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English-Speaking Children's Comprehension of Relative Clauses: Evidence for General-Cognitive and Language-Specific Constraints on Development

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Children must possess some ability to process input in a meaningful manner to acquire language. The present study reports on data from an experiment investigating 3- to 5-year-old English-speaking children's understanding of restrictive relative clauses manipulated for embeddedness and focus. The results of the study showed that English-speaking children acquire right-branching before center-embedded structures. Comparisons made with data from Portuguese-speaking children suggest general-cognitive and language-specific constraints on development, and with respect to English, a "clause expansion" approach to processing in development.

KEY WORDS: Relative clauses; syntax; language acquisition; English.

INTRODUCTION

A traditional focus of child language research has been the documentation of children's grammatical knowledge, with less emphasis placed on the development of processing capabilities. In contrast, current theories of language processing generally begin with the adult state (Frazier & Clifton, 1996; Gibson, 1998; MacDonald, Pearlmutter, & Seidenberg, 1994), paying little attention to development. Consequently, with some exceptions (e.g., Bates & MacWhinney, 1989; Frazier & deVilliers, 1990), the fields of language acquisition and language processing have largely remained distinct.

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This presents psycholinguists with a problem: For children to acquire a language they must possess some capacity to process linguistic input in some meaningful way. The present study investigated English-speaking children's acquisition of restrictive relative clauses, and argues that an intimate relationship exists between children's grammatical knowledge, their processing capacity, and their input language.

The acquisition of sentences with embedded clauses is a major achievement in the child's linguistic development. Of particular interest to researchers of child language development has been the age at which relative clauses (RCs) are acquired. Early research suggested that acquisition was not complete until late childhood (e.g., Cook, 1975; deVilliers, Flusberg, Hakuta, & Cohen, 1979; Fluck, 1978; Sheldon, 1974). However, more recent studies that have used more appropriate methodologies have shown acquisition to occur much earlier, and have questioned the processing strategies proposed for earlier findings (Correa, 1982, 1995a; Fragman & Goodluck, 2000; Hamburger & Crain, 1982). Elicited production studies also suggest that children produce RCs from an early age, albeit mostly in a structurally impoverished form (e.g., Crain, McKee, & Emiliani, 1990; Dasinger & Toupin, 1994; McDaniel, McKee, & Bernstein, 1998; McKee, McDaniel, & Snedeker, 1998).

Studies investigating children's knowledge of RCs have typically investigated the role which two structural variables, *embeddedness* and *focus*, play in children's understanding. Four RC constructions manipulating embeddedness and focus, as used by Sheldon (1974), are shown in (1)–(4):

(1) SS: The dog [that ____ jumps over the pig] bumps into the lion.
(2) SO: The lion [that the horse bumps into ____] jumps over the giraffe.
(3) OO: The dog stands on the horse [that the giraffe jumps over ____].
(4) OS: The pig bumps into the horse [that ____ jumps over the giraffe].

Embeddedness refers to the position of the RC in the sentence. It changes according to the constituent it modifies in the main clause. In a subject embedded sentence, the RC occurs after the subject of the main clause and is often referred to as center-embedded because it breaks up the main clause subject and the verb phrase (VP). In an object embedded sentence, the RC occurs after the object of the main clause and so is often referred to as right-branching.

Focus refers to the role the head noun plays in the RC, as indicated by the underscore "gaps" in (1)–(4). For example, in (1) the head noun (*the dog*) has the role of subject in the RC; in (2) the head noun (*the lion*) has the role of object in the RC. Each sentence type is identified by a two-letter

acronym referring to its embeddedness and focus. OS, for example, denotes sentence (4), because the RC is right-branching, modifying the main clause direct object (O), and the head noun occupies the subject focus position (S) in the RC.

Past Research and Methodological Considerations

Children's knowledge of RCs has typically, although not solely, been tested using the "act-out" or "figure manipulation" task (henceforth, standard act-out task). In the standard act-out task, the experimenter presents the child with an RC construction and instructs the child to act out the sentence using toys and props. In sentence (1), for example, the child would be required to make the dog jump over the pig and then bump the lion. Successful completion of these two actions is taken as evidence that the child is sufficiently capable of representing and comprehending the construction being tested.

A striking feature of early studies investigating acquisition of RCs was the apparent difficulty children had in comprehending these constructions. In general, children less than 5-years-old tended to perform badly on all structural variations and were attributed little knowledge of the recursive function of language. When children exhibited some knowledge of constructions tested there was little consistency in results across studies. Table I presents findings from four early studies that tested 3- to 5-year-old children's knowledge of RCs manipulated for embeddedness and focus.

Different processing strategies were proposed to account for the range of findings listed in Table I. Two of those strategies, Sheldon's (1974) Parallel Function hypothesis and Tavakolian's (1981) Conjoined-Clause Analysis, have received the most attention in the developmental literature. Both are briefly reviewed here (see Crain & Thornton, 1998; Correa, 1995a; Lebeaux, 1990; and Vainikka, 1990, for further information).

Table I. A Summary of the Findings from Early Studies Investigating RC Comprehension

Study	Finding*
de Villiers *et al.* (1979)	(OS, SS) > OO > SO
Sheldon (1974)	(SS, OO) > (SO, OS)
Smith (1974)	OS > SS > OO > SO
Tavakolian (1981)	SS > (OO, SO) > OS

*The greater than sign (>) implies "easier to comprehend than." Constructions in brackets are predicted to be of equal difficulty to comprehend.

Sheldon's (1974) Parallel Function hypothesis predicts that co-referential NPs that have the same grammatical function in their respective clauses (SS, OO) are easier to process than co-referential NPs with different grammatical functions (SO, OS). The Parallel Function hypothesis is a processing heuristic proposed to be used by children who are yet to acquire the grammatical knowledge necessary for RC comprehension. It is proposed that children will predict that the head noun will occupy the same grammatical function in the RC as it does in the main clause. Hence the SS and OO constructions are predicted to be easier to comprehend than the SO and OS constructions.

In proposing the Conjoined-Clause Analysis, Tavakolian (1981) claimed that children's grammars lack recursion within the NP and are therefore unable to process RCs as noun modifiers. The conjoined-clause analysis predicts that in the absence of recursive grammar children will interpret RC constructions as consisting of conjoined simplex sentences. For example, a child would be predicted to interpret (4) as:

(5) The pig bumps into the horse *and* jumps over the giraffe.

Both the Parallel Function Hypothesis and the Conjoined-Clause Analysis attribute little grammatical knowledge to children, and instead suggest that children less than 5 years rely on heuristic and default strategies to interpret RCs. Both strategies were developed from the results of studies that used the standard act-out task, based on the assumption that the standard act-out task adequately taps children's grammatical knowledge. Some researchers, on the other hand, have criticized the standard act-out task on the basis of this very assumption.

Hamburger and Crain (1982) and Correa (1982, 1995a, 1995b) have highlighted the shortcomings of the standard act-out task. Hamburger and Crain were first to note that the task violated certain pragmatic/semantic aspects of language use. Correa offered more criticisms still, the most pertinent of which suggested that the standard act-out task presented children with conflicting task demands. Correa noted that the standard act-out task was a metalinguistic task ("game with language") disguised in the context of a game with toys. In a game with toys, the test sentences provide information about the toys; the NPs serve a pragmatic function relevant to the task. In a game with language, however, the test sentences have no immediate communicative purpose. Successful completion of the task requires that the child first attends to the purely metalinguistic component of the task ("game with language") and ignores the toys in the experimental setting. The child is then required to translate the semantic representation of those sentences into actions with the toys provided, despite the nonreferential function of the NPs and the nonfunctional use of linguistic constructions. The suggestion is that the conflicting demands presented by a game with

toys and a purely metalinguistic task is a problem quite distinct from the comprehension problem presented by the test sentences.

To address the above criticisms, Correa developed an alternative test of children's comprehension of RCs. The difficulties ascribed to the standard act-out task were overcome by creating a situation in which restrictive RCs could be processed as pragmatically functional noun modifiers. The task initially presents children with two background scenes, an example of which is shown below in (6a):

(6a) A horse jumps over a sheep. Another horse pushes a cow.

After viewing the sequence of actions as acted out and described by the experimenter, the child is asked to act out the test sentence, an example of which is shown in (6b):

(6b) The pig bumps the horse that jumped over the sheep.

The alternative act-out task has many advantages. By presenting two NVN relationships before the test sentence, it minimizes the tendency for children to invoke a conjoined-clause analysis (see Tavakolian, 1981). Additionally, creating a situation in which restrictive RCs can be processed as pragmatically functional noun modifiers overcomes the problem of presenting children with test sentences in a null context.

Correa (1982, 1995a) has tested the alternative act-out task on English- and Portuguese-speaking children ages 3 to 6 years. Children were tested on structures manipulated for embeddedness, focus, and animacy; all structures contained three NPs and two verbs (as in [6b]). The results suggested that children from both languages had mastered RC comprehension by 5 years, producing adult-like patterns of responding. Across all age-groups and across both languages, the OS construction was found to be the easiest to comprehend, followed by the SS construction, the OO construction, and the SO construction. A main effect for animacy suggested that the structures with three animate nouns were more difficult for children to process than structures with two animate nouns. Two distinct acquisition periods were identified from an analysis of children's error patterns. An improvement between the ages of 3 and 4 years was attributed to the children being able to keep the stimulus in immediate memory. An improvement between the ages of 4 and 5 years was attributed to children's ability to cope with the internal processing of the RC.

Correa reported that children from the two different languages performed the same on the modified act-out task. One might then hypothesize that the results from English and Portuguese reflect a set of processing constraints on development shared by the two languages, but there are arguments against this view. Portuguese is an SVO right-branching language like English, and the two languages are structurally similar in many respects.

However, Portuguese uses a richer inflectional morphology than English, and like other Romance languages, has case-marked relative pronouns. Studies investigating children's production of relative clauses have consistently shown children acquiring languages from the Romance group to produce RCs before children acquiring English (Crain, McKee, & Emiliani, 1990; Dasinger & Toupin, 1994). Furthermore, relative constructions have been found to be used with greater frequency by speakers of Romance languages than by English-speakers (Bates & Devescovi, 1989). This amounts to a corresponding difference in input to the children of each language group.

A study by Bates, Devescovi, and D'Amico (1999) reported differences in the cues Italian- and English-speakers use to interpret complex sentences. Whereas Italian-speakers tend to rely heavily on semantic and morphological cues, English-speakers rely more heavily on word order, such that there is a high processing cost associated with center-embedding. Such findings are consistent with the Competition Model (Bates & MacWhinney, 1989), which states that speakers exploit multiple cues to understand language; with the validity of each cue the product of its availability and reliability in the input language. Assuming that there is some continuity throughout development into the adult state, it is not implausible to suggest that English-speaking children might also experience greater processing difficulty with center-embedded structures.

The results reported by Correa (1982, 1995a) suggest that children learning two structurally different languages use the same processing strategies to interpret relative constructions. This may seem unusual, given that there is a large body of literature indicating the existence of language-specific constraints on development (see MacWhinney & Bates, 1989; Slobin, 1985a, 1992, 1997). The present study therefore aimed to investigate English-speaking children's understanding of relative constructions manipulated for embeddedness and focus, using the alternative act-out task developed by Correa. It was predicted that the English-speaking children would experience a greater processing cost when tested on center-embedded structures than when tested on right-branching structures. Thus we expect embeddedness to largely mediate the course of RC acquisition in English-speaking children.

METHOD

Participants

Forty-two children were recruited for the present study from the La Trobe University Child Development Unit registry, local kindergartens, and local primary schools. The sample was equally divided into three age-

groups. The 3-year-old age-group consisted of six females and eight males aged between 3;0 and 3;8 (mean: 3;3). The 4-year-old age-group consisted of eight females and six males between 4;0 and 4;6 (mean: 4;3). The five-year-old age-group consisted of five females and nine males between 5;0 and 5;6 (mean: 5;4). The children were monolingual and possessed no known language impairment.

Materials

A set of farm animal toys containing two identical tokens of each animal was used. Six different animal types were used: cow, goat, horse, kangaroo, pig, and sheep. Twelve sentences were tested: eight restrictive relatives manipulated for embeddedness and focus (Table II), two conjoined sentences, and two simple sentences. The conjoined and simple sentences served to introduce the child to the task, providing items that demanded less processing capacity.

Animacy was not included as an independent variable because only the structural constraints on comprehension were of interest in the present study. This enabled us to test children on two each of the SS, SO, OO, and OS constructions. Whilst Correa (1982, 1995a) also tested children on eight relative constructions in total, the lexical variable of animacy provided a marked situation whereby children were able to use the presence of an inanimate object as a clue to minimize processing load in four of the eight test sentences.

Procedure

Children were tested individually. The task followed the procedure designed by Correa (1995a), as outlined above. Before testing commenced, children were introduced to the toys and were required to name the animals. Children had no difficulty identifying the animals. The experimenter then told the child that the farm animals were naughty, and showed the child the

Table II. Comprehension Task Test Sentences

Sentence type	Sentence
SS	The cow [that ____ jumped over the pig] bumps the sheep.
	The horse [that ____ pushed the goat] stands on the cow.
SO	The sheep [that the goat bumped ____] pushes the pig.
	The cow [that the sheep pushed ____] stands on the kangaroo.
OS	The kangaroo stands on the goat [that ____ bumped the horse].
	The cow pushes the kangaroo [that ____ jumped over the goat].
OO	The horse jumps over the pig [that the kangaroo bumped ____].
	The kangaroo stands on the pig [that the sheep pushed ____].

ways in which the animals could be naughty. There were four actions in total: *bump, jump over, push,* and *stand on.*

Pretest

As a pretest, children were invited to play a game in which they themselves could make the animals be naughty. The experimenter placed the animals that were to be referents in the pretest sentences in front of the child. The pretest sentence was then presented with the request, "Can you make the. . . ." Two simple sentences and two conjoined clauses with a missing subject were then presented. For example, a simple sentence was presented with the request, "Can you make the kangaroo jump over the pig." A conjoined pretest sentence was then presented with the request, "Can you make the horse jump over the cow and stand on the sheep." No children experienced any difficulty completing the pretest items.

Test condition

The test condition was introduced as another game with the naughty animals. Children were instructed to pay careful attention to what the experimenter did because they would have to help the experimenter make the animals be naughty again. The experimenter then presented the child with two background scenes (e.g., one horse performing an action and then another horse performing a different action). Children were encouraged to participate in the acting-out of the two background scenes by performing the NVN actions themselves, rather than merely watch the experimenter perform them. Requesting children to act out the background scenes ensured that they were attentive. The test sentences were presented with the request, "Now, can you make . . ." The order of presentation of the test sentences was counterbalanced to control for ordering effects.

A common criticism of figure-manipulation tasks is that children often choose the toy nearest to them as the agent of a sentence, regardless of that toy's role in the test sentence (Hirsh-Pasek & Golinkoff, 1996). To control for this, both the incorrect and correct referent for the complex NP were placed equal distances from the child. Furthermore, the side at which the correct referent was placed varied to control for hand preference. Note that Correa (1982, 1995a) placed the incorrect referent closest to the child. It is unclear why this was the case; placing the incorrect referent closest to the child does not rule out the possibility that the child could develop a heuristic strategy that specifies the referent *furthest* away as the agent. In each scene, only two tokens of the head referent and three singletons involved in the background scenes and the test sentence were available to the child. All other toys were out of the child's view.

Scoring

Responses to the comprehension task were scored as correct/incorrect. Incorrect arrangements of animals were noted for error analysis. An analysis of erroneous responses offered by children is useful because it allows for the identification of any aberrant processing strategies children may be using to interpret the test sentences (de Villiers *et al.,* 1979; Hamburger & Crain, 1982; Slobin, 1985b). Comparing children's errors across age-groups also allows the identification of developmental changes that may underlie RC acquisition.

Children's errors were classified into six categories, as developed by Correa (1995a). Main clause (MC) described responses in which the main clause was correctly acted out, but with the incorrect token of the head referent. Relative clause (RC) referred to responses in which children acted out the relative clause of the test sentence. Pseudoclause (PC) referred to responses in which an actor–action–object relationship was performed, but when actual clause boundaries were not taken into account.[3] Double response (DR) referred to responses in which two NVN propositions were acted out, but were incorrect. Note, however, that a conjoined clause response on an SS relative was interpreted as correct, despite the fact that it was also technically a DR. Rearrangement (Re) responses referred to responses that failed to correspond to the linear ordering of the constituents of the test sentences. A miscellaneous Other (O) category was included to categorize any responses that did not fit into the above categories. Examples of possible erroneous arrangements for sentence (7) are given in Table III.

(7) The horse that the goat bumped pushed the sheep.

In Table III, N1 refers to the first noun, *horse.* Similarly, N2 and N3 refer to the second and third nouns in the sentence—*goat,* and *sheep,* respectively. V1 refers to the first verb *bump,* and V2 refers to the second verb *push.*

[3] Note that a PC differs from a "pseudo-relative clause," as discussed by McCawley (1988).

Table III. Examples of Error Categories for Sentence (3)

Error type/Arrangement	Erroneous action(s)
MC: N1/V2/N3 (incorrect referent)	Horse pushes sheep (incorrect horse)
RC: N2/V1/N1	Goat bumps horse
PC: N2/V2/N3	Goat pushes sheep
DR: N1/V1/N2 − N2/V2/N3	Horse bumps goat/goat pushes sheep
Rearrangement: N3/V1/N2	Sheep bumps goat

RESULTS

The correct answers to each grammatical construction on the act-out task were collated and converted to percentage form. The percentages of correct responses to each grammatical construction for each age-group are presented in Fig. 1.

Figure 1 shows that children's understanding of restrictive relative clauses increases with age, although actual development appears to depend on the construction tested. A 3 (age) $\times$ 2 (embeddedness) $\times$ 2 (focus) split plot ANOVA was performed on the correct responses to each construction. A significant main effect for embeddedness suggested that center-embedded structures were more difficult than right-branching structures [$F(1,39) = 18.846$, $p < .001$]. Performance differed across age-groups, yielding a significant main effect for age [$F(2,39) = 33.037$, $p < .0001$]. The main effect for focus was not significant [$F(1,39) = 1.884$, $p = .178$]. Two interactions were observed. A two-way embeddedness by age interaction suggested that children have a better understanding of center-embedded structures as they get older [$F(2,39) = 3.446$, $p < .05$]. A two-way embeddedness by focus interaction suggested that children's responses varied according to the two manipulated variables [$F(1,39) = 5.295$, $p < .05$]. It is likely, however, that this interaction was carried largely by the main effect for embeddedness.

Error Analysis

Erroneous responses to the test sentences were categorized according to the system outlined above. Children's errors, together with the correct responses (C), were converted to percentage form for each age-group. The

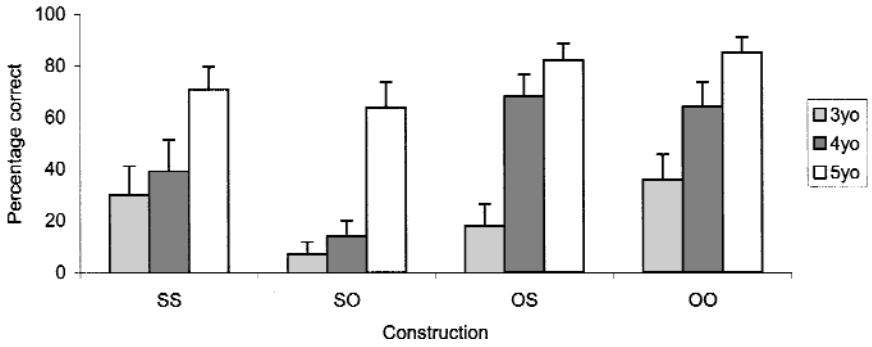

Fig. 1. Percentage correct responses to each grammatical construction for each age-group.

percentage distribution of each response type for each age-group is shown in Fig. 2.

The values in Fig. 2 suggest that the types of errors made by children vary with age. The errors made by the 3-year-old children covered the whole range of error categories, including a large proportion of O errors. In contrast to the 3-year-olds, the 4- and 5-year-olds made fewer errors; the most prevalent were MC responses.

As was observed by Correa (1995a), the improvement in responding observed between 3 and 4 years in the present study appears to be children's ability to keep the stimulus sentence in immediate memory. This is evident from the decrease in the number of atypical responses that do not respect clausal boundaries, such as PC, Re, and O. As also observed by Correa (1995a), the increase in correct responding between 4 and 5 years appears to be due to the decrease in the number of MC responses. The prevalence of MC responses in 4-year-olds suggests that they are having difficulty processing within the RC. If the prediction that English-speaking children would have more difficulty processing center-embedded structures is correct, then a secondary prediction would be that children would produce more MC responses on center-embedded structures than on right-branching structures, owing to processing limitations. Fig. 3 displays the average number of MC responses to each RC construction for 4- and 5-year-old children.

Figure 3 shows that 4-year-old children made a greater number of MC errors than 5-year-old children on all four constructions. Children made more MC errors on center-embedded structures than on right-branching structures. There was no immediately discernible pattern of responding for the focus variable.

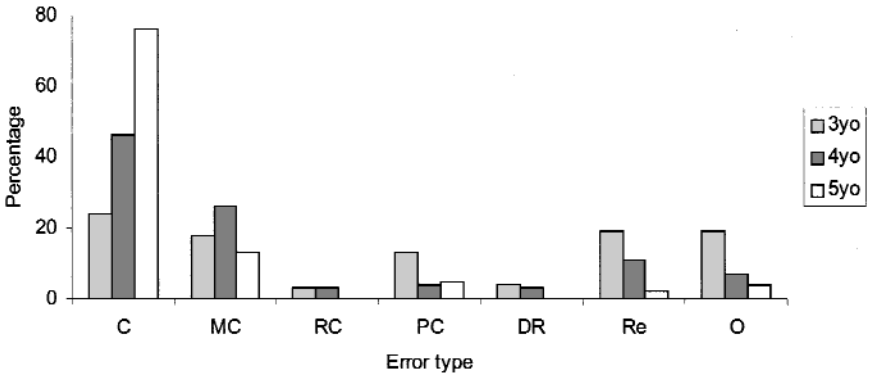

Fig. 2. Percentage distribution of response types to all test structures according to age.

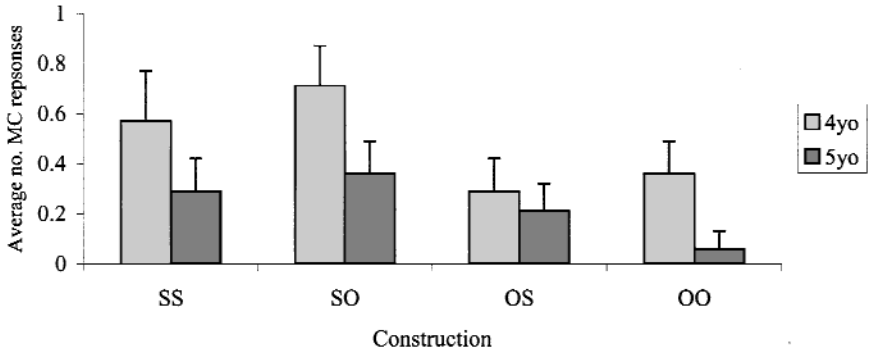

Fig. 3. Average number of MC responses for 4- and 5-year-old children.

The MC responses were analyzed by means of a 2 (age) $\times$ 2 (embeddedness) $\times$ 2 (focus) split plot ANOVA. A significant main effect for embeddedness indicated that children made more MC errors on center-embedded structures [$F(1,26) = 6.886$, $p < .02$]. A significant main effect was also observed for age [$F(1,26) = 8.327$, $p < .01$]. No other significant effects were observed.

DISCUSSION

The prediction that English-speaking children would experience more difficulty processing center-embedded structures than right-branching structures was supported by the results. It is appropriate, then, to consider some possible reasons why center-embedded structures should present English-speaking children with more processing difficulty.

Slobin (1973) suggested that avoiding interruption or rearrangement of linguistic units is a basic operating principle of language processing. Various typological studies have also suggested that languages avoid center-embedding of subordinate clauses (Dryer, 1980; Kuno, 1973, 1974). In English, such avoidance may enable the language processor to parse sentences in a more efficient manner.

Correa (1995b) has suggested that right-branching structures relieve the language processor of much of the complexity attributed to subject- and object-extraction in center-embedded sentences (thus reducing the role *focus* plays in comprehension). This is because the main clause of a right-branching structure occurs before the RC and can be closed off once the relative pronoun has been identified. The suggestion is that a deeper, propositional representation of the main clause can be constructed, freeing pro-

cessing resources that can be used to process the RC. This would explain why the children in the present study performed equally well on the OO and OS constructions. Apparently the difficulty ascribed to object-focus RCs is inconsequential when the RC is right-branching, because there are sufficient processing resources available to deal with object-extraction in this instance.

Difficulty does arise, however, when the child is required to identify a complex noun-modifier relationship before the main clause is complete. Bates *et al.* (1999) found that whereas English-speaking adults preferred to process main and relative clauses that followed canonical word order [i.e., N(VN)VN (an SS) and NVN(VN) (an OS)], center-embedded structures posed such difficulty for subjects that performance on OO structures (NVN[NV]—non-canonical RC) was better than that on SS structures. They concluded that this result was due to English-speaking subjects' heavy reliance on word order as a cue to sentence comprehension. The results from the present study concur with this explanation.

That the children in the present study experienced the most difficulty with center-embedded sentences suggests that they have difficulty integrating information across clausal boundaries that are incomplete. This may be because English-speaking children of preschool age expect whole clauses to be serially presented in utterances and only later begin to identify that subordinate clauses may occupy an internal position within an utterance. Thus the results of the present study could be used to argue for a "clause expansion" view of development. The clause expansion view has been reported elsewhere by researchers investigating children's spontaneous productions in naturalistic settings (see Bloom, 1991; Diessel & Tomasello, 2000). Lois Bloom and her colleagues (1980, 1984, 1989) investigated acquisition in four children longitudinally during their third year, finding that children link clauses according to the following hierarchy: *conjunction* $<$ *complementation* $<$ *relativization.* These data suggest that children first begin to produce complex sentences by linking two separate propositions via conjunction. Although this would not argue for the existence of grammatical knowledge enabling the use of complex sentences, it could be viewed as a precursor to such, indicating that children know an utterance can express more than one proposition. This is captured by Tavakolian's (1981) Conjoined-Clause-Analysis, which children seem invoke under the infelicitous discourse demands of the standards act-out task.

Diessel and Tomasello (2000) have shown that the first relative constructions children produce are propositionally simple, and that as children's utterances become more grammatically complex, they tend to attach relative clauses to a noun in a fully fledged NP. The results of this investigation, which studied four English-speaking children's (Peter, Sarah, Nina, and

Adam) utterances from the CHILDES database (MacWhinney & Snow, 1985), showed that the most prevalent relative constructions that were propositionally complex (i.e., consisting of more than one proposition) were right-branching. That children have been observed to both produce and understand right-branching RCs before center-embedded RCs provides support for the hypothesis that children develop complex sentence structure via clause expansion.

A Cross-linguistic Comparison: General-Cognitive and Language-Specific Constraints on Development

A detailed comparison of children's error patterns in the present study with the results reported by Correa (1995a) suggests that there are similarities and also cross-linguistic differences in the development of complex sentences. We compare the results of the present study to Correa's results with Portuguese-speaking children only.

Both studies report that 3-year-olds made similar errors in the act-out task. The predominance of Re, PC, and O errors, responses that do not respect the clausal boundaries of the test sentences, suggest that children have difficulty maintaining the test sentence in immediate memory. As a result, children may either perform the last NVN sequence heard (PC) or attempt to reconstruct an NVN sequence on the basis of a diminished memory trace (Re). The most prevalent O error occurred when children simply re-enacted one of the background scenes, suggesting that the test sentence presented a particularly difficult challenge, causing children to reinvest in a prior proposition that they had already processed.

Responses that did not take into account the clausal boundaries diminished between the ages of 3 and 4. As in Correa's (1995a) study, this finding suggests that the improvement observed between these ages is due to children's ability to maintain the test stimulus in immediate memory. In contrast to 3-year-olds, the most prevalent error in the 4-year-old age-group was the MC response. Correa also observed this trend. However, she found that Portuguese-speaking children made more MC errors on the OO and SO constructions, whereas the present study found that English-speaking children made the majority of MC errors when tested on center-embedded structures (SS and SO). The commonality between the two studies is that children produced the most MC responses on the structures that they found most difficult to comprehend.

The differences between the Portuguese and English data suggest that the structural properties of a language influence children's acquisition of RCs. Correa's (1995a) Portuguese data suggests that children from this language group are less constrained by word order. The input supports this

explanation. Dasinger and Toupin (1994) note that relative clauses in Romance languages such a Portuguese and Spanish have fewer constraints on accessibility than they do in English. Relative clauses show the same flexible word order as do simple clauses, and because Portuguese has only one relative pronoun (*que*), the production of RCs allows a speaker to delay identification of the relativized NP, which Bates and Devescovi (1989) suggest preserves the coherence and well-formedness of the utterance. It comes as no surprise then that speakers of Romance languages, and other languages in which RCs behave similarly (e.g. Hebrew), use RCs earlier and more frequently than do speakers of English (Bates & Devescovi, 1989; Crain *et al.*, 1990; Dasinger & Toupin, 1994). Therefore we can identify a role for language-specific input and usage patterns in the acquisition of grammar.

The predominance of MC errors in the 4-year-old group suggests that when children are unable to process the entire relative structure they give priority to the parsing of the main clause over the RC. This finding is consistent with studies investigating children's memory for complex sentences (Smith & McMahon, 1970; Townsend, 1974; Townsend & Erb, 1975; Townsend, Ottaviano, & Bever, 1979). These studies have shown that children encode the main clause of a relative construction first, regardless of the position of the subordinate clause in the sentence. The RC is then encoded. Subject to the availability of sufficient computational resources, the information within the RC can be integrated into the semantic representation of the sentence. However, as has been observed when children make MC errors, sufficient computational resources may not always be available. Consequently, the subordinate clause remains in a verbatim form, and may be lost before the adequate computational resources can be mobilized to process the embedded syntactic constituents. It is of interest to note that Mazuka (1998) has found this same effect in Japanese-speaking children, suggesting that the effect may be a universal feature of sentence processing.

Five-year-olds made fewer MC errors than 4-year-old children, suggesting the improvement observed between these two ages results from children's ability to process within the RC. The 5-year-old children's performance was above chance levels for each structural variation tested, suggesting that acquisition of the more complex aspects of syntax is largely complete by this age.

Language Processing and Development

We assume that children must possess some capacity to process their input in order to acquire language. Researchers who discuss processing in development have generally drawn a distinction between the parser and the

underlying grammatical competence of the child (Frank, 1998; Goodluck, 1989; Goodluck & Tavakolian, 1982). Ignoring for the moment the issue of whether young children possess syntactic competence, it is, at least in the case of very young children, difficult to attribute performance limitations solely to the parser, regardless of the theoretical perspective from which one chooses to work. Children must apply a meaningful analysis to their input regardless of what *a priori* knowledge they bring to the problem of acquisition; thus they must parse their input in order to acquire language (for a similar argument see Fodor, 1998).

The present paper has argued for general-cognitive and language-specific constraints on the development of grammar. It has been suggested that English-speaking children's acquisition of relative clauses is constrained by, among other things, the word-order restrictions of their input language in combination with their limited resource capacity. The notion that a limited resource capacity constrains acquisition is an important one and is central to the argument that the parser shapes acquisition. Newport (1988, 1990) argues for a "Less is More" hypothesis, which states that the efficiency with which a language is learned declines as cognitive abilities increase, suggesting that the child is an especially privileged language learner. By necessity, children can only analyze the linguistic input to which they can attend, suggesting that an account of language acquisition must be explained within an account of processing and resource capacity. Elman (1993) has argued along similar lines. A likely source of cognitive resources is memory. A recent study by Booth, MacWhinney, and Harasaki (2000) identified roles for short-term and working memory in older children's (8–11 years) processing of relative clauses. This appears to be a promising avenue of investigation in developmental research.

A final discussion point concerns the differences between the results of the present study and Correa's (1982) English data. One possible reason for this difference was that Correa only tested each construction with three animate NPs only once. Because animacy was a variable, the other sentences tested contained animate and inanimate NPs. We assume that children's processing strategies are tested when no animacy cues are available, as in the present study. It is of interest to note that a recent eye-movement study by Weighall and Altmann (2001) found 6- and 7-year-old children to experience greater difficulty with the center-embedded SS structure than the right-branching OS structure.

CONCLUSION

Contrary to the results of early research, the present study has reported results that show English-speaking children understand the structural varia-

tions of relative clauses by age 5. The present study thus provides further evidence to suggest that the inconsistent results found in early studies of RC acquisition were due to the infelicitous nature of the standard act-out task. A comparison with data from Portuguese-speaking children suggests that features of the child's input language shape the sequence of acquisition of relative clauses. Such language-specific constraints are argued to interact with the developing resource capacity of the child and the status of information in discourse.

REFERENCES

Bates, E., & Devescovi, A. (1989). Crosslinguistic studies of sentence comprehension. In B. MacWhinney & E. Bates (Eds.), *The crosslinguistic study of sentence processing* (225–253). Cambridge: Cambridge University Press.

Bates, E., Devescovi, A., & D'Amico, S. (1999). Processing complex sentences: A crosslinguistic study. *Language and Cognitive Processes, 14,* 69–123.

Bates, E., & MacWhinney, B. (1989). Functionalism and the competition model. In B. MacWhinney & E. Bates (Eds.), *The crosslinguistic study of sentence processing* (3–73). Cambridge: Cambridge University Press.

Bloom, L., (1991). *Language development from two to three*. Cambridge: Cambridge University Press.

Bloom, L., Lahey, M. Hood, L., Lifter, K., & Fiess, K. (1980). Complex sentences: Acquisition of syntactic connectives and semantic relations they encode. *Journal of Child Language, 7,* 235–261.

Bloom, L., Rispoli, M., Gartner, B., & Hafitz, J. (1989). Acquisition of complementation. *Journal of Child Language, 16,* 101–120.

Bloom, L., Tackeff, J., & Lahey, M. (1984). Learning *to* in complement construction. *Journal of Child Language, 11,* 391–406.

Booth, J. R., MacWhinney, B., & Harasaki, Y. (2000). Developmental differences in visual and auditory processing of complex sentences. *Child Development, 74,* 981–1003.

Cook, V. J. (1975). Strategies in the comprehension of relative clauses. *Language and Speech, 18,* 204–212.

Correa, L. M. (1982). Strategies in the acquisition of relative clauses. *Working Papers of the London Psycholinguistic Research Group, 4,* 37–49.

Correa, L. M. (1995a). An alternative assessment of children's comprehension of relative clauses. *Journal of Psycholinguistic Research, 24,* 183–203.

Correa, L. M. (1995b). The relative difficulty of children's comprehension of relative clauses: A procedural account. In: K. Nelson & Z. Reger (Eds.), *Children's language* (Vol. VIII) (225–243). Hillsdale, NJ: Erlbaum.

Crain, S., McKee, C., & Emiliani, M. (1990). Visiting relatives in Italy. In: L. Frazier & J. de Villiers (Eds.), *Language processing and language acquisition* (335–354). Dordrecht: Kluwer Academic.

Crain, S., & Thornton, R. (1998). *Investigations in universal grammar*. Cambridge, MA: MIT Press.

Dasinger, L., & Toupin, C. (1994). The development of relative clause functions in narrative. In R. A. Berman & D. I. Slobin (Eds.), *Relating events in narrative: A crosslinguistic development study* (457–514). Hillsdale, NJ: Erlbaum.

de Villiers, J. R., Flusberg, H. B. T., Hakuta, K., & Cohen, M. (1979). Children's comprehension of relative clauses. *Journal of Psycholinguistic Research, 8,* 499–518.

Diessel, H., & Tomasello, M. (2000). The development of relative constructions in early child language. Unpublished manuscript, Max Planck Institute for Evolutionary Anthropology.

Dryer, M. (1980). The positional tendencies of sentential noun phrases in universal grammar. *Canadian Journal of Linguistics, 25,* 123–195.

Elman, J. (1993). Learning and development in neural networks: The importance of starting small. *Cognition, 48,* 71–99.

Fluck, M. J. (1978). Comprehension of relative clauses by children aged five to nine years. *Language and Speech, 21,* 190–201.

Fodor, J. D. (1998). Parsing to learn. *Journal of Psycholinguistic Research, 27,* 339–374.

Fragman, C., & Goodluck, H. (2000). Children's knowledge of the grammar of restrictive relative clauses. In C. Howell *et al.* (Eds.), *Proceedings of the 24th Boston University Conference on Language Development* (299–307). Somerville, MA: Cascadilla Press.

Frank, R. (1998). Structural complexity and the time course of grammatical development. *Cognition, 66,* 249–301.

Frazier, L., & Clifton, C., Jr. (1996). *Construal.* Cambridge: MIT Press.

Frazier, L., & de Villiers, J. (Eds.) (1990). *Language processing and language acquisition.* Dordrechht: Kluwer Academic.

Gibson, E. (1998). Linguistic complexity: locality of syntactic dependencies. *Cognition, 68,* 1–79.

Goodluck, H. (1989). When grammar wins over sense: Children's judgements of extraposed relatives. *Journal of Psycholinguistic Research, 18,* 389–416.

Goodluck, H., & Tavakolian, S. (1982). Competence and processing in children's grammar of relative clauses. *Cognition, 11,* 1–27.

Hamburger, H., & Crain, S. (1982). Relative acquisition. In: S. Kuczaj II (Ed.), *Language development Vol. 1: Syntax and semantics* (245–274). Hillsdale, NJ: Erlbaum.

Hirsh-Pasek, K., & Golinkoff, R. (1996). *The origins of grammar.* Cambrigde, MA: MIT Press.

Kuno, S. (1973). Constraints on internal clauses and sentential subjects. *Linguistic Inquiry, 4,* 363–385.

Kuno, S. (1974). The position of relative clauses and conjunctions. *Linguistic Inquiry, 5,* 117–136

Lebeaux, D. (1990). The grammatical nature of the acquisition sequence: adjoin-a and the formation of the relative clause. In: L. Frazier & J. de Villiers (Eds.), *Language processing and language acquisition* (13–82). Dordrecht: Kluwer Academic.

MacDonald, M. C., Pearlmutter, N. J., & Seidenberg, M. S. (1994). Lexical nature of syntactic ambiguity resolution. *Psychological Review, 101,* 676–703.

MacWhinney, B., & Bates, E. (1989). *The crosslinguistic study of sentence processing.* Cambridge: Cambridge University Press.

MacWhinney, B., & Snow, C. (1985). The child language data exchange system. *Journal of Child Language, 12,* 457–472.

Mazuka, R. (1998). *The development of language processing strategies: A crosslinguistic study between Japanese and English.* Mahwah, NJ: Erlbaum.

McCawley, J. D. (1988). *The syntactic phenomena of English* (Vols. 1 & 2). Chicago: UCP.

McDaniel, D., Mckee, C., & Bernstein, J. (1998). How children solve a problem for minimalism. *Language, 74,* 308–334.

McKee, C., McDaniel, D., & Snedeker, J. (1998). Relatives children say. *Journal of Psycholinguistic Research, 27,* 573–596.

Newport, E. L. (1988). Constraints on learning and their role in language acquisition: Studies of the acquisition of American Sign Language. *Language Sciences, 10,* 147–172.

Newport, E. L. (1990). Maturational constraints on language learning. *Cognitive Science, 14,* 11–28.

Sheldon, A. (1974). The role of parallel function in the acquisition of relative clauses in English. *Journal of Verbal Learning and Verbal Behaviour, 13,* 272–281.

Slobin, D. I. (1973). Cognitive prerequisites for the development of grammar. In: C. A Ferguson & D. I. Slobin (Eds.), *Studies of child language development* (175–208). New York: Holt, Rinehart and Winston.

Slobin, D. I. (Ed.) (1985a). *The crosslinguistic study of language acquisition.* Vol. 1: The data. Hillsdale, NJ: Erlbaum.

Slobin, D. I. (1985b). Introduction: Why study acquisition crosslinguistically? In: D. I. Slobin (Ed.), *The crosslinguistic study of language acquisition.* (Vol. 1: The Data) (3–27). Hillsdale, NJ: Erlbaum.

Slobin, D. I. (Ed.). (1992). *The crosslinguistic study of language acquisition* (Vol. 3). Hillsdale, NJ: Erlbaum.

Slobin, D. I. (Ed.) (1997). *The crosslinguistic study of language acquisition* (Vol. 4). Mahwa, NJ: Erlbaum.

Smith, M. (1974). Relative clause formation between 29–36 months: a preliminary report. *Papers and Reports on Child Language Development, 8,* 104–110.

Smith, K., & McMahon, L. (1970). Understanding order information in sentences: Some recent work at Bell Laboratories. In: G. Flores d'Arcais & W. Levelt (Eds.), *Advances in psycholinguistics* (45–69). Amsterdam: North-Holland.

Tavakolian, S. (1981). The conjoined clause analysis of relative clauses. In: S. Tavakolian (Ed.), *Language acquisition and linguistic theory* (167–187). Cambridge, MA: MIT Press.

Townsend, D. J. (1974). Children's comprehension of comparative forms. *Journal of Experimental Child Psychology, 18,* 293–303.

Townsend, D. J., & Erb, M. (1975). Children's strategies for interpreting complex comparative questions. *Journal of Child Language, 2,* 1–7.

Townsend, D. J., Ottaviano, D., & Bever, T. G. (1979). Immediate memory for words from main and subordinate clauses at different age levels. *Journal of Psycholinguistic Research, 8,* 31–101.

Vainikka, A. (1990). The status of grammatical default systems: Comments on Lebeaux. In: L. Frazier & J. de Villiers (Eds.), *Language processing and language acquisition* (83–105). Dordrecht: Kluwer Academic.

Weighall, A, & Altmann, G. (2001, April). *Integration between language and visual context: A re-investigation of children's interpretation of relative clauses.* Paper presented at the biennial meeting of the Society for Research in Child Development, Minneapolis, MI.