Detecting the Ambiguity of Sentences: 
Relationship to Early Reading Skill

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The authors of this article report on a preliminary study of 18, 4- and 5-year-old children, followed by a longitudinal study of 44 children, who were tested in the first, second, and third grades. The children’s ability to detect the ambiguity of lexically ambiguous sentences (e.g., “The children saw the bat lying by the fence”) and structurally ambiguous sentences (e.g., “The girl tickled the baby with the teddy bear”) was assessed in the preliminary study and in Experiments 1 and 2, which were conducted when the children were in the first and second grades, respectively. Ambiguity detection skill was found to be related to first-grade reading readiness and to second- and third-grade reading achievement. The results suggest that the detection of lexical ambiguity develops in first grade, correlates highly with reading readiness measures, and is a strong predictor of second-grade reading ability, indicating that it is a precursor of reading skill. In this study, the ability to detect structural ambiguity emerged in second grade and was a predictor of third-grade reading ability. Clinical implications for the use of ambiguity detection tasks to identify children who are at risk for reading difficulty are discussed.

The acquisition of metalinguistic skills in middle to late childhood has long been an important area of research in typical first-language development. Initially, this interest was motivated by the fact that metalinguistic development involves an intersection of linguistic and nonlinguistic cognitive systems. The child’s ability to address the form of language as distinct from its content was viewed as a specific ramification of a general perceptual flexibility that develops in middle childhood. Interest in metalinguistic development has been heightened in recent years, however, by the discovery that these skills are related to, and predictive of, successful reading acquisition. Syntactic awareness (sensitivity to the structure of sentences), pragmatic awareness (understanding of the appropriate use of language), and—most importantly—phonological awareness (the perception of the sound structure of words) have all been implicated causally in emerging literacy. In the studies to be described here we investigated another type of metalinguistic skill, ambiguity detection (i.e., the ability to detect and report that a sentence can have more than one meaning).

Phonological awareness clearly is related to early reading ability because reading begins with an understanding of grapheme–phoneme correspondence. Phonemes, which are not present in the speech signal but are abstract objects available only through the perceptual system, must be accessible to the child. Phonological awareness, then, underlies the ability to decode. Decoding is half of “the simple view” of reading, identified by Gough and his colleagues (Gough & Tunmer, 1986; Hoover & Gough, 1990; Tunmer & Hoover, 1992). It may be stated as \( R = D \times C \), where \( R \) is reading comprehension, \( D \) is decoding, and \( C \) is listening comprehension. The power of this view is that it identifies the interaction of de-
caching and listening comprehension as the proximal cause of successful reading comprehension. Both are necessary, but neither by itself is sufficient, for reading success.

The importance of decoding and its antecedent, metalinguistic skills in phonological awareness, for early reading success is well known and has been well documented (National Reading Panel, 2000). The other component of the simple view, listening comprehension, has not been as well investigated as has decoding. We believe that the detection of ambiguity in sentences involves the same computationally processes as does listening comprehension. Thus, as phonological awareness demonstrates that the child possesses the perceptual precursors of decoding, ambiguity detection evaluates the lexical and structural processing operations that the child must transfer from auditory comprehension to text comprehension. The comprehension of spoken language is a psycholinguistic skill that is now quite well understood, and the processes involved in the comprehension of spoken language are the same as those used in the comprehension of sentences in text. Reading is, therefore, in large part a psycholinguistic skill. It is not a psycholinguistic guessing game (Goodman, 1976) but rather a task that recruits processing operations described by the psycholinguistic theory of auditory comprehension.

Two kinds of sentence ambiguity—lexical and structural—have been identified and studied. A lexically ambiguous sentence is one in which its dual meaning turns on the ambiguity of a single item. “The children saw the bat lying near the fence” has two meanings, depending on whether “bat” is taken to be a baseball bat or a flying mammal. An example of a structural ambiguity is the following sentence: “The girl tickled the little boy with the stuffed animal.” The sentence does not contain ambiguous lexical items, but there are two possible syntactic structures that could be used to organize the words of the sentence, each of which gives rise to a different meaning. In one structural analysis, the prepositional phrase “with the stuffed animal” is associated with (attached to) the verb, meaning that the girl used the stuffed animal to tickle the boy. In the other, the prepositional phrase is associated with (attached to) the noun phrase “the little boy,” indicating which boy the girl tickled. Detecting the ambiguity of a lexically ambiguous sentence thus involves lexical processing operations, whereas the detection of the ambiguity of a structurally ambiguous sentence uses processing operations that compute structure. The psycholinguistic theory of auditory sentence comprehension is an account of those operations.

Psycholinguists substantially agree that when an auditory sentence is processed, acoustic information is transformed into phonetic information and stored in working memory. Individual lexical items are then retrieved from the hearer’s internal lexicon, making available lexical information that can be used in the computation of the meaning of the sentence being processed. Simultaneously, the parser is creating a structural organization for the words. Once structure and lexical meanings are in place, the basic meaning of the sentence can be computed because the basic, literal meaning of a sentence is a function of the meanings of its words and their structural organization (Cairns, 1999; Frazier & Fodor, 1978; Mitchell, 1994; Pritchett, 1988, 1992; Simpson, 1994; Swinney, 1979).

For a lexical item to be accessed from the lexicon, phonetic information in working memory must make contact with the phonetic representation stored in the lexicon, and information about the meaning of the word (as well as other grammatical information) is retrieved (Cairns, 1999; Garnsey, Pearlmutter, Myers, & Lotocky, 1997; Lively, Pisoni, & Goldinger, 1994). In the case of homophones (ambiguous lexical items), multiple meanings are retrieved (because all are associated with the same phonetic representation). The individual selects one meaning, using relevant context, if available, and inserts it into the sentence being processed (Simpson, 1994; Swinney, 1979). Swinney and Prather (1989) and Love, Swinney, Bagdasaryan, and Prather (1999) have demonstrated that children process ambiguities in the same way as adults do, retrieving all meanings of an ambiguous lexical item and rapidly selecting one.

Structural processing works a bit differently, in that under ordinary circumstances only one structural analysis will be computed, even if more than one is compatible with the grammar. (Cairns 1999; Mitchell, 1994). The parser operates with a number of extragrammatical preferences that guide initial computation of structure. Consider, for example, the following structurally ambiguous sentence: “The student told the professor that everyone hated a lie.” In one structural analysis, “that everyone hated” is a relative clause modifying “the professor.” That analysis is not initially entertained by the parser, however, because several internal preferences guide him or her to the alternative analysis in which “that everyone hated a lie” is a clausal complement to the verb “tell.” Thus, parsing preferences in conjunction with the hearer’s internalized syntactic system leads to a preferred analysis for structural ambiguities that either is temporary (i.e., resolved before the end of the sentence) or results in a structurally ambiguous sentence.

The reader employs the same psycholinguistic processing operations as does the hearer, except that the initial phonological representation that is stored in working memory is derived from an orthographic representation (via decoding), rather than from an acoustic signal (via the speech perception system). Lexical and structural processing is essentially the same. Higher-level processes integrate sentences that have been read or heard into the context of discourse or narrative, calculate nonliteral meanings, form the basis for inferences, and so forth.

We are now in a position to think of ambiguity detection within the context of processing theory. If one hears the sentence, “The children saw a bat lying by the fence,” both meanings of the word bat are retrieved (unconsciously) from the lexicon, and one meaning is selected (also unconsciously) to
participate in the meaning of the sentence. Let us assume that the baseball bat meaning is selected for reasons of discourse context or particular experience of the listener. To declare that there is another meaning for that sentence, the hearer must reprocess the sentence and select the flying mammal meaning of the word bat the second time around. Both meanings are retained simultaneously, and ambiguity detection has been achieved. To perceive the ambiguity of a structurally ambiguous sentence, two things must happen: (a) the structure of the sentence must be reprocessed, and (b) the second time around, the preferences of the parser must be set aside so that a completely new structure (such as the one with a relative clause analysis in the example sentence) may be computed. Again, both meanings are retained simultaneously, and ambiguity detection is achieved.

Based on this analysis of ambiguity detection, two points follow: first, the ability to reprocess a sentence underlies ambiguity detection, and second, reprocessing a lexically ambiguous sentence is easier than reprocessing a structurally ambiguous one because the alternative meaning of the ambiguous lexical item has been available (briefly and unconsciously) during the initial processing of the sentence. This is not the case for the alternative structural analysis. We suggest that successful reading comprehension depends upon the ability to carry out lexical and structural processing operations rapidly and efficiently and to recover from errors by reprocessing information when initial processing goes awry. The less competent the reader, the more reprocessing will be necessary to derive meaning from the text. It is this reprocessing ability, which relies upon basic lexical and structural processing operations, that underlies success in both ambiguity detection and reading.

A number of researchers have investigated the ability to detect the ambiguity of sentences (Keil, 1980; Shultz & Pilon, 1973; Wankoff, 1983). Consistent findings in the literature have been that (a) ambiguity detection ability develops during early school age and (b) lexical ambiguity detection develops earlier than does the ability to detect structural ambiguities. Only a few studies on its relationship to early reading have been conducted, but the ones that exist have shown a correlation between early reading skill and ambiguity detection ability. Hirsh-Pasek, Gleitman, and Gleitman (1978) studied the ability of children in the first through sixth grades to appreciate humor that turned on various types of linguistic ambiguity. In every grade, good readers were better able to appreciate the jokes than poor readers; the researchers indicated that they had used reading skill as a general measure of verbal ability. Wankoff demonstrated that there was a correlation between ambiguity detection ability and scores on a standardized reading test administered to 5- to 8-year-olds and thus suggested that ambiguity detection is one of an ensemble of metalinguistic abilities related to early reading. These studies do not clearly indicate whether ambiguity detection is a precursor of reading ability or a result of a successful reading experience. The theory we present predicts that the processing and reprocessing operations employed in ambiguity detection will be precursors of early reading skill, thus enabling children who can apply those operations fluently in listening comprehension to excel in reading acquisition. Our goal was to trace the development of ambiguity detection skill and test the hypothesis that it is a predictor, rather than a result, of early reading ability.

We began with a preliminary study involving a small number of 4- and 5-year-old children to confirm reports in the literature that preschool-age children are not skilled at detecting the ambiguity of sentences. We then conducted a longitudinal study with a group of children, following them from early first grade (when they were prereaders) through the second and third grades, assessing their ability to detect the ambiguity of sentences and relating it to their reading ability as measured by a standardized measure of reading employed by the school.

**PRELIMINARY STUDY**

**METHOD**

**Participants**

The participants were 18 children who attended a nursery school in Bayside, Queens, in New York City. The nursery school draws from middle and upper-middle class families in the local area. Some children were multilingual, but all of them had acquired English natively; they were judged by their teachers to be typical in terms of intelligence and language development. Ten of the children were 4 years old (mean age = 4 years, 5 months) and eight were 5 years old (mean age = 5 years, 3 months).

**Materials and Procedure**

For the ambiguity detection task, we used 8 lexically ambiguous sentences, 8 structurally ambiguous sentences, and 8 unambiguous filler sentences. The 16 ambiguous sentences are presented in Appendix A.

The ambiguity detection task was preceded by a pretest to make sure that the child knew both meanings of the 8 ambiguous lexical items in the sentences. There was a picture for each of the 16 referents, and the 16 pictures were presented in arrays of 4. The child was asked, for example, to "Point to the picture that shows glasses." If the child did not recognize the picture spontaneously, the experimenter helped with identification. All of the children demonstrated knowledge of the relevant lexical items. We then talked with each child about the fact that sometimes a sentence can have more than one meaning, and then we gave the child 6 practice sentences, 2 of which were lexically ambiguous, 2 were structurally ambiguous, and 2 were unambiguous. The sentences were accompanied by pictures to illustrate their ambiguity, and we gave the
children feedback to help them grasp the ambiguity of the sentences.

The test sentences were then presented in the following way. The experimenter said the sentence, attempted to elicit the child’s preferred meaning, then asked if it could mean anything else. (If the child did not articulate the preferred meaning, the experimenter asked whether the sentence could mean more than one thing.) The child thus had an opportunity to detect the ambiguity spontaneously. If he or she failed to do so, a series of prompts followed. A verbal prompt was given first. For example, for the sentence “The children saw the bat lying near the fence,” the verbal prompt was “Think about the bat. What did the bat look like?” For the sentence, “The girl tickled the baby with the stuffed animal,” the prompt was “Who has the stuffed animal?” Verbal prompts were also given following the unambiguous sentences. If the verbal prompt failed to elicit detection of ambiguity, the experimenter produced two pictures, each depicting one of the meanings of the ambiguity. The two pictures for the bat sentence are shown in Figure 1. If the child then asserted that the sentence was, in fact, ambiguous, she or he was encouraged to explain the ambiguity. An acceptable response was (pointing), for example, “That’s a bat, and that one is, too.” If the child gave six incorrect responses in a row, the experimenter stopped the testing. A response counted as correct only if the child articulated the intended source of the ambiguity. We have found that children who do not detect the true ambiguity may insist that the sentence has many different meanings, all of which are irrelevant. For instance, one little girl said the bat sentence could mean many different things—the children could be out playing, they could be coming home from a party, and so forth. She vehemently rejected the animal meaning of the word bat, however.

RESULTS

We used a scoring system that reflected the greater metalinguistic skill involved in spontaneous, rather than prompted, detection. For each sentence, the following scores were awarded: 5 for spontaneous ambiguity detection, 3 for detection in response to the verbal prompt, 2 for detection in response to the picture prompt, and 1 if the ambiguity was acknowledged but not explained in response to the pictures. Because there were 8 sentences for each ambiguity type, a maximum possible score was 40 for each. Scores calculated in this manner are presented in Table 1. Because of the low scores and small number of participants who completed the task, we could not perform statistical analyses of these data. Seven of the 10 children who were 4 years old failed to complete the experiment, but only 2 of the 8 children who were 5 years old failed to do so. Even for the children who completed the task, many of the scores were extremely low. In the entire experiment, there was only one spontaneous detection (of a lexical ambiguity by a 5-year-old), and in the majority of trials, the children failed to perceive the ambiguity, even when shown pictures depicting both meanings.

DISCUSSION

The results of studies on ambiguity detection have indicated poor ambiguity detection skills in preschool-age children. However, those studies used materials and procedures very different from the ones we employed here. The results of our preliminary study did confirm that, based on our techniques and materials, the detection of sentence ambiguity is not well developed in preschoolers.

EXPERIMENT 1

Participants in this experiment were first-grade children who also participated in Experiment 2 when they were in second grade. The results from Experiments 1 and 2 were related to the children’s reading readiness scores at the beginning of first grade and to their reading achievement scores in the second and third grades.
TABLE 1. Preliminary Experiment: Ambiguity Detection Scores and Standard Deviations, by Age and Ambiguity Type

<table>
<thead>
<tr>
<th>Age</th>
<th>Lexical ambiguities</th>
<th>Structural ambiguities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Score</td>
<td>SD</td>
</tr>
<tr>
<td>4 years</td>
<td>2.4</td>
<td>4.2</td>
</tr>
<tr>
<td>(n = 10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 years</td>
<td>3.7</td>
<td>3.6</td>
</tr>
<tr>
<td>(n = 8)</td>
<td></td>
<td></td>
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</tbody>
</table>

Note. Highest possible score = 40.

METHOD

Participants
Forty-four children beginning first grade in a public elementary school participated. They ranged in age from 6 years 0 months to 7 years 3 months, with a mean age of 6 years 6 months. The school was located in a middle and upper-middle class area of Westchester County in New York State. Consent forms were distributed to all first-grade classes except for the special education classes. The children were typical of suburban public elementary school pupils. Some were from immigrant families, most were White, and all were fluent speakers of English. None of the children had any speech, language, or hearing difficulties, according to teacher reports. Due to the confidentiality policies of public schools, detailed information about the individual children is not available.

Materials and Procedure
We changed the ambiguous sentences somewhat from their form in the preliminary experiment. We used the same ambiguous lexical items, plus the word bow, but we recast the sentences so they would have similar, simpler structures. We also changed two types of structural ambiguities. The ambiguous sentences used in Experiments 1 and 2 are listed in Appendix B. Procedures for presentation and scoring were identical to those used in the preliminary experiment.

RESULTS
The mean score for lexical ambiguities was 23.52 (of a possible 40), whereas the mean score for structural ambiguities was 6.88 (of a possible 40). This difference was highly significant in a correlated samples t test, \( t(43) = 11.65, p < .0001 \).

DISCUSSION
The ability of the 6-year-olds to detect lexical ambiguities was clearly superior to that of the 5-year-olds in the preliminary study (23.52 vs. 3.7). Detection of structural ambiguities, however, continued to be poor in first grade. This is consistent with the results of other studies in which detection of lexical ambiguities was consistently superior to detection of structural ambiguities.

EXPERIMENT 2

METHOD

Participants
Thirty-six of the original 44 first-grade children participated in the second experiment. Of the 8 children who did not participate, 3 had moved away and 5 were unavailable on the day of testing. (Reading scores for the latter were available, however.) The children were now in second grade and were a year older.

Materials and Procedure
Lexically and structurally ambiguous sentences used were identical to those used in Experiment 1. The procedures for presentation and scoring were identical to those used in Experiment 1 also.

RESULTS
Table 2 presents the children’s ambiguity detection scores from Experiments 1 and 2. Because only 36 of the original 44 children participated in both experiments, as noted previously, the first-grade means reported in Table 2 differ slightly from those reported for the results of Experiment 1. An ANOVA revealed a main effect for ambiguity type, \( F(1, 32) = 159.42, p < .0001 \), and for age, \( F(1, 32) = 37.53, p < .0001 \), but no interaction between ambiguity type and age.

The number of lexical ambiguities that were detected spontaneously doubled, from a mean of 3 in first grade to a mean of 6 in second grade. No structural ambiguities were
detected spontaneously in first grade and an average of only 1 was detected in second grade. Thus, the scores for structural ambiguity detection reflected the need for either a verbal or picture probe, whereas lexical ambiguity scores were attributable to spontaneous detections. The only significant correlation was between lexical ambiguity detection in first grade and in second grade, \( r = .447, p < .006 \).

**DISCUSSION**

The children clearly improved from first grade to second grade in their ability to detect the ambiguity of sentences, with the detection of lexical ambiguities being far superior to that of structural ambiguities. Five second graders obtained perfect scores on lexical ambiguity detection; none of them came close for structural ambiguities. Furthermore, every child had a better score on lexicals than on structurals at both testing periods. It thus appears that the ability to detect the ambiguity of lexically ambiguous sentences is well developed by the end of second grade (around the age of 7). Lagging far behind, however, is the ability to detect structural ambiguities.

**RELATIONSHIP BETWEEN AMBIGUITY DETECTION AND EARLY READING**

**READING TESTS**

At the beginning of first grade, the school administered the Slingerland Reading Readiness Test (Slingerland, 1977). This test consists of three subtests: Auditory, Visual, and Letter Knowledge. Scores are expressed in raw scores. In the spring of the second- and third-grade years the children were given the fourth edition of the Gates-MacGinitie Reading Test (MacGinitie, MacGinitie, Maria, & Dreyer, 2000), which consists of three subtests: Comprehension, Vocabulary, and Decoding. A total score is also reported. All scores are initially reported as percentile ranks, but we converted them to extended standard scores, which are more amenable to statistical manipulation. The Gates-MacGinitie is widely used in schools in the United States. Teachers who have used a variety of reading tests report that the Gates-MacGinitie scores best reflect their classroom intuitions about children’s reading ability. The relationship between ambiguity detection measures and these reading scores was explored.

**RELATIONSHIP BETWEEN AMBIGUITY DETECTION AND READING READINESS (GRADE 1)**

There was a clear relationship between lexical ambiguity detection scores and both the Slingerland and Gates-MacGinitie scores. The correlations between each of the three sections of the Slingerland (administered early in the first grade) and the lexical ambiguity detection task were highly significant: Letter Knowledge, \( r = .698, p < .0001 \); Visual, \( r = .516, p < .003 \), but the highest correlation was between lexical ambiguity detection and the Auditory section, \( r = .779, p < .0001 \).

Correlations between the total score (untimed) for the Gates-MacGinitie and two sections of the Slingerland were significant: Auditory, \( r = .584, p < .001 \); Letter Knowledge, \( r = .572, p < .001 \); Visual, \( r = .241, ns. \) However, the correlation with the test of lexical ambiguity detection was the highest, \( r = .698, p < .0001 \). Lexical ambiguity detection correlated significantly with all sections of the Gates-MacGinitie: Comprehension, \( r = .686, p < .0001 \); Vocabulary, \( r = .643, p < .0001 \); Decoding, \( r = .654, p < .0001 \), but the highest correlation was with the total score, \( r = .698, p < .0001 \).

Partial correlations revealed that lexical ambiguity detection in the first grade and reading scores in the second grade, when controlling for auditory reading readiness, correlated significantly, \( r = .5698, p < .001 \), but the correlation between second-grade reading scores and first-grade auditory reading readiness scores, when controlling for lexical ambiguity detection, did not, \( r = -.064, ns. \) A step-wise multiple regression analysis revealed a similar pattern. Lexical ambiguity detection accounted for half the variance of the Gates-MacGinitie total reading score: \( R^2 = .51 \), adjusted \( R^2 = .49 \), with neither auditory reading readiness nor age accounting for significantly more of the variance. The ANOVA used to analyze the effect of lexical ambiguity detection was also highly significant, \( F(1, 28) = 29.149, p < .0001 \). A regression analysis in which each subtest of the Slingerland and lexical

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**TABLE 2.** Means and Standard Deviations of Ambiguity Detection Scores, by Grade and Ambiguity Type, for Experiments 1 and 2

<table>
<thead>
<tr>
<th>Grade</th>
<th>Lexical ambiguities</th>
<th>Structural ambiguities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>First</td>
<td>24.7</td>
<td>8.2</td>
</tr>
<tr>
<td>Second</td>
<td>331</td>
<td>5.7</td>
</tr>
</tbody>
</table>

Note. Highest possible score = 40. \( N = 36 \).
ambiguity detection were predictors of reading scores produced a similar finding. All variance was accounted for by lexical ambiguity detection. It thus appears that the ability to detect the ambiguity of lexically ambiguous sentences in the first grade, before children learn to read, is a strong predictor of their reading ability more than a year later in second grade (in fact, it is a better predictor than a standardized reading readiness test). This finding clearly suggests that the previously identified relationship between ambiguity detection and reading ability is not because good reading enhances ambiguity detection ability but rather because there is some ability associated with ambiguity detection that is a precursor to reading skill. In the general discussion section, we extend our argument that the relevant ability is the efficient recruitment of auditory language-processing procedures.

Another way to investigate the relationship between reading skill and ambiguity detection ability is to divide the second graders into reading groups based on their total scores on the Gates-MacGinitie and calculate the mean lexical ambiguity detection scores from first grade for each group. As noted previously, reading scores were available for 41 of the second-grade children. The highest reading group was composed of children whose scores were more than 1 standard deviation above the mean (n = 7), the lowest reading group was composed of children whose scores were less than 1 standard deviation below the mean (n = 9), and the middle group consisted of children whose scores fell between plus and minus 1 standard deviation from the mean (n = 25). Mean lexical detection scores for each group, as well as the average number of spontaneous detections in each group, are provided in Table 3. An ANOVA revealed a highly significant difference among the means for lexical ambiguity detection scores, F(2, 38) = 11.42, p < .0001, and also for spontaneous detections, F(2, 38) = 14.00, p < .0001. Multiple mean comparisons on lexical ambiguity detection scores indicated that the difference between the middle and lowest groups was highly significant (p < .001), whereas the difference between the middle and highest groups only approached significance (p = .07). For spontaneous detections, however, the difference between the middle and lowest groups was more significant (p < .0001), and the difference between the highest and middle groups was also significant (p = .04). The rate of spontaneous detections thus might be a more sensitive measure of lexical ambiguity detection ability than is the total detection score (which includes points earned when using verbal and picture probes).

### RELATIONSHIP BETWEEN AMBIGUITY DETECTION ABILITY (GRADE 2) AND READING ABILITY (GRADE 3)

The school administered the Gates-MacGinitie again in the third grade. Reading scores were unavailable for 6 of the 36 children who participated in the Experiment 2. Lexical ambiguity detection was still highly correlated with total reading score, r = .50, p = .005, but structural ambiguity detection in second grade emerged as strongly related to third-grade reading, r = .376, p = .04. What is perhaps most interesting, however, is that for structural ambiguity detection, spontaneous detection was more strongly related to reading ability than was total detection score; the correlation between the number of spontaneous detections of structural ambiguity and reading ability was the strongest of any of the detection scores, r = .592, p = .001. In regression analyses, spontaneous detection of structural ambiguity was an even stronger predictor of total reading score than was the spontaneous detection of lexical ambiguity (although both were significant independent predictors). The partial correlation between spontaneous detection of structural ambiguities and total reading score, when holding spontaneous lexical detection constant, was r = .55 (p = .002), whereas the partial correlation between spontaneous detection of lexical ambiguities and total reading score, when holding spontaneous structural detection constant, was r = .43 (p = .022).

In an additional test of the effect of spontaneous detection of structural ambiguities, the children were divided into two groups based on their second-grade detection scores. One group was composed of children who had at least one spon-

<table>
<thead>
<tr>
<th>Grade</th>
<th>Reading group</th>
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<tbody>
<tr>
<td></td>
<td>Highest&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>M</td>
</tr>
<tr>
<td>Lexical detection score&lt;sup&gt;d&lt;/sup&gt;</td>
<td>30.3</td>
</tr>
<tr>
<td>No. spontaneous detections&lt;sup&gt;e&lt;/sup&gt;</td>
<td>50</td>
</tr>
</tbody>
</table>

Note. N = 41.

<sup>a</sup>n = 7. <sup>b</sup>n = 25. <sup>c</sup>n = 9. <sup>d</sup>Highest possible score = 40. <sup>e</sup>Highest possible score = 8.
taneous detection \((n = 19)\); the other group was composed of children who had no spontaneous detections \((n = 11)\). We performed a \(t\) test, with the dependent variable being the children’s third-grade reading scores, and the differences were highly significant, \(t(28) = 2.49, p = .019\). It was not possible to do a similar analysis based on spontaneous lexical detection, however, because all but 2 of the children produced at least one spontaneous detection. It is interesting to note that the only 2 children who had no spontaneous lexical detections in second grade both had third-grade reading scores more than 1 standard deviation below the mean.

The differential importance of spontaneous detections for lexical versus structural ambiguities is revealed by the composition of detection types for the two kinds of ambiguities. The first-grade children detected 299 ambiguities, 46% of which were detected spontaneously and 46% in response to picture probes. (Only 8% were detected in response to verbal probes.) There were fewer than half as many detections (111) for the structural ambiguities, with only 20% of those spontaneous, 78% in response to picture probes, and 2% in response to verbal probes. A further difference between the two types of ambiguity, in addition to the number of detections, thus is the proportion that were spontaneous as opposed to responses to probes (primarily picture probes).

**GENERAL DISCUSSION**

The major empirical findings from our study are that the detection of the ambiguity of lexically ambiguous sentences develops in preschool children correlates highly with reading readiness measures and is a strong predictor of second-grade reading ability. The ability to detect the ambiguity of lexically ambiguous sentences appears to be a precursor of reading skill rather than a result of successful reading, which confirms the hypothesis that motivated this study. The ability to detect the ambiguity of structurally ambiguous sentences emerges in second grade and is a predictor (along with lexical ambiguity detection) of third-grade reading ability. Furthermore, spontaneous detection is a more sensitive measure for relating both lexical and structural detection to reading ability than is detection in response to verbal and visual probes.

We have argued that the relationship between ambiguity detection and early reading is mediated by the efficient application of those lexical and structural processing skills required for auditory comprehension. These processing operations are used to reprocess initial meanings to yield secondary meanings. Fluent processing and reprocessing are both requirements for successful reading comprehension.

Data that we cite as support for our position come from a number of sources. First, perceiving the ambiguity of a sentence involves more than simply being aware of the fact that individual words can have dual meanings. Peters and Zaidel (1980) investigated the development of homonym detection and demonstrated that children as young as 4 years old could report that words such as *bat* can refer to either a flying animal or a baseball bat. The 4-year-olds in our preliminary study, however, were completely unsuccessful in perceiving the ambiguity of sentences that turn on homonyms, often even after viewing pictures depicting both meanings. There is, then, something special about detecting the ambiguity of sentences beyond detecting the dual meaning of individual words. We believe that the difference lies in the need to reprocess the sentence, engaging lexical retrieval operations, to perceive and report its ambiguity.

The manner in which the comprehension system deals with ambiguity has always been of major importance in research on sentence processing. In large part, this is because ambiguity is rampant in natural language, so no theory of sentence processing will be adequate unless the processing of ambiguity is understood (Cairns, 1999; Mitchell, 1994; Simpson, 1994). The most frequently used words in every language are multiply ambiguous, so meanings must be selected and revisited throughout the processing of most sentences in normal conversation. We have already cited work by Swinney and his colleagues demonstrating the initial (unconscious) retrieval of all meanings of ambiguous items by both children and adults, followed by the selection of a single meaning based either on context or preference. Also, most sentences are temporarily structurally ambiguous, so structures must be constructed and revised during sentence processing (Ferreira & Henderson, 1998; Frazier & Clifton, 1998; Gorrell, 1998; Lewis, 1998). To illustrate this point, consider a sentence with a common structure, such as “Everyone believed John was intelligent.” The first three words, “everyone believed John,” are temporarily structurally ambiguous; “John” can either be the object of “believed” or the subject of a new clause. The latter analysis turns out to be the correct one, but the structural processor could not have known that when only the first three words had been received. In fact, there is reason to believe that the initial analysis would be the incorrect one, in which “John” is analyzed as the object of “believed.” In that case, the processor would have to reprocess the structure online, when “was” is received. The language processing system thus must constantly deal with ambiguity “online,” that is, as sentences are being processed word by word. In addition to the work investigating how children deal with lexical ambiguity, that we previously cited, recent work by Trueswell, Sekerina, Hill, and Logrip (1999) has shown that 5-year-olds are not able to revise online their incorrect structural analysis of temporarily ambiguous sentences as efficiently as adults do. These results demonstrate that there is a developmental component to the ability to revise syntactic analyses. It appears that children process lexically ambiguous items in an adult-like manner at an earlier age than they do structurally ambiguous items.

Studies of good and poor readers that go beyond investigations of decoding suggest that good readers are better able than poor readers to make use of their developing lexical and structural processing skills. For instance, it has been shown that speed of naming familiar objects (when vocabulary is controlled) is a predictor of early reading success (Snowling,
Van Wagtendonk, & Stafford, 1988; Wolf, Bowers, & Piddle, 2000). We suggest that this is the result of greater speed and efficiency of lexical access in good readers. Poor readers also require more phonological information about a word before they can retrieve it (Metsala & Walley, 1997). Other studies have indicated that good readers tend to be better than poor readers at processing the structure of sentences (Bentin, Deutsch, & Liberman, 1990; Bowey, 1986; Byrne, 1981; Menyuk et al., 1991; Stein, Cairns, & Zurif, 1985; Waltzman & Cairns, 2000), implying that children with reading difficulty have an impaired syntactic processing system. Finally, it is well known that early reading is enhanced if a child can recover from a reading mistake (miscue) by reprocessing the sentence or passage until comprehension is achieved (O’Donnell & Wood, 1999, and references cited therein). We suggest that successful miscue repair engages the same lexical and structural processes that are used in ambiguity detection.

In summary, we have shown that the metalinguistic skill of detecting the ambiguity of sentences is a precursor to early reading success. Ambiguity detection requires that the detector examine form and meaning independently while holding and attending to two representations simultaneously. It is, however, more than “merely” metalinguistic. Psycholinguistic operations associated with auditory comprehension must be used to produce the representations on which metalinguistic skills will operate. Ambiguity detection thus is, at least in large part, a reflection of the fluency, automaticity, and speed of one’s ability to employ those processing operations. Successful reading and miscue repair depend on the efficiency of those auditory comprehension processes in tandem with decoding skill.

The clinical implications of our findings and analysis are clear. Lexical ambiguity detection can take its place alongside phonological awareness as an identifier of children who are at risk for reading difficulty. Analogously, auditory comprehension processes should take their place alongside decoding as necessary components of reading acquisition. Intervention studies are needed to determine whether ambiguity detection can be accelerated by training and, if so, whether enhancing ambiguity detection enhances early reading. Other methods of training children to reprocess auditory information might also enhance their success in miscue analysis and reading ability.

The diversity of participants in the study reported here is both an advantage and a disadvantage in interpreting the results. On the positive side, such statistically powerful emerging from a sample that probably has a large amount of variability demonstrate exceptionally strong relationships among variables. On the negative side, we need to know whether more narrowly defined groups of children, such as second-language learners, bilingual children, and children with language learning disabilities, will show similar results with respect to the development of ambiguity detection and its relation to reading skill.


APPENDIX A: PRELIMINARY EXPERIMENT—AMBIGUOUS SENTENCES

**Lexical Ambiguities**
1. The children were told to stop because nails were making too many scratches on the furniture.
2. The children saw the bat lying near the fence.
3. Peter felt terrible after the punch at the party.
4. The waitress became upset when the glasses fell on the floor and broke.
5. It was the cold that made Berry feel terrible.
6. The little boys told the cowboy that they loved playing with the straw that they found.
7. The man in the shop brought the pipe home with him.
8. The lady was annoyed by her weight/wait in the doctor’s office.

**Structural Ambiguities**
1. The fat soldier’s wife always stood by the window.
2. The white dog’s sweater needed to be cleaned.
3. The police were asked to stop smoking on the train.
4. The janitor was asked to stop the noisemaking in the hallway.
5. The lady knew that the elephant was ready to lift.
6. Everyone knew that the chicken was ready to eat.
7. The little girl tickled the cute little baby with the stuffed animal.
8. The sheriff caught the robber with the gun.

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APPENDIX B: EXPERIMENTS 1 AND 2—AMBIGUOUS SENTENCES

**Lexical Ambiguities**
1. The man’s nails were very sharp.
2. The children saw a bat lying by the fence.
3. The glasses fell on the floor and broke.
4. The kids showed the man the straw.
5. The cold made Betty feel terrible.
6. The weight/wait made the boy angry.
7. The boy picked up the bow.
8. The man held the pipe.

**Structural Ambiguities**
1. The elephant was ready to lift.
2. The chicken was ready to eat.
3. The sheriff caught the man with a gun.
4. The girl tickled the baby with the stuffed animal.
5. Flying kites can be exciting.
6. Bouncing balls can make people laugh.
7. The boy watched the little fish and turtles.
8. The woman saw the broken cups and dishes.