

# Exploration of Strategies for Facilitating the Reading Comprehension of High-Functioning Students with Autism Spectrum Disorders

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Many students with autism spectrum disorders show good decoding combined with poor comprehension. Twenty adolescent students with autism spectrum disorders participated in a study concerning the effects of three kinds of facilitation on reading comprehension. In a within-subjects design, each students read passages under four conditions: answering prereading questions, completing cloze sentences embedded in the text, resolving anaphora by identifying relevant antecedents, and control (reading only). A repeated measures analysis of variance indicated that conditions differed significantly in their effects on reading comprehension. Post hoc contrasts showed that the effects of anaphoric cuing were statistically significant and medium in size; the effects of prereading questions and cloze completion were small and not statistically significant. Instructional implications for text preparation, remedial instruction, and the design of educational software are discussed.

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**KEY WORDS:** Autism; Asperger's syndrome; reading comprehension; strategy.

Traditionally, reading instruction for people with autism has received relatively little research attention. Perhaps this was because for people with classical Kanner syndrome, behavioral and social needs were perceived to be most pressing. However, in recent years the number of children identified with autism has increased, including the number of children identified with High-Functioning Autism, Asperger Disorder, and Pervasive Developmental Disorder–Not Otherwise Specified (Bryson & Smith, 1998; Kadesjo, Gillberg, & Hagberg, 1999; Wing, 1996). For these high-functioning students, cognitive and language abilities are less impaired, and a greater range of academic skills is within reach (Goldstein, Minschew, & Siegel, 1994; Minschew, Goldstein, Taylor, & Siegel, 1994; O'Connor & Hermelin, 1994). An increasing number of these students attend partially or fully integrated educational

settings, with some proceeding to tertiary education and entering either supported or open workplaces (Burack, Root, & Zigler, 1997; Gerhardt & Holmes, 1997). Therefore, it is important for these students to learn to read well.

However, most high-functioning people with autism show distinctive difficulties in reading (Goldstein *et al.*, 1994; Happe, 1997; Snowling & Frith, 1986). These difficulties imply the need to develop reading interventions for this clientele. Several previous studies have paved the way for such interventions by indicating the specific aspects of reading that are impaired. These studies have demonstrated a paradoxical combination of good word identification with poor comprehension (Goldberg, 1987; O'Connor & Hermelin, 1994; Patti & Lupinetti, 1993; Whitehouse & Harris, 1984). In the extreme case, the term "hyperlexia" has been used to refer to decoding skills of a savant-like nature, combined with comprehension that is partially or, some researchers would claim, totally lacking (Healey, 1982). However, not all students who show hyperlexia have a diagnosis of autism; conversely,

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most high-functioning students with autism show a disjunction between decoding and comprehension, but one that is less extreme than “hyperlexia.”

With respect to decoding, high-functioning students with autism spectrum disorders show skills that are generally adequate, but that can be below, equal to, or above chronological age norms (Eskes, Bryson, & McCormick, 1990; Frith & Snowling, 1983; Goldstein *et al.*, 1994; O'Connor & Hermelin, 1994). Like other readers, these students can decode novel pseudowords and can read phonetically regular words more easily than phonetically irregular words, showing that they can use phonetic strategies to decode (Frith and Snowling, 1983). In addition, they are able to decode phonetically irregular words and show evidence of treating familiar words such as “the” as single units, indicating that they have lexical reading skills as well as phonetic ones (Frith & Snowling, 1983; Snowling & Frith, 1986).

Most high-functioning students with autism show reading comprehension that is impaired but not entirely lacking. Various samples of students have shown levels of reading comprehension that are variously age appropriate but lower than decoding ability (O'Connor & Hermelin, 1994); less than age appropriate, but approximately consistent with verbal ability or cognitive level (Goldstein *et al.*, 1994; Patti & Lupinetti, 1993); or below both age level and verbal or cognitive level (Happe, 1997). Goldstein *et al.* (1994) found that reading comprehension for high-functioning children with autism was similar to IQ-matched controls, but for adolescents, reading comprehension was lower than controls, possibly reflecting the greater inferential demands of age-normed tests for older students. Snowling and Frith (1986) found that students with autism and high verbal ability showed reading comprehension that was below age level but similar to controls of the same decoding ability; however, students with autism and low verbal ability showed reading comprehension that was significantly poorer than decoding-matched controls. In summary, both decoding and reading comprehension skills in this population show a continuum of performance levels, but reading comprehension typically falls below both decoding skills and age-level norms.

Previous research indicates which aspects of reading comprehension are relatively impaired in high-functioning students with autism spectrum disorders, and which aspects are relatively intact. The single-word reading comprehension of high-functioning students with autism appears to be largely intact. Using the Stroop paradigm, Snowling and Frith (1983) showed that the meaning of a color word interfered with naming

the color in which the word was printed, indicating that readers were automatically accessing its meaning. Moreover, students with autism showed this effect for abstract, as well as concrete, printed words (Eskes *et al.*, 1990). However, it should be noted that few studies have examined semantics in the reading of children with autism, and these studies have examined the comprehension of nouns representing single concepts with relatively stable referents.

For linguistic units beyond the word, the reading comprehension of most high-functioning students with autism is more limited. On one hand, most are able to use syntactic context to pluralize words and to generate syntactically appropriate words to complete sentence cloze tasks, showing that they have some comprehension of syntactic context (Frith & Snowling, 1983). On the other hand, the grammatical ability of students with autism is delayed relative to other students, (e.g., Tager-Flusberg, 1981; Tager-Flusberg *et al.*, 1990), so it might be expected that when grammatical complexity reaches some level, it will impose limits on reading comprehension. In addition, these students' understanding of the semantics of sentences is more limited. In a study using cloze tasks, they selected words that were syntactically appropriate, but often semantically inappropriate (Frith & Snowling, 1983). Most could not use sentence context to pronounce the correct version of a homograph, showed little awareness of these errors, and seldom self-corrected (Frith & Snowling, 1983; Happe, 1997). However, other research has indicated that for more verbal students with autism, performance on homograph disambiguation was not different from younger controls matched on decoding ability (Frith & Snowling, 1986).

To understand text, readers must go beyond the level of the clause, integrating clauses and sentences to synthesize a representation of the gist (Kintsch, 1998; Pressley & Afflerbach, 1995; Whitney & Budd, 1996). However, many students with autism appear to have difficulty integrating information. This may include difficulty switching attention among parts of a task (Courchesne *et al.*, 1994), switching attention from a local level to the global level (Plaisted, 1999), or attending both to the parts of a task and to the whole (Shah & Frith, 1993). Therefore, the students might be also expected to have difficulty integrating information from previous text to understand the gist of a passage. Snowling and Frith (1986) presented students with autism with a cloze task in which they read a passage and were required to fill in blanks in particular sentences, given a choice of words that were inappropriate, sentence-appropriate (but not story-appropriate), or

sentence- and story-appropriate. Students with high verbal ability did not perform differently from decoding-matched controls, but students with low verbal ability performed below controls and did not distinguish between sentence-appropriate and story-appropriate completions. Similarly, in a task in which students were asked to cross out words that were story-inappropriate or sentence-inappropriate, they showed high levels of “false alarms” indicative of random responding.

One of the most common ways in which a text coheres is through anaphora, the reference of a text back to earlier elements of itself. According to Givon's (1995) analysis, anaphoric devices are pragmatic signals that inform listeners or readers where to search for a referent: zero anaphora signals that the referent is currently the focus of attention; a pronoun signals that the referent was recently discussed and is available in memory, but is not currently in attention. Given the difficulties that people with autism have in understanding mental states and managing attention, they might be expected to have difficulties interpreting such cues. Consistent with this, in speech, students with autism refer less to previous discourse and more to the environment (Fine, Bartolucci, Szatmari, & Ginsberg, 1994). The most common form of anaphora is the pronoun (e.g., Chafe, 1994), and many students with autism show limitations in producing and comprehending pronouns in speech (Fine *et al.*, 1994; Lee, Hobson, & Chiat, 1994). Oakhill and Yuill (1986) found that less-skilled reading comprehenders made errors in identifying pronoun referents, and that these errors increased with the complexity of sentences. Therefore, it could reasonably be expected that difficulties resolving pronouns in text may affect the reading comprehension of students with autism.

A second aspect of reading comprehension that is difficult for students with autism spectrum disorders is the use of prior knowledge to interpret text. Skilled readers make use of prior knowledge to support reading comprehension (Pressley & Afflerbach, 1995). However, Snowling and Frith (1986) found that students with autism make limited use of prior knowledge during reading. On the basis of a pair of passages concerning nature topics, they created two kinds of questions: factual recall questions that depended only on information presented in the text, and general knowledge questions that required students to apply common prior knowledge to the text. Overall, students with autism or mental retardation scored lower than decoding-matched controls. Control students with low or high verbal ability scored higher on general knowl-

edge questions than on the factual recall questions. High-verbal ability students with autism or mental retardation showed the same “general knowledge” advantage as the controls, but low-verbal ability students with autism or mental retardation did not show this general knowledge advantage. Moreover, this trend obtained even when a control group of inner-city preschoolers, who were expected to have limited knowledge about nature, made up the control group. Subsequently, Snowling and Frith suggested that although students with autism probably had relevant prior knowledge, they did not apply it during reading.

The use of prior knowledge during reading, and the integration of text above the level of the clause, may be closely related processes. During reading, words in the text activate corresponding concepts in long-term memory. These concepts remain activated, increasing the probability that they will be retrieved during the reading of subsequent text propositions (Ericsson & Kintsch, 1995). This would assist readers in relating early text elements to later text elements. Recall, for example, that pronouns signal that the referent is not currently in attention, but is available for retrieval from long-term memory (Givon, 1995). As a consequence, activating prior knowledge and integrating text above the level of the clause are not wholly independent processes.

Therefore, the goal of this study was to investigate ways of supporting students' understanding of text at the level of the sentence and above, and their use of background knowledge. The approach taken was procedural facilitation (Bereiter & Scardamalia, 1987; Montague, Graves, & Leavell, 1991; Zellermayer & Cohen, 1996). In procedural facilitation, the researcher or teacher assists the student with a task by prompting executive processes. This differs from substantive facilitation, in which the researcher directly assists students with the content of a task. Procedural facilitation also differs from cognitive strategy instruction, insofar as the researcher does not expect that the student will necessarily internalize the procedure and perform it independently at the end of the intervention. Given the metacognitive difficulties of students with autism, procedural facilitation seemed to provide a more attainable goal. The use of procedural facilitation also allowed the researchers to examine the effectiveness of several different strategies, rather than investing substantial training effort in a single strategy that may or may not have proven effective for students with autism. Three means of facilitation were selected because they have proven effective in previous research with readers whose difficulties resemble those of students with autism, or

because they were relevant to the problem of integrating text content. Each is consistent with the finding that active performance of a task improves recall for high-functioning people with autism (Summers & Craik, 1997).

One form of procedural facilitation selected for this study was answering prereading questions. This was intended to address the possibility, noted above, that students do not consistently access prior knowledge during reading. Prereading questions make up a form of priming: The question acts as a probe to activate information from long-term memory. This information remains activated for several minutes beyond the span of working memory alone, continuing to support reading comprehension (e.g., Baddeley & Logie, 1999; Kintsch, 1998). Intentionally activating relevant prior knowledge is a strategy used primarily by skilled readers; requiring less-skilled students to ask or answer questions before reading or during reading generally improves their use of prior knowledge and, hence, their comprehension (Carr & Thompson, 1996; Dewitz, Carr, & Patberg, 1987; Pressley & Afflerbach, 1995; Spires & Donley, 1998). Therefore, it was reasoned that extending this method to students with autism could aid them by alerting them to important information in the text and increasing the likelihood that prior knowledge will be used to interpret this information.

A second form of facilitation was "anaphoric cuing." As noted earlier, students with poor reading comprehension and students with autism do not consistently relate pronouns to antecedent nouns. Informally, the researchers had noted that students with autism read quickly over anaphora, without pausing, even when they were uncertain of the referent. We reasoned that cuing students to choose among three possible referents of a pronoun could assist them in two ways: first, it could prompt them to pause and monitor whether or not they were understanding the text (Snowling & Frith, 1986); second, students could look back in the text to consolidate or repair their comprehension. Looking back and rereading is a strategy used by skilled readers, and teaching this strategy to less-skilled readers improves their comprehension (Bossert & Schwantes, 1995–96; Garner, Macready, & Wagoner, 1984; Pressley & Afflerbach, 1995).

The third procedural facilitation of interest was a cloze task. Cloze, like anaphoric cuing, requires students to make use of information in the text to make predictions as they read. Therefore, like anaphoric cuing, it was expected that this concrete activity could prompt students to monitor their understanding, reread if necessary, and thereby consolidate or repair their

text representation. In previous research, cloze tasks of various kinds have improved the reading comprehension of nonautistic students (Sinatra, 1977; Wisher, 1986; for a review, see Jongsma, 1980).

On the basis of these considerations, we hypothesized that procedural facilitation, in the form of anaphoric cuing, prereading questions, or cloze sentences, would produce significantly greater comprehension of text passages than a control condition in which students did not receive facilitation.

## METHOD

### Participants

Participants were drawn from a large-scale longitudinal study concerning the development of students with autism spectrum disorders. Initially, a sample of 72 students was selected, and from these, 25 participants were chosen for showing moderate to high levels of decoding, conjoined with lower levels of reading comprehension (see following for details). The 25 eligible participants and their parents or guardians were contacted by letter, and all agreed to participate. Five students participated in the pilot research, and 20 participated in the study itself. Of these 20 participants, 10 had been assessed to meet Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV; American Psychiatric Association 1994) criteria for autism; six met criteria for Asperger Disorder, and four met criteria for Pervasive Developmental Disorder–Not Otherwise Specified. Nineteen were male, and one was female. The students' mean age was 15.11 years ( $SD = .99$ ). Four of the students attended segregated classrooms, six students attended regular classrooms with some resource support, and 10 attended partially integrated programs. As readers, these students resembled high-functioning students with autism spectrum disorders described in previous research, with standardized reading comprehension scores that were significantly lower than their standardized word identification scores [ $t(1,19) = 28.71$ ,  $p < .001$ ; see Table I for additional details concerning the participants].

### Materials

Five stories were adapted from the grade 6 level of a reading series (Science Research Associates, 1974). The passages involved human participants but emphasized nonfiction content (e.g., a story about an archeological dig), so that the demand for understanding of

**Table I.** Means and Standard Deviations, and “Low,” “Medium,” and “High” Ranges of Participant Characteristics

	Mean	SD	Range		
			Low (1st–6th)	Medium (7th–14th)	High (15th–20th)
Age (years)	15.11	.99	14.00–14.41	14.41–15.25	15.25–17.50
Stanford-Binet Intelligence Scale: Composite Score	88.15	16.06	72–80	81–93	98–116
Woodcock Johnson Reading Mastery Test-Revised					
Word Identification	93.60	14.64	70–88	89–100	102–123
Word Comprehension	88.50	13.35	62–78	85–93	94–111
Passage Comprehension	84.25	14.36	54–78	82–86	87–117
Test of Language Development-2	8.60	2.01	2–8	8–10	10–13
Intermediate Grammatical Comprehension					

the characters' thoughts and feelings was neither extremely high nor extremely low. The passages were modified slightly so that the total number of words ( $n = 630$ ), the Fleish-Kincaid readability estimates (grades 6.00–6.82), and the number of short and long sentences were as similar as possible.

Four versions of each passage were prepared. The control version of each passage was unaltered. The cloze version of each passage included 12 blanks distributed evenly throughout the text. Each blank replaced a word, other than a pronoun, that could be completed by referring to information within the previous three sentences. The anaphoric cuing version of each passage was similar to the format of Frith and Snowling's (1986) "restricted choice" materials: Twelve instances of pronouns, evenly distributed throughout the passage, were selected and underscored. Three possible referent words appeared under each blank: One was inappropriate, one was sentence-appropriate but not story-appropriate, and one was story-appropriate. All three choices were of the correct syntactic class; the order of the choices was randomized. For the prereading condition, a set of five questions was designed intended to elicit common knowledge and experiences relevant to the main ideas of the story. The questions were sequenced from general to specific to increase the probability of eliciting some response even from participants with limited relevant background knowledge.

For each passage, a set of 12 questions was prepared, permitting a total score of up to 25 points (see Table II for examples of questions and a scoring key; cf. Lovett *et al.*, 1996). The sequence of questions included free retelling (3 points), identifying the main idea of the story (2 points), generating a title for the story (2 points), detecting an incongruous sentence in a paragraph from the story (2 points), four "why or

how" questions that required students to make inferences about information not explicitly stated in the passage ( $4 \times 2$  points), and four "who, what, where, when" questions that required students to recall factual information explicitly stated in the passage ( $4 \times 2$  points).

### Procedure

Reading sessions were carried out in quiet settings; 14 participants and their families chose to complete the study at home, and six chose to do so at school. The students were accustomed to participating regularly in assessment sessions as part of a long term study. The researcher was introduced as a "friend of F\_\_\_\_", the psychometrist from the long-term study, and the tasks were presented as "reading games," because they did not affect their school grades.

Participants were asked to "read each story out loud and pay close attention. Afterward I am going to ask you some questions." Each student read five stories, one each in the prereading question condition, the anaphoric cuing condition, and the cloze condition, and two in the control condition. Assignment of passages was counterbalanced with the intervention; that is, four students read Passage A in the anaphoric cuing version, four read Passage A in the cloze version, and so forth. The sequence of the interventions was randomized and balanced across students; that is, four students read Passage A first, four read Passage B first, etcetera. Students read all five passages in one session, with a break between the third and fourth passages. Each passage and the break required about 10 minutes, for a total session of approximately 60 minutes.

Instructions for each type of intervention were given immediately before the passage. For the prereading question condition, the researcher said, "Before

**Table II.** Scoring Key for Postreading Questions (based Lovett *et al.*, 1996)

Number	Question and scoring rubric
1	Unguided retelling: "Can you tell me the story in your own words?" 3 = Main idea and unguided retelling of some of the main points 2 = Main idea only, no elaboration 1 = Stating a main point, but not stating the main idea 0 = Wrong answer, no answer
2	Main idea: "What is the main idea that the author is trying to tell us in this story?" 2 = Stating the main idea 1 = Stating part of the main idea 0 = Wrong answer or no answer
3	Title: "What is a good title for this story?" 2 = Title expresses the main idea 1 = Title expresses part of the main idea 0 = Wrong answer or no answer
4-7	Guided retelling/inference questions ("Why? How?" questions) Examples: "Why did Ruz dig under the pyramid?" "How did Dr. Ford solve the problem of robins crashing into planes?" 2 = Complete answer 1 = Part of the answer 0 = Wrong answer or irrelevant detail
8-11	Fact questions ("Who?, what?, when?, where?" questions) Examples: "Where did this story happen?" "Who trained the falcons?" 2 = Complete answer 1 = Part of the answer 0 = Wrong answer or irrelevant detail
12	Detecting an incongruous sentence Example: "It was late afternoon on a hot, dry day in Spain. At the end of the runway Dr. Ford stood near the birds. One peregrine was released. She circled to a height of three hundred feet and waited until some dogs chased out a flock of robins. <i>Robins lay eggs which are light blue.</i> The falcon dived from her position and hit one of the robins. Mission successful!" 2 = Correct selection of incongruous sentence 1 = Selecting part of the incongruous sentence, or selecting the incongruous sentence plus another sentence of part of another sentence 0 = Selecting the wrong sentence

*Note:* The questions were based on the following passages:

Gaddis, V. (1972). *SRA Reading Lab, Level 6.0: First passage*. Toronto, ON: Science Research Associates.

Newmark, J., & Newmark, G. (1972). *SRA Reading Lab, Level 6.0: A spider in the hand*. Toronto, ON: Science Research Associates.

Nicolle, D. C. (1972). *SRA Reading Lab, Level 6.0: The man with the jade mask*. Toronto, ON: Science Research Associates.

Mowat, F. (1972). *SRA Reading Lab, Level 7.0: Retriever's triumph*. Toronto, ON: Science Research Associates.

Restall, R. L. (1972). *SRA Reading Lab, Level 6.0: The peregrines of Torrejon*. Toronto, ON: Science Research Associates.

we get started, I'd like to ask you a few questions." The researcher posed the questions and the student answered verbally.

The anaphoric cuing task required students to perform an unfamiliar task; the instructions followed Yuill and Oakhill (1988, p. 179):

When you say things or read them, sometimes there are short ways of saying them. Sometimes a person called "Robert" is called "Rob" for short. "Rob" stands for "Robert." Sometimes in a story there are short ways of saying things. These shortcuts point back to something else in the story that has been said before. I am going to ask you about some of these shortcuts. I will ask you to tell me what they

stand for. The shortcut words are underlined. I want you to circle one of the words underneath that you could put instead of the shortcut, to say it the long way.

The students were then shown an example and tried a practice question.

Students were familiar with cloze tasks as part of the long-term study. Before the cloze task, the participants were given the following instructions:

This story (experimenter points to the closed folder containing the story) has some blanks in it. I want you to fill in the blanks as you read. Write down the word that belongs in the blank.

After each passage, the researcher posed the questions verbally and the students responded verbally, to minimize the effects of differences in students' writing skills. Students did not have access to the passage when they were answering the questions.

### Analysis

All students appeared to understand the instructions, in that they followed directions and completed all of the reading and facilitation tasks appropriately and showed no apparent signs of confusion, although their comprehension of the passage content varied. Students' answers to the reading comprehension questions were transcribed. The conditions under which each question was asked were masked, and responses were scored independently by two raters (Table II). Total reading comprehension scores showed very high interrater reliability (intraclass correlation coefficient  $\alpha = .95, p < .001$ ). Subsequently, for specific questions, scores that were more than 1 point apart were discussed by the two raters and differences resolved. For the five passages, overall interitem reliability among questions was high, ranging from  $\alpha = .80$  to  $.87$ .

## RESULTS

### General

Overall, most students showed modest comprehension of the passages ( $M = 13.76$ ;  $SD = 5.83$ ) out of a possible 25 points; see Table II for scoring. This made up the dependent variable for the study; scores on particular items or categories of items should be interpreted with caution, because reliability was established for the total test score, rather than for individual test questions, which made up the items. For spontaneous retelling, the mean score was 1.76 ( $SD = .85$ ) out of 3 possible points; the modal score was 1, indicating a list-like recall of main events. For the main idea question, the mean was .92 ( $SD = .76$ ) out of 2; the modal score was 1, indicating identification of an aspect of the main idea but not the entire main idea. Similarly, for the title creation question, the mean score was 1.37 ( $SD = .70$ ); the modal score was 1, indicating a title that referred to a main character or object of the story, but not to the main idea. Students detected the incongruous sentence in slightly more than half of the stories ( $M = 1.13$  out of 2 points;  $SD = .98$ ). The four inference questions generated a mean score of 4.47 ( $SD = 2.39$ ) out of 8 possible points. The fact questions

**Table III.** Means and Standard Deviations of Total Reading Comprehension Score by Facilitation Condition

Condition	Mean	Standard deviation
Anaphoric cuing	15.41 <sup>a</sup>	6.28
Prereading questions	13.88 <sup>ab</sup>	5.47
Cloze	13.83 <sup>ab</sup>	5.14
Control 2	12.86 <sup>b</sup>	6.27
Control 1	12.79 <sup>b</sup>	6.33

Note: Means that do not share a common superscript differ significantly,  $p < .05$ .

generated a mean score of 4.12 ( $SD = 2.08$ ) out of 8 points.

Table III presents the mean total reading comprehension scores following each procedural facilitation, adjusted for passage difficulty. Mauchley's test indicated that the data did not significantly violate the sphericity assumption ( $W = .52, df = 9, p = .25$ ), so it was an appropriate candidate for a repeated measures analysis of variance. The analysis was based on one independent variable (type of facilitation) with five conditions (cloze, anaphoric cueing, prereading questions, and two control passages). The result was a statistically significant, medium-size effect of procedural facilitation  $F(4,76) = 2.49, \eta^2 = .12, p = .05$ .

Post hoc contrast tests were used to determine which of the three interventions affected the dependent variable. Of the two control passages, control 2 was used as the contrast, as its slightly larger mean gave a more conservative test. The effect size of each facilitation was calculated in standard deviations (Glass, McGaw, & Smith, 1981). In addition, to estimate how many students benefited from each intervention, a criterion was set of 0.5 standard deviations above reading comprehension score in the control condition, corresponding to a medium effect size, and the number of students whose scores exceeded this level was tabulated. Correlations between participant characteristics (IQ, TOLD-Grammatic Comprehension score, etc.) and scores under each intervention were calculated, with reading comprehension score in the control condition partialled out (Table IV).

Finally, for each facilitation, the two students who benefited the most (i.e., those whose reading comprehension scores were greatest compared to their own scores in the control condition) and the two students who benefited the least (those whose reading comprehension scores were smallest relative to their own scores in the control condition) were identified. The transcripts and records of their responses to the interventions (answers to prereading questions, cloze

**Table IV.** Raw Correlations and Partial Correlations of Participant Characteristics With Reading Comprehension Scores in Three Facilitation Conditions

	Raw Pearson correlation			Partial correlation, controlling for comprehension score in control condition		
	Cloze	Anaphoric Cuing	Prereading Question	Cloze	Anaphoric Cuing	Prereading Question
IQ <sup>a</sup>	.43	.47*	.73**	-.21	-.04	.44
TOLD <sup>b</sup>	-.17	-.29	-.06	-.30	-.46*	-.12
Word identification <sup>c</sup>	.24	.34	.38	-.03	.15	.19
Word comprehension <sup>d</sup>	.43	.55*	.63**	-.14	.14	.28
Passage comprehension <sup>e</sup>	.54*	.52*	.80**	.07	.09	.61**

<sup>a</sup> Stanford-Binet Intelligence Scale: Composite IQ.

<sup>b</sup> Test of Language Development-2 Intermediate: Grammatical Comprehension.

<sup>c</sup> Woodcock-Johnson Reading Mastery Test-Revised: Word Identification.

<sup>d</sup> Woodcock-Johnson Reading Mastery Test-Revised: Word Comprehension.

<sup>e</sup> Woodcock-Johnson Reading Mastery Test-Revised: Passage Comprehension.

\*  $p < .05$  (two-tailed).

\*\*  $p < .01$  (two-tailed).

completions, and anaphoric cuing selections) were compared sentence by sentence to both the story and their postreading comprehension answers. This allowed the researchers to infer whether a given students' immediate responses to the interventions were appropriate to the passage content and, if so, whether or not these responses also made up the basis for their answers to the postreading comprehension questions. The researchers also noted whether these students' scores on each of the participant variables were in the lower third ("low"), middle third ("medium"), or upper third ("high") of the distribution of this sample (Table I).

### Anaphoric Cuing

Anaphoric cuing significantly increased students' passage comprehension, producing medium effect sizes [ $F(1,19) = 5.60, p = .03, \eta^2 = .42$ ]. Consistent with this, students resolved most anaphors correctly ( $M = 10.10$  [ $SD = 2.55$ ] out of 12). The number of anaphors resolved correctly correlated with total passage comprehension score [ $r(20) = .49, p < .05$ ], and when reading comprehension ability was controlled statistically by partialling out students' control condition comprehension scores, the correlation between number of pronouns resolved correctly and postreading comprehension score was moderate but not statistically significant ( $r = .29$ ). Eleven of the 20 participants made gains of .50 standard deviations or more relative to their own scores in the control condition. The correlation between students' TOLD Grammatical Comprehension scores and their reading comprehension in the anaphoric cuing condition was significantly negative,

with reading comprehension in the control condition partialled out (Table IV). This indicates that anaphoric cuing was more beneficial for students with lower grammatical ability.

The two students who showed the greatest gains in comprehension with anaphoric cuing, relative to their own comprehension scores in the control condition, both had IQ scores that were low relative to this sample, combined with WJRM-T-R Word Identification and Passage Comprehension scores that were medium or high. One student had a diagnosis of Pervasive Developmental Disorder–Not Otherwise Specified, and the other a diagnosis of autism. During reading, one of the students resolved 11 anaphors and other resolved 10 out a possible 12. Both of the students were observed to stop reading and reread the text to resolve the anaphora correctly. This is particularly significant, in that neither of these students could answer these anaphora items correctly without rereading, yet neither paused or reread in the control condition. This supports the view that these students did not correct "missed" referents for pronouns spontaneously but, with prompting, did so correctly, and thereby improved their understanding of the passage. For example, in the control condition, one or the two students, when asked to retell the story in his own words, simply said, "It was about a boat . . . a ship."

In contrast, after correctly resolving the pronouns, he gave this retelling of an equally difficult passage:

Well the planes that were coming in from the airport in Spain, well the birds were hitting the planes, and they tried to like, find ways to get the robins, the robins away from the airplane, and then this

Dr. Ford and then an Italian, they got this bird, like a peregrine, to um, try and get away the birds and managed to work.

The students who showed the poorest comprehension in the anaphoric cuing condition relative to their performance on the control passage presented profiles different from one another. One student with a diagnosis of Asperger Disorder had a high IQ but low scores on WJRT-R Word Identification and Passage Comprehension. This student resolved only three anaphors correctly; three errors were appropriate to the sentence context only, and six errors were inappropriate to both the sentence context and the story context. The researcher's impression was that decoding the text required most of this student's attention, leaving little capacity to resolve the anaphora. As a consequence the student's answers to questions were brief and fragmentary, retelling the story in this way: "It was about a plane and a peregrine."

In contrast, the same student's retelling in the control condition was more complete and coherent:

"It was a story about a little boy and his brother George and they were teachers and they went on a trip in the woods to visit the mountain and they found a marble spider and the spider was a black widow. Informed the teacher it was a black widow. Thank you."

The other student who performed most poorly in the anaphoric cuing condition relative to his own score in the control condition had a diagnosis of autism, a low IQ relative to other students in the sample, and medium to high scores on WJRT-R reading measures. This student completed 11 of the anaphors correctly, but after being unable to answer one postreading question correctly, appeared to "give up" on answering subsequent questions, so motivation appeared to be the critical issue.

### Prereading Questions

The effects of prereading questions on comprehension were small and not statistically significant [ $F(1,19) = 1.19, p = .29, \eta^2 = .36$ ]. The comprehension scores of seven of the 20 students in the prereading question condition exceeded their scores in the control condition by .50 standard deviations. When participants' total reading comprehension scores in the control condition were partialled out, their total reading comprehension scores in the prereading question condition correlated significantly with WJRT-R Passage Comprehension (Table IV). That is, prereading questions appeared to contribute more to the comprehension of students whose comprehension ability was higher to begin with.

An examination of the students' transcripts shed some light on their response to the prereading questions. The two students who showed the greatest total reading comprehension scores in the prereading question condition, relative to their own control condition comprehension scores, showed similar profiles. Both had diagnoses of autism, IQs that were low relative to other students in this sample, and WJRT-R Word Identification and Passage Comprehension scores that were medium or high. Each provided answers to prereading questions that were factually correct and congruent with the content of the story. For example, both students correctly answered the prereading question, "What would happen if a poisonous spider bit you?" by stating that they would be hurt or killed. Subsequently, in the postreading comprehension question, they inferred the central idea, unstated in the story, that the two main characters who had unknowingly collected a black widow spider had barely avoided being poisoned.

Of the two students whose comprehension was poorest in the prereading question condition, relative to their own comprehension scores in the control condition, one had a diagnosis of autism and the other a diagnosis of Asperger Disorder. Both had medium IQ scores and low WJRT-R Passage Comprehension scores. The student with autism had a high WJRT-R Word identification score, and the one with Asperger Disorder had a low Word Identification score. Both students responded to prereading questions with information that was inaccurate, irrelevant, or fantasy-based. For example, for a story about an archeological dig, one prereading question asked, "How do we find out about people who lived a long time ago?" A low-scoring student responded "Travel back in time." In other instances, the students suggested answers that were appropriate to the prereading question in itself, but not relevant to the specific story, then appeared to rely on this information to answer the postreading comprehension questions. For instance, in response to a prereading question about sailing, a student commented that a ship sailing in winter could hit an iceberg and sink, and later mentioned that he had seen the movie *Titanic*. In the reading passage, a ship was abandoned by its crew after becoming icebound. However, in answering the postreading questions, this student relied on the irrelevant information that he had generated earlier: "It was a sailing ship . . . it was a good size. It probably sunk because it hit an iceberg."

### Cloze

The effects of the cloze facilitation were small and not statistically significant [ $F(1,19) = 1.06, p = .32$ ,

$\eta^2 = .28$ ]. Seven of the 20 students showed gains of more than .50 standard deviations relative to their own reading comprehension scores in the control condition. Overall, students executed the cloze task well, completing 78% of the blanks with story-appropriate answers, 19% with sentence-appropriate but not story-appropriate answers, and only 4% with inappropriate answers. However, the number of cloze items completed successfully did not correlate substantially with postreading comprehension scores [ $r(20) = .23$ ].

The two participants whose reading comprehension scores were highest in the cloze condition, relative to their own scores in the control condition, both had diagnoses of autism and IQ scores that were low for this sample; one showed medium to high scores on the WJMT-R literacy subtests, and the other showed low literacy scores. They respectively completed 10 and eight of the 12 cloze blanks correctly. In some cases, carryover from completion of cloze to the postreading comprehension was explicit. One of the students read, "The \_\_\_\_ from New York was about to make more jokes about Mutt when he saw something that made him stop." He hesitated, said, "Hmm . . . this is a hard one," then reread the sentence, and finally wrote the correct word "man" in the blank. Later, in his retelling, he recalled the episode that provoked the story: "And the man from New York is being very mean and *joking around* about Mutt," whispering the italicized words. This joke about Mutt is a main event that provokes a bet about the dog's retrieving skill, which is resolved by a test making up the climax of the story.

In contrast, of the students whose comprehension appeared to be most undermined by the prereading question intervention, one had a diagnosis of autism, a high IQ relative to this sample, and medium WJMT-R literacy scores. The other had a diagnosis of Asperger Syndrome, a high IQ, and high WJMT-R literacy scores. Comparison of these students' cloze completions with their answers to reading comprehension questions illuminated the way in which this task failed to assist them. In various instances, they said that they "did not know" the answer, or gave clearly wrong answers; in neither case did they search the text to find an appropriate completion. In a more subtle error, one of the students read a story describing archeologists discovering a skeleton in a tomb inside a pyramid, learning for the first time that the purpose of the pyramid was to contain the tomb. In response to the cloze sentence, "The tomb at Palenque was an amazing discovery. It also gave the solution to one question—the purpose of the \_\_\_\_," the student chose the partially correct answer "tomb," but needed the more general answer "pyramid" to capture the point

of the story. Later, in response to a postreading comprehension question, the student could not answer, "what new thing Ruz learned about the Mayan pyramids." In contrast, there were *no* instances in which these students correctly completed a cloze sentence, then failed to correctly answer a postreading comprehension question based on the same information, indicating that cloze completion could improve comprehension for students who complete cloze items correctly.

## DISCUSSION

To summarize the results, the procedural facilitation variable significantly affected students' comprehension of the texts. Post hoc analysis indicated that these effects were accounted for by the anaphoric cuing facilitation, which produced medium effect sizes and appeared to benefit more than half of the students substantially. The effects of the other two interventions were smaller and not statistically significant. The strengths and weaknesses of each of these facilitations can be interpreted with respect to three key aspects of reading comprehension: activation of prior knowledge, monitoring of comprehension, and repair of text representations.

Activation of prior knowledge was most directly addressed in this study using prereading questions. The results indicate the double-edged nature of this intervention. On one hand, previous research has shown that activating prior knowledge usually improves students' recall and comprehension of text (Carr & Thompson, 1996; Dewitz, Carr & Patberg, 1987; Pressley & Afflerbach, 1995; Spiers & Donley, 1998). On the other hand, the transcripts in the present study indicate that for some students, prereading questions activated prior knowledge that was irrelevant or inaccurate, and that they perseverated on this information throughout the reading and postreading phases, negatively affecting their comprehension. This problem is not unique to students with autism: Previous research has shown that for skilled "normal" readers, prior beliefs can undermine comprehension, particularly if these beliefs conflict with text information and if students do not explicitly monitor and repair these conflicts (e.g., Chan, Burtis & Bereiter, 1997; Lipson, 1982). However, because many students with autism show strong idiosyncratic interests, conflicts may be more likely to arise for this group, and because they have difficulty monitoring their comprehension, these conflicts are less likely to be noticed and resolved. In addition, it is possible that some students will lack relevant prior

knowledge or will have relevant knowledge but fail to recognize its importance for understanding a particular text.

Therefore, future research could examine methods of activating prior knowledge that rely less on students selecting relevant, accurate prior beliefs. For example, instructors could provide students with an advance organizer in the form of an abstract of the passage, which might activate prior knowledge while preventing students from “getting on the wrong track.” In addition, some reviewers have recently argued that graphic advance organizers are more effective than textual advance organizers (Sadoski & Paivio, 2001), and graphic organizers have proven effective for assisting students with autism in nonreading tasks (e.g., Bryan & Gast, 2000; Quill, 1997). This indicates that graphic advance organizers should be investigated as a means of activating relevant prior knowledge before reading.

The second aspect of reading comprehension, self-monitoring, is difficult for most students with autism spectrum disorders. In this study, postreading questions showed that most students had limited comprehension of the passages, yet they read the control passages one time through from front to back, seldom spontaneously pausing to verify or repair their comprehension of the material. Both anaphoric cuing and the cloze tasks appeared to be effective in inducing some self-monitoring behavior: When the students were required to select an antecedent pronoun or complete a cloze, none were able to produce every answer immediately, but some commented on this fact, reread portions of the text to locate relevant information, and subsequently showed gains in comprehension.

The third aspect of reading comprehension, repairing failures to comprehend, initially appeared to be accomplished through both the anaphoric cuing and cloze interventions: All students completed these tasks, and collectively, they selected correct anaphoric antecedents and cloze completions approximately 80% of the time, indicating that they were implementing this procedure meaningfully. However, the effects of these two interventions on postreading comprehension differed: Anaphoric cuing contributed to the students' postreading comprehension, and partial correlations confirmed that postreading comprehension was mediated by students' successful resolution of pronouns. In contrast, the cloze intervention was not significantly effective, and postreading comprehension was not mediated by the number of cloze sentences completed correctly. This difference in effectiveness invites further investigation.

The relationship of individual differences to the effects of these interventions also invites further study. Because the number of participants was modest, it is not possible to powerfully test hypotheses about interactions between participant variables and specific interventions while controlling for experiment-wise inflation of type II errors. However, examination of the correlations between participant characteristics and postreading comprehension, with control condition comprehension scores partialled out statistically, indicates three general trends. First, although postreading comprehension scores predictably correlated positively with individual differences in most cognitive and language abilities, when reading comprehension scores in the control condition were partialled out, most (but not all) of these correlations dropped to near zero. This indicates that in general, the effects of the interventions added to, but did not interact with, individual ability levels. Second, the positive correlation between WJRM-T-R Passage Comprehension and the effectiveness of prereading questions, combined with the qualitative analysis of the outlying cases, indicates that lower-ability students may have been misled by this intervention, whereas higher-ability students benefited from it. Third, the negative correlation between TOLD Grammatical Comprehension and reading comprehension in the anaphoric cuing condition requires explanation. One possibility is that students with high grammatical ability were processing the relationships between pronouns and their referents automatically and that prompting disrupted this process, or that students with low grammatical ability were not processing these relationships automatically, and prompting encouraged them to do so.

This is the first experimental study, as far as we were able to determine, that has examined the effects of facilitating strategies on the reading comprehension of students with autism spectrum disorders. The results tentatively indicate several educational implications. First, teachers, parents, and educational assistants could encourage students with autism spectrum disorders to check the antecedents of pronouns as they read. Second, this facilitation could be automated using computer software. Pronouns and possibly other forms of anaphora could be highlighted on the screen, and students could be required to “mouse-click” on the antecedent referent before proceeding to the next paragraph. As a given student's accuracy in identifying the antecedents increases, the program could gradually fade out this prompting. Third, students could be taught to check the referents of pronouns as an independent strategy. Effective strategy instruction requires teaching

students to apply procedures flexibly, in a variety of settings (Garner, 1990). It remains to be seen whether such instruction will permit students to enact reading comprehension strategies independently. However, this study invites cautious optimism that educators can assist students with autism to better understand the texts that they read.

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