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Sentence Processing by Adolescents With and Without Mental Retardation

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A more thorough test of the hypothesis that persons with mental retardation are less likely to construct semantically integrated representations of sentences that they hear than are subjects without mental retardation (Merrill & Bilsky, 1989; Merrill & Mar, 1987) was provided. A series of sentences were presented to adolescents with and without mental retardation. Their memory for the object nouns of the sentences was then tested when they were provided with either the subject noun, the verb, or the subject plus verb of the sentence as a retrieval cue. The two-word cue was relatively better if an integrated semantic representation was constructed. Manipulations included decreasing the processing time given to subjects (expected to inhibit the construction of integrated representations) and presenting a picture with the sentence (expected to facilitate the construction of integrated representations). The reduction in time decreased performance for the subjects without mental retardation to the level normally observed for those with mental retardation; presenting a picture increased performance of subjects with mental retardation to the level of comparison subjects. Results support the suggestion that previously observed differences in sentence processing between individuals with and without mental retardation may be due to differences in generating integrated representations of the sentences during processing.

Current theories of discourse comprehension suggest that one important aspect of sentence processing is establishing cohesive relations among the individual words in a sentence (see, e.g., Kintsch, 1988; Rumelhart & McClelland, 1986; Waltz & Pollack, 1985). Professionals generally assume that these relations are established through some form of integration process. Although the exact nature of this integration process is under theoretical debate, some of the characteristics of the resulting semantic representations of sentences in memory have been reported in the literature.

One aspect of sentence comprehension and memory that appears to be influenced by the integration of individual words

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of sentences is the activation of a context-specific meaning of the words. The initial processing of sentences involves accessing all of the information contained in the conceptual nodes represented by the constituents of the sentence. This information includes meanings that are both appropriate and inappropriate to the current context of the words (Conrad, 1974; Kintsch & Mross, 1985; Swinney, 1979). Such a representation is conceptually similar to a general associative model in which strings of words are linked by simple associations (cf. Anderson & Bower, 1971, 1972). Over time, usually less than a second, the context-appropriate word meanings come to dominate the semantic representation constructed for the sentence, and the context-inappropriate meanings are lost (e.g., Till, Mross, & Kintsch, 1988). The context supplied by the sentence and the individual's knowledge base is integrated with the individual words of the sentence to specify the meaning of the words more precisely (see Kintsch, 1988).

Research has also shown that the semantic integration of the sentence constituent involves accessing meaning from the sentence that is not available from the combined meanings of the individual words, but only available from the overall configuration of the sentence (e.g., Barclay, 1984; Till, 1977). For example, Till (Experiment 3) presented subjects with sentences such as "The millionaire fell from the window." Recall of the sentences was cued with either words such as *suicide* that were related to the overall meaning of the sentences but not related to individual words (an inference cue), words that were only related to the subjects of the sentences, or words that were only related to the predicates of the sentences. Retrieval was best when subjects received the cues that referred to emergent configural properties (e.g., suicide) relative to cues that referred to individual sentence components. Because the information in the inference cue was not directly related to the particular words of the sentence, it is likely that it was an inference that emerged as the result of the integration of the sentence constituent. In addition, because cues that were related to the overall meaning of the sentence were most effective at eliciting retrieval, it appears that the integrated representation takes precedence over other representational forms.

The research reported in the present study also focuses on the observation that providing information about the meaning implied by the overall configuration of sentences as retrieval cues leads to better retrieval of the sentences than does providing only information about the individual words of the sentences (e.g., Foss & Harwood, 1975; Merrill & Bilsky, 1990; Till, 1977). Merrill and Bilsky (1990) recently obtained evidence suggesting that the retrieval of sentences by individuals with mental retardation is facilitated less by increasing the amount of configural information about the sentence meaning in retrieval cues than is the performance of individuals without mental retardation matched on either mental age (MA) or chronological age (CA). They asked subjects with and without mental retardation to listen to a series of agent–action–object sentences, after which recall of the sentences was tested under conditions in which subjects received the subject only, verb only, or subjects plus verb of the original sentences as recall cues. The measure of interest was the degree to which recall of the object noun of the sentence from the two-word cues was greater than would be predicted from subjects' performance to the one-word cues. The subjects' predicted two-word cue performance was based on the formula:

$$[P(O/SV) \leq P(O/S) + P(OV) - P(O/S)\,9 \times P(OV)],$$

where P(O/S), P(OV), and P(O/SV) refer to the probability of recalling the object noun of the sentence from the subject only, verb only, and subject plus verb cues, respectively (see Foss & Harwood, 1975). This

formula reflects the operation of an associative network representation of sentences in memory that does not include information provided by the overall configuration of the sentence (cf. Anderson & Bower, 1971, 1972). If subjects construct representations of sentences that do not include meaning implied by the configuration of the sentences, then their ability to recall the object noun of a sentence when provided a cue containing both subject and verb can be predicted on the basis of their recall of the object noun from a cue containing only the subject noun and a cue containing only the verb. More specifically, recall of the object noun when provided a cue containing both the subject and verb can be no greater than the level of recall predicted from the one-word cues.

Merrill and Bilsky (1990) assumed that the degree to which subjects constructed representations that did include configural information about sentence meanings would be reflected in the degree to which the number of object nouns recalled from the subject plus verb cues exceeded the number predicted by this formula. More configural information was available in the two-word cues than in the one-word cues. Hence, the two-word cues should have led to better object noun recall than would be predicted by performance with the one-word cues for subjects who include this configural information in their sentence representations.

Merrill and Bilsky's (1990) results indicate that the CA-matched subjects without mental retardation exhibited the largest two-word cues advantage; the MA-matched subjects without mental retardation, the second largest two-word cues advantage; and the subjects with mental retardation, the smallest. Hence, they concluded that the subjects with mental retardation constructed semantic representations of sentences that contained less configural information than did the subjects without mental retardation. Further, because accessing configural information requires looking at relations among words in a sentence, these results provided some indirect support for the hypothesis that individuals with mental retardation relative to those without mental retardation exhibit a deficiency in semantically integrating the words of a sentence during sentence processing. The present paper was designed to provide a stronger test of this hypothesis.

The general procedure used was similar to that of Merrill and Bilsky (1990). In addition, we manipulated two variables that were expected to differentially influence the likelihood that individuals would construct integrated representations of sentences. One manipulation was to reduce the amount of processing time available. The integration of sentence constituents takes place over time (see, e.g., Kintsch, 1988; Till et al., 1988); thus, a reduction in the amount of sentence-processing time should interfere with the formation of an integrated representation of the sentence and with the accessing of information available in the configuration of the sentence. The reduction of processing time should, therefore, impact upon the performance of the subjects without mental retardation who access relational information available in the sentences and not the subjects with mental retardation who do not. The former subjects should exhibit a smaller recall advantage when presented the two-word relative to the one-word cues when processing time is reduced, and the subjects with mental retardation should exhibit no difference between conditions of fast and slow sentence-processing times.

The second manipulation was to present a picture depicting an integrated representation of the sentence as each sentence was heard. We reasoned that presenting a picture would encourage subjects to access relational information from the sentence. If this is the case, then the manipulation should not influence the performance of the subjects without mental retardation because they are already accessing the relational information and generating integrated representations of the sentences in memory. However, we expected that presenting a picture to the

subjects with mental retardation would increase the likelihood of their generating integrated representations of the sentences and incorporating relational information into those representations. Therefore, the subjects with mental retardation should exhibit a greater advantage of the two-word cues relative to the one-word cues when pictures are presented with the sentences than when they are not. No difference between picture and no picture (slow processing time) was expected for the subjects without mental retardation.

Merrill and Bilsky (1990) found that the proposed measure of performance differences (predicted vs. actual object noun recall) is sensitive to difference in overall recall. As the number of items recalled from the one-word cues increased, the predicted recall of the object noun to the subject plus verb cue approached ceiling. The actual recall of the object noun to the two-word cue cannot be greater than ceiling; therefore, the potential difference between the two conditions is smaller for subjects who recall more from the one-word cues than it is for subjects who recall less. If the subjects in each Group x Condition combination recall the same amount when presented one-word cues, this is not a problem. However, it is not likely that individuals with and without mental retardation will recall the same amount under similar presentation conditions. We resolved this problem by presenting sentence lists of different lengths as a function of groups and conditions. The purpose was to equate, as nearly as possible, the number of object nouns recalled by subjects in each condition. Thus, we were able to compare predicted versus actual object noun recall across conditions. However, a potential confounding was introduced: Subjects with mental retardation received shorter sentence lists than did comparison subjects. However, because the shortest list contained 21 sentences, it seemed reasonable to conclude that we were measuring long-term memory performance in each condition rather than different memory systems across groups.

Method

Subjects

Subjects were 54 individuals with mild mental retardation recruited from local senior high schools and rehabilitation centers and 54 individuals without mental retardation selected from freshman classes at the University of Alabama. The mentally retarded sample had a mean CA of 16.9 years (standard deviation [*SD*] = 1.4) and a mean IQ of 61.3 (*SD* = 17.6). The nonretarded sample had a mean CA of 17.9 years (*SD* = .6).

Materials

Experimental sentences were 42 agent–action–object sentences generated by the experimenter, with care taken to ensure that preexperimental associations among the constituents of each sentence were minimal (e.g., "The mailman watched the kite"). An additional 26 sentences were used as filler sentences and enabled us to vary list length to ensure equivalent levels of recall across conditions. The presentation order of the experimental sentences was randomized. Filler sentences were selected randomly as needed. Pictures that accurately depicted the meaning of each sentence were selected from children's books or drawn by an artist. Pictures were such that subjects could recognize their relation to the sentences but would not spontaneously generate the corresponding sentences upon viewing the picture; thus, subjects were required to listen to the sentence in order to recall the object nouns. The sentence list was tape recorded twice, with either a 1-second or a 3-second pause between sentences. Each sentence was also typed individually on a 5 x 8 inch index card.

Test materials were three equivalent forms of a 42-item cued-recall test derived from the experimental sentences. Each cue, typed separately on a 5 x 8 inch index card, consisted of either one or two words. Fourteen of the cues on each form provided only

the subject noun of the original sentence (e.g., mailman), 14 provided only the verb (e.g., watched) and 14 provided both the subject and verb of the original sentence (e.g., mailman watched). Presentation order of cues within each form was determined randomly. The three test lists were constructed such that in each list every sentence was tested only once, and across all lists every sentence was tested three times, once with each type of cue. Subjects received only one form of the test materials, with an equal number of subjects in each Group x Condition combination receiving a particular version of the test materials.

Design and Procedure

The variables in the experiment were group (mentally retarded, nonretarded), presentation condition (1-second delay, 3-second delay, picture), and type of cue (subject only, verb only, subject plus verb).

Presentation condition was manipulated between subjects, with 18 subjects per group randomly assigned to each condition. Type of cue was manipulated within subjects. The dependent variable was the proportion of object nouns recalled from each type of cue.

Subjects were tested individually in a single session. On the basis of pilot work, we determined that equivalent levels of recall could be obtained by providing subjects with sentence lists of the following lengths. Subjects with mental retardation received two lists of 21 experimental sentences per list (half of the experimental sentences in each list) in the 1-second and 3-second delay conditions, and one list of 42 experimental sentences in the picture condition during the study phase of the procedure. Subjects without mental retardation received one list of 42 experimental sentences in the 1-second delay condition, one list of 58 sentences (42 experimental and 16 filler sentences) in the 3-second delay condition, and one list of 68 sentences (including 26 filler sentences) in the picture condition during the study phase of the procedure. When filler sentences were used, half were presented at the beginning of the list and half were presented at the end of the list.

During the experimental session, subjects were informed that they would be hearing a list of sentences after which their memory for the sentences would be tested. In the 1-second and 3-second delay conditions, subjects were allowed to read each sentence as it was presented orally. Both written and auditory presentations of sentences were used because pilot work for Merrill and Bilsky (1990) had indicated that written sentences increased the likelihood that subjects would attend to the sentences throughout the session. In particular, we found that subjects with mental retardation (including subjects who were unable to read the sentences) performed better when written sentences were provided than when written sentences were not provided. This manipulation did not influence the performance of the subjects without mental retardation. In the picture condition subjects received sentences at the 3-second delay and were presented a picture depicting the meaning of the sentence as the last word of the sentence was presented. These subjects were not shown the written sentences. After all of the sentences in the list were presented, the subjects were given the cued-recall test. Cues were provided in both oral and written form. The subjects were informed that each cue was a part of one of the sentences that they had just heard and that they were to fill in all of the missing parts of the sentences that they could remember. Oral responses were recorded verbatim by the experimenter. Fifteen seconds were allowed for a response. Once a test item was passed, returning to that item was not allowed. Subjects who received two lists of 21 sentences went through the procedure separately with each list.

Results

The proportion of words recalled cor-

rectly to each type of cue and the predicted value of P(O/SV) are reported in Table 1. The predicted value of P(O/SV) was calculated separately for each subject and then averaged to obtain the values reported in Table 1. Protocols were scored for both verbatim and substance recall. Verbatim scoring allowed only abbreviations and changes in number or tense. Substance scoring allowed both synonyms and close superordinates (e.g., "food" for "dinner") of the original sentences to be scored as correct. Two independent raters scored each protocol. There were only two disagreements in scoring, which were resolved through discussion. The analyses of verbatim and substance recall yielded identical results; therefore, only the analysis of substance recall is reported here.

A preliminary analysis was conducted to compare the number of object nouns recalled from each type of cue. This analysis was a 2 (group: retarded, nonretarded) x 3 (presentation condition: 1-second delay, 3-second delay, picture) x 3 (type of cue: subject only, verb only, subject plus verb) analysis of variance, with type of cue treated as a within-subjects factor. The analysis revealed a significant effect of type of cue, $F(2, 204) = 166.082$, $p < .001$, with subjects recalling the largest proportion of object nouns from the subject plus verb cue (.515), second largest from the subject only cue (.320), and least from the verb only cue (.212). In addition, there was a significant Group x Type of Cue interaction, $F(2, 204) = 3.078$, $p < .05$, with the subjects without mental retardation exhibiting a higher level of recall than did the subjects with mental retardation from the subject plus verb cue (.486 and .560 for the subjects with and without mental retardation, respectively), $F(1, 51) = 10.1$, $p < .001$, but equivalent levels of recall from the subject-only (.300 vs. .335 for the subjects with and without mental retardation, respectively) and verb-only cues (.221 vs. .204, respectively). This latter finding is particularly important to the design of this study in that it was necessary that groups recall approximately the same in the subject only and verb only cue conditions in order to justify a direct comparison of predicted and obtained recall from the subject plus verb cues.

The analyses of primary interest compared actual recall from the subject plus verb cue to predicted recall from the subject-only and verb-only cues (see Table 1). The analysis was a 2 (groups) x 3 (type of presentation) x 2 (type of cue: obtained and predicted) analysis of variance, with type of cue as a within-subjects variable. There a significant main effect of type of cue, $F(1, 102) = 64.366$, $p < .001$. Actual recall was better than predicted recall regardless of group or type of presentation (.523 vs. .450, respectively). There was a significant interaction of Group x Type of Cue, $F(1, 102) = 6.600$, $p < .05$, with the difference between actual and predicted recall being greater for the subjects without mental retardation (mean= .096, SD = .075) than for the subjects with mental retardation (mean = .050; SD = .099). There was a significant Type of Presentation x Type of Cue interaction, $F(1, 102) = 3.287$, $p < .05$,

Table 1
Proportion of Object Nouns Recalled by Group, Type of Presentation, and Type of Cue

	Type of cue						Predicted	
	Subject		Verb		Subject/Verb		Subject/Verb	
Group/Presentation	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Mentally retarded								
1 second	.294	.187	.218	.129	.457	.217	.417	.244
3 second	.281	.176	.214	.095	.444	.200	.431	.187
Picture	.321	.198	.230	.133	.560	.221	.462	.199
Nonretarded								
1 second	.290	.165	.155	.087	.448	.236	.392	.205
3 second	.373	.218	.206	.139	.619	.209	.496	.206
Picture	.341	.176	.250	.161	.611	.182	.501	.185

with the difference between actual and predicted recall being largest for the picture condition (mean= .104, *SD* = .086), second largest for the 3-second delay condition (mean = .068, *SD* = .082), and least for the 1-second delay condition (mean = .048, *SD* = .097). However, these effects were qualified by the significant interaction of Group x Type of Presentation x Type of Cue, $F(2, 102) = 3.159$, $p < .05$.

The significant three-way interaction was analyzed by looking at the effect of group and type of cue separately for each type of presentation. In the 1-second delay condition, there was a significant main effect for type of cue, $F(1, 34) = 7.321$, $p < .01$. There were no group differences in the size of this effect (mean = .040, *SD* = .112 for the retarded group and mean = .056, *SD* = .085 for the nonretarded group). In the 3-second delay condition, there was a significant effect of type of cue, $F(1, 34) = 16.482$, $p < .001$, and a significant Group x Type of Cue interaction, $F(1,34) = 10.803$, $p < .01$. Actual recall was greater than predicted for both groups, but the difference was greater for the subjects without mental retardation (mean = .123, *SD* = .066) than for those with mental retardation (mean = .013, *SD* = .097). In the picture condition, there was also a significant effect of type of cue, $F(1, 34) = 67.584$, $p < .001$. As in the 1-second delay condition, there were no group differences in the magnitude of this effect (mean = .098, *SD* = .092 for the mentally retarded group and mean = .110, *SD* = .081 for the nonretarded group). However, a direct comparison of the 1-second delay and picture conditions revealed that they were not identical. The difference between actual and predicted recall was significantly greater in the picture condition (mean = .104) than in the 1-second delay condition (.048), indicating a higher degree of subject-plus-verb cue advantage for both groups in the picture condition.

Discussion

The results of this study were consistent with our hypotheses. When task conditions were structured to inhibit accessing relational information about the words of the sentences and constructing integrated sentence representations, the difference between predicted and observed object noun recall by the subjects without mental retardation was reduced to the level exhibited by the subjects with mental retardation. The subjects with mental retardation did not exhibit a decrease in observed object noun recall when processing time was reduced, indicating that they performed similarly with long and short processing times. When task conditions were structured to facilitate the formation of an integrated semantic representation of the sentences, the difference between predicted and observed object noun recall by the subjects with mental retardation increased to a level that was similar to that of the subjects without mental retardation. The performance of the subjects without mental retardation was not affected by presenting pictures with the sentences. Taken together, these results support the hypothesis that individuals with mental retardation are less likely than individuals without mental retardation to incorporate information about the relations between words in the semantic representations of sentences that they hear and read.

The patterns of performance exhibited by the subjects with and without mental retardation suggests that the difference in how they integrate relational information may be strategic in nature. The subjects without mental retardation were not able to access and use relational information when processing time was reduced to one second. If relational information were automatically incorporated into the semantic representations of the sentences by the subjects without mental retardation, then a reduction in processing time should not have interfered with accessing the relational information. Hence, it appears to be an active, effortful component of sentence processing that distinguishes the performance of individuals with and without mental retardation (see

Kintsch, 1988). The former seem to have processed the sentences in a relatively passive manner, regardless of processing time. One expected consequence would be that the semantic representations of sentences generated by the subjects with mental retardation would be less context-specific than those generated by individuals without mental retardation (see, e.g., Barclay, Bransford, Franks, McCarrell, & Nitsch, 1974; Merrill, Sperber, & McCauley, 1981); that is, the representations of the individuals with mental retardation would contain fewer context-appropriate features and more context-inappropriate features. In addition, individuals with mental retardation would be expected to be less likely than those without mental retardation to generate appropriate inferences from sentences that they read and hear (see Seidenberg, Tanenhaus, Leiman, & Bienkowsky, 1982; Till et al., 1988). Both of these consequences would lead to general deficiencies in language comprehension.

We cannot rule out the possibility that the difference in sentence processing between the subjects with and without mental retardation was simply the result of the failure of the subjects with mental retardation to recognize the semantic relations between the words used in the study. However, we did find that they were able to recognize and make use of the appropriate relations when they were presented in pictures. We have, therefore, tentatively concluded that their difficulty was specific to accessing context-appropriate relational information from the sentences. However, it is not clear whether this sentence-processing deficiency will generalize to a wider range of sentences. We were careful to ensure that there were no preexperimental associations between the words of the sentences used in this experiment in order to prevent biasing the results in favor of holistic, integrated representations of the sentences. Perhaps individuals with mental retardation would be more likely to exhibit an ability to access and use relational information between words in sentences if the associative relations between the words were stronger and more obvious. Future research should be directed at determining the nature of the task conditions and sentences that may enable individuals with mental retardation to acquire relational information from sentences.

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