Errors involving universal quantification are common in contexts depicting sets of individuals in partial, one-to-one correspondence. In this article, we explore whether quantifier-spreading errors are more common with distributive quantifiers each and every than with all. In Experiments 1 and 2, 96 children (5- to 9-year-olds) viewed pairs of pictures and selected one corresponding to a sentence containing a universal quantifier (e.g., Every alligator is in a bathtub). Both pictures showed extra objects (e.g., alligators or bathtubs) not in correspondence, with correct sentence interpretation requiring their attention. Children younger than 9 years made numerous errors, with poorer performance in distributive contexts than collective ones. In Experiment 3, 21 native, English-speaking adults, given a similar task with the distributive quantifier every, also made childlike errors. The persistence of quantifier-spreading errors in adults undermines accounts positing immature syntactic structures as the error source. Rather, the errors seemingly reflect inaccurate syntax to semantics mapping, with adults and children alike resorting to processing shortcuts.

1. INTRODUCTION

Natural language expressions must be represented in a format that allows one to distinguish between properties and the individuals having those properties (Braine and O’Brien (1998), O’Brien et al. (2003)). Quantificational terms such as all, usually, and most are a crucial type of linguistic device used to indicate which sets of individuals or events have which properties and relationships. Although quantifiers play a very important role in logical reasoning (Braine and O’Brien (1998)), their acquisition may be delayed relative to other sorts of lexical items (e.g., nouns and verbs) because their complex patterns of usage often result in interpretive ambiguities. Thus, all is often ambiguous between quantifier and...
intensifier interpretations. For instance, in *The children ate all of the cookies*, the quantifier interpretation of *all* emphasizes that the cookies, as opposed to the children, are finished. In spoken language, however, the intensifier interpretation is predominant in which it is conventional to say *all* even when it does not imply exhaustivity (Labov (1984; 1985)). For example, for a person to say that *I left all my money at home* would not preclude their having money in the bank (or a few coins in their pocket). Rather, it would merely serve as a means of emphasizing that they did not presently have adequate funds at hand. This pattern of using a universal quantifier as an intensifier is also evident in children’s earliest utterances containing *all*. An examination of transcripts in the CHILDE database (MacWhinney (1995)) indicates that *all* is used primarily as an adverbial intensifier in both child language and child-directed speech (e.g., Naomi 1;11.2 *it is all dirty*; Adam 2;7.14 *kitty eat a apple all up*; Nina 2;2.6 *it’s all gone*; see also Gelman, Coley, Rosengren, Hartman, and Pappas (1998)).

The universal quantifiers *every* and *each* involve additional lexical complexity (Langacker (1991), Vendler (1967)). *Every* appears inside compounds—for example, *everybody*—and it vacillates between collective and distributive interpretations when used as a quantifier (e.g., *Every boy went to a movie* is ambiguous as to whether they all went to the same movie, and if it was the same movie, whether the boys went at the same time or at different times). *Each* is more uniformly distributive but has the further conceptual requirement that the individuals modified by *each* be successively scanned as in *The boys arrived each with his mother* or *The boys each lifted the chair* (Langacker (1991), Roeppe, Strauss, and Pearson (2005)). *Every* and *each* both occur only rarely in either child-directed or child speech, which limits opportunities for children to acquire their patterns of usage.

It comes as no surprise that numerous experiments, starting with the classic studies of class inclusion (Inhelder and Piaget (1958; 1964)), have shown that children, and even adults, make errors in interpreting universal quantifiers (e.g., Bucci (1978), Donaldson and Lloyd (1974), Donaldson and McGarrigle (1974), Freeman and Schreiner (1988), Freeman and Sepahzad (1987), Freeman and Stedmon (1986), Johnson-Laird (1969a; 1969b), Neimark and Chapman (1975), O’Brien et al. (1989)). Errors with universal quantifiers seem to be common in studies using the Truth Value Judgment Task (cf. Crain and Thornton (1998)), especially for scenes in which two sets of individuals are associated with each other in partial, one-to-one correspondence (Drozd (2001), Drozd and van Loosbroek (2006), Philip (1995)). For example, when shown a picture of three boys, each riding an elephant, along with an extra elephant with no rider, children often will answer *no* to the question *Is every boy riding an elephant?* in spite of the fact that every boy is indeed riding an elephant. The error—referred to in the literature as overexhaustive search (Freeman (1985)), exhaustive pairing (Drozd (2001)), Type-A response (Geurts (2003)), and classic spreading (Roeppe et al. (2005))—involves failure to properly restrict the domain of the universal quantifier to the
noun phrase (NP) it modifies. In addition, children often make a complementary error referred to as underexhaustive search (Freeman (1985)), underexhaustive pairing (Drozd (2001)), or Type-B response (Geurts (2003)). When shown a picture of three cars with each car parked in a garage, along with an extra car with no garage, children often will answer yes to the question Is every car in a garage? in spite of the fact that one of the cars is not in a garage. Very young children occasionally make other, more surprising errors in interpreting universal quantifiers, such as answering no to the question Is every bunny eating a carrot? when shown, for example, a picture of three rabbits, each eating a carrot, along with a dog eating a bone. This error is referred to as “bunny” spreading (Roepet al. (2005)) or Type-C response (Geurts (2003)). In this article, we use a sentence–picture matching task as opposed to a Truth Value Judgment Task and focus on errors analogous to classic quantifier spreading (Types A and B) to examine their occurrence in school-age children and adults.

Children’s errors with universal quantification have led to controversies with respect to how to explain them. One view is that the errors stem from children’s deficient syntactic representations (Kang (2001), Philip (1995; 1996), Roepet al. (1993), Roeper and Matthei (1975), Rooper et al. (2005)). Philip (1995; 1996), following Roepet al. (1975) suggested that the classic spreading error is due to the fact that children syntactically misinterpret distributive universal quantifiers (e.g., each or every in English, cada in Spanish or Portuguese) as sentential adverbials that range over events as opposed to individuals. Rooper et al. (2005) described a sequence of steps of how children start with a general syntactic representation of every as an adverbial intensifier that gets progressively more specific as every changes its position in the syntactic representation. A general assumption of the syntactic accounts is that quantifier-spreading errors reflect immature syntactic representations and therefore should not occur in grammatically competent adult speakers.

Alternatively, quantifier-spreading errors may not reflect developmental changes in syntactic representations (i.e., there may be nothing wrong with the child’s syntax). Rather, the errors are presumed to involve shallow processing, resulting in inaccurate mapping between syntactic and semantic representations (Brooks and Braine (1996), Brooks, Braine, Jia, and Dias (2001), Brooks, Jia, Braine, and Dias (1998), Bucci (1978), Drozd (2001), Geurts (2003)). Bucci (1978) argued that children frequently resort to a “scope-guessing” strategy in class inclusion tasks when they are unsure as to which NP is modified by a universal quantifier. Drozd (2001) proposed that children treat universal quantifiers as weak cardinal quantifiers, as opposed to strong presuppositional quantifiers, because they fail to distinguish and compare the observed set (e.g., of elephant-riding boys) with a presupposed set (e.g., of boys). This failure leads the child to interpret the question Is every boy riding an elephant? as “about every boy who ought to be riding an elephant or every boy whom the speaker intends to be riding an elephant given the situation” (Drozd (2001, 358)). Geurts (2003) similarly
interpreted quantifier-spreading errors as indicative of the use of a simpler processing strategy in mapping syntactic structures to semantic representations. Like Drozd (2001), Geurts argued that children treat universal quantifiers as if they were weak quantifiers and assign semantic interpretations that fail to properly identify the quantifier’s domain. Given such an underspecified semantic representation, they resort to pragmatic mechanisms in responding to experimental questions.

Brooks and her colleagues (Brooks and Braine (1996), Brooks et al. (2001), Brooks et al. (1998)) have argued that a prototypical scenario for usage of a distributive universal quantifier such as every or each involves perfect, one-to-one mapping between sets of individuals or entities. Children, and sometimes adults, make errors in situations that deviate from this prototype. Unlike the preceding accounts, Brooks and her colleagues have predicted that quantifier-spreading errors should be more prevalent in contexts with a distributive interpretation of a universal quantifier in comparison to a collective one because the symmetry of one-to-one pairing does not provide any salient cues as to which set of entities is the domain of the universal quantifier.

Both claims, that child and adult syntactic representations differ qualitatively and that children make errors in mapping between syntactic and semantic representations, have been highly controversial. Crain et al. (1996) argued in a very influential article that children’s errors with quantifiers are an artifact of inappropriate testing procedures that do not satisfy pragmatic felicity conditions for yes–no questions. Crain and Thornton (1998) stated, more generally, that in experiments using the Truth Value Judgment Task, an alternative to the depicted (actual) scenario must be under consideration for the question to be pragmatically appropriate (i.e., so-called conditions of plausible assent or plausible dissent need be satisfied). That is, a yes–no question is only felicitous if the child can conceive of a situation different from the actual scene acted out or depicted. Crain et al. (1996, Experiments 1 and 2) showed that the same children who consistently made errors in a task similar to Philip (1995) were almost errorless when given short stories satisfying the condition of plausible dissent that were acted out with various puppets and small props. Crain et al. concluded, based on children’s success, that even preschool-age children have full competence with universal quantification.

This conclusion, however, may be premature due to two methodological issues regarding their experimental design (cf. Drozd (2004) for a more detailed critique of the methodology espoused by Crain and Thornton (1998)). First, Crain et al. (1996) did not systematically vary the position of the universal quantifier in the test questions or statements while holding constant the introductory story and scenario. For example, we do not know whether children would distinguish the questions Is every farmer feeding a donkey? and Is a farmer feeding every donkey? when presented in an identical context. Second, the protagonists in the Crain et al. stories always corresponded to the NP that was modified by the universal quanti-
vier in the test question or statement. This feature of their design provided children with unambiguous cues as to which set of entities was the focus of attention. Highlighting one set of entities (i.e., people) relative to another set served to familiarize children with the intended domain of the universal quantifier (cf. Drozd (2001), Drozd and van Loosbroek (2006)). More generally, the Crain et al. (1996) experiments failed to test whether children could reliably use the position of the universal quantifier in the sentence, as opposed to a biasing context, to determine its domain.

Crain et al.’s (1996) claim that preschoolers have full competence with universal quantifiers would seem to be undermined by the fact that even older school-age children make errors identifying the domain of a universal quantifier. Such errors have been observed in studies using a sentence–picture matching task in which two alternative interpretations of an event are clearly displayed, thus satisfying the condition of plausible dissent. Brooks and Braine (1996, Experiment 1) specifically examined children’s ability to use the syntactic position of a universal quantifier (each or all) to restrict its domain and found comprehension errors in children as old as 8 to 9 years of age. Children were presented with distributive pictures for sentences with each and collective pictures for sentences with all because they are the preferred interpretations of these universal quantifiers (Brooks and Braine (1996, Experiments 2 and 3), Ioup (1975), Vendler (1967)). In the distributive picture pairs, people and objects were arranged in partial, one-to-one correspondence with each other, with either people or objects left over (see Figure 1 for an example). In the collective picture pairs (see Figure 2 for an example), one picture (Figure 2a) showed a group of people acting on a single object (with two objects left over), and the other (Figure 2b) showed one person acting on a group of objects (with two people watching). Brooks and Braine (1996, Experiment 1) observed that only the oldest participants (9- to 10-year-olds and adults) were above chance (as a group) in selecting the correct distributive picture when presented with sentences with each (e.g., There is a man washing each of the bears). In contrast, the children were much more successful when presented with collective pictures and corresponding sentences containing all (e.g., There is a man washing all of the bears), with even 4-year-olds performing at above-chance levels.

The present experiments, which use the sentence–picture matching methodology of Brooks and Braine (1996), make several contributions to the existing literature. First, there have been great discrepancies in error rates across the many studies that have almost exclusively utilized the Truth Value Judgment Task, ranging from near perfect performance in Crain et al. (1996) to extremely high error rates in Kang (2001), that is, over 80% errors in 6- to 7-year-olds. Our sentence–picture matching task does not have the same demand characteristics as the Truth Value Judgment Task, and in our opinion, it provides a more accurate way of evaluating whether children’s interpretations of sentences with universal quantifiers vary systematically as a function of the position of the
quantifier in the sentence and the type of scene (e.g., collective vs. distributive, actional vs. locative).

Second, we examine whether there is an asymmetry in the distribution of errors as a function of the syntactic position of the universal quantifier. To date, there has been some evidence with actional predicates (e.g., Brooks and Braine (1996), Philip (1996)) that children are more accurate with universal quantifiers modifying the subject as opposed to the direct object of a transitive verb. In Brooks and Braine (1996), the effect of quantifier position varied across age groups, with 6- to 8-year-olds displaying a much stronger subject/object asymmetry than 4- to 5-year-olds. Kang (2001) reported that across transitive (actional) and intransitive (locative) sentences, Korean-speaking and English-speaking children were more accurate with universal quantifiers modifying the subject. This finding, however, needs to be replicated, as the error rates in the Kang study were extremely high, with older children making significantly more errors than younger children. This suggests that the children may have been uncertain about the task requirements. Additionally, in the Kang study, the scenes associated with yes responses were not well balanced across sentence types with respect to the objects shown and did not provide a well-controlled test of how syntactic position affects quantifier interpretation (e.g., for the question Is every bear holding a honeypot?, a yes response was appropriate for a distributive scene of three bears each holding a honeypot along with a piglet holding a honeypot; for the question Is a bear holding every honeypot?, a yes response was appropriate for a collective scene of three bears and one piglet, with one of the three bears holding three honeypots). The issue of subject/object asymmetry is an important one to resolve, as Kang’s (2001) syntactic account predicts an advantage for interpreting universal quantifiers in subject position across constructions.

Third, we address the controversy as to whether children perform better in tasks with collective universal quantifiers (cf. Brooks and Braine (1996)) or with distributive ones (cf. Drozd (1996)). As summarized previously, the children studied by Brooks and Braine (1996) made relatively few errors for sentences containing all that were paired with collective scenes. In contrast, Drozd and van Loosbroek (2006) observed that Dutch children found it difficult to match sentences containing a distributive universal quantifier (translated as every) with collective scenes even when the intended domain of quantification was made salient as topical information. To provide a more controlled comparison than that of any previous study, we modified our collective picture pairs to make the collective foils totally comparable to the distributive foils with respect to the number and type of extra objects in the scenes. To allow a direct comparison of children’s accuracy with sentences containing the quantifier all with sentences containing each or every, in a second experiment, we changed the nature of the predicates from actional, for example, men washing bears (Experiment 1) to locative, for example, alligators in bathtubs (Experiment 2). The locative scenes, unlike the actional ones, readily support distributive interpretations of sentences with all (Brooks et
al. (2001), Brooks et al. (1998)). The locative context also permitted variation in the content of the NP modified by a universal quantifier in subject position (e.g., we could compare children's picture choices for the sentences *All of the alligators are in a bathtub* and *All of the bathtubs have an alligator in them*).

Finally, because accounts positing syntactic deficits as the source of quantifier-spreading errors (e.g., Kang (2001), Philip (1996), Roeper et al. (2005)) generally assume that adults are essentially error free in their comprehension of basic sentences containing universal quantifiers (i.e., their syntax is perfect), we tested a group of adults on a version of our task (Experiment 3) to evaluate this claim and to allow a more complete investigation of the developmental trajectory of quantifier acquisition from 5-year-olds to adults.

2. EXPERIMENT 1

2.1. Method

2.1.1. Participants. We recruited and tested twelve 5-year-olds ($M = 5;5$, range = 5;2–5;11), twelve 6-year-olds ($M = 6;6$, range = 6;2–6;10), twelve 7-year-olds ($M = 7;6$, range = 7;1–7;11), twelve 8-year-olds ($M = 8;6$, range = 8;0–8;11), and twelve 9-year-olds ($M = 9;6$, range = 9;1–9;11) at private elementary schools and after-school programs in Atlanta, Georgia.

2.1.2. Materials. The experimental stimuli were 24 pairs of pictures depicting people involved in various activities such as carrying boxes, washing pets, or watering plants. Four types of picture pairs were constructed. Distributive picture pair type 1 showed three people individually engaged in an activity with three distinct objects or animals, for example, three men each washed a bear (see Figure 1). In one picture, two objects or animals were left over (Figure 1a), and in the

![FIGURE 1 Distributive Picture Pair Type 1 used in Experiment 1.](image)
other, two extra people were present but not directly involved in the action (Figure 1b).

Collective picture pair type 2 showed three people engaged in an activity with three objects (see Figure 2). In one picture, three people acted collectively on a single object or animal, and two extra objects or animals were left over; for example, three men worked together to wash one bear, with two bears remaining in the background (Figure 2a). In the other picture, one person acted on a collection of objects or animals, with two extra people depicted; for example, one man washed three bears and two men watched (Figure 2b).

Collective picture pair types 3 and 4 were variations of collective picture pair type 2, with new foils created to match the distributive pairs in terms of target–foil similarity. Collective picture pair type 3 presented two depictions of three people acting collectively on a single object (see Figure 3). One picture showed three
people engaged with one object, with two objects left over (Figure 3a, identical to Figure 2a), and the other picture showed three people engaged with one object, with two people watching (Figure 3b). Collective picture pair type 4 presented two depictions of one person acting on a collection of three objects (see Figure 4). One picture showed one person engaged with three objects, with two objects left over (Figure 4a), and the other picture showed one person engaged with three objects, with two people watching (Figure 4b, identical to Figure 2b).

Across picture pairs, a variety of contexts with transitive actional verbs were used so that each sentence type could be presented multiple times without repeating any pictures. All of the contexts involved humans acting on animate or inanimate objects (e.g., men carrying boxes, girls washing dogs). Six sentence types were used. These sentence types, shown in (1) to (6), comprised conditions corresponding to three universal quantifiers (all, each, every) presented in two different syntactic positions:

(1) Each of the (people) is (verb)ing an (object), for example, Each of the men is washing a bear.

(2) There is a (person) (verb)ing each of the (objects), for example, There is a man washing each of the bears.

(3) Every (person) is (verb)ing an (object), for example, Every man is washing a bear.

(4) There is a (person) (verb)ing every (object), for example, There is a man washing every bear.

(5) All of the (people) are (verb)ing an (object), for example, All of the men are washing a bear.

FIGURE 4  Collective Picture Pair Type 4 used in Experiment 1.
(6) There is a (person) (verb)ing all of the (objects), for example, *There is a man washing all of the bears.*

We presented the four sentence types with the quantifiers *each* and *every* (i.e., (1)–(4)) three times each with picture pairs of Type 1 (see Figure 1). These sentence types comprise a $2 \times 2$ design with quantifier (*each, every*) and the syntactic position of the quantifier (subject vs. object) as within-subjects factors. Sentences with *each* provide a replication of one of the experimental conditions of Brooks and Braine (1996, Experiment 1).

For sentences with *all*, we replicated the task of Brooks and Braine (1996, Experiment 1) and introduced a modified version. Brooks and Braine observed that children as young as 4 years of age made correct picture choices as the syntactic position of *all* was varied. However, Brooks and Braine presented children with collective pictures (Figure 2) that may have been distinguished without the children attending to the universal quantifier in the sentence. (For example, the pictures in Figure 2 roughly correspond to the sentences *Men are washing a bear* and *A man is washing bears*, which do not contain universal quantifiers.) The modified task used new foils that differed from the target pictures only with respect to the extra objects or people in them (Figures 3 and 4). We presented the two sentence types with the quantifier *all* (i.e., (5) and (6)) three times each with picture pairs of Type 2 (see Figure 2). We presented Sentence Type 5 an additional three times with picture pairs of Type 3 (see Figure 3), and Sentence Type 6 was presented three times with picture pairs of Type 4 (see Figure 4). Thus, to examine performance for sentences with *all*, we used a $2 \times 2$ design with task version (original Brooks and Braine (1996) pictures [Picture Pair Type 2] vs. modified pictures [Picture Pair Types 3 and 4]) and the syntactic position of the universal quantifier (subject vs. object) as within-subjects factors.

Twelve additional pairs of pictures served as filler items. The pictures of such pairs differed in one salient semantic feature (e.g., activity depicted, sex of the actor) and were described by filler sentences that did not contain any universal quantifier (e.g., *The boy is smelling the flower*).

2.1.3. Procedure. We tested children individually in a single, 20-min session conducted in a quiet room of their school. We showed children two pictures at a time and asked them to point to the picture that went best with a sentence read aloud. After the child looked at both pictures, the experimenter read the corresponding sentence and asked the child to point to the picture that went best with the sentence. The experimenter would say “Show me the picture where . . .” followed by the sentence, for example, “Show me the picture where all of the men are washing a bear” with emphasis on the entire NP modified by the universal quantifier (e.g., *all of the men*). The child was then given an opportunity to point to or select one of the pictures. After the child’s response, the experimenter re-
moved the pictures and presented the next picture pair without providing any corrective feedback. Across trials, we randomized the position of the correct picture (right or left). The first three trials we presented were filler items to ensure that children understood the task. The order of presentation of the experimental and filler items was quasi-random such that successive sentences did not contain the same universal quantifier, and no more than three experimental trials occurred consecutively.

2.2. Results

Table 1 presents the mean percentage of correct picture selections in Experiment 1. Children made no errors on filler sentences, and these trials were not examined further. We first examine children’s performance on sentences containing the quantifiers *each* and *every* and then their performance on sentences with *all*.

We analyzed children’s picture choices for sentences with *each* and *every* using a mixed-design analysis of variance (ANOVA) with within-subjects factors of Quantifier (*each* and *every*) and Syntactic Position (subject vs. object), and Age as a between-subjects factor. The dependent variable was the proportion of correct picture choices for Sentence Types 1 through 4. We arcsine transformed these proportions and all others reported in this article, as is recommended (Cohen and Cohen (1983)). The analysis showed significant main effects of syntactic position, $F(1, 55) = 19.03, p < .001$, and age, $F(4, 55) = 7.22, p < .001$. No other main effects or interactions were significant. When presented with distributive pictures (see Figure 1), children averaged 80.6% correct picture selections for sentences with the universal quantifier modifying the subject (e.g., *Every man is washing a bear*) but only 57.5% correct selections for sentences with the universal quantifier modifying the direct object (e.g., *There is a man washing every bear*). As shown in Table 1, comparisons against chance performance (50%) revealed that only the 9-year-olds as a group were above chance in selecting the correct pictures (Figure 1b) for sentences with the universal quantifier modifying the direct object.

Additionally, we examined whether individual children showed above-chance performance in selecting the appropriate distributive picture for the 12 trials containing the universal quantifiers *each* or *every*. According to the binomial distribution ($p < .05$), above chance performance requires 10 out of 12 correct picture selections. At this criterion, one 5-year-old (8%), two 6-year-olds (17%), five 7-year-olds (42%), five 8-year-olds (42%), and nine 9-year-olds (75%) performed above chance.

We examined children’s performance for sentences with *all* using a mixed design ANOVA with Task Version (original Brooks and Braine (1996) pictures [Picture Pair Type 2] vs. modified pictures [Picture Pair Types 3 and 4]) and Syntactic Position (subject vs. object) as within-subjects factors and Age as a be-
## TABLE 1
Mean Percentages of Correct Responses in Experiment 1

<table>
<thead>
<tr>
<th>Sentence Type</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picture Pair Type 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Each of the men is washing a bear.</td>
<td>66.7 (34.8)</td>
<td>86.1* (17.2)</td>
<td>86.1* (30.0)</td>
<td>80.6* (33.2)</td>
<td>91.7* (20.7)</td>
</tr>
<tr>
<td>There is a man washing each of the bears.</td>
<td>38.9 (27.8)</td>
<td>41.7 (40.5)</td>
<td>55.6 (35.8)</td>
<td>55.6 (45.7)</td>
<td>83.3* (22.5)</td>
</tr>
<tr>
<td>Every man is washing a bear.</td>
<td>55.6 (29.6)</td>
<td>83.3* (22.5)</td>
<td>83.3* (30.2)</td>
<td>80.6* (33.2)</td>
<td>91.7* (20.7)</td>
</tr>
<tr>
<td>There is a man washing every bear.</td>
<td>47.2 (33.2)</td>
<td>44.4 (29.6)</td>
<td>52.8 (38.8)</td>
<td>66.7 (37.6)</td>
<td>88.9* (21.7)</td>
</tr>
<tr>
<td>Picture Pair Type 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All of the men are washing a bear.</td>
<td>88.9* (21.7)</td>
<td>100* (0.0)</td>
<td>100* (0.0)</td>
<td>97.2* (9.6)</td>
<td>100* (0.0)</td>
</tr>
<tr>
<td>There is a man washing all of the bears.</td>
<td>83.3* (22.5)</td>
<td>91.7* (20.7)</td>
<td>97.2* (9.6)</td>
<td>100* (0.0)</td>
<td>100* (0.0)</td>
</tr>
<tr>
<td>Picture Pair Type 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All of the men are washing a bear.</td>
<td>66.7* (20.1)</td>
<td>94.4* (13.0)</td>
<td>97.2* (9.6)</td>
<td>83.3* (22.5)</td>
<td>91.7* (15.1)</td>
</tr>
<tr>
<td>Picture Pair Type 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There is a man washing all of the bears.</td>
<td>66.7 (34.8)</td>
<td>69.4 (38.8)</td>
<td>83.3* (26.6)</td>
<td>88.9* (21.7)</td>
<td>88.9* (16.4)</td>
</tr>
</tbody>
</table>

**Note.** N = 12 in all groups. Standard deviations are in parentheses.

*p < .05 (above chance).
tween-subjects factor. The dependent variable was the proportion of correct picture choices for Sentence Types 5 and 6. The ANOVA revealed significant main effects of task version, $F(1, 55) = 27.80, p < .001$, and age, $F(4, 55) = 6.91, p < .001$. Overall, children were correct in 95.8% of their picture selections when the original collective pictures of Brooks and Braine were used (see Figure 2) but only 83.1% of trials with the modified collective pictures (see Figures 3 and 4).

The only other effect to approach significance was a marginal effect of syntactic position, $F(1, 55) = 3.87, p = .054$: Children showed a weaker version of the same subject/object asymmetry observed with each and every, averaging 91.9% correct for trials with all modifying the subject in comparison to 86.9% for trials with all modifying the direct object. This pattern of better performance for sentences with the universal quantifier modifying the subject held most strongly for the 6- and 7-year-olds. As shown in Table 1, children’s responses became more consistently correct with age, with only children 7 years and older performing above chance as a group in the modified task when the quantifier modified the direct object.

To examine whether individual children were above chance in selecting the appropriate collective picture on the modified task with all, we again used the binomial distribution ($p < .05$), with above-chance performance requiring 6 out of 6 correct responses. At this criterion, zero 5-year-olds (0%), five 6-year-olds (42%), seven 7-year-olds (58%), seven 8-year-olds (58%), and seven 9-year-olds (58%) performed above chance. If we adopt a more lenient criterion (5 of 6), which is proportionally comparable to the 10 of 12 required for above-chance performance with sentences containing each or every, then six 5-year-olds (50%), eight 6-year-olds (67%), ten 7-year-olds (83%), eight 8-year-olds (67%), and ten 9-year-olds (83%) showed consistently strong individual performance.

Finally, to compare children’s performance on the modified task with all with their performance on sentences with each and every, we conducted one additional mixed-design ANOVA with Quantifier (all, each, every) and Syntactic Position as within-subjects factors and Age as a between-subjects factor. In addition to a main effect of age, $F(4, 55) = 8.11, p < .001$, the ANOVA yielded a main effect of quantifier, $F(2, 55) = 14.65, p < .001$, with planned comparisons showing better performance for sentences with all presented with collective scenes in comparison to sentences with each, $F(1, 55) = 11.45, p < .001$, or sentences with every, $F(1, 55) = 10.12, p < .001$, presented with distributive scenes. The main effect of syntactic position was significant, $F(1, 55) = 16.38, p < .001$, but was qualified by an interaction of quantifier and age, $F(1, 55) = 2.35, p < .10$. As summarized previously, comprehension performance was more accurate when the universal quantifier modified the subject of the sentence. This effect of syntactic position, however, was highly significant for sentences with each or every but only marginally significant for sentences with all (see above for $F$ tests for main effects of syntactic position in separate analyses by quantifier). No other interactions were significant.
2.3. Discussion

In Experiment 1, school-age children showed poor performance in matching sentences containing a distributive universal quantifier, *each* or *every*, with corresponding pictures depicting sets of objects in partial, one-to-one correspondence. In general, their picture selections were more accurate for sentences with a universal quantifier modifying the subject in comparison to the direct object of a transitive actional verb. These results replicate Brooks and Braine (1996), who attributed the subject/object asymmetry to the greater discourse prominence of the subject NP in comparison to the direct object NP, which may have helped focus children’s attention toward the appropriate set of entities. The pattern also matches the results of Philip (1996), who presented yes–no questions such as *Is every turtle carrying a bird?* or *Is a turtle carrying every bird?* to Dutch children and adults. Although Philip’s (1996) pictures were configured somewhat differently than those of this experiment, participants were nonetheless more accurate when the universal quantifier modified the subject as opposed to the direct object NP in the question. Philip (1996) attributed the high error rate with questions such as *Is a turtle carrying every bird?* (i.e., approximately 70% errors in 8-year-olds) to children’s difficulties in applying quantifier raising (May (1985)). Kang (2001) similarly reported significantly lower error rates for sentences with a universal quantifier modifying the subject as opposed to the direct object in a yes–no task. Kang interpreted this pattern in syntactic terms pertaining to the relative ease of detaching a universal quantifier in object as opposed to subject position. Although the Philip (1996) and Kang studies have shown a similar pattern of subject/object asymmetry to this study and Brooks and Braine (1996), we note that children performed at much higher levels of accuracy in our sentence–picture matching task compared to the Truth Value Judgment Task. In none of our conditions, at any age, were children significantly below chance in their picture selections. This contrasts especially with Kang, who reported error rates over 80% in both English-speaking and Korean-speaking 6- and 7-year-olds. Future work using a within-subjects design is needed to directly compare these tasks and their demand characteristics.

In Experiment 1, we also examined children’s performance with the quantifier *all* presented with collective scenes. In contrast to Brooks and Braine (1996, Experiment 1), in this study, we modified the collective foils so that the only difference between target and foil was whether two extra people or two extra objects were depicted. With the modified task, the 5- and 6-year-olds performed at chance when the quantifier applied to the direct object NP (e.g., *There is a man washing all of the bears*). However, by age 7, children were consistently correct in their picture choices regardless of the syntactic position of *all* in the sentence. Children (especially 6- to 8-year-olds) were more successful in restricting the universal quantifier in sentences with *all* in comparison to sentences with *each* or *every*. This suggests that the collective groupings may have helped focus their at-
tention on the relevant set of entities modified by the quantifier. Brinkmann, Drozd, and Krämer (1996) similarly reported that Dutch children made fewer errors for sentences containing mass nouns, such as Did all the bad guys burn hay?, when shown a collective scene (e.g., three guys burning one large pile of hay with some hay left over) as opposed to a distributive scene (e.g., three guys each burning a separate pile of hay with one pile left over). We note, however, that Drozd ((1996), Drozd and van Loosbroek (2006)) has observed significantly worse performance for sentences with universal quantifiers paired with collective as opposed to distributive pictures. In both of these studies, the distributive scenes showed three actors each paired with a unique object along with one extra object (e.g., three boys each riding an elephant, along with an extra elephant), whereas the collective scenes showed a three-to-one mapping of actors to objects, along with two extra objects (e.g., three boys riding one elephant, along with two extra elephants). We suspect that more errors were made with these collective scenes on account of the equal numbers of actors and objects depicted; for example, when shown three boys and three elephants in the collective scene, the children may have responded no to the question Is every boy riding an elephant? simply because they thought that each boy should have his own elephant (i.e., given equal numbers of boys and elephants, they ought to be in one-to-one correspondence). That is, children may have made more errors with the collective pictures because they preferred distributive arrangements of the entities involved (cf. Drozd and van Loosbroek (2006)). More generally, the Truth Value Judgment Task allows children to reject a picture for a variety of reasons (and it is often hard to discern the basis for children’s pattern of responding). The Drozd ((1996), Drozd and van Loosbroek (2006)) experiments may have unintentionally confounded the issues of preference for collective versus distributive scope with children’s ability to restrict the domain of a universal quantifier. In Experiment 1, we used a sentence–picture matching procedure in which children needed only to find the picture that matched the sentence. This task eliminated opportunities for participants to consider whether a collective versus distributive interpretation of the sentence was preferred and furthermore allowed us to carefully match our collective and distributive pictures with respect to the composition of the foils.

We are not yet in a position to fully attribute the observed advantage for sentences with all over sentences with each or every to the collective scenes, because the children in our study may simply have had greater familiarity with this quantifier, in comparison to each or every, on account of its much higher frequency of use in the English language. In Experiment 1, we always presented sentences with all with depictions of collective scenes and sentences with each or every with depictions of distributive scenes. The choice of quantifier and the choice of collective versus distributive scene were unavoidably confounded due to lexical biases constraining possible interpretations of sentences with all and each in sentences with transitive actional verbs. That is, for many speakers of English, the sentence Each man is washing a bear only supports a distributive interpretation and the
sentence *There is a man washing all of the bears* only supports a collective one. Furthermore, as our previous research (Brooks (1993), Brooks et al. (2001), Brooks et al. (1998)) indicated, children are sensitive to these interpretive differences between the two quantifiers.

We designed Experiment 2 to eliminate this interpretive confound through the use of locative scenes. Brooks et al. (1998) introduced locative pictures with animals and other entities shown in containers of various sorts (e.g., bananas in baskets, bears in beds). These locative pictures promote somewhat different interpretations of sentences with universal quantifiers than the actional pictures used in Experiment 1 (cf. Brooks et al. (2001)). Most important, distributive arrangements of entities in containers (see Figure 5) can be described naturally using sentences with *all, each,* or *every.* We used locative pictures in Experiment 2 to examine whether children would be successful in identifying the domain of the quantifier *all* when presented with distributive scenes. If no effect of quantifier occurs in Experiment 2, it would suggest that children’s difficulties in Experiment 1 stem from a failure to specify the domain of a universal quantifier when sets are in partial, one-to-one correspondence rather than to a familiarity effect.

3. EXPERIMENT 2

In Experiment 2, we presented universal quantifiers in three syntactic constructions that support distributive interpretations in a locative context. Across constructions, we systematically varied both the syntactic position of the universal quantifier and whether the subject of the sentence referred to the containers or the entities in them. This allowed a test of whether children would still show better performance when the universal quantifier modified the sentence subject, as predicted by Kang (2001). This prediction, however, runs counter to a large number

![Figure 5](image)

**FIGURE 5** Distributive Picture Pair Type 5 used in Experiment 2.
of early experiments that have presented children with arrays of objects (as opposed to pictures) along with questions such as *Are all the cars in the garages?* or *Have all the garages got cars in them?* (e.g., Donaldson and Lloyd (1974), Freeman (1985), Freeman and Schreiner (1988), Freeman and Stedmon (1986)). These studies have consistently reported that many children given sentences with a universal quantifier modifying the subject (as in *Are all the cars in the garages?*) made a preponderance of exhaustive (Type A) errors when presented with an array containing an extra (empty) garage. Donaldson and McGarrigle (1974) suggested that there was “something peculiarly fundamental and compelling about the notion of fullness, that it can override other criteria and powerfully influence the judgment of truth value” (p. 186). Many of the children in these early studies were described as “garage-centered,” and additionally made underexhaustive (Type B) errors (i.e., ignoring an extra car without a garage when asked *Are all the cars in the garages?*). These results led us to expect considerable numbers of errors in Experiment 2.

3.1. Method

3.1.1. Participants. Twelve 7-year-olds ($M = 7;6$, range = 7;1–7;10), twelve 8-year-olds ($M = 8;6$, range = 8;0–8;11), and twelve 9-year-olds ($M = 9;5$, range = 9;0–9;10) took part in the experiment. We recruited and tested these children at the same schools as in Experiment 1. None of the children in Experiment 2 participated in the previous experiment.

3.1.2. Materials. Stimuli were 27 pairs of pictures depicting various entities arranged in containers (e.g., alligators in bathtubs, turtles in tanks, apples in bowls). The pictures showed distributive arrangements with the entities and containers in partial, one-to-one correspondence with each other. Both pictures depicted three entities each located in a unique container. One picture showed two extra empty containers (see Figure 5a), and the other picture showed two objects that were not in containers (see Figure 5b).

We presented nine sentence types. These sentence types comprise conditions defined by the three universal quantifiers (*all, each, every*) combined with three syntactic constructions:

(7) All of the (objects) are in a (container), for example, *All of the alligators are in a bathtub.*

(8) All of the (containers) have an (object) in them, for example, *All of the bathtubs have an alligator in them.*

---

1We did not present the sentence type “A (container) has all/each/every (object) in it” because it does not support a distributive interpretation.
(9) There is an (object) in all of the (containers), for example, *There is an alligator in all of the bathtubs.*

(10) Each of the (objects) is in a (container), for example, *Each of the alligators is in a bathtub.*

(11) Each of the (containers) has an (object) in it, for example, *Each of the bathtubs has an alligator in it.*

(12) There is an (object) in each of the (containers), for example, *There is an alligator in each of the bathtubs.*

(13) Every (object) is in a (container), for example, *Every alligator is in a bathtub.*

(14) Every (container) has an (object) in it, for example, *Every bathtub has an alligator in it.*

(15) There is an (object) in every (container), for example, *There is an alligator in every bathtub.*

We presented each sentence type three times with unique pairs of pictures. Across subjects, we counterbalanced the assignment of sentence types to particular pairs of pictures. Twelve additional pairs of pictures served as filler items. The filler pictures and sentences were identical to those of Experiment 1.

3.1.3. Procedure. The procedure was the same as in Experiment 1.

3.2. Results

Table 2 presents the percentage of correct responses for Sentence Types 7 to 15. We analyzed children’s picture selections using a mixed-design ANOVA with Quantifier and Syntactic Construction as within-subjects factors and Age as a between-subjects factor. The dependent variable was the proportion of correct picture choices for each sentence type. The ANOVA showed main effects of syntactic construction, $F(2, 66) = 39.56, p < .001$, and age, $F(2, 33) = 4.55, p < .05$, and a two-way interaction of syntactic construction and age, $F(4, 66) = 4.19, p = .01$. The main effect of quantifier and all of the interactions involving quantifiers were not significant.

Across syntactic constructions, 7-year-olds preferred the picture with the extra animals or objects as opposed to the picture with the extra containers. Both the 7- and 8-year-olds made correct picture selections at an above-chance level only for sentences with the universal quantifier modifying the noun correspond-
ing to the containers irrespective of the syntactic construction. In contrast, the majority of 9-year-olds correctly varied their picture selections in accordance with the varying syntactic constructions and performed above chance as a group for all sentence types.

To evaluate the performance of individual children, we again used the binomial distribution ($p < .05$). To maintain comparability with Experiment 1, we examined sentences with the universal quantifier (all, each, or every) modifying the subject when it corresponded to the objects in containers (i.e., Sentence Types 7, 10, and 13) and sentences with the quantifier modifying the prepositional object corresponding to the containers (i.e., Sentence Types 9, 12, and 15). For these six sentence types (presented three times each), above-chance performance required 14 of 18 correct picture selections. At this criterion, five 7-year-olds (42%), six 8-year-olds (50%), and ten 9-year-olds (83%) demonstrated above-chance performance across quantifier positions.

### 3.3. Discussion

Experiment 2 replicated one of the main findings of Experiment 1: Only 9-year-olds as a group consistently identified the domain of the universal quantifier and selected the appropriate picture at above-chance levels for distributive events in which sets of objects were in partial, one-to-one correspondence. In contrast to Experiment 1, in which children made fewer errors when the universal quantifier
modified the subject as opposed to the direct object of a transitive actional verb, in Experiment 2, children failed to show the same subject/object asymmetric pattern with the locative predicates. Rather, irrespective of the syntactic construction, they showed better performance on sentences with the quantifier modifying the containers (e.g., *All of the bathtubs have alligators in them* or *There is an alligator in all of the bathtubs*), as opposed to the entities in them (e.g., *All of the alligators are in a bathtub*). The observed bias to prefer locative scenes in which all of the containers were filled (the so-called garage-centered bias) has been observed many times; see Drozd (2001) for a review. The different response pattern for sentences with actional and locative predicates seems to be independent of the syntactic position of the universal quantifier (counter to syntactic proposals) and most likely stems from extralinguistic factors (e.g., which picture was more interesting). These results are difficult to reconcile with Kang’s (2001) syntactic account that posits differences in the relative difficulty of detaching a quantifier from subject as opposed to object position.

Moreover, all of the age groups failed to show any effect of quantifier in Experiment 2 in contrast to Experiment 1. That is, the children failed to show a familiarity effect with better performance for sentences with *all*. The differing results for the two experiments indicate that the collective scenes used with *all* in Experiment 1 were easier than the distributive ones used in Experiment 2 (see also Brinkmann et al. (1996)). It appears that these scenarios involving partial, one-to-one correspondence pose considerable challenges for children. Taken together, the results of the two experiments contrast most with Crain et al. (1996) and suggest that children have difficulty selecting the domain of a distributive universal quantifier in the absence of a narrative context that focuses their attention on the appropriate sets, as originally proposed by Drozd (2001). Future work is needed to determine whether ordinary conversations scaffold children’s attention in such a way that they are able to restrict the domain of quantifiers appropriately.

Although Experiment 2 provided no evidence that children distinguished the quantifier *all* from *each* or *every*, we emphasize that previous work (Brooks et al. (2001), Brooks et al. (1998)) has shown that children do readily distinguish these quantifiers on semantic grounds. When given a choice between collective and distributive pictures, children show different patterns of responding to sentences such as *All of the alligators are in a bathtub* and *Each alligator is in a bathtub* by selecting collective interpretations much more often for sentences with *all*. Furthermore, Freeman and Schreiner (1988) observed differences in the distribution of quantifier-spreading error types for sentences with *all* versus *every single*, with more underexhaustive search errors for sentences with *all* and equal numbers of underexhaustive and overexhaustive search errors for sentences with *every single*. This differential pattern, however, was obtained only when the universal quantifier in the sentence was manipulated in a between-subjects design and did not replicate in a within-subjects design. Additional work is needed to explore how the lexical biases of universal quantifiers interact with quantifier-spreading phenomena.
4. EXPERIMENT 3

In Experiment 3, we examined whether adults would make errors restricting the domain of a universal quantifier in a similar picture-selection task with distributive, locative scenes. Testing adults is important because syntactic accounts do not readily predict errors in syntactically competent adults. In contrast, mapping accounts, such as Geurts (2003), assume that syntactic operations incur processing costs, which might lead adults to behave like children and misinterpret a strong universal quantifier as a weak quantifier. Brooks and Braine (1996, Experiment 1) tested adults with actional scenes and found no errors. Their data, however, came from 10 undergraduates at a highly selective private university (Carnegie Mellon) and thus may not be representative of adults in general. Here we tested monolingual English-speaking undergraduates at a highly diverse public university. This experiment constituted pilot work to establish a paradigm suitable for an eye-tracking study. As a result, we made several modifications to the procedure. First, we included two filler pictures along with each target and foil picture, and second, we presented sentences with the quantifier every but did not test each or all.

4.1. Method

4.1.1. Participants. We recruited 22 monolingual, adult native speakers of English (16 women, 6 men; M age = 26 years, range = 18–49) from introductory psychology classes at the College of Staten Island, City University of New York, who received extra credit for their participation.

4.1.2. Materials. We created PowerPoint® slides comprising four pictures that were presented simultaneously (see Figure 6 for an example). These slides depicted two sets of objects in partial, one-to-one correspondence (e.g., alligators in bathtubs). Each array contained two pictures similar to those used in Experiment 2 (compare Figures 5 and 6), along with two filler pictures. One of the filler pictures showed the same container type with a different object type (e.g., ducks in bathtubs), whereas the other filler picture showed the same object type in/on a different container type (e.g., alligators in beds). We presented two sentence types that were identical to Sentence Types 13 and 14 of Experiment 2, repeated below. We presented each sentence type six times, in randomized order, for a total of 12 trials:

(13) Every (object) is in a (container), for example, Every alligator is in a bathtub.

(14) Every (container) has an (object) in it, for example, Every bathtub has an alligator in it.
4.1.3. Procedure. We tested adults individually in a single, 20-min session conducted in a psychology laboratory. We presented stimuli using PowerPoint software. For each of 12 trials, we showed participants a slide comprising four pictures (see Figure 6) and we asked them to select the picture that went best with a recorded instruction. These instructions were recorded using a female native speaker of English at 22,000 Hz. Participants were instructed to, for example, “Name the picture where every alligator is in a bathtub” followed by an instruction to name one of the two filler pictures, for example, “Now name the picture where there are five beds.” To permit naming, we numbered the pictures from 1 to 4, with the position of the target randomized across trials. We used a tape recorder to record participants’ responses. The first two trials we presented were practice items (i.e., fillers) to ensure understanding of the task. Throughout the task, an experimenter remained with the research participant and used the computer keyboard to control presentation of each stimulus array and set of instructions.

4.2. Results and Discussion

Table 3 presents the percentages of correct responses for the two critical sentence types. Across all participants, no errors were made on filler sentences indicating that the participants were generally compliant with the task instructions. Surpris-
ingly, however, performance on the task was not at ceiling, with adults making errors on an average of 21% of the trials. This error rate, which is numerically higher than the rate observed with the 9-year-olds of Experiments 1 and 2, is likely due to the added complexity of the task involving four pictures as opposed to two. Across the trials involving sentences with every, adult participants never selected either of the filler pictures. This indicates that their response set was effectively the same as that of the children in Experiment 2. Comparisons against chance (50%, given that the filler pictures were never selected) indicate that the adults as a group performed at above-chance levels for both sentence types. A paired-samples \( t \) test showed no significant variation in adult performance as a function of the syntactic construction, \( t(21) < 1 \). Thus, unlike the children in Experiment 2, the adults did not show a preference for locative scenes in which all of the containers were filled.

Given that the adults restricted their picture selections for sentences with every to one of the two pictures showing sets of objects and containers in partial, one-to-one correspondence, we again used the binomial distribution to compute whether individual participants performed above chance. For 12 trials, above chance (\( p < .05 \)) requires 10 of 12 correct picture choices. Using this criterion, only 11 of 22 adults (50%) demonstrated above-chance performance. A further examination of data indicated that two adults selected the same picture on 12 of 12 trials indicating no sensitivity to the position of the quantifier in the sentence.

How can we explain these unexpected childlike errors in adults? The fact that half of our adult participants made considerable numbers of errors in restricting every to its domain is not readily explicated by syntactic accounts positing immature syntactic representations as the source of children’s quantifier-spreading errors. Our findings that both children and adults make errors in quantifier interpretation are more readily explained by the underspecification account of Sanford and Sturt (2002). According to this account, adults engaged in language comprehension often create underspecified representations of constructions that involve complex syntactic structures, quantifier scope ambiguities, and closely related semantic anomalies (e.g., as in the Moses illusion). Even more surprisingly, Ferreira (2003) found evidence that even relatively simple unambiguous constructions such as passives in English can be underspecified, allowing people to process

### Table 3

#### Mean Percentages of Correct Responses for Adults in Experiment 3

<table>
<thead>
<tr>
<th>Sentence Type</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Every alligator is in a bathtub.</td>
<td>78.8*</td>
</tr>
<tr>
<td>Every bathtub has an alligator in it.</td>
<td>79.5*</td>
</tr>
</tbody>
</table>

*Note.* For both sentence types, participants were shown Picture Array Type 6. \( N = 21 \). Standard deviations are in parentheses. *\( p < .05 \) (above chance).
them without committing themselves to a particular thematic role assignment to
the agent and patient NPs. Note that the underspecification account when applied
to quantifiers results in shallow processing that is strikingly parallel to the map-
plained children’s errors in processing quantifiers as a parsing problem in which
children prefer to adopt the simpler processing of strong quantifiers as conjoined
instead of separated. The crucial step involves deficient mapping from syntactic
structure to a semantic representation, as in (15) from Geurts (2003, 208), in
which the domain of quantification is, in effect, underspecified:

(15) [. . . : . . .] \langle\text{every}\rangle [x, y: \text{NP}_1(x), \text{NP}_2(y), x \text{ Verb } y]

In the Geurts account, children then proceed to invoke pragmatic principles to re-
strict the domain of quantification, with their application leading to errors in
quantifier interpretation.

Although grammatically competent adults are capable of construing correct
and fully specified semantic representations of utterances with quantifiers, it does
not always happen. In the two-stage processing model of Townsend and Bever
(2001), “quick and dirty” strategies can be applied first as the initial step that may
or may not be followed by a “deep,” time-consuming application of an algorithm.
Thus, adults have an option of stopping at the simplest, one-to-one correspon-
dence interpretation of utterances with quantifiers, yielding an error pattern simi-
lar to children.

5. GENERAL DISCUSSION

We conducted three experiments to test child and adult comprehension of rela-
tively simple, affirmative sentence structures containing universal quantifiers.
The results demonstrate that many school-age children and adults had consider-
able difficulty in restricting the domain of a universal quantifier, especially when
two sets of entities were in partial, one-to-one correspondence. This result con-
trasts most dramatically with the near perfect performance of preschool children
in Crain et al. (1996). The errors observed in our experiments, however, cannot be
attributed to the pragmatic infelicity of the task. Whereas Crain et al. attributed
their low error rates to the satisfaction of the condition of plausible dissent, we
follow Drozd ((2001), Drozd and van Loosbroek (2006)) in attributing children’s
greater success in their task to the rich narrative contexts provided, which estab-
lished one set of entities as the focus of attention (see also Freeman and Sepahzad
(1987) for similar results when questions were asked following the presentation
of a conditional syllogism). In the absence of a biasing context, performance
drops off markedly. This suggests that the problem does not reside in the child’s
syntax, given the similarities in sentence structures used across studies, but in-
stead has to do with the difficulty of selecting the appropriate set of entities and avoiding distraction by salient objects.

An important goal of our study was to directly compare children’s performance on collective versus distributive universal quantifiers. This is a topic that has received very little attention in the literature, and most studies have not been properly designed to make a valid comparison possible (e.g., Brooks and Braine (1996), Drozd (1996), Drozd and van Loosbroek (2006)). In Experiment 1, children made fewer errors for collective scenes (accompanied by sentences with all) in comparison to distributive scenes (accompanied by sentences with each or every). In Experiment 2, we presented only distributive scenes to examine whether children would still perform better on sentences with all (relative to each or every) and found no effect of quantifier. Taken together, the experiments suggest that it was the collective scenes as opposed to the use of all that improved children’s performance in Experiment 1. Collective scenes were easier presumably because the group depiction aided the child in isolating one set of entities relative to the other (see also Brinkmann et al. (1996)). Conversely, the distributive scenes were more difficult because the pictures were more visually symmetric. The observed difference in performance for collective versus distributive scenes seems to undermine syntactic accounts of children’s errors given that the structures of the corresponding sentences were essentially the same.

We found a subject/object asymmetry in the distribution of errors as a function of the syntactic position of the universal quantifier for sentences with actional verbs in Experiment 1 but not for locative ones in Experiment 2. We observed a developmental trajectory in Experiment 1, with 6- and 7-year-olds showing the strongest subject/object asymmetry and only 9-year-olds performing above chance, as a group, in selecting the correct picture for sentences with the distributive universal quantifiers in object position. In contrast, in Experiment 2, irrespective of whether the universal quantifier was used in the subject position or in object position in a construction with there, the 7- and 8-year-olds selected the correct pictures, at an above-chance level, only for sentences with the quantifier modifying the noun corresponding to the containers. The fact that children’s errors in Experiment 2 were not randomly distributed indicates that they noticed the extra objects and/or containers in the distributive pictures. Again, only 9-year-olds consistently varied their picture selections in accordance with the varying syntactic constructions and did not show a strong preference for one picture configuration at the expense of the other.

A surprising finding emerged from Experiment 3 with college-age adults. Their performance on a modified version of the sentence–picture matching task was not only below ceiling, but their error rate was numerically higher than that of the 9-year-olds of Experiments 1 and 2. Note, however, that in contrast to the 7- and 8-year-olds’ patterns, the adults’ errors were equally distributed between the locative pictures with extra animals or objects versus extra containers. Taken together, the disappearance of the effect of the syntactic position of the universal...
quantifier in the sentences with locative predicates in the children’s data and the unexpectedly high error rate in the adults’ data provide evidence against syntactic analyses of quantifier-spreading errors according to which children have deficient syntactic representations of universal quantifiers in comparison to adults. Accounts positing syntactic deficits in children are also difficult to reconcile with the fact that children make use of complex, hierarchical syntactic structures in producing speech (cf. Crain et al. (1996) for evidence of correct use of universal quantifiers in children’s speech). We suspect that both children and adults make errors in comprehension because they engage in shallow processing that causes inaccurate mapping between syntactic and semantic representations. In interpreting universal quantifiers, children construct underspecified representations using simpler processing strategies and then rely on pragmatics to solve the task. Adults also may construct underspecified representations as a first step that may or may not be followed by the application of algorithm. We speculate that adults stop at an underspecified representation when there are other demands on attention under conditions of working memory load, fatigue, or lack of cognitive effort.

What is it about the task that leads children to err? A good candidate, as was originally suggested by Donaldson and Lloyd (1974) and Donaldson and McGarrigle (1974), is the salience of particular entities such as empty containers and a compulsion for them to be filled. In accordance with this hypothesis, Freeman ((1985), Freeman, Sinha, and Stedmon (1982)) has shown that children’s error patterns shifted with the addition or subtraction of extra, irrelevant objects in the displays. For example, when shown three cars, each in a garage, along with an extra garage, overexhaustive responses to the question *Are all of the cars in a garage?* decreased significantly when a boat was placed in the empty garage. Freeman’s ((1985), Freeman et al. (1982)) observations that error distributions were influenced by seemingly superficial changes in the arrays (i.e., filling the empty garage) are difficult to explain under the assumption that errors stem from deficient syntactic representations. Rather, they clearly show how children’s attention is pulled toward the various irrelevant entities introduced in the scenes and point toward a deficit in selective attention in sentence processing.

Another possibility with respect to the results of Experiment 2 is that the children may have gradually picked up on the fact that the universal quantifier modified the noun corresponding to the containers in two of three of the sentences. This possibility, that the children were sensitive to statistical properties of the experimental materials, needs to be tested in future work. In either case, once children were fixated on a particular picture configuration, they perseverated and were reluctant to consider a competing picture as a possible alternative, even in the face of a conflicting sentence structure. The suggestion that the children processed the sentences deterministically is not a new one. Several studies of children’s understanding of reduced relative clauses (Hurewitz, Brown-Schmidt, Thorpe, Gleitman, and Trueswell (2000), Trueswell, Sekerina, Hill, and Logrip (1999)) and ambiguous pronouns (Sekerina, Stromswold, and Hestvik (2004))
have indicated that children tend not to revise their initially incorrect interpretations of temporary syntactic or referential ambiguities even when disambiguating information becomes available.

Shallow processing also provides a straightforward explanation of the errors made by adults in Experiment 3. Their high error rates suggest that adult listeners often do not tax their limited information-processing capacities by conducting exhaustive syntactic analyses of sentences but rather make use of simpler strategies in generating reasonable guesses (Sanford and Sturt (2002), Townsend and Bever (2001)). Ferreira and her colleagues (Christianson, Hollingworth, Halliwell, and Ferreira (2001), Ferreira (2003), Ferreira, Bailey, and Ferraro (2002)) have observed that college students often make errors in identifying the agent and patient arguments of implausible passive sentences (e.g., The dog was bitten by the man) and object-cleft sentences (e.g., It was the dog the man bit), suggesting reliance on an NVN (i.e., agent-verb-patient) heuristic in assigning thematic roles to predicates. Christianson et al. (2001) showed that college students presented with garden path sentences (e.g., While Anna dressed the baby played in the crib) often ended up with incorrect interpretations, even after syntactic reanalysis had taken place (by judging, e.g., that Anna dressed the baby who played in the crib). These findings led Ferreira et al. (2002) to conclude that “the meaning people obtain for a sentence is often not a reflection of its true content” (p. 11) and that language processing often yields a merely “good enough” representation of a sentence’s meaning. This statement is an apt characterization of the performance of many school-age children and adults in our experiments. More generally, the comprehension of universal quantifiers seems an ideal domain for exploring the dynamics of attention allocation, and cognitive effort, in language processing.

ACKNOWLEDGMENTS

This project was completed with the assistance of parents, teachers, and children at Immaculate Heart of Mary School, Oak Grove Preschool, and St. Thomas More School in Atlanta, Georgia. We thank Ariel Sionov for his assistance with data collection and Ken Drozd for his helpful comments.

REFERENCES


Submitted 2 February 2004

Final version accepted 28 November 2005