy overall.

Second, the context was also simplified by reducing the relevance of the event ordering in the test sentence. This change allowed for more focus to be placed on other elements in the adjunct clause; specifically, the direct object, which provided information to contrast the antecedent of PRO with another referent.

Finally, in Experiment 2 we used the Coloring Book task (Pinto & Zuckerman 2015; Zuckerman et al. 2016), which allows children to indicate their interpretation of a test sentence without evaluating the truth value of the test sentence. Rather, the task involves coloring in an item in a black and white picture – an activity that preschool-aged children are especially familiar with. For sentences with adjunct control, this task is particularly appropriate, as we can direct children to color in a picture to indicate their interpretation of adjunct PRO. If children's grammars are adultlike, then the test sentences should indicate unambiguously which item should be colored in. Otherwise, as with the act out task,

no clear preference is predicted for one interpretation over another. Thus, any differences between the coloring task and the act out task would be due to the differences in demands of producing a response in each respective task. Importantly, these predictions contrast with those of the Principle of Charity with a TVJT, since the task does not involve a true/false judgment (Crain & Thornton 1998).

3.1 Participants

Participants for the coloring task were 32 children (15 males) ages 4;0–5;3 (M = 4;9) who were recruited through the University of Maryland Infant and Child Studies Database or participated at their local preschools. An additional 9 children were excluded from the final sample for answering too many control sentences incorrectly (6), inattention (2), or equipment failure (1).

Adult controls (n = 6) were also tested on the coloring task. They performed at 100% accuracy for all items with no variation, and their results are not included in further analyses. The adults were undergraduate students in introductory Linguistics classes at the University of Maryland, College Park, and they received course credit for their participation.

3.2 Design

We used the Coloring Book task introduced above, which allowed children to show their interpretation of the test sentence by coloring in a black and white picture (Pinto & Zuckerman 2015; Zuckerman et al. 2016). For example, with the sentence in (15), children are prompted to color either Dora's apple or Diego's apple.

(15) Dora washed Diego before PRO eating the red apple.

The test sentence is presented with the black and white picture in Figure 2.

Because one goal of the coloring book task was to eliminate the extra steps from the task in Experiment 1, a response in the coloring book task only involved coloring in one of two objects. For example, for the test sentence in (15), the adultlike interpretation of the adjunct clause is that Dora ate the red apple (with no color specified for Diego's apple). However, if PRO is interpreted as the main clause object, then the interpretation of (15) would be that Diego ate the red apple. Based on their choice of which object to color in, children's answers can therefore be categorized based on whether a child gave a *subject* response or an *object* response. With no conditions analogous to those in Experiment 1,

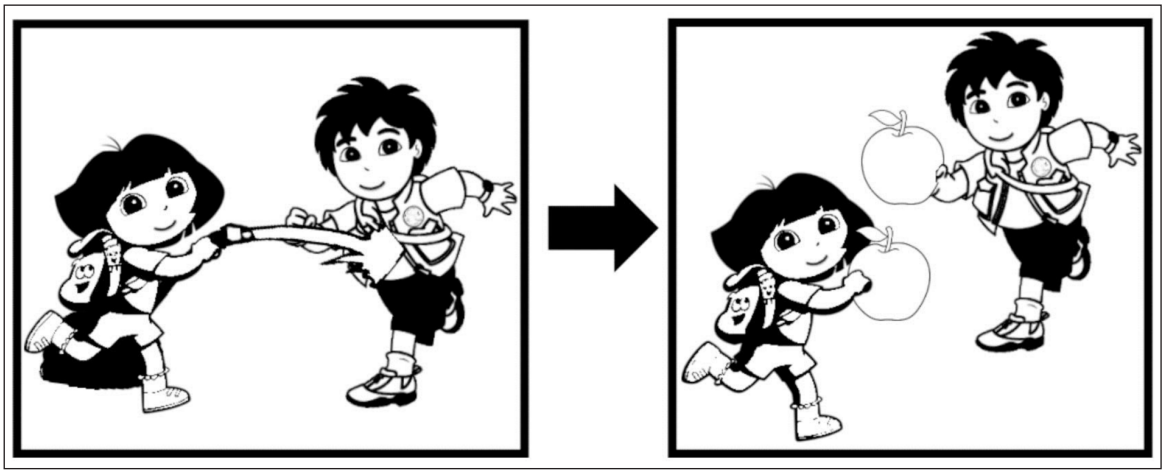


Figure 2: Example item for Experiment 2, to go with (15).

the dependent measure in Experiment 2 is simply the proportion of *subject* responses, with adultlike behavior indicated by a higher proportion of *subject* responses.

3.3 Materials

Each item in Experiment 2 had the form in (15). The main clause was depicted in one picture (Dora washing Diego), while the other picture contained both characters performing the action described in the adjunct clause (eating an apple).

For each item, coloring in one of the two objects corresponded to an adultlike interpretation of PRO (Dora's apple in (15)), while the other object corresponded to a non-adultlike interpretation (Diego's apple in (15)), with the correct antecedent of PRO (*Dora* or *Diego*) counterbalanced across items. Because interpreting the responses depended on children coloring only one of the objects, the task was administered on a touchscreen computer and programmed so that only the two relevant objects could be colored in. Additionally, children learned during the training session that only one object should be colored in for each trial.

Two orders were constructed, with two different lists for each order. The correct antecedent of PRO, character position on the screen, and whether the sentence contained *before* or *after* were all counterbalanced across items and lists. Although the order of events was not a main feature of the design, test sentences still described sequences of events. To support the use of a temporal adjunct, an arrow between the two pictures indicated the order of events, with the first event always in the left picture. This ordering allowed us to counterbalance which picture contained the main clause event, and which contained the adjunct clause event. In sentences with *before* (e.g. in (15)), the main clause event appeared on the left, while in sentences with *after*, the main clause event appeared on the right.

Finally, with just two possible answers to choose from, various strategies might be available for picking out the correct (subject) item on every test trial, resulting in the same behavior as the adult grammar for adjunct control. To rule out a strategy and make sure that children's interpretations were due to the adjunct control dependency, we included control sentences with a finite adjunct that had an overt subject, as in (16):

(16) a. Dora washed Diego before she ate the red apple. (pronoun subject antecedent)
b. Dora washed Diego before he ate the red apple. (pronoun object antecedent)

In order to color the correct item on the control sentences as well as the test sentences with adjunct control, children needed to consider both characters as possible antecedents, with no difference between control trials and adjunct trials until the presentation of the adjunct clause. High performance on the control items therefore serves as an indication that both the subject interpretation (in (16a)) and the object interpretation (in (16b)) are available without a syntactic restriction, and adultlike behavior on the test sentences can be interpreted as a preference that is specific to sentences with adjunct control.

3.4 Procedure

The training session for the coloring task was designed to familiarize children with coloring in a single object based on a sentence with a temporal adjunct. The pictures were presented with an array of colored squares, and to color in an object, children were instructed to "tap the color, and then tap the thing." After an initial warm up to practice coloring with the touchscreen, two additional training items focused on coloring in a single object

based on a sentence describing a sequence of pictures. All sentences used in the training session had overt subjects, and no features of control were included in the training trials. All children could color the objects by the end of the training session.

In addition to the training items, the stimuli included 4 test items, 4 control items with a pronoun referring to the main clause subject (as in (16a)), and 4 control items with a pronoun referring to the main clause object (as in (16b)). Children who responded incorrectly to more than one control item with a subject pronoun or to more than one item with an object pronoun were excluded from the analysis. That is, children could answer up to two control items incorrectly (one of (16a) and one of (16b)) and still be included in the analysis.

To familiarize the children with the pictures, the actions were introduced at the beginning of each new trial:

(17) In this picture we have Dora washing Diego, but first there's Dora eating an apple, and there's Diego eating an apple too.

Next, to balance the salience of both potential antecedents of PRO, a preamble was included before each test sentence that contained both names of the potential antecedents of PRO in a conjunct:

(18) So here's how we should color this picture of Diego and Dora: [test sentence]

The order of mention of the characters in the picture introductions (17) and the preamble (18) was counterbalanced across items and lists. Test sentences all had the structure like in (15), with emphasis on the color, and the stimuli were presented to children with the Coloring Book app (Pinto & Zuckerman 2015; Zuckerman et al. 2016) on a Dell touchscreen computer. Each participant was tested in a single session that lasted from 10 to 15 minutes for the children, and less than 5 minutes for the adults.

3.5 Predictions

With no differences between the participants in Experiments 1 and 2 in terms of age or demographics, any differences in accuracy can be attributed to the task. If the processing demands associated with the TVJT in Experiment 1 influenced children's behavior, then the absence of these factors in the experimental design should result in increased accuracy for the coloring book task.

3.6 Results

A one-sample t-test confirmed that the proportion of *subject* responses for children was well above chance at 0.85 ($t(31) = 10.96$, $p < .001$).[1]

While the pattern of behavior in Experiment 1 alone did not clearly indicate whether children's grammars are adultlike, the pattern in Experiment 2 provides much stronger evidence for task effects as the source of children's errors in previous studies.

[1] With different dependent measures, it is not appropriate to do a statistical comparison between the results from Experiment 1 and Experiment 2. However, if children's responses in Experiment 1 are recoded to reflect their *subject* responses (i.e. if we code responses in the subject-true condition as *subject* if a child answered "true" and *object* if a child answered "false," and vice versa for the object-true condition), then a mixed effects logistic regression with Task as a fixed effect and subject and item as random effects reveals a main effect of task ($\beta = 1.4$, $Z = 2.47$, $p = .01$), with a higher proportion of *subject* responses for the coloring task in Experiment 2 (0.85) than for the TVJT in Experiment 1 (0.61, which was still significantly higher than chance ($t(33) = 2.73$, $p = .01$)). The same result is obtained using children's justifications to their true/false answers in Experiment 1.

The coloring task involves reduced processing demands compared to the TVJT. It does not eliminate them, and some children still made some errors with the coloring task. Importantly, the pattern is much more adultlike, with much less variation than in Experiment 1 (Table 4). Although the pattern in Table 4 is consistent with a grammatical account where half of the children have the adult grammar and half have a free reference grammar, a grammatical account alone does not explain the overall subject preference or, more importantly, the increase in subject preference from Experiment 1 to Experiment 2.

3.7 Discussion

In Experiment 2, children's performance was much more adultlike than in Experiment 1. What can be concluded from this result is that children's behavior for sentences with adjunct control was likely influenced by task demands in previous studies, including Experiment 1. These demands may be linked to the additional steps involving the order of events when resolving the control dependency, the pragmatics of the context, or the salience of the possible antecedents, which may not have been fully balanced in previous tasks. The coloring book task allows us to address many of these concerns, providing a clearer picture regarding the source of children's errors for sentences with adjunct control.

Importantly, the results from Experiment 2 do not constitute evidence that the coloring book task categorically eliminates the difficulties associated with the TVJT, regardless of the linguistic phenomena. The influence of these difficulties can vary widely depending on the specific design of the experiment, and preschool-aged children have exhibited adultlike behavior for many other structures with a TVJT, e.g. Principle C (Crain & McKee 1985; Crain & Thornton 1998), Principle B (Conroy et al. 2009), Quantifier Raising (Musolino & Lidz 2006; Gualmini et al. 2008; Viau, Lidz & Musolino 2010), and others. In cases where children do not exhibit adultlike behavior with a TVJT, the coloring book task provides an alternative means of evaluating children's performance, with the potential to demonstrate improved performance in a context that avoids some of the difficulties associated with the TVJT (Pinto & Zuckerman 2015; Zuckerman et al. 2016). Since children's interpretations are clear from what they choose to color, no additional justifications are needed, and many of the complications that are introduced by pragmatic pressures in a TVJT are avoided. At the same time, any task will introduce some level of task demands. Understanding the source of these demands can be beneficial for understanding parsing procedures in different contexts. We will explore this further in the following section.

4 General discussion

In this study, we examined how task demands can influence children's interpretations of sentences with adjunct control. In Experiment 1, we reproduced children's non-adultlike behavior using a Truth Value Judgment Task. Although children's behavior patterned in the same direction as adults, they gave many non-adultlike responses. Various grammatical

Table 4: Distribution of responses in Experiment 2 by number of trials where the *subject* item was colored in, children only.

Number of trials where the *subject* item was colored in	Number of children
4 subject trials (strict subject/adult-like)	17
3 subject trials (1 object trial)	10
2 subject trials (2 object trials)	5
1 subject trial (3 object trials)	0
0 subject trials (strict object)	0

accounts have been proposed to explain children's non-adultlike behavior, but the pattern in Experiment 1 – especially with such a wide range of responses – did not clearly match the predictions of any one account. However, by simplifying the task in Experiment 2, we observed a much higher rate of subject responses. These results suggest that task demands are responsible for at least some of the non-adultlike behavior that has been observed for adjunct control.

With different patterns of behavior observed across studies and tasks, this raises further questions about the demands involved in previous tasks, and how they compare with the current study. In the following sections we consider how these demands might have influenced children's behavior, as well as implications for acquisition.

4.1 Act out task revisited

Used in most studies on the acquisition of adjunct control, the act out task allows children to demonstrate their understanding of a test sentence by acting out their interpretation with a set of toys. As discussed in §1.2, this is problematic for children whose grammars generate multiple readings, which motivated the judgment of reference task (McDaniel et al. 1991; Cairns et al. 1994) and the TVJT (Broihier & Wexler 1995; Adler 2006) for probing individual interpretations of adjunct PRO. Meanwhile, the current study used the coloring book task, which has the same limitation of the act out task of revealing only one interpretation at a time, but for which children showed a much more adultlike pattern of behavior overall. This limitation alone therefore cannot account for children's non-adultlike interpretations; as discussed in §2.7 for the TVJT, other demands to consider are those involved in arriving at an interpretation and producing a behavioral response.

Compared to the TVJT, the context for arriving at an interpretation in an act out task is similar to the coloring task, with minimal pragmatic context by design. For both the act out task and the coloring book task, however, there are various factors that may influence the steps involved in producing a behavioral response. For example, for sentences with adjunct control, both the act out task and the coloring task involve planning and executing two distinct actions, either of which may directly influence the demands of the task: in the act out tasks, children were asked to act out both the main clause and the adjunct clause (e.g. for (15), Dora washing Diego, and then Dora eating the red apple). Meanwhile, in the coloring task, coloring in the correct object involved first selecting the correct color from the array of colored squares below the picture sequence from Figure 2, and then coloring in the correct object.

In both the act out task and the coloring task, it is the second of these actions – acting out the adjunct clause, or coloring in the correct object in the adjunct clause – that most clearly indicates the interpretation of adjunct PRO. However, for both tasks, these first actions introduce an additional memory load: the second action, indicating the antecedent of PRO, must be held in memory while the first action is carried out. If carrying out the first action interferes with the representation of the test sentence, then this may result in higher rates of non-adultlike behavior, independent of the grammar. In sum, both actions in both tasks can vary in complexity (Table 5), and for the act out task, this may account for some of the variation across previous tasks.

Similar to the TVJT, we do not take children's high accuracy in the current study to mean that the coloring task addresses all difficulties with the act out task. However, the comparison in Table 5 highlights some advantages of the coloring task, particularly with respect to consistency and replicability. These are clearest in the first step in both tasks, which for an act out task involves acting out different actions with different characters in different agent/patient relations for each trial, compared to selecting one of seven colors from the same array for the coloring task. If this difference affects how well the representation of

Table 5: Breakdown of steps to produce a behavioral response for the act out task and the coloring book task.

Task	Steps for (15) *Dora washed Diego before eating the (red) apple.*
Act out	1. a. identify one toy as main clause agent (*Dora*) and one as patient (*Diego*) b. plan and execute action for main clause verb (*washing*) 2. a. identify one toy as agent of adjunct verb (also adjunct PRO) b. plan and execute action for adjunct verb (*eating an apple*)
Coloring	1. a. identify one color from the array of seven colored squares (*red*) b. plan and execute action of selecting that color from the array 2. a. identify item to color based on test sentence interpretation (*one of the apples, based on antecedent of PRO*) b. plan and execute action of coloring in the item

the test sentence is maintained in memory, then children's behavior will be different in the different tasks, independent of their grammars. Finally, the pre-programmed set-up in the coloring task also allows for a more consistent delivery, compared to the more open-ended format of the act out task, which may introduce complications if any other parts of the sentence are acted out incorrectly or left out altogether. This can make it difficult to define a level of comparison like chance performance, to compare non-adultlike behavior on the act out task with tasks used in other studies.

4.2 Memory for events

In §3 we outlined various aspects of the TVJTs used to investigate children's interpretations of adjunct control that might have introduced task effects for those studies in particular. For example, these TVJTs have used event order to distinguish between true and false contexts. Holding events in memory to compare with the story may have increased the difficulty associated with the task. At the same time, children usually provided clear justifications for their true/false judgments. This suggests that any difficulty associated with keeping track of event order did not prevent children from selecting an antecedent to adjunct PRO, at least for the trials where clear justifications were provided. Children were also generally accurate in their judgments of event order, including for sentences with *after* (Clark 1971), but it is also possible that difficulty with comparing events interfered with children's ability to deploy the relevant grammatical constraint when retrieving an antecedent for PRO. If so, this would predict that the same high accuracy observed in the coloring task should also be exhibited for a TVJT with a contrast other than temporal ordering to determine the truth value of the test sentences.

If we observed higher accuracy in a TVJT with some contrast other than the order of events in the sentence, this would provide support for the difficulty associated with evaluating the order of events as one source of children's non-adultlike behavior. However, it would not speak to the question of *how* the event order comparison should interfere with children's ability to retrieve the correct antecedent of adjunct PRO. If comparing event orders interferes with sentence processing abilities in general, then children should exhibit lower accuracy for all tasks with event order as a relevant contrast (compared to minimally different sentences with a different contrast).

4.3 Pragmatic context

If children's ability to compare the relevant events was affected by the pragmatic context of the stories, then children might exhibit higher accuracy with the same contrast between temporal orders, but with a modified context to highlight different aspects of the stories (e.g. by making the relevance of temporal ordering more salient in the stories).

In contrast, there is little to no pragmatic context involved in the coloring task, which translates to fewer opportunities in the coloring task for children's interpretations to be influenced by the context. Therefore, as observed for numerous other types of structures, children should exhibit higher accuracy for sentences with adjunct control in a TVJT which sets up the right pragmatic context. From the studies conducted so far, however, it is not clear exactly how this context should differ from the ones used for the TVJT in Experiment 1.

4.4 Implications for acquisition

With the simplified context of the coloring task, children's interpretations were usually adultlike. This change in behavior is not consistent with the strict object or free reference grammars proposed in previous studies, neither of which predict an increase in subject responses with a decrease in task demands. Importantly, this direction of change is predicted for a strict subject grammar with an immature deployment system, which would be susceptible to errors in a context with higher processing costs (e.g. in Experiment 1).

In addition to an adultlike grammar, the increase in subject responses is also consistent with a bias for subject interpretations rather than strict subject control. With both subject and object interpretations available in the coloring task (as verified by the control sentences), such a bias would need to be associated with adjunct control sentences themselves, rather than the task. However, this raises questions about the linguistic input and the kind of evidence that would lead children to discard a subject preference grammar in favor of a strict subject grammar (Gerard 2016; Gerard et al. 2017). Another option is that children's knowledge of adjunct control is adultlike by age 4, but can be obscured in contexts with high task demands.

In the simplified context of the coloring task, most children were able to deploy their knowledge, in contrast to other contexts with higher task demands. At the same time, instances of adjunct control in the linguistic input are unlikely to occur in this type of context; minimally, for sentences with the complementizers *before* and *after*, event order is likely to be relevant in the discourse context. This is true for nearly all such instances in CHILDES, for example:

(19) *CHI: you want a story (.) Mom?
*MOT: yes (.) I want a story before going to sleep.
nina15.cha 2;2.28, from the CHILDES Suppes corpus (Suppes 2004)

In contrast with a context outside the laboratory setting, the context provided in the coloring task provides just enough detail to focus on the construction of interest.

For grammatical accounts of adjunct control, where children are tasked with transitioning from a non-adult grammar to an adult grammar, it is not clear whether their representations of the linguistic input would be the same as adults' representations. If the processing costs in the input are at all comparable to those in previous tasks, then children are likely to access a non-adultlike interpretation of adjunct control at least some of the time. With the exception of Wexler's (1992) maturation account, this is problematic for previous grammatical accounts, which have proposed that children acquire the adult grammar by experiencing sentences with adjunct control in the input. If children misrepresent their linguistic input (Gagliardi & Lidz 2015; Omaki & Lidz 2015), then an alternative account is needed for children's acquisition of adjunct control, that does not depend on children accessing a subject interpretation of PRO (Goodluck & Behne 1992).

If the coloring task is not representative of the linguistic input, then what do we gain? In Experiment 2 with the coloring task, we observed an increase in adultlike behavior for

adjunct control, suggesting that children's grammars are adultlike despite their non-adultlike behavior in previous studies (and Experiment 1). This raises new questions about how the grammar of adjunct control is acquired, given that (a) it is acquired by age 4, and (b) children can still access non-adultlike interpretations at age 4, despite having acquired the adult grammar.

More broadly, these questions arise for any structure where (a) and (b) apply, allowing for more general questions about children's errors with complex structures. Examining the specific source of the task effects in structures like adjunct control will give a clearer picture of the parsing mechanisms involved.

4.5 Conclusion

The experiments in the current study provide evidence for task demands as a source of children's non-adultlike behavior. With the new Coloring Book task in Experiment 2 that addressed a number of methodological concerns with previous studies, including Experiment 1, children's behavior was more adultlike, with no meaningful change in the subject population. This change in the pattern of behavior from Experiment 1 to Experiment 2 suggests that children's grammars for adjunct control are adultlike, and raises new questions about children's acquisition of adjunct control, and about the role of the specific task.

Abbreviations

TVJT = Truth Value Judgment Task

Acknowledgements

The authors wish to thank the children and schools that participated in this study. We would also like to thank the members of the Maryland Cognitive Neuroscience of Language Lab and the Project on Children's Language Learning for valuable feedback on the issues in this article, as well as the audiences at CUNY 29 and GALANA 7. This work was funded by an NSF Doctoral Dissertation Research Improvement Grant (BCS-1551662).

Competing Interests

The authors have no competing interests to declare.

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How to cite this article: Gerard, Juliana, Jeffrey Lidz, Shalom Zuckerman and Manuela Pinto. 2018. The acquisition of adjunct control is colored by the task. *Glossa: a journal of general linguistics* 3(1): 75. 1–22, DOI: https://doi.org/10.5334/gjgl.547

Submitted: 18 October 2017 **Accepted:** 24 April 2018 **Published:** 20 June 2018

]u[*Glossa: a journal of general linguistics* is a peer-reviewed open access journal published by Ubiquity Press.

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