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ORIGINAL PAPER

Reading Comprehension Instruction for Young Students with Autism: Forming Contextual Connections

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Abstract

Central coherence is the ability to perceive and connect salient information in a context such as a narrative text. Individuals with autism exhibit a detail-focused cognitive style of processing information that overlooks connections and shows weak central coherence. A six-session instructional intervention to foster coherence processing was administered to first and second graders (N = 10) while a control group (N = 10) received an irrelevant treatment, mean age 7.06 years, 18 males and 2 females. Results showed that the instruction benefited children's comprehension of narrative text. The intervention improved children's ability to retell a narrative text and improved first graders' use of sequence words to retell a story compared to control students. Findings carry implications for designing reading instruction for this special population.

Keywords Autism · Reading comprehension · Central coherence · Story retell · Reading instruction

Introduction

In early elementary school children begin their journey in acquiring literacy. Reading instruction for beginners has a strong focus on developing foundational skills that provide them with access to reading and comprehending text. Comprehension of text remains a vital goal of literacy instruction throughout schooling. Balanced literacy programs provide instruction in both foundational skills and comprehension through a variety of teacher-supported reading experiences. Some children with autism enter school having already achieved foundational skills in reading. Others may acquire those skills easily in school. However, most tend to struggle in understanding what they read (Nation et al. 2006). Differentiated reading instruction is needed to address this atypical skill development in young students with autism.

Reading comprehension is a complex construct that describes how readers derive meaning from texts. It is a multilayered process that involves skills the reader brings to the text through background knowledge combined with decoding ability, and how the reader interacts with the text to build meaning. Kintsch's model of reading comprehension describes relationships between idea units that are formed through coherence processing of interconnected concepts contained within the text (Kintsch and van Dijk 1978). Anaphor resolution is the process by which a reader understands a reference to a previously stated concept. Readers make inferences through analysis and understanding of causal connections between propositions. Related propositions of the text form microstructures, which when combined together, either explicitly or implicitly, form the overall concept of a text. The readers' connections of local and global concepts form the textbase and are derived directly from evidence from the text. Kintsch and van Dijk note that the readers' ability to store and recall information has notable impact on comprehension processes. In order to make an inference, resolve an anaphor, or derive word meaning from context one must monitor comprehension while reading and stop when text is unclear or ambiguous.

Atypical cognitive processes observed in children with autism may interfere with their ability to comprehend text (Nation et al. 2006). Central coherence, the ability to process global concepts, is an aspect of cognitive processing found to be impaired in people with autism (Frith 2003). In a study that compared students with and without autism, Hala et al. (2007) investigated how executive dysfunction and weak central coherence impacted readers' use of context to pronounce homographs. This study found that executive

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functioning had a greater impact than central coherence on the ability of students with autism to pronounce homographs correctly after priming, compared with typically developing peers. Students with autism with average to above average cognitive ability exhibit deficits in executive functioning, such as inhibitory control, the ability to regulate and organize thoughts, plan, and employ metacognition (Pellicano 2010; Ozonoff et al. 1991). This weakness may contribute to the tendency of students with autism to fail to monitor their comprehension while reading, a factor that may contribute to poor reading comprehension. The concept of context blindness, which refers to misperceptions caused by difficulties in adjusting thought processes based on situational information, further explains why students with autism may misunderstand meaning (Vermeulen 2012).

The purpose of the current study was to investigate an instructional intervention designed to foster students' use of comprehension strategies. The strategies involved teaching students to intentionally monitor context cues in order to derive meaning from narrative text. This instruction was expected to hold potential for mitigating some of the challenges children with autism demonstrate in language and reading comprehension. The content of this instruction involved fostering coherence processing. In addition, executive functioning was addressed by teaching students to organize thoughts and monitor their understanding.

Executive Functioning and Reading Comprehension

Students who exhibit strong executive functioning are observed to monitor their comprehension and stop for clarification during reading as needed. Elosúa et al. (2013) investigated improving reading comprehension in primary grade students using an intervention designed to impact working memory executive processes. This intervention was provided over ten sessions. Participants were trained to invoke executive function routines and procedures while reading using visual icons as cues to support learning. Elosúa et al. created a series of eight tasks that tapped the following executive functions: focusing, switching, connecting and updating mental representations, and inhibiting irrelevant information. These tasks included sequencing vignettes or sentences in logical order, resolving anaphors, detecting inconsistencies and making inferences. It was reported that students performed significantly better on reading comprehension measures after training. The Elosúa et al. study may offer some understanding about the sources of difficulty facing students with autism as they read and comprehend text.

Kintsch's model of reading comprehension describes the reading process as a complex series of open-ended tasks that require the readers' active engagement before, during, and after reading. A study by White et al. (2009) examined executive functioning in children with autism and IQ matched controls using a variety of executive function tests. Though participants with autism were found to perform more poorly on all EF measures, significant differences in performance were observed only for open-ended tasks, such as planning an efficient solution to a problem. Studies have shown that many students with autism possess strong decoding skills and learn to read with facility at an early age (Nation et al. 2006; O'Connor and Klein 2004). In their study, Nation et al. (2006) found that children with autism possessed adequate word reading skills but poor comprehension. One explanation is that the atypical cognitive processes observed in autism, specifically weak central coherence, executive dysfunction especially for open-ended tasks, and context blindness, limit students' ability to form semantic connections during text reading. Kintsch's model provides guidance in designing instruction to address these difficulties.

Weak Central Coherence and Context Blindness

The weak central coherence theory of autism, first described by Frith (1989), is defined as the tendency of individuals with autism to process information by focusing on detail rather than global meaning (Happé and Frith 2006; Jolliffe and Baron-Cohen 1999). Frith describes a processing style in which individuals with autism do not strive to establish coherence in contrast to typically developing individuals. Two studies by Jolliffe and Baron-Cohen (1999,2000) used homographs in sentences where the meaning of the word could be inferred from context. Participants with autism in these studies were able to provide more than one meaning for the homographs in isolation, but had difficulty inferring non-familiar meanings of the words in context as determined by their pronunciation of the word (Jolliffe and Baron-Cohen 1999). Even when the students with autism knew multiple meanings for the homographs out of context, they tended to choose the more common meaning and its pronunciation in context, even in sentences where it did not make sense. A detail-focused style of information processing was shown to be a disadvantage to successful performance.

Vermeulen (2012) wrote, "Context prepares us for which words to expect so that we can process language quickly and efficiently," (p. 186). For typically developing individuals, this processing happens automatically and spontaneously, often without conscious effort. But what happens if an individual's cognitive style does not automatically adjust to involve consideration of a current situation? Interpretation of a word, sentence, or idea that does not take the context into account may be compromised and is defined by Vermeulen as "context blindness." Vermeulen proposed the concept that all words may have multiple meanings; context specifies which meaning is activated in each situation. Pronoun reversals that are common in young children with autism can be understood as a difficulty in using context to comprehend.

Pronouns change according to their use in situations and their referents may sometimes be vague as in the sentence, "John did not give Pete a present because he was angry," (Noens and van Berckelaer-Omnes 2005; Vermeulen 2012).

Individuals with autism may possess adequate word knowledge and may be able to make inferences but fail to comprehend information through the construction of meaning in context (Jolliffe and Baron-Cohen 1999; Happé and Frith 2006; Norbury and Bishop 2002). If, as Frith (2003) suggested, individuals with autism do not strive for global meaning spontaneously, then meaning may be misconstrued, especially when an unexpected meaning is suggested by the context. Evidence for differences in how children with autism and typically developing children process pragmatic information was shown in a study by Loukusa et al. (2007). The children with autism in this study had more difficulties than the control group in answering contextually demanding questions and providing explanations for their correct answers. It remains to be seen whether children with autism can be taught to search for global meaning and how to make use of context to understand text.

Instructional Interventions

Studies that have investigated the effectiveness of instructional practices for children with autism provide clues that point to where comprehension breakdowns might occur. Roux et al. (2014) conducted a study where students with autism were randomly assigned either to a control condition receiving standard reading instruction, or a four month intervention instruction in reading comprehension. The intervention involved targeted instruction in vocabulary, main idea, text structure and anaphoric relations over a total of 48 sessions. Results showed significant differences at posttest. Students in the intervention group scored higher than the control group in knowledge of definitions, identification of main idea, and retelling of text. At follow-up, the students in the intervention condition continued to score higher on knowledge of definitions and identification of main ideas but not on the other tasks.

O'Connor and Klein (2004) compared the effects of three kinds of strategy facilitation for students with autism; each was designed to support the child's ability to make coherence connections to support comprehension. One technique investigated anaphoric cuing. Pronouns were underscored in a passage and students were given a choice of three referent words, one inappropriate, one syntactically correct but did not make sense in context, and one appropriate in context of the story. This approach had the greatest impact on reading comprehension, which yielded medium effect sizes. The success of this strategy suggests that referential cuing may be directly targeting a central coherence weakness of individuals with autism. The forced choice imposed coherence processing on the reader, thereby supporting the use of cohesive devices to understand the text. In addition, the cuing process encouraged comprehension monitoring, an executive function, in that students were not allowed to continue reading before attempting to resolve the anaphor. Instruction that includes strategies to apply stop-and-monitor skills could possibly provide the executive function support needed by students with autism.

Though their study did not involve students with autism, Zipke et al. (2009) employed a series of instructional sessions that targeted understanding of semantic ambiguity in text in order to support third graders' reading comprehension and metalinguistic awareness. For their study, Zipke et al. taught subjects to identify semantic ambiguities over four contexts in four separate sessions. Participants were taught directly to understand multiple meanings of words (homonyms), understanding the nature of riddles and how manipulation of words with lexical ambiguity allowed for the humor in riddles. The *Amelia Bedelia* series by Peggy Parish was used to further instruction regarding semantic ambiguity. One of the two posttests used to assess reading comprehension yielded significant results of the intervention.

Previous studies have demonstrated that people with autism can make coherence connections when primed to attend to the context (O'Connor and Klein 2004; Roux et al. 2014). In the current study, it was expected that young children with autism could be taught to take context into account when listening to or reading a story. A question of interest was whether instruction that directed children to strategize by considering the context would improve comprehension. Also, would this instruction transfer and facilitate students' learning and use of the strategies when encountering novel texts? Past studies have shown differences in cognitive processing and development observed in people with autism, but there are few studies investigating strength-based instruction that targets these learning differences. The goal of the current study was to determine the effectiveness of instruction in the use of strategies to foster coherence processing and understanding of narrative text. Instruction involved a series of lessons designed to teach students to employ metacognitive skills to look for context cues in order to understand narratives. Based on the Kintsch and Dijk (1978) model, poor reading comprehension in students with autism may result from weak central coherence that limits their ability to form semantic connections. Furthermore, executive disfunction, observed in students with autism, may further interfere with students ability to activate and apply knowledge while reading. The following research question was addressed in this study: Will instruction in thinking strategies to foster coherence processing improve reading comprehension ability including students' ability to disambiguate multiple meaning words, to resolve anaphors,

to retell stories in sequence, to detect semantic mismatches, and to make causal inferences?

Method

Participants

First and second grade students with autism ($N=25$) were recruited from two New York City public schools. The diagnosis of autism was confirmed by parent report. Teachers identified those whose retelling and/or comprehension skills were limited but who possessed grade level word identification skill. All participants were fluent in English and had vocabulary knowledge within the average range. Though some students were bilingual, all were English dominant, and none received ESL services. Demographic information is presented in Table 1.

Materials and Procedures

Participants were pretested for word reading ability, receptive vocabulary knowledge, linguistic coherence processing ability, and reading comprehension ability. Eight tasks were administered as pretests and five re-administered as posttests to individual students. Performance on one reading comprehension assessment (Fountas and Pinnell Benchmark Reading Assessment) and four coherence processing measures provided information about students' strategy use. The materials and tasks for the four coherence processing measures and instructional sessions were designed and pilot tested specifically for this study based on previous studies with older participants (Zipke et al. 2009; Jolliffe and Baron-Cohen 1999, 2000; Norbury 2005; O'Connor and Klein 2004). Performance was audiotaped and reviewed for scoring and reliability purposes. Participants' retell narratives were transcribed and use of sequence words was recorded and counted. Two research assistants, blind to the condition of the participants, administered most of the pretests and all posttests. Testing periods were conducted in short sessions of approximately 20–35 min over 3–4 sessions. Two researchers scored non-standardized pretests and posttests to establish inter-rater reliability for these measures. Assessments were administered in the following order.

1. Word Reading

The WRMT-R Word Identification subtest (Woodcock 1987) measures the ability to read a list of words graded in difficulty. Scores were used to match students within each grade level, and members of matched pairs were assigned randomly to the intervention or control group. The test manual reports a split half reliability of .97.

2. Receptive Vocabulary

The Peabody Picture Vocabulary Test, Fourth Edition, Form B (PPVT-4) (Dunn and Dunn 2007) was administered to screen students for receptive vocabulary in English. Participants chose from four illustrations the one that best depicted a vocabulary word presented orally. Alpha reliability is reported to be .94–.96 for the age range of participants in this study. Students had to score at least at the 25th percentile to be included in the study. All students qualified.

3. Nonword Reading

The Word Attack subtest of the WRMT-R (Woodcock 1987) assessed participants' ability to decode a list of nonwords of increasing difficulty. Internal consistency is reported as .98.

4. WRMT-R Reading Comprehension

The Passage Comprehension subtest of the WRMT-R (Woodcock 1987) assessed students' ability to understand short passages read independently. This test uses a one-word cloze format, with some picture support for younger readers. Form A was administered as the pretest and Form B as the posttest. The manual reports split-half reliability as .94.

5. Fountas and Pinnell Reading Comprehension

The Fountas and Pinnell Benchmark Reading Assessments also measured reading comprehension (Fountas and Pinnell 2010). This is a formative assessment for which students were tested individually using running records chronicled as students read aloud the leveled book, A (easy) to Z (hard), chosen according to participants' word reading ability. For the present study, students were assessed using the fictional texts. After the texts were read aloud, students were asked to retell the story and answer literal and inferential questions based on the story. Comprehension scores range from 0 (unsatisfactory understanding) to 3 (excellent understanding). Participants' independent reading levels were determined by text read with 96% accuracy and with comprehension scored as 2 (satisfactory) or above. Self-corrections were not considered miscues. The manual reports test–retest reliability as .93 for levels A–N. All students for the current study read between levels G–N. Pretest and posttest grade reading levels and numeric scores were determined by using school benchmarks provided every two months for meeting standards (Level 3) according to the Common Core Learning Standards.

Retelling Rubric A retelling rubric was created to assess the quality of students' spontaneous and independent responses to the leveled texts A–N, without any prompts provided.

Table 1 Characteristics and mean performance of instructional intervention and control groups on pretests

	Intervention ($n=10$)	Control ($n=10$)		F	p
Age (in years)	7.06 (.92)	7.07 (.69)	I	.009	.927
Grade	6 first, 4 second	6 first, 4 second			
Gender	10 male, 0 female	8 male, 2 female			
Ethnicity					
Caucasian	4	3			
African-American	2	2			
Hispanic-American	3	3			
Asian-American	1	2			
WRMT-R word ID raw Sc	56.70 (14.77)	55.60 (14.19)			
Age equivalent	8.91 (1.82)	8.65 (1.16)	I	.278	.605
Grade 1 ($n=12$)	8.37 (1.28)	8.53 (1.37)	G	1.460	.253
Grade 2 ($n=8$)	9.73 (2.39)	8.83 (0.90)	IxG	.588	.455
WRMT-R word attack raw Sc	22.20 (11.98)	27.20 (6.30)	I	1.056	.319
Age equivalent	9.79 (4.67)	9.70 (1.99)	I	.002	.965
Grade 1 ($n=12$)	9.30 (4.56)	9.15 (1.25)	G	.580	.457
Grade 2 ($n=8$)	10.53 (5.43)	10.53 (2.79)	IxG	.002	.965
PPVT-4 standard score	100.60 (5.74)	99.10 (8.05)	I	.171	.685
WRMT-R compreh. raw Sc	24.80 (6.63)	25.30 (5.95)	I	.025	.877
Age equivalent	7.75 (0.56)	7.74 (0.51)	I	.002	.961
Grade 1 ($n=12$)	7.65 (0.69)	7.65 (0.64)	G	.892	.359
Grade 2 ($n=8$)	7.90 (0.32)	7.88 (0.21)	IxG	.002	.961
F&P reading assessment GL	1.66 (0.50)	1.82 (0.58)	I	.375	.549
Grade 1 ($n=12$)	1.33 (0.33)	1.63 (0.71)	G	9.892	.006**
Grade 2 ($n=8$)	2.15 (0.19)	2.10 (0.12)	IxG	.376	.404
Retell scores (max = 6)	2.90 (1.20)	2.80 (1.55)	I	.083	.777
Grade 1 ($n=12$)	3.33 (1.03)	2.17 (1.33)	G	.187	.671
Grade 2 ($n=8$)	2.25 (1.26)	3.75 (1.50)	IxG	5.319	.035*
Coherence processing					
Homographs part 1 (max = 8)	2.50 (1.35)	1.90 (1.66)	I	.771	.393
Homographs part 2 (max = 8)	4.80 (1.03)	4.60 (1.07)	I	.108	.747
Anaphor resolution (max = 16)	9.50 (4.01)	5.90 (4.58)	I	3.842	.068
Grade 1 ($n=12$)	8.33 (4.45)	3.50 (4.09)	G	7.048	.017*
Grade 2 ($n=8$)	11.25 (2.87)	9.50 (1.73)	IxG	.843	.372
Story sequencing (SS) (max = 14)	12.40 (1.90)	11.60 (1.96)	I	1.559	.230
Use of sequence words (SS task)[a]	2.59 (1.42)	2.87 (.88)	I	.515	.484
Grade 1 ($n=12$)	2.88 (1.28)	2.70 (1.10)	G	.078	.784
Grade 2 ($n=8$)	2.15 (1.69)	3.13 (.43)	IxG	1.102	.310
Use of sequence words (F&P)	1.80 (2.70)	1.60 (2.46)	I	.050	.826
Grade 1 ($n=12$)	2.67 (3.20)	.67 (.82)	G	.006	.941
Grade 2 ($n=8$)	.50 (1.00)	3.00 (3.56)	IxG	4.060	.061

WRMT-R is the Woodcock Reading Mastery Test-Revised. Raw Sc. is Raw Scores. PPVT-4 is the Peabody Picture Vocabulary Test-4th Edition. F&P Reading Assessment GL is the Fountas and Pinnell Benchmark Reading Assessment Grade Level, Homographs is the Homographs embedded in ambiguous measures (Part 1 is Multiple meanings, Part 2 is Detecting mismatches)

I intervention, *G* grade

*$p<.05$, **$p<.01$

[a]Sequence word score is the mean number per picture set over seven sets

Texts on these levels have an explicit text structure with few characters (1–2 main characters) based on a story narrative, a sequence of events including a problem/solution framework. A maximum of 6 points was given for the following information contained in the unprompted retell: one point each for a story-driven event from the beginning, middle,

and end, identification of at least one main character (e.g. using name), and story setting. The student received a 6th point if all of this information was included in the spontaneous retell without additional probing from the examiner. If students' narrative contained incorrect information, one point was subtracted from the score.

6–8. Coherence Processing Tasks

A series of coherence processing tasks were designed for the current study to investigate whether direct instruction in coherence-based reading strategies would impact student's performance. These tasks were based on past studies that investigated reading strategy training or facilitation (Zipke et al. 2009; O'Connor and Klein 2004), weak central coherence theory (Jolliffe and Baron-Cohen 1999, 2000), and comprehension monitoring (Norbury 2005). Participants for these past studies were older than the students of the current study, so coherence processing task items were rewritten for younger students. Each task is described in detail as follows.

6. Coherence Processing: Homographs in Ambiguous Sentences

Ambiguous sentences are those having two alternative meanings. For example, *The boy had caught a nasty little bug, bug* can mean either an insect or a sickness. The homograph task assessed students' knowledge of multiple meanings of eight homographs embedded in ambiguous sentences and their ability to detect whether disambiguated sentences matched pictures of the eight homographs.

To assess knowledge of multiple meanings, the examiner showed and read an ambiguous sentence containing an underlined homograph and told students to say as many meanings as they knew for the homograph. Then to assess sentence-picture matching, the examiner read another sentence that disambiguated the previous homograph, showed a picture of one of the meanings, and asked students whether the sentence matched the picture. (See Appendix A for examples) Half of the eight pictures matched the sentence meaning and half did not. Students received one point for each homograph given more than one acceptable meaning (8 maximum, Homograph, Part 1 score) and one point for each correct response to the matching question (8 maximum, Homograph, Part 2 score). Different versions of this test were given as a pretest and posttest.

7. Coherence Processing: Anaphor Resolution

The Anaphor Resolution task assessed whether students could identify the noun referents of pronouns embedded in sentences contained in short passages. Students were shown text and listened twice to two short passages that included underlined pronouns, *he, she, we, they, them, it, his,* and *her*. A variety of referents, totaling 16, was tested. (See Appendix A for examples) During the second reading, the examiner stopped after each sentence containing a pronoun and students identified the referent. The number of correct referents was scored. Different passages were given as pretest and posttest.

8. Coherence Processing: Story Sequencing

Since students were beginning readers, illustrations rather than written text were used to assess their ability to sequence a story. Two Carlson et al. (2004) games provided the sets of pictures depicting three- and four-scene sequences. Students were shown each of seven sets of pictures out of order. They were told to place them in an order that told a story, to tell their story, and to give it a title. (See example in Appendix A) Students received one point for pictures placed in the correct sequence and one point for a title that fit the sequence (14 points maximum). In addition, students' use of sequence words was recorded and counted. Their score was divided by seven to reflect the number of sequence words per picture set. Items for the pretest and posttest were matched for complexity.

Intervention and Control Group Procedures

After the pretests, participants were ranked according to their scores on the WRMT-R Word Identification subtest (Woodcock 1987) within each school. Then, members of adjacent pairs were randomly assigned to the intervention or control group by grade and within school. The intervention was taught to groups of two students in the same grade with similar word reading levels over six sessions, 20–30 min each. In the control condition, small groups of 2–4 students in the same grade received three 20–30-min sessions of play-based activities over the same period. The first author administered all intervention and control group activities. The full set of instructional materials and procedures can be obtained from the first author.

Instruction in Coherence Processing to Form Contextual Connections

Each of the intervention sessions was designed to provide students with a model how to construct meaning when reading short narrative texts. Students were taught in dyads to allow them to interact so that they supported each other's metalinguistic thinking and use of strategies. Each session was introduced by connecting it to the previous lesson teaching the use of coherence processing strategies. See Appendix B for examples of materials for Sessions 1–6.

Throughout all six session, students were presented with *thinking questions* that included the following: "Where is this [story] happening? What is the character doing? Decide. What [meaning] makes sense?" These questions were introduced to emphasize the importance of making sense of stories while reading. Visuals for the *thinking questions* were used as tools to guide students' use of the strategies taught and to provide explicit direction for where to find meaning clues in text. (See Fig. 1 for visuals that depicted the *thinking questions*.) Students were encouraged to stop-and-think and to look back in the text to ascertain the meaning of a story. The visuals and strategies embedded into each instructional session were designed to help students to organize and focus their thinking on the processing of context so that they could make sense of the texts they read. Sessions 4 and 5 in particular involved instruction in sequencing and organizing students' retelling of narratives.

Session 1: Ambiguous Words and Sentences

Twelve homographs, *cold*, *bat*, *star*, *straw*, *deck*, *wave*, *speaker*, *bank*, *glasses*, *school*, *bow*, and *trunk* were presented, and multiple meanings for each word was discussed. Two illustrations that depicted the different meanings of each word were presented to aid understanding. For the practice example, the instructor showed the students the word, *cold,* and asked students to discuss its different meanings. Then the instructor read the ambiguous sentence, "The cold made Barry feel terrible," with two illustrations depicting the two possible meanings. The students discussed how the sentence could represent either of the two pictures. Then the instructor read a disambiguating sentence, "He just couldn't stop sneezing," and modeled self-questioning using the *thinking questions* to decide which picture was relevant. The alternate disambiguating sentence, "He just couldn't stop shivering," was also presented to show how the meaning changed with context. For each of six ambiguous sentences and 12 context-providing sentences, students were encouraged to decide together which of the two meanings was correct and to point out the clues in the context-providing sentence that affirmed their choice.

Session 2: Detecting Matches and Mismatches Using Homographs

The instructor explained that sometimes while reading, something does not make sense and that it is important to stop and think when that happens in order to make sense of the story.

The first sentence, "Peter swung the bat," was presented along with an illustration of an animal bat. The instructor modeled by thinking aloud to scaffold use of the *thinking questions* to demonstrate the use of the look-back strategy. The instructor pointed to the verb as the clue to understanding. This was further clarified when the instructor read the next sentence suggesting the alternate meaning of *bat,* and modeled thinking to describe how for the second sentence, "Peter ran away from the bat," the animal bat matched the meaning of the sentence. Half of the eight sentences were presented with pictures that matched the context and half did not match. The second sentence suggesting the alternate meaning of the word was presented to provide explicit instruction in how the meaning of the word changed in different situations/contexts. Scaffolding was provided as needed.

Session 3: Anaphor Resolution: People and Objects

In this lesson students were taught that sometimes people use different names for the same person and that readers need to figure out all the possible names of a character. A graphic organizer was created using a visual for *mom*, and students were asked to generate different names they might use for *mom*. Pronouns for *mom* (e.g. *she*, *her*) were introduced after several names were added to the web.

Students received explicit instruction about pronouns with some additional practice with other noun anaphors to support flexibility of thinking and generalization. *He* or *she*, *we* or *they, his* or *her* were defined as pronouns that are used to refer to people. Visuals were shown to the students to represent the different pronouns. Then participants were taught to look for clues to figure out which character the pronoun referred by asking themselves the question, "Who is [pronoun]?" The short passages that included underlined pronouns were read aloud. The instructor modeled how to

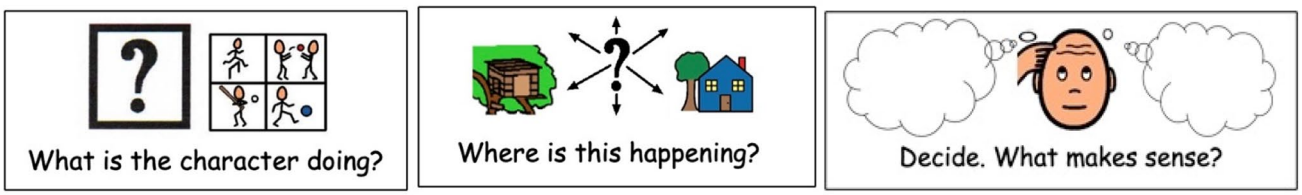

Fig. 1 Visuals of thinking questions used for sessions 1–6

look back in the text, using the *thinking questions* to ascertain to whom the anaphors referred. If students were unsure or if they disagreed with each other, they were instructed to substitute the noun they chose into the sentence to see if it made sense.

Session 4: Story Sequencing With and Without Illustrations

For this session the instructor explained to students they could use the *thinking questions* to help them establish the order of events that occur in a story. Stories were comprised of four sentences that described an event with a clear logical order but did not contain temporal (e.g. *morning*) or sequence words (e.g. *first*, *then*) to cue ordering of the sentences. The first two story sequences were presented as four sentences with accompanying pictures out of order. Two additional stories were presented without accompanying illustrations. The instructor modeled by thinking aloud and using the *thinking questions* to order the story's events. The instructor placed the sentences/pictures in order, pointing to each in turn, and used a visual (see Fig. 2) to cue use of the sequence words, *first, then* or *next, finally* or *last,* to describe the decisions made to order the four sentences. After sequencing the story, the instructor modeled composing a title for the story that included the name of the character and the important event of the story. This instruction was used to support students' use of situational information to consolidate important ideas contained in the story.

Session 5: Retelling Stories Using Sequence Words

The instructor explained to the students that when they retell a story they have read, they can use the sequence words, *first, then, next, finally, last* to recall the events of a story. The instructor reread Passage 3 from the previous session and modeled by thinking aloud and using the *thinking questions* to recall the story and then used the sequence words to retell the story (see Fig. 2). Passage 4 from the previous session

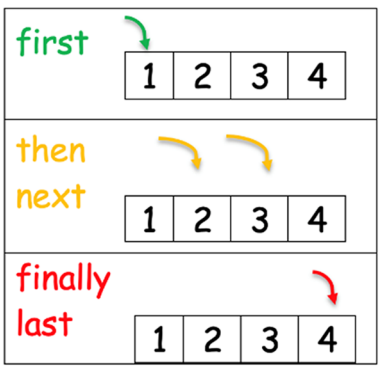

Fig. 2 Sequence words visuals used for sessions 4 and 5

was read aloud next. Without looking at the text, students practiced retelling this story with a reminder to review the story using the *thinking questions*. Two more passages not previously read provided additional practice.

Session 6: Making Causal Inferences in Stories

In this last instructional session, the instructor explained to students that sometimes readers need to make an *inference,* defined as a smart guess, based on the events that happen in a story because authors do not always write everything that occurs in a story. This session was designed to develop students' ability to think beyond the text. The question following each passage was formulated to probe whether the student understood the implicit information contained in the text with a follow-up question to have students discuss their thinking about how they decided on the answer they gave.

Passages for this session were adapted from a study that investigated use of context in pragmatic language comprehension by children with autism (Loukusa et al. 2007). The instructor showed students the first passage and read it aloud. Participants were directed to think about where the story was happening (outside the school on a rainy day) and what the character was doing (running to school and holding a book over his head) in order to decide how to answer the question, "Why is the boy holding a book over his head?" For subsequent passages the instructor prompted students to look in the text for clues and explain their thinking before responding.

Control Group Treatment

The control group received a non-literacy-based treatment. Playing games in small groups was chosen as a beneficial activity for students with high functioning autism who exhibit challenges in social behaviors. Groups of two to four students met with the principal investigator for three sessions during the same period as their matched pairs. For each session, participants were given a choice of playing a game, Trouble®, Uno®, or Simon®, or to learn how to make and play with simple origami figures, such as the *fortune teller* or *airplane*. After posttests were administered, control group participants received the intervention if parents requested it.

Reliability of Retell Scores and Coherence Processing Measures

For the retell scores, the coherence processing measures, and the frequency counts of sequence words on all pretest and posttests were scored independently by the principal investigator and a research assistant trained on scoring procedures for each measure. Inter-rater reliability was calculated. Participants' retell narratives following their reading

of the leveled texts of the Fountas and Pinnell Benchmark Reading Assessment were transcribed, and a retell rubric was used to score the narratives. Inter-rater reliability for the retell rubric was calculated as 90% for an exact match on pretest and 95% on posttest scores.

For the four coherence processing measures, Homographs Embedded in Ambiguous Sentences (Parts 1 and 2), Anaphor Resolution, and Story Sequencing, notes and responses were taken during administration, and in addition, recordings were reviewed later for scoring. Agreement ranged from 85 to 95% on the pretests and 95–100% on the posttests.

Results

Pretests

Table 1 shows the demographic characteristics and pretest performance of the participants. The ethnicity of the sample was diverse. Receptive vocabulary knowledge was within the average range for all participants, indicating average verbal cognitive ability. As evident in Table 1, word identification and word attack mean scores revealed above average word reading ability. Reading comprehension and vocabulary knowledge were at expected levels.

Two way ANOVAs were conducted with Intervention and Grade as the independent variables and performance on each pretest as the dependent variable. Table 1 reports F values in full (I, G, I × G) when at least one was statistically significant. As evident in Table 1, few differences were detected. A significant main effect of grade was evident on the Fountas and Pinnell (F&P) Benchmark Reading Assessment, but no significant difference between intervention and control groups was shown on this pretest. A significant interaction was found for F&P retell scores as follows. At the first grade level, mean retell scores were higher in the intervention than in the control group, whereas at the second grade level, the control group mean exceeded the intervention group mean. On the anaphor resolution task, a significant effect of grade was detected, with 2nd graders outperforming first graders. Except for performance on the retell task, we conclude that the intervention and control groups did not differ upon entry into the experiment.

Effectiveness of Instruction

The instructional intervention was designed to improve students' ability to make coherence connections, thus supporting their comprehension of narrative texts. In order to determine the effectiveness of the six-session instruction, the groups' posttest scores were compared using 2 × 2 ANOVAs. The independent variables were treatment (intervention vs. control) and grade (first grade vs. second grade). The dependent measures were drawn from the posttests. Mean performance is reported in Table 2 along with test statistics and effect sizes (*d*) comparing the intervention and control groups.

Reading comprehension as assessed by the WRMT-R (Woodcock 1987) showed no significant differences as a function of the intervention or grade. However, the Fountas and Pinnell measure of reading comprehension did detect a significant effect of grade with 2nd graders outperforming 1st graders. Although no significant effect of the intervention emerged on the F&P comprehension measure, a significant difference was apparent on the F&P retell measure, with the intervention group outperforming the control group (see Table 2). Also grade proved significant, with 2nd graders showing superior retellings of the stories than 1st graders. The interaction between intervention and grade was not significant.

Because a significant interaction was found on the retell measure given at pretest, an additional analysis, ANCOVA, was run with the retell pretest scores as a covariate. The main effect of the intervention remained significant, $F(1,15) = 9.29$, $p = .008$, as well as the main effect of grade, $F(1,15) = 14.42$, $p = .002$. The interaction was not significant, $F(1.15) = 2.36$, $p = .146$. These results reveal that instruction in coherence processing enhanced students' ability to retell stories that they had read.

No significant differences were found between intervention and control groups on the four coherence processing measures (see Table 2). For Part 1 of the Homographs task, participants appeared to have difficulty identifying more than one meaning for the homographs when presented in ambiguous sentences. Rather they might give multiple examples of the same meaning, for example, a baseball, soccer ball, and a football for meanings of the word, *ball*. Part 2 of this task provided a scaffold to think differently for participants who got stuck on their first definition of the word. The context-providing sentence and the visual enabled them to realize that they knew a second meaning for the word. The mean score rose from 46 to 61% at the completion of Part 2.

The Anaphor Resolution measure required students to identify sixteen referents, mostly of pronouns, in two short paragraphs that were read aloud twice. Some students at first responded generally to questions, such as when asked, "Who is he?" responded "he is a boy or man." The examiner then needed to clarify with, "in this sentence, who does *he* refer to?" Though participants appeared to understand the general characteristics of pronoun referents (that *he* refers to a boy or man for example) some seemed to have trouble getting the meaning accurate within the context of the narrative presented.

The last coherence processing task, Story Sequencing, was a favorite of the participants. Three and four event

Table 2 Mean performance of intervention and control groups on posttests and test statistics

	Intervention ($n=10$)	Control ($n=10$)	d[a]		F (1,19)	p
WRMT-R compreh. raw scores	26.90 (5.99)	26.50 (6.64)	.06	I	.01	.945
Age equivalent	7.94 (.68)	7.49 (1.09)	.49	I	.79	.387
Grade 1 ($n=12$)	7.92 (0.88)	7.12 (1.29)	.72	G	1.48	.241
Grade 2 ($n=8$)	7.97 (0.29)	8.05 (0.29)	.28	IxG	1.15	.299
F&P reading assessment GL	2.08 (.49)	2.12 (.47)	− .08	I	.04	.841
Grade 1 ($n=12$)	1.80 (.44)	1.87 (.45)	− .16	G	16.62	.001**
Grade 2 ($n=8$)	2.50 (.12)	2.50 (.12)	.00	IxG	.04	.841
Retell scores (max = 6)	4.30 (1.26)	2.40 (1.96)	1.15	I	10.00	.006**
Grade 1 ($n=12$)	3.83 (1.33)	1.17 (.98)	2.28	G	15.47	.001**
Grade 2 ($n=8$)	5.00 (.82)	4.25 (1.50)	.62	IxG	3.15	.095
Coherence processing						
Homographs part 1 (max = 8)	4.10 (2.03)	3.20 (2.57)	.38	I	1.19	.291
Homographs part 2 (max = 8)	5.20 (1.40)	4.60 (1.17)	.46	I	1.16	.297
Anaphor resolution (max = 16)	12.90 (2.03)	10.90 (3.54)	.69	I	2.17	.160
Grade 1 ($n=12$)	12.33 (2.34)	9.33 (3.88)	.93	G	5.05	.039*
Grade 2 ($n=8$)	13.75 (1.26)	13.25 (.50)	.53	IxG	1.11	.308
Story sequencing (SS) (max = 14)	11.60 (1.84)	11.70 (2.31)	− .05	I	0.12	.735
Use of sequence words (SS task)[b]	2.76 (1.15)	2.42 (1.12)	.30	I	0.08	.787
Grade 1 ($n=12$)	3.48 (.44)	2.27 (1.35)	1.21	G	2.62	.125
Grade 2 ($n=8$)	1.68 (1.01)	2.65 (.77)	− 1.08	IxG	6.20	.024*
Use of sequence words (F&P)	3.00 (2.71)	1.61 (2.01)	.58	I	0.95	.343
Grade 1 ($n=12$)	3.50 (2.43)	.50 (.84)	1.65	G	0.54	.474
Grade 2 ($n=8$)	2.25 (3.30)	3.25 (2.22)	− .35	IxG	3.82	.068

WRMT-R Comp is the Woodcock Reading Mastery Test-Revised. Reading Comprehension subtest (raw scores and age equivalent scores). F&P Reading Assessment GL is the Fountas and Pinnell benchmark reading assessment grade level. Homographs is the homographs embedded in ambiguous measures (part 1 is multiple meanings; part 2 is detecting mismatches)

I intervention, *G* grade

*$p<.05$; **$p<.01$

[a]Cohen's effect size *d* compares the Intervention to Control group overall means and within grade means on the measures. *d* = Intervention minus Control group means divided by the pooled standard deviation

[b]Sequence word score is the mean number per picture set over seven sets

picture sequences were presented, and participants were told to place the pictures in order, tell the story, and create a title for the story. A ceiling effect was noted for the picture sequence part of this measure. Most students were able to place pictures in the correct order ($M=86\%$ on pretest and $M=83\%$ on posttest), indicating that this was a relatively easy task.

In telling the stories conveyed by the sequence of pictures, students often used sequence words. Frequency of use was measured. As seen in Table 2, there were no significant main effects of intervention or grade. However, the interaction was significant. Inspection of means in Table 2 reveals the source. Among first graders, those in the intervention group used more sequence words than controls, whereas among 2nd graders, controls used more sequence words than intervention students. Comparison of scores of matched pairs revealed that 5 out of 6 first graders in the intervention group produced more sequence words than their control mates. These results suggest that the intervention enhanced first graders' use of sequence words but not second graders' use.

Sequence words were also used by students as they retold stories in the F&P task. Their frequency of use was counted. The number ranged from 0 to 7. As evident in Table 2, main effects of intervention and grade were not significant. However, the interaction just fell short of significance, with $p=.068$. Inspection of means reveals superior use of sequence words among intervention first graders and among control second graders. The effect size favoring the first grade intervention group was large, $d=1.65$. Comparison of scores of matched pairs revealed that 5 out of 6 intervention first graders produced more sequence words than their control mates. These findings are consistent with findings in the story sequence task showing that the intervention was effective in teaching first graders to use sequence words in telling stories.

Discussion

Effects of Instruction on Reading Comprehension

One purpose of the current study was to examine the impact of coherence processing instruction on reading comprehension using visual cues to direct students' thinking while reading. Significant effects were detected on the measure of story retelling that followed text reading in the Fountas and Pinnell posttest assessment. The retelling rubric evaluated whether the instructional intervention improved the quality of participants' retell narratives, considered an important indicator of reading comprehension. Quality retelling includes the following components of coherence processing: sequencing story events (beginning, middle, and end) and references to character actions and setting. Results showed that the instructional intervention group significantly improved the quality of their retelling of narratives compared to the control group. Both the six-session instructional intervention and students' grade level exerted an impact on the retelling ability of first and second graders with autism. A large effect size favoring the intervention group was noted for first graders ($d = 2.28$) compared to a medium effect for second graders ($d = .62$).

Retelling skill is a focus of early childhood reading instruction and is considered an important step towards fostering the ability to identify main ideas in narrative text. In defining his theory, Vermeullen (2015) emphasizes that context blindness in autism can be viewed as a deficit in the use of context to identify and evaluate meaning. In his article, he poses a challenge regarding the implications of this for educators in understanding and teaching the use of context to individuals with autism. The six-session instruction used in the present study sought to target this deficit through training in understanding and using coherence devices. Although improvement was observed on the retelling measure of reading comprehension, it was not observed on the other measures of reading comprehension.

Students' use of sequence words such as *first, next, then, finally,* and *last* was recorded for the story sequencing task and story retell. The intervention improved the mean scores of first graders over that of control students but did not improve scores among second graders. Instruction in the use of sequence words was included in two of the six sessions (i.e., Sessions 4 and 5), thus enhancing the likelihood that this organizing skill would generalize to the posttest measures. Use of sequence words was intended to impact participants' organization of thoughts, an important aspect of executive function. In their study, Hala et al. (2007) noted that executive function skill had a greater impact on reader's use of context to derive meaning than central coherence ability.

In the present study, the instructional intervention group did not show evidence of improvement in reading comprehension compared to the control group. One explanation is that our students possessed above average word decoding skill, performance on the Grade 1–2 level reading comprehension assessments was more heavily influenced by word reading skill than language comprehension ability, and this precluded detection of differences that arose from improved text coherence processing skills. Keenan et al. (2008) conducted a study that compared how decoding and oral comprehension skills differentially affected performance on four standardized reading comprehension tests. They found that much of the variance of the cloze format of the Woodcock Johnson Passage Comprehension Test (2001) was accounted for by decoding skill. In the present study, performance on the cloze format of the WRMT-R may have been dominated by the strong decoding skills of the participants of the present study. A different standardized reading comprehension assessment may have been more sensitive to comprehension changes resulting from the intervention.

Participants in the present study did not show significant improvement in performance on the coherence processing measures after receiving the six-session instruction. Design of the four coherence processing measures was based on research from previous studies with older participants (Zipke et al. 2009; Jolliffe and Baron-Cohen 1999; Norbury 2005; O'Connor and Klein 2004). There were indications of problems in our adaptations for younger students and may account for the lack of significant results. Participants expressed some confusion with some of the tasks, and the use of illustrations for the Story Sequencing measure proved to be too easy for these participants. Further research in adapting coherence processing measures for younger students with autism is warranted.

Strengths, Limitations and Future Research

The present study utilized a strength-based model of instruction that was intended to develop thinking skills for young, academically and cognitively able children with autism. Participants had word reading skills beyond their age and reading comprehension ability. Instruction provided guidance in strengthening coherence processing skills to improve students' ability to construct meaning from text. Instruction was adapted to provide better access to the complex task of understanding text through the use of visuals to support executive functioning. The model developed here provides an example showing teachers how to be intentional in designing instruction that taps students' strengths to foster growth in deficit areas. Participants in the present study were observed to make use of the visuals that cued their thinking processes during the lessons. The instructional sessions were designed tap into the cognitive strengths of

participants by providing students with the *whats* (use of cohesive devices), the *whys* (goal of reading is to construct meaning), and the *hows* (thinking strategies of where to look and using sequence words to organize responses) in reading for meaning.

It is clear from the results of this study that a larger scale study is needed to determine whether instruction in coherence processing would benefit children with autism in their ability to comprehend narrative text. Lower statistical power in the present study is one potential reason for the limited number of significant findings, especially at the second grade level. Also, instructional time might have been insufficient. We attempted to teach several coherence processing skills in only six sessions whereas Roux et al. (2014) spent 48 sessions teaching reading comprehension skills. The focus of early reading instruction has been primarily on acquisition of word attack skills. Research on reading comprehension for this young population is limited and thus deserves more attention in the future.

Conclusions

Despite the limitations in the present study, the instructional intervention did improve the quality of participants' narrative retelling of a text read independently. The effect was especially strong for first graders, indicating that instruction in coherence processing could benefit young students with more advanced word reading skill. In addition, the intervention appeared to improve first graders' use of sequence words, an organizational reading behavior, though results were not significant for second graders. A larger sample may have yielded better results.

Executive function has been found to be an area of deficit in individuals with autism particularly for open-ended tasks (White et al. 2009). Coherence processing and reading comprehension have been shown to benefit from improvement in executive function (Hala et al. 2007; Elosúa et al. 2013). It remains to be determined whether instruction in the ambiguous nature of text, scaffolding efforts of students to think flexibly, and taking into account situational information, has potential to improve reading comprehension in students with autism. Instruction that includes visual materials to cue readers to think about characters' actions within the context of the story is likely to guide students in the construction of meaning. Also direct instruction in the use of sequence words to organize retelling has the potential for improving comprehension. Further research is needed to support the education of these able students, to improve their comprehension and to provide training in how to derive meaning from context.

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Author Contributions KSE and LE conceived of the research ideas and design. KSE devised and performed the experiments. KSE wrote the manuscript with support from LE who supervised the project.

Compliance with Ethical Standards

Conflict of interest Karen S. Engel received partial funding for this study with a Dissertation Year Fellowship 2016–2017 received from The Graduate Center of the City University of New York. The authors have no financial or other conflicts of interest related to this research.

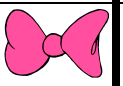
Research involving human participants All procedures performed in this study involving human participants were in accordance with the ethical standards of The Graduate Center of the City University of New York and NYC Department of Education. The study received IRB approval from The Graduate Center University Integrated Institutional Review Board, #2016-0583 and NYC DOE IRB, #1332. We have complied with APA ethical standards in the treatment of our participants.

Informed consent Informed consent was obtained from all parents or guardians of participants and also from all participants included in this study.

Appendix A

Coherence Processing Task: Homographs Embedded in Ambiguous Sentences

Pretest *Posttest*

Part 1 Give multiple meanings	*Part 2 Do sentence and picture match?*	*Part 1 Give multiple meanings*	*Part 2 Do sentence and picture match?*
Sandy picked up the bow.	She spotted the target. 	His dad hated the jam.	He was going to be late for work. 
Hannah found a bat in the closet.	She jumped back in surprise. 	Jessica thought the ball was fun.	She loved all kinds of sports. 
The man showed Peter the pen.	Peter closed and locked it. 	Mrs. Smith showed the girl the letter.	The girl opened it to see who it was from. 

Coherence Processing Task: *Anaphor Resolution*

Example. Pretest Passage: John loved to fish with his friends, David and Larry. The weather was beautiful, so he decided to go fishing. He called his friends and got out his fishing rod. His father gave it to him for his birthday. He walked to the shore excited to meet his friends, thinking about catching fish. But the fish just would not bite that day. David looked at his watch. He sighed, "I have to go home now." All day John and Larry waited and waited, but still no fish. They were hungry and thirsty. It was getting late. But even as the sun went down, they did not move. It was dark when John got home. He called his friend. "We should have left with you." he said. David laughed, "We can go fishing again. We will catch them tomorrow."

Example Posttest Passage: Gail walked over to her best friend Kathy's home. They were playing a game together when they started to fight. Gail said her turn was skipped. She wanted to start over. The game pieces fell on the floor. Kathy turned her back on her friend. "Pick them up!" Kathy shouted. "No. I'm leaving!" Gail shouted back. She slammed the front door shut as she left. After a few minutes, Kathy was sorry for what she had said. She ran out the front door and headed toward her friend's home. Gail was already on her way back. "I am sorry," she said. Kathy smiled at her and they walked back down the street together. When they got back to Kathy's home, they saw the game on the floor. The two friends picked it up and started to play again. "We are friends again," Gail laughed.

Coherence Processing Task: *Story Sequencing*

Example. Script. "Place the pictures in the correct order and then tell me the story. What is the title for your story?"

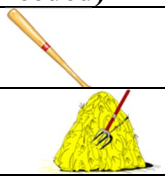
Appendix B

Examples Used During Sessions 1–6 of the Intervention

Session 1: Examples used for ambiguous words and sentences

Sentences used for instruction	Pictures
1. The cold made Barry feel terrible. a. He just couldn't stop shivering. b. He just couldn't stop sneezing.	
2. The school was very big. a. There were so many fish! b. There were so many students!	

Session 2: Examples used for detecting inconsistencies with ambiguous words

Sentences used for instruction	Pictures shown first	Pictures shown second (as needed)
1. a. Peter swung the bat. b. Peter ran away from the bat.		
2. a. Judy sat in the straw. b. Judy sipped the straw.		

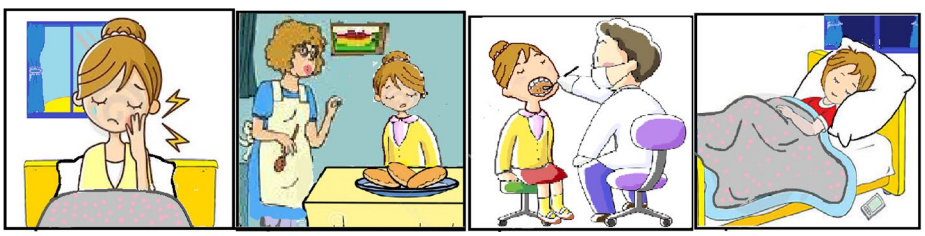
Session 3: Example of passages used for anaphor resolution

1 Fred wanted to wake up early to get to school, but he forgot to set his clock. His father woke him up. He jumped out of bed when he realized he had overslept. Then he ran out of the door. Bill ran up to his friend to walk to school.

2 Daniel, Brett, and their mom went out to the farmer's market on a beautiful sunny day. The boys were shopping for plants for their garden. They chose three plants to take home.

Session 4: Example passage with illustrations used for sequencing

1.	Alice woke up because her tooth was hurting so badly.
	Alice told her mom her toothache was so bad that she couldn't eat.
	Alice and her mother went to the dentist.
	Alice slept much better since her tooth had stopped hurting.



Session 5: Example of passages used for retelling

1 Eric went to the green market to buy an apple tree. He took out his gardening tools to get ready to dig a hole. He dug a big hole and planted his tree. Eric watered the tree and it grew very big. Eric picked some apples from his tree to make an apple pie.
2 Mrs. Smith went out to the supermarket to buy food for her family's dinner. She got home from the shop. She began chopping the carrots and onion and placed them in a bowl. Mrs. Smith checked to see if the food was ready. Mrs. Smith called her family to eat a great big meal.

Session 6: Example of passages used for inferencing

1 It was a rainy day in the city. There were many cars driving on the street. A boy was running along the sidewalk to get to school. He was holding a book over his head.

   (a) Question: Why is the boy holding a book over his head?"
   (b) Follow-up: How do you know that?

2 Kevin's little brother, Mike played with his scooter all morning. He went inside when Mom called him to eat his lunch. Kevin finished lunch then ran out of his house to play football with his friends. All of a sudden, Kevin tripped and fell, breaking his leg.

   (a) Question: Why did Kevin trip?
   (b) Follow-up: How do you know that?

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