Pied-piping in embedded contexts in the acquisition of English:
A qualitative study of comprehension

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1. Introduction

The alternation between pied-piping and preposition-stranding offers a window into the interaction between phrase and clause structure and movement (Hornstein and Weinberg 1981, Chomsky 1995, Suñer 1998). As Cowper (1987) notes, pied-piping may interact differently with main and embedded clause structure. In English, the alternation is also subject to the subtle variation across embedded clause types seen in (1)-(2), where wh-forms, prepositions, and verbal inflection all interact.

(1) **Tensed relative clause**
   a. Eeyore pushes the boat [**behind which** Pooh runs t]
   b. Eeyore touches the boat [**Op** Pooh runs behind t]
   c. Eeyore touches the boat [**which** Pooh runs behind t]

(2) **Infinitival relative clause**
   a. Pooh picks the blanket [**under which** to rest t]
   b. Pooh picks the blanket [**Op** to rest under t]
   c. ***Pooh picks the blanket [**which** to rest under t]

In the pied-piped examples in (1-2a), the preposition accompanies the wh-form in clause-initial position. Both tensed and infinitival relative clauses permit a null operator in preposition-stranding structures, as in (1-2b), but the two clause types are distinguished in whether they permit an overt operator with preposition-stranding, as in (1c), or not, as in (2c). Inflection of the embedded verb thus interacts with clause structure and operator syntax in the domain of pied-piping.

The results reported in this paper are part of a larger project investigating the acquisition of pied-piping and preposition-stranding across embedded contexts. In the production component of the larger project (Foley 1998, Foley and Fugett-Fuller 2002), 80 children acquiring English (5;6-9;5) and 20 adults were tested in an elicited imitation experiment including tensed and infinitival relative clauses and embedded questions. The experiment tested the hypothesis that if pied-piping and preposition-stranding truly interact with both verbal inflection and clause structure, children's production might distinguish pied-piping across embedded clause types. Pied-piping was imitated with less success overall than preposition-stranding, consistent with earlier work (French 1984, McDaniel and McKee 1996, McDaniel, McKee and Bernstein 1998). However, both the quantitative results and qualitative analysis of errors revealed that children distinguish pied-piping across the three embedded types. For example, the difference in percentage of "correct" imitations across pied-piping and preposition-stranding was much larger for infinitival relative clauses than for the two relative clause types (quantitative), and the specific types of structural changes children made differed across embedded clause types (qualitative).

The experiment reported here explores the comprehension of both pied-piping and preposition stranding in language acquisition for two of the embedded clause types tested in the production study: tensed and infinitival relative clauses. (Because we used an act-out method, discussed below, the design could not easily include embedded questions.) This initial, exploratory study included a fine-grained qualitative analysis of a set of responses from ten children and ten adult control subjects.

2. Limitations and advantages of the qualitative approach

Like most qualitative work in language acquisition, this study is limited in that the findings reported here, from only twenty subjects, are not generalizable. On the other hand, the more-in-depth analysis permitted in a qualitative study has the potential to yield insights worthy of systematic study. (See Adams, Fujii and Mackey 2006 for a fuller discussion of qualitative approaches.)

As we discuss below, in this particular case, a qualitative approach offered several advantages important to our aims. First, it allowed us to transcribe the act-out data using two different approaches,

and weigh their benefits and drawbacks. Second, it provided the opportunity to analyze features of act-out data that large-scale studies often do not or cannot analyze in depth, such as action order. Third, it unearthed surprising findings related to predicate semantics that can now be investigated in larger-scale, controlled studies.

3. Design

Our experimental varied pied-piping and preposition-stranding across two embedded clause types, tensed and infinitival relative clauses, as summarized in Table 1. We included coordinate sentences and sentences with purpose clauses as experimental controls. All sentences included 7-9 words and all included 10-12 syllables.

Table 1. Experimental sentences.

Tensed relative clause
Pied-piping
Eeyore pushes the boat behind which Pooh runs. (A2)
Bert kicks the box under which Cheezer hides. (B1)
Preposition-stranding
Pooh touches the boat which Eeyore crawls over. (A4)
Bert pushes the shell which Piglet stands behind. (B6)
Infinitival relative clause
Pied-piping
Pooh picks the blanket under which to rest. (A5)
Cheezer picks the shell over which to jump. (B2)
Preposition-stranding
Tigger chooses the cup to jump into. (A6)
Piglet chooses the box to crawl into. (B4)
Experimental controls
Coordinate
Tigger feels the blanket and Pooh feels the blanket. (A1)
Cheezer touches the spoon and Bert touches the spoon. (B5)
Purpose clause
Eeyore picks a cup to drink some water. (A3)
Piglet chooses a spoon to eat some soup. (B3)

4. Experimental method

The study tested the sentences in Table 1 using an act-out method (Lust, Chien and Flynn 1987). A pretraining battery of sentences was presented first, and then the experimental sentences were presented in two independently randomized batteries of six sentences each. (Parentheses in Table 1 present the battery, A or B, and the number within a battery for each sentence.) Battery order was also varied across participants such that half the participants heard battery A first, and half heard B first.

For each battery, one experimenter and one research participant sat together on the floor (child participants) or at a table (adults). A second experimenter operated a video camera, which recorded all batteries. The first experimenter introduced three dolls (e.g., Eeyore, Tigger and Pooh) and placed them to one side of the research participant. Next, the experimenter introduced three sets of props, each an

identical pair (e.g., two cups, two blankets and two toy boats), placing these roughly in a row, forming a semicircle together with the three dolls. The middle of the semicircle, in front of the research participant, remained clear and empty. The pretraining battery included some toys and props from battery A and some from B; see Appendix A. After all toys and props were introduced, the participant was asked to identify several toys and props (e.g., "Can you show me Tigger? Can you show me a boat?").

Before the pretraining battery, the experimenter introduced the task by roughly following the script in (3.)

(3) **Introducing the method**. In this game, I'm going to tell you a story, and I'd like you to show me the story using the dolls and toys here. You can choose whatever you want to show me the story, and bring whatever you want to the middle to show me the story. Then when you're done, you can put everything back, so I know you're done.

The script was modified slightly for adults, substituting "sentence" for "story." Adults were told that they were participating in a control group for a study with children.

The pretraining battery (included in Appendix A) included seven sentences designed to meet the criteria in (4).

(4) **Criteria for design of the pretraining battery**

a. Introduce participants to the general experimental set-up: three dolls, three pairs of identical props
b. Gradually increase in length from very short (two-word) sentences to sentences that match word and syllable length, but not syntactic complexity, of experimental sentences
c. Explicitly call for actions on the same object and on different objects in the same category, to show that the "game" permits either type of action
d. Explicitly call for different characters to perform different actions relative to the same object
e. Include locative verb phrases (e.g., jump into the box)
f. Include alternative sentences (with the same structure as pretraining battery sentences) to be used if participants received coaching on one of the pretraining sentences, to be sure the participant was capable of acting out the structure unaided

The pretraining battery is discussed at greater length below in section 7.

After successful completion of the pretraining battery, all dolls and props were cleared away. The experimenter explained that next, there would be a game that was just like the first game. The experimenter introduced each of the two experimental batteries in the same manner as the pretraining battery. However, while the pretraining battery permitted coaching and repetitions, for the experimental sentences, no coaching or reinforcement was offered during the act-out. At the end of each act-out, the participant was briefly praised, regardless of the action performed. Only one repetition was permitted in cases where the participant asked for a repetition, or where an external interruption took place. In cases of repetition, all dolls and props were replaced in their original positions before the repetition.

5. Participants in the study

Ten children ranging in age from 5 years, 8 months to 7;2 (mean 6 years, 5 months; four boys and six girls) participated in the study. Children were recruited through letters sent home to parents at two schools in Morehead, Kentucky. Ten adults also participated; adults were university students recruited through posters or announcements in classes.

6. Data analysis

6.1. Transcription

All videotapes of the child participants were transcribed independently by two researchers using a transcription form designed to capture the number and order of actions completed for each experimental

sentence, and to describe the actions. An excerpt from the transcription form is included in Appendix B. The two transcription forms were then compared, and for any sentence where the two transcriptions disagreed, a third, independent transcription was completed and compared with the first two. When the third transcription agreed with one of the first two, that transcription was used for coding. When the third transcription agreed with neither of the other two, the three researchers sat together with the videotape to discuss the source of disagreement and decide on the best way to transcribe the sentence. The final decisions of the transcribers were captured on a single transcription form, which was then used for coding.

All videotapes of the child participants were also transcribed using a second method of narrative transcription, where the child's actions were recorded sequentially, including detail not included in the transcription form, such as which hand was used to pick up objects, or whether the child hesitated or dropped objects in the course of the act-out. An excerpt is included in Appendix C. Each narrative transcription was checked by a second experimenter who watched the videos while reading the narratives. These transcription forms were mined for detail in the fine-grained qualitative analysis of unexpected interpretations discussed below.

All videotapes of the adult participants were transcribed once using the form and once using the narrative method. Forty percent of the matched transcriptions of sentences were then compared (for each sentence, pairs of transcriptions from four subjects were compared; subjects were varied across sentences). The information in the narratives agreed with that captured in the form in 100% of these comparisons.

6.2. Coding

Transcription forms were used for coding (see above). For all sentences, responses were coded as involving no error, lexical errors, structural errors, or both. These errors are defined in (5) and (6).

(5) **Lexical error:** a mismatch between stimulus sentence and response in subject or object referent (e.g., Pooh instead of Tigger), predicate action (e.g., sit instead of crawl), or preposition (e.g., under instead of over)

(6) **Structural error**:

a. In relative clause sentences: referent for main clause object not identical to that for relative clause gap; or only one clause acted out

b. In purpose clause or infinitival relative clause sentences (main clause verb "pick" or "choose"): action on two objects (i.e., no choice of object)

Our categorization of sentences as involving errors was conservative in that we coded some responses as involving structural errors when they might reflect a possible interpretation of the sentence. For example, for the sentence, "Cheezer picks the shell over which to jump," we classified the action as a structural error if the participant showed Cheezer jumping over more than one shell. It is possible, though, to interpret jumping over more than one shell as repeated act-outs of the sentence (e.g., one child had Cheezer jump repeatedly over one shell and then the other).

For tensed relative clauses and coordinate sentences, responses were also coded according to whether the actions corresponding to the two clauses were sequential or simultaneous. There were three possibilities, as shown in (7).

(7) **Coding categories for action sequence**

a. Sequential: action 1 began and ended, then action 2 began

b. Partly sequential: action 1 began and continued while action 2 began

c. Simultaneous: actions 1 and 2 began and ended together

If responses were either sequential or partly sequential, they were also coded according to which clause's action began first—the action corresponding to the main clause or that corresponding to the subordinate clause. (Action order coding is irrelevant for infinitival relative clause and purpose clause sentences: "pick" and "choose" require main clause first in 2-action act-outs.)

Finally, for some sentences types, other coding categories were added. These are discussed below in the results section.

7. Results

7.1. Analysis across clause types

Overall, both children and adults acted out the experimental sentences with relatively few lexical or structural changes. Table 1 presents the results across different clause types.

Table 1. Percentage of responses with no lexical or structural changes, by sentence type.

	Experimental controls		Tensed relative clause		Infinitival relative clause	
	Coordinate	Purpose clause	Pied-piping	Preposition stranding	Pied-piping	Preposition stranding
Children (N=10)	90%	80%	70%	80%	70%	95%
Adults (N=10)	95%	100%	95%	100%	95%	100%

Example of lexical change:

Experimenter: Tigger feels the blanket and Pooh feels the blanket.

Child: First Tigger feels a blanket, then Eeyore feels the same blanket. (age 6;6)

Example of structural change:

Experimenter: Pooh picks the blanket under which to rest.

Adult: Pooh moves to the center of the table, then both blankets cover Pooh.

Although these results must be viewed with caution, because they derive from a small number of participants, Table 1 shows that for all structural types, for children, 70% or more of sentences were acted out without lexical or structural "errors;" for adults, 95%.

In children's responses, lexical changes outnumbered structural changes, as shown in Table 2.

Table 2. Number of child act-outs with lexical or structural errors, or both.

	Experimental controls		Tensed relative clause		Infinitival relative clause	
	Coordinate	Purpose clause	Pied-piping	Preposition stranding	Pied-piping	Preposition stranding
Lexical errors	2	3	4	4	5	1
Structural errors		1	1		1	
Both lex and str			1			

One of the types of lexical error observed in children's act-outs involved the interpretation of the preposition, as in the example in (8).

(8) **Example of a lexical preposition error**

Experimenter: Bert pushes the shell which Piglet stands behind.

Child: Holds both Bert and Piglet in right hand. Picks up shell with left hand and puts on floor. Makes Piglet stand on top of shell. Uses right hand to make Bert push shell with Piglet standing on it.

In this act-out, the child has apparently substituted the preposition *on* for *behind.* This error type differed for pied-piping and preposition-stranding across clause types: In infinitival relative clauses, there were more lexical preposition errors for pied-piping [5] than for preposition stranding [1]. In contrast, in tensed relative clauses, there were more lexical preposition errors for preposition stranding [4] than for pied-piping [2].

This distinction, though it must be viewed as a preliminary and non-generalizable finding, suggests that children interpret pied-piping with reference to the structure of the subordinate clause where it appears.

7.2. Analysis of action order and verb phrase telicity

Although all verbs in the design are atelic in isolation (run, crawl, climb, hide, rest, jump), in combination with prepositional phrases, they yield VPs that vary in telicity—that is, they vary in whether the predicate's meaning inherently involves an endpoint or not. Table 3 shows this variation for three of the relative clause sentences in the design. (The fourth relative clause sentence is discussed in section 7.3 below.)

Table 3. Telicity of embedded clause VP in embedded clauses

Telicity	Sentence
Telic VP	Pooh touches **the boat which Eeyore crawls over**.
Ambiguous: Telic or atelic VP	Bert kicks **the shell under which Cheezer hides** (hiding under a shell as either achievement or state)
Atelic VP	Bert pushes **the shell which Piglet stands behind**.

Both children and adults more frequently acted out the main clause first when the subordinate clause VP was telic, and subordinate first for atelic, as shown in Table 4.

Table 4. Action order for three of the four tensed relative clause sentences, by telicity of relative clause VP

		Telic	Telic/Atelic	Atelic
Children (N=10)	Main first	9	5	2
	Subordinate first	0	5	8
	Simultaneous	1	0	0
Adults (N=10)	Main first	8	1	2
	Subordinate first	1	9	7
	Simultaneous	1	0	1

"Main first" and "subordinate first" categories include act-outs that were sequential or partly sequential (see example (6) above for definitions).

As Table 4 shows, for the stimulus sentence with a telic relative clause predicate, both children and adults acted out the main clause first in almost all of the ten tokens. For the atelic predicate, the pattern is reversed, with more children and adults acting out the subordinate clause first. In the case of an ambiguous (telic or atelic) predicate, half of the children acted out the main clause first, and half the subordinate; adults predominantly selected the subordinate clause first.

7.3. Unexpected eventive interpretation

One of the tensed relative clause structures, shown in (9), was given an unexpected eventive interpretation.

(9) Eeyore pushes the boat behind which Pooh runs.

The interpretation we anticipated for this sentence was one where a boat would be identified by being pushed by Eeyore, and Pooh would run behind that boat. The unexpected interpretation this sentence yielded involved Eeyore pushing the boat, and Pooh running along behind the entire boat-pushing event. An example narrative transcription of this type of interpretation appears in (10).

(10) **Example eventive interpretation by child, age 7;2**: Child picks up Eeyore with left hand and boat with right hand. Child puts boat down in front of child and picks up Pooh. Child holds Pooh facing Eeyore's back, and holds Eeyore facing boat. Child makes Eeyore push boat and makes Pooh move along behind Eeyore in same direction.

Four children and all ten adults demonstrated an eventive interpretation of this sentence. The order of actions for this sentence is summarized in (11).

(11) **Order of actions for sentence (9)**
a. Children: Main first 7 / subordinate first 1 / simultaneous 1
b. Adults: Main first 5 / subordinate first 0 / simultaneous 5

7.4. Analysis of pretraining responses

As noted in section 4, the pretraining battery included seven structures, each with alternative forms (see Appendix A). The alternative forms were included for the experimenter to use if the child had been coached on the act-out for the first token of a particular structural type. (For example, if the child needed coaching or demonstration to act out "Eeyore jumps," then the alternative form "Tigger runs" was available for the experimenter to give next to see whether the child could in fact act out that structural type independently.) Children completed a mean of 8.5 tokens in the pretraining batteries.

Qualitative analysis of the pretraining responses showed that eight of the ten children were coached on putting toys in the middle of the semi-circle for the act-out and returning them to their original positions when the act-out was finished, making this the most common kind of coaching.

Coaching that demonstrated sequential act-outs did not seem to bias children toward only sequential act-outs in their subsequent responses. For example, in one case, experimenter demonstrated a sequential act-out, and the child then performed five sequential act-outs, followed by a simultaneous act-out.

One of the pretraining sentences included a juxtaposed structure that permitted the same kind of eventive reading shown above: "Cheezer shoves the boat; Eeyore runs behind the boat." Three of the four children showing eventive readings in the test batteries showed similar interpretations for this pretraining sentence.

8. Discussion

8.1. Implications for the acquisition of syntax

The results reported here suggest that although children may produce preposition-stranding structures more readily than pied-piped structures (as shown, for example, by French 1984, McDaniel, McKee and Bernstein 1998, Foley 1998, and Foley and Fugett-Fuller 2002), they comprehend both. The data reported here are from a small set of children, and the lower boundary of the age range (5;6) is old relative to the youngest ages that have been successfully tested in other comprehension studies of relative clauses in English (e.g., three-year-olds in Flynn and Lust 1981, Tavakolian 1981, Hamburger and Crain 1982, and Kidd and Bavin 2002, among others). Nevertheless, the results here are suggestive: more errors appear in the pied-piping examples, despite the overall high percentages of successful act-outs, and yet these errors do not appear to be due only to the syntax of pied-piping, because more lexical preposition errors appear for pied-piping in one relative clause type (infinitival) than in another (tensed). If this result is corroborated in a larger, controlled study, it would support the hypothesis guiding the larger project: that pied-piping is grammatical, and interacts with the syntax of phrase structure, clause structure, movement, and verbal inflection.

The findings suggest a possible new window into children's (and adults') knowledge of lexical aspect. As shown above, for tensed relative clauses, when the relative clause predicate denoted an event with an inherently specified endpoint in time (telic: crawling over a boat), the main clause tended to be acted out first—a pattern that was reversed when the relative clause predicate denoted an event with no

inherently specified temporal endpoint (atelic: standing behind a shell). The difference suggests that an atelic predicate in a relative clause influences children's interpretation of the clause, perhaps leading them to view the event denoted by the relative clause as background. Because it derives from a small number of subjects, the observation calls for systematic investigation of whether lexical aspect influences the way children interpret relative clauses (building on earlier work on the interaction between tense and aspect in two- to three-year-olds' comprehension (e.g., Wagner 2001) and production (e.g., Johnson and Fey 2006)). If studied across a wider span of ages, the difference could be a way to pinpoint a possible shift (if one truly exists) from a juxtaposed-type interpretation of the two clauses to interpretation of embedding. In this sense, the findings here are relevant to the long-standing debate over children's interpretation of relative clauses (e.g., Sheldon 1974, Goodluck and Tavakolian 1982, Hamburger and Crain 1982, and more recently, Correa 1995).

The qualitative finding that some children choose an eventive-type interpretation when the predicate semantics permit it suggests that children are able to attach relative clauses with pied-piping not only at the level of the head noun, as in Figure 1, but also at the level of the clause, as in Figure 2, and to modulate their choice of attachment point based on the semantics of the embedded predicate.

Figure 1. Tensed relative clause, with pied-piping.

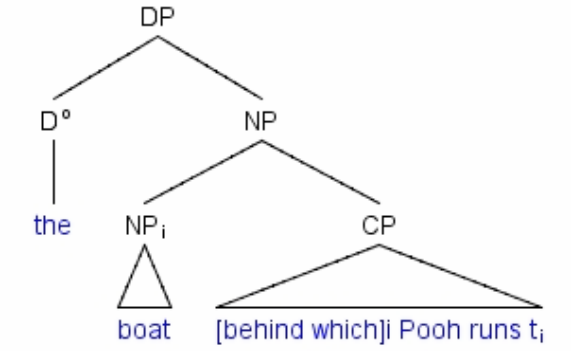
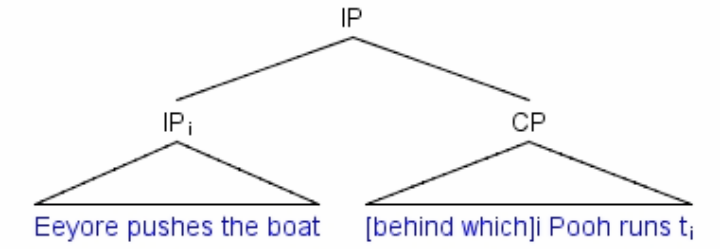


Figure 2. Unanticipated structure projected by children and adults for sentences with tensed relative clauses, with pied-piping.



The finding that sometimes children chose actions depicting the attachment in Figure 2 suggests that they are not only able to comprehend the embedded predicate with the preposition pied-piped into clause-initial position, but that they are sensitive to the different indexical features possible for the wh-form within the pied-piped phrase.

Still awaiting systematic test is whether the attachment in Figure 2 (reflecting a non-restrictive interpretation) would be chosen more often for pied-piping structures than for preposition-stranding structures (e.g., "Eeyore pushes the boat which Pooh runs behind"). This possibility, only hinted at in the data here, is important, because if this interpretation were chosen more often for pied-piping, that would imply that feature composition may be different in the two cases, and that the alternatives are not always merely "options," as assumed by Chomsky (1995) and others.

8.2. Implications for methodology

These findings shed light on some practical considerations surrounding the act-out task. The first concerns transcription. A transcription form (as in Appendix B) lends itself to reliability comparisons more easily, and ultimately provides a more efficient basis for coding act-outs according to the criteria outlined above. A narrative transcription (as in Appendix C), while more difficult to subject to reliability comparisons, provides richer information for qualitative explorations.

The analysis of pretraining findings suggests that most children need coaching on basic procedures of the act-out task, such as returning toys and dolls to their original places, and that time should be allotted for this coaching. The pretraining results and the experimental results together point out a possible pitfall in coaching: although our results showed that a demonstration with sequential actions did not prohibit children from later showing simultaneous act-outs, experimenters should seek ways to demonstrate actions that do not risk biasing a child toward a particular (or any) ordering of actions.

As Eisenberg (2002) also found, in this experiment, subjects sometimes demonstrated actions with juxtaposed structures in pretraining that were similar to their actions with test sentences. This finding suggests that although not a part of experimental designs, pretraining act-outs may be a valuable source of qualitative data.

These findings also provide insights into the way the act-out task can reveal grammatical knowledge. First, they show that the freedom the act-out task offers can yield unanticipated evidence of participants' knowledge (Goodluck 1996). The unexpected demonstration of the eventive reading is a new example of this strength of the act-out task. It is worth noting that the set of actions required to depict the eventive interpretation schematized in Figure 2 is arguably more complicated to execute, requiring more coordination in time and space, which suggests that the choice overrides any purely pragmatic act-out preference for simpler actions.

Second, the fact that children's errors patterned differently across structural types (pied-piping vs. preposition-stranding, and tensed vs. infinitival relative clauses) further confirms that children's performance in the act-out task is sensitive to grammatical constraints, as has been shown in act-out studies in other grammatical domains (e.g., Cohen Sherman and Lust 1993).

Third, the results relating action order to telicity of the embedded predicate suggest that action order in act-out studies is a window into grammatical knowledge that has not yet been fully tapped. While investigators of temporal adjuncts have studied action order (e.g., Clark 1971, Winskel 2004), this study suggests it can reveal knowledge related to other subordinate types where less attention has been paid to ordering.

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Appendix A Pretraining battery

1. Pooh jumps.
   Alternative: Cheezer runs.

2. Eeyore runs; Cheezer runs.
    Alternative: Pooh jumps; Cheezer jumps.
    Alternative: Dumbo falls down; Cheezer falls down.
3. Cheezer touches the box; Pooh touches the box.
    Alternative: Eeyore pushes the spoon; Cheezer pushes the spoon.
4. Pooh shoves the boat; Eeyore shoves the same boat.
    Alternative: Cheezer touches the box; Eeyore touches the same box.
5. Dumbo kicks the spoon; Cheezer kicks the other spoon.
    Alternative: Pooh touches the box; Eeyore touches the other box.
6. Pooh touches the box; Eeyore jumps into the box.
    Alternative: Eeyore hits the spoon; Cheezer hops over the spoon.
7. Cheezer shoves the boat; Eeyore runs behind the boat.
    Alternative: Pooh moves the box; Eeyore rolls under the box.

Appendix B Excerpt from blank transcription sheet

1. Tigger feels the blanket and Pooh feels the blanket.

First action		*object*
___ Tigger	___ feels	___ blanket
___ Pooh	___ other action _____	
___ Eeyore	___ _____	

Second action		
___ Tigger	___ feels	___ same blanket
___ Pooh	___ other action _____	___ different blanket
___ Eeyore	___ _____	

Repetitions after first reading: ___0 ___ 1 ___ more than one
First and second action begin and end together____
First action begins and continues while second action takes place ___
Actions performed on objects in their original position ___
Other notes:

Appendix C Sample narrative transcription

A1 Tigger feels the blanket and Pooh feels the blanket

Child picks up blanket with right hand, then says "which one again?" REPETITION
Child picks up blanket with right hand and puts in middle. Child picks up T with right hand and makes T feel blanket, then puts T back. Then child says "Eeyore?" and then picks up E with right hand and makes E touch blanket, then puts E back.

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