American Journal on Mental Retardation
1992, Vol. 97, No. 2, 173-185

Degree of Associative Relatedness and Sentence Processing by Adolescents With and Without Mental Retardation

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Previous research has suggested that individuals with mental retardation are less likely than individuals without mental retardation to access and incorporate information about the relations between words of sentences in the representations of those sentences in memory (e.g., Merrill & Bilsky, 1990; Merrill & Jackson, in press). A cued recall study and a semantic verification study were conducted to determine whether the magnitude of this group difference could be made smaller by increasing the degree to which the words in the sentences were semantically related. In both experiments, individuals with mental retardation exhibited an ability to utilize contextual information to a greater extent when the words were related. In the highly related conditions, the differences between groups was virtually eliminated.

Comprehending spoken and written language is a critical skill. Individuals who possess weaker language comprehension skills typically function much less effectively in everyday life. Persons with mental retardation often exhibit a variety of difficulties when processing even relatively simple sentences (see, e.g., Bilsky, 1985). For example, they perform more poorly than do individuals without mental retardation on tasks involving recall of individual sentences (e.g., Bilsky, Walker, & Sakales, 1983). In addition, although there is some evidence to suggest that they are able to make appropriate inferences when listening to sentences (Paris, Mahoney, & Buckholt, 1974), there is also evidence indicating that this tendency is not as strong as for individuals without mental retardation (e.g., Mar & Jones, 1983).

Several years ago, we began a series of studies to investigate some of the underlying cognitive causes of the deficiencies in sentence-processing exhibited by persons with mental retardation. The results of several studies indicated that there were clear differences in the quality of the semantic representation that individuals with and without mental retardation encode while processing sentences that they hear and read (Merrill & Bilsky, 1989; Merrill & Mar, 1987; Merrill & Jackson, in press). In particular, we focused

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on the possibility that persons with mental retardation would be less likely to construct semantic representations of sentences in which the components of the sentences are well-integrated. Most current theories of discourse processing consider integrating individual words of a sentence with each other and with existing knowledge structures to be an important aspect of sentence comprehension (see Kintsch, 1988; Rumelhart & McClelland, 1986). The initial processing of sentences appears to involve accessing all of the information contained in the conceptual nodes represented by the constituents of the sentence. This initial information includes meanings that are both appropriate and inappropriate to the current context of the words (see Conrad, 1974; Kintsch & Mross, 1985; Swinney, 1979). We have viewed such a representation as similar to a general associative model in which strings of words are linked together by simple associations (cf. Anderson & Bower, 1971, 1972). Over time, usually 300 to 500 msec, the context-appropriate word meanings become dominant in the semantic representation constructed for the sentence, and the context-inappropriate meanings are lost (e.g., Till, Mross, & Kintsch, 1988). The semantic and syntactic context supplied by the sentence frame and the individual's knowledge base is apparently used to specify the meaning of the sentence in general and of the individual words more precisely through some form integration process (see Kintsch, 1988).

One example of how this works is found in the research of Barclay et al. (1974). Subjects were presented sentences in which the sentence context biased the interpretation of one of the words in the sentence toward one or another aspect of the word's meaning. For example, the word *piano* was presented in one context in which the important feature of piano was that it is a heavy object ("The man pushed the piano") or in a second context in which the important feature was that it is a musical instrument ("The man played the piano"). When asked to recall the words in a cued recall test, subjects who had received the first sentence were able to recall the word best if the cue supplied at recall focused on the "heaviness" of the piano rather than its "musical" quality. Subjects who had received the second sentence were better at remembering the word *piano* when the cue focused on its "musical" quality. Given the logic of the cued recall paradigm, Barclay et al. concluded that the semantic representations of individual words are flexible in that they are changed to reflect the context in which they appear.

A failure to contextually specify the meanings of words in sentences does not necessarily render the sentences completely incomprehensible (see Merrill & Mar, 1987; Merrill, Sperber, & McCauley, 1981). Rather, this is a "deeper" level of analysis and not the only level that allows comprehension. For example, Kintsch (1988) discussed at least three levels of analysis that occur during discourse comprehension: (a) There is a *linguistic representation* that is analogous to what we have called an *associative network representation*; this is the level of representation that maintains independent information about the individual word concepts. (b) In a more conceptual level of representation, sentence phrases are turned into propositions and basic inferences are made. (c) There is a level of analysis where the specific text is lost, and the information presented in the text is incorporated into some larger information structure, such as a schema representing related information. Our focus in these studies has been on the transition from the initial level of analysis to the next level, where context-specific meanings and inferences dominate the semantic representation of the sentence (see Kintsch, 1988; Till et al., 1988). Because these aspects of sentence processing are assumed to result from integrating information available from the individual word concepts (Kintsch, 1988), we reasoned that we could assess differences in the ability of persons with and without mental retardation to achieve this level of analysis by examining the semantic representations that they encode during sentence

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Merrill and Bilsky (1990) compared the semantic representations encoded by persons with and without mental retardation using a cued-recall procedure patterned after Foss and Harwood (1975). Participants listened to a series of agent–action–object sentences, after which their ability to recall the sentences was tested under conditions in which they received the subject only, verb only, and subject plus verb of the original sentences as recall cues. We were interested in the degree to which recall of the object noun of the sentence from the double-word cues was greater than that predicted from subjects' performance with the one-word cues, where subjects' predicted double-word cue performance was based on the formula $P(O/SV) \leq P(O/S) + P(O/V) - P(O/S) \times P(O/V)$. *P(O/S)*, *P(O/V)*, 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 is based on an associative network representation of the sentence in memory that does not include information provided by the overall syntactic and semantic context of the sentence (cf. Anderson & Bower, 1971, 1972). If some forgetting occurs, P(O/SV) can be smaller than predicted from P(O/S) and P(O/V), but it cannot be greater than predicted unless the subject plus verb cue includes information that is not available from the subject only and verb only cue.

In Experiment 1, this probability formula was used in the following manner. We reasoned that a more integrated representation of the sentence would incorporate information from the overall context as well as the individual words of the sentence. In contrast, less well-integrated representations would be expected to more closely resemble the linguistic or surface structure of the sentence. Because more of the contextual information is also present in the double-word than in the single-word cues, the degree to which subjects construct integrated representations that include this contextual information would be reflected in the degree to which the actual number of object nouns recalled from the subject plus verb cues exceeds the number predicted by this formula; that is, performance is best when the cue and the semantic representation both contain the additional contextual information. Merrill and Bilsky's (1990) results revealed that subjects without mental retardation matched on CA with the retarded sample exhibited the largest double-word cue advantage, subjects without mental retardation matched on MA exhibited the second largest double-word cue advantage, and subjects with mental retardation exhibited the smallest advantage. Hence, the authors concluded that the subjects with mental retardation were less likely to incorporate contextual information and construct integrated representations of sentences that they heard and read than were the subjects without mental retardation.

Merrill and Bilsky's (1990) results were confirmed and extended in a subsequent study (Merrill & Jackson, in press). Subjects were presented a series of sentences under conditions in which there was a 1-second pause between sentences, a 3-second pause between sentences, or a picture presented depicting the meaning of each sentence as the sentence was presented. The results of the 3-second condition essentially replicated the results of Merrill and Bilsky (1990). In the 1-second pause condition, the level of performance exhibited by the subjects without mental retardation was reduced to the level exhibited by the subjects with mental retardation. This was interpreted as indicating that the difference in recall performance between subjects with and without mental retardation in the 3-second condition was likely to be due to a strategic and effortful difference between groups (Merrill & Jackson, in press). If accessing relational information from sentences is relatively automatic, then the performance of the subjects without mental retardation should not have been affected by the reduction of processing time (see also Kintsch, 1988; Till et al., 1988).

In the picture condition, the performance of the subjects with mental retardation was increased to the level exhibited by the subjects without mental retardation. Apparently, the added contextual information supplied by the picture was sufficient to encourage the subjects with mental retardation to incorporate that information into their semantic representations of the sentences. However, they did not focus on the context-specific meanings of the words when pictures were not present.

Taken together, the results of these earlier studies suggest that the failure of individuals with mental retardation to incorporate context-specific information into their semantic representations of sentences may be mediated by the ease with which the contextual information can be retrieved from semantic memory and used in the construction of the semantic representation of the sentence. When a picture was supplied, the contextual information was relatively easy to access and incorporate into the semantic representation of the sentence. When a picture was not supplied, this information was less easy to access and use. In the experiments reported here, we used the cued-recall procedure previously used by Merrill and Bilsky (1990) and Merrill and Jackson (in press) to examine another way to increase the likelihood that persons with mental retardation might access and incorporate contextually relevant information about words in their semantic representations of sentences. A group of equal-CA subjects without mental retardation was used as our standard for comparison because this group proved to be the most efficient at using contextual information in our earlier research. To facilitate accessing and using contextually relevant information, we manipulated the degree to which the words included in the sentences were semantically related to each other. Subjects with and without mental retardation received agent–action–object sentences in which there was either a high, moderate, or low degree of semantic relatedness among the words of the sentence. We assumed that increasing the degree of semantic relatedness would increase the ease with which context-relevant information about the words in a given sentence can be retrieved from semantic memory. Overall, we expected that the subjects without mental retardation would exhibit a significantly greater recall to the subject plus verb cue than predicted by the subject only and verb only cues, relative to the subjects with mental retardation. However, if using sentences in which words were highly related made it easier to access the context-relevant information about the words, then the degree to which our groups of subjects differed in the advantage observed for the two word cues was expected to be smaller for the highly related sentences relative to sentences in which the degree of association was not as strong.

As in previous studies using this method (Merrill & Bilsky, 1990; Merrill & Jackson, in press), we expected that the proposed measure of performance differences (predicted vs. actual object noun recall) would be sensitive to differences in overall recall. The predicted level of recall to the subject plus verb cue approaches ceiling as the number of object nouns recalled to the subject only and verb only cue conditions increases. Because the actual level of recall to the subject plus verb cue cannot be greater than ceiling, the potential difference between actual and predicted object noun recall is smaller for subjects who recall more from the subject only and verb only cues relative to those who recall less. As in Merrill and Jackson (in press), this problem was resolved by presenting sentence lists of different lengths to the different Group × Condition combinations in order to equate, as nearly as possible, the number of object nouns recalled by the subjects in the various conditions. Thus, it was possible to compare actual and predicted object noun recall across conditions.

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EXPERIMENT 1

Method

Subjects

Subjects were 63 persons with and 63 without mental retardation. Those with mental retardation had a mean IQ of 61.6 (standard deviation [*SD*] = .7) and a mean CA of 17.4 years (*SD* = 1.4). They were recruited from the community and paid for their participation. The subjects without mental retardation had a mean CA of 18.2 years (*SD* = 1.1) and were recruited from introductory psychology courses. They received course credit for participating. Twenty-one subjects from each group were randomly assigned to receive high-association sentences; 21, medium-association sentences; and 21, low-association sentences.

Materials

Three sets of 36 agent–action–object sentences were generated from the same 36 object nouns. One was constructed such that there was a high degree of semantic relatedness among the subject, verb, and object noun (e.g., The hunter shot the rabbit). In the second set, there was a medium degree (e.g., The photographer shot the rabbit), and the third set, a low degree (e.g., The photographer chased the rabbit). To ensure that our sentences represented the three different levels, we asked college students to rate the degree to which the subject, verb, and object of each sentence were related on a 7-point scale, with 1 reflecting no relation among the words and 7 reflecting a strong relation. The mean ratings were 6.35 (*SD* = .46) for high; 4.04 (*SD* = 1.12) for medium; and 2.46 (*SD* = .63) for low-associative relatedness. The differences between conditions were highly significant, $F(2, 70) = 298.64$, $p < .001$, with all three conditions being significantly different from each other, all $ps < .01$, using Tukey HSD. We also attempted to obtain similar ratings from a group of subjects with mental retardation; however, they found it difficult to perform the rating task. Instead, we asked 15 subjects from this group to rank the members of each triad of sentences in terms of which made the most sense. Their rankings corresponded to the ratings of the college students 89% of the time. None of the sentences that were differently ranked were done so consistently, and the average ranking was identical for the two groups. It is important to recognize, however, that this procedure does not ensure that associative relatedness was the same for the two groups; it only indicates that they were similar in the grossest relative sense. It is also the case that the ratings supplied by the individuals without mental retardation do not reflect interval measures, and we made no assumption that the magnitude of the difference of high versus medium and medium versus low, although both were significant, was equal in magnitude for either group.

We wanted to ensure that the object nouns were not predictable from the subject and verb in the high-associative condition. Therefore, college students were given sentence frames containing the subject and verb of each high-associative sentence and asked to predict the object noun. No object noun used in the experiment was predicted from its high-associative sentence context more than 25% of the time, with the average being considerably lower (less than 9% of the time).

Twenty-four filler sentences were constructed in a manner similar to the test sentences. These sentences were used to adjust the length of the experimental sentence lists without disrupting the number or order of the test sentences. This was done by adding an equal number of filler sentences to the beginning and end of each experimental list as needed. The exact number of filler sentences was determined by pilot work in each Group × Condition combination that was designed to achieve approximately a 25 to 30% level of object noun recall to the subject only and verb only cues. Each sentence was typed individually on 12.7 × 20.32 cm index card, and each sentence list was

tape recorded with a 3-second pause between sentences for presentation to subjects.

Three equivalent forms of a 36-item cued recall test were constructed for each list of experimental sentences. Each cue, typed separately on a 12.7 × 20.32 cm index card, consisted of either one or two words. Twelve of the cues on each form provided only the subject nouns of the original sentence, 12 provided only the verb of the original sentence, and 12 provided both the subject and verb of the original sentence. Presentation of the cues within each form was determined randomly. The three forms for each experimental list were constructed such that every sentence was tested only once, and across all three forms 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 × Condition combination receiving a particular version of the test materials.

Design and Procedure

The variables in the experiment were group (mentally retarded, nonretarded), level of association (high, medium, low), and type of cue (subject only, verb only, subject plus verb). Group and level of association were manipulated between subjects. Type of cue was manipulated within subjects. The dependent variable was the number of object nouns recalled to 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 length during the study phase. Subjects with mental retardation received three lists of 12 sentences (one third of the experimental sentences in each list) in the low-association condition, two lists of 18 sentences (one half of the experimental sentences in each list) in the medium-association condition, and one list of 36 experimental sentences in the high-association condition. The subjects without mental retardation received two lists of 24 sentences (18 experimental and 6 filler sentences in each list) in the low-association condition and one list of 60 sentences (36 experimental and 24 filler sentences) in both the medium- and high-association conditions.

During the experimental session, subjects were informed that they would be hearing a list of sentences and then asked to recall them. They were allowed to read each sentence as it was presented orally. Both written and oral presentation were used because this procedure increases level of attention of the persons with mental retardation. Indeed, in pilot work Merrill and Bilsky (1990) found that presenting both oral and written sentences increased the performance of the subjects with mental retardation but not the subjects without mental retardation. Because subjects who did not read were also able to benefit from this manipulation, we assumed that it operated as an attentional manipulation more than anything else. After all of the sentences in the list had been presented, the subjects were given the cued recall test, in both oral and written form. The subjects were told that each cue was a part of one of the sentences that they had just heard and were asked to fill in all of the missing parts that they could remember. Oral responses consisting of one or two words were recorded verbatim by the experimenter. Fifteen seconds were allowed for a response. Once an item was past, returning to that item was not allowed. Subjects who received two or three lists of sentences went through this procedure separately with each list.

Results

The number of object nouns recalled 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 recall* allowed

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Table 1
Mean Number of Object Nouns Recalled by Subjects With and Without Mental Retardation as a Function of Level of Association and Type of Cue

	Type of cue			
Group/ Association	Subject	Verb	Subject + verb	Predicted
Mentally retarded				
High	3.9	2.7	6.5	5.5
Medium	3.8	3.7	5.3	5.9
Low	3.9	2.9	4.7	5.2
Nonretarded				
High	5.2	4.0	7.7	7.2
Medium	5.2	3.1	7.8	6.8
Low	4.8	2.9	7.6	6.4

only abbreviations and changes in number or tense. *Substance scoring* allowed both synonyms and close superordinates (e.g., food for dinner) of the original sentence to be scored as correct. Two independent raters scored each protocol. Agreement between raters was extremely high (over 97% for all groups), with disagreements resolved through discussion. Analysis of verbatim and substance recall yielded essentially identical results; therefore, only the analysis of substance recall is reported.

A preliminary analysis was conducted on object noun recall to the three types of cue. The analysis was a 2 (group) × 3 (association level) × 3 (type of cue) analysis of variance, with type of cue treated as a within-subjects factor. The analysis revealed a main effect of group, $F(1, 120) = 10.33$, $p < .01$, with subjects without mental retardation recalling more object nouns than did those with mental retardation (16.0 vs. 12.5, respectively). In addition, there was a main effect of type of cue, $F(2, 240) = 123.08$, $p < .001$. Object nouns were recalled most from the subject plus verb cues (6.6), second most from the subject only cues (4.5), and least from the verb cues (3.2), with all the differences being significant, $ps < .05$ using Tukey HSD. These effects were qualified by a significant interaction of Group × Type of Cue, $F(2, 240) = 9.72$, $p < .001$. Tests of simple effects revealed that groups did not differ in object noun recall from the verb only cues (3.3 and 3.1 for subjects without and with mental retardation, respectively), were marginally different in recall from the subject only cue (5.1 and 3.9, respectively), $p < .07$, and were significantly different in recall from the subject plus verb cues (7.7 and 5.5, respectively), $p < .01$. The performance of the subjects in the subject only and verb only cue conditions did not quite meet the criterion that groups recall essentially the same amount in these two cue conditions. However, the difference was relatively small (8.4 vs. 7.0 out of 24) and in favor of the subjects without mental retardation. Therefore, the group comparison of the observed versus predicted object noun recall to the subject plus verb cue would tend to be more rather than less conservative (i.e., underestimate the difference between conditions for subjects without relative to subjects with mental retardation). Hence, we decided to proceed with the main analysis.

The primary analysis compared observed object noun recall from the subject plus verb cue to predicted object noun recall from the subject only and verb only cues. These data are presented in Table 1. The analysis was a 2 (group) × 3 (association level) × 2 (type of cue: observed and predicted) analysis of variance, with type of cue treated as a within-subjects factor. The analysis revealed a main effect of group, $F(1, 120) = 13.05$, $p < .001$, with the subjects without mental retardation recalling more object nouns than those with mental retardation (7.2 vs. 5.6). There was also a significant Group × Type of Cue interaction, $F(1,120) = 4.56$, $p < .05$, with the subjects without mental retardation exhibiting a greater effect of type of cue than did those with mental retardation (1.0 vs. 0.0). However, these effects were qualified by the significant interaction of Group × Association Level × Type of Cue, $F(1,120) = 3.15$, $p < .05$.

To facilitate the interpretation of the three-way interaction, we looked at the effects of association level and type of cue separately by group. For subjects without mental retardation, this analysis only re-

vealed a main effect of type of cue, $F(1, 60) = 5.39$, $p < .05$, with obtained recall being greater than predicted recall (7.7 vs. 6.7). Neither the main effect of association nor the Association × Type of Cue interaction approached significance. Apparently, the subjects without mental retardation were able to access information about the relations between the words of the sentences and incorporate them into the semantic representations of the sentences at all three levels of associative relatedness tested in this experiment. For the subjects with mental retardation, neither main effect was significant. However, the Association Level × Type of Cue interaction was significant, $F(2, 60) = 5.05$, $p < .01$. Test of simple effects revealed that the difference between obtained and predicted recall was not significant in the low- (–.5) or in the medium-association condition (–.6), but was significant in the high-association condition (1.0). In fact, the data in the low- and medium-association conditions were in the opposite direction from expectations. Nevertheless, even though the subjects with mental retardation exhibit difficulty in accessing and using contextual information about words in sentences when the words are not independently related, they are reasonably efficient at using this information and incorporating it into their semantic representations of the sentences when the relations are strong. When sentences are constructed from words that are highly related, subjects with mental retardation perform the cued-recall task in a manner that is similar to the way subjects without mental retardation perform the task.

EXPERIMENT 2

One issue that was entirely unresolved by the results of previous research is whether the differences that have been observed between persons with and without mental retardation are due to processing differences that occur during initial encoding and comprehension or due to processing differences at some later stage of processing, such as retrieval. Because previous researchers have used a cued recall procedure, it is impossible to separate effects associated with any particular processing stage. The performance of subjects with mental retardation in the high-association condition in Experiment 1 may have been the result of enhanced retrieval as a function of the relatedness between words, whereas the performance of the subjects without mental retardation was the result of accessing and retrieving relations during encoding and comprehension. Experiment 2 was designed to examine encoding and comprehension operations during sentence processing under conditions in which the influence of retrieval operations was minimized.

The basic procedure was a semantic verification task patterned after Experiment 3 in Merrill and Mar (1987). Subjects with and without mental retardation listened to a sentence followed by the presentation of a picture that either accurately or inaccurately depicted the meaning of the sentence. Subjects were required to determine, as rapidly as possible, whether the picture and sentence were semantically identical. The critical manipulation was the length of time between the presentation of the sentence and the presentation of the picture (the interstimulus interval). The picture was presented either simultaneous with the last word of the sentence or 600 msec following the last word of the sentence. Merrill and Mar found that the longer interval facilitated the performance of their subjects without mental retardation more than it facilitated that of subjects with mental retardation. Sentence verification times improved by 321 msec for the former subjects, but only improved by 149 msec, for the latter. The authors suggested that the quality of the semantic representations encoded by the groups was different. When the picture and sentence were presented simultaneously, the sentence had to be encoded prior to verification with the picture for both groups so verification times were relatively long. However, at the longer

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intervals subjects had time to construct a semantic representation of the sentence prior to the presentation of the picture, and verification was made between the semantic representation of the sentence and the picture. Because this was the only difference between the conditions, the degree of improvement associated with the increase in the interstimulus interval was, therefore, assumed to reflect something about the quality of the sentence representation. That the subjects with mental retardation exhibited less improvement in verification times than did those without mental retardation was taken as an indication that the subjects with mental retardation encoded the sentences in a manner that was different and resulted in a lower quality representation.

In Experiment 2 we chose to use the difference between simultaneous and delayed presentation of the picture as a measure of encoding quality to determine whether the change in performance due to association level exhibited by the subjects with mental retardation in Experiment 1 reflects a change in the manner in which sentences are encoded. Subjects received the low-association and high-association sentences of Experiment 1. The subjects without mental retardation were expected to exhibit a greater difference in verification times between the simultaneous and delayed picture conditions than would the subjects with mental retardation for low-association sentences. This is essentially a replication of Experiment 3 in Merrill and Mar (1987) and would converge on the difference in encoding for low-association sentences observed in Experiment 1. To the extent that the change in recall performance for high-association sentences exhibited by the subjects with mental retardation in Experiment 1 is due to changes associated with initial encoding and comprehension processes, we expected the difference between simultaneous and delayed picture presentations to be greater for high- than for low-association sentences for these subjects. In addition, the difference between subjects with and without mental retardation was expected to be smaller in the high-association relative to the low-association condition.

Method

Subjects

Thirty subjects with and 30 subjects without mental retardation were recruited in a manner similar to that used in Experiment 1. The subjects with mental retardation had a mean IQ of 63.3 (SD = 8.8) and a mean CA of 17.9 years (SD = 1.3). The subjects without mental retardation had a mean CA of 18.3 years (SD = 1.6).

Apparatus

The apparatus were a cassette tape recorder, a carousel slide projector, a tachistoscopic lens, a voice-operated relay, a millisecond timer, and a clock. The millisecond timer was interfaced with the tachistoscopic lens and clock to control the presentation of the picture and start the clock. The voice-operated relay was interfaced with the millisecond timer and the clock such that an inaudible signal on the tape initiated the timing cycle of the timer, and the subjects' vocal response stopped the clock and ended the trial.

Design and Materials

The variables in the experiment were group (mentally retarded, nonretarded), association level (high, low), and length of delay (0, 600 msec). A delay of 600 msec was chosen on the basis of results of Merrill and Mar (1988), who reported that 600 msec was enough time for both groups of subjects to completely encode sentences of the type used in the experiment. The dependent variable was sentence-verification time.

We selected 18 low-association and 18 high-association sentences from the first experiment for use as experimental sen-

tences. An additional 36 sentences were constructed for use as filler sentences. Pictures that accurately depicted the meaning of the experimental sentences and inaccurately depicted the meaning of the filler sentences were selected from various sources or drawn by an artist. All of the experimental sentences semantically matched their corresponding pictures. Photographic slides were made from the pictures, which were essentially black and white line drawings. The order of the 72 sentences was randomized and tape recorded for presentation. Each sentence was preceded by a warning signal. There was a 5-second interval between the end of one sentence and the beginning of the next.

Procedure

Subjects were tested individually in one session. Half of the subjects in each group received the 0-msec delay and half, the 600-msec delay. They were asked to listen carefully to each stimulus sentence and verify whether or not the picture (presented at the designated interstimulus interval) was an accurate representation of that sentence. Subjects were instructed to respond yes if they were and no of they were not as rapidly as possible without error. The experimental session began with 15 practice trials that were identical in format to the experimental trials. Verification times were recorded to the nearest msec by the experimenter.

Results

Mean semantic verification times for the experimental sentences are presented in Table 2. Errors were rare (2.2% and 2.7% for the subjects without and with mental retardation, respectively) and did not vary systematically as a function of group or condition. These data were analyzed using a 2 (group) × 2 (delay) × 2 (association level) analysis of variance, with association level treated as a within-subjects variable. The analysis revealed a significant main effect of group, $F(1, 56) = 79.96$, $p < .01$, with verification times of the subjects without mental retardation being faster than those of the subjects with mental retardation (857 msec vs. 1,136 msec); a significant main effect of delay, $F(1, 56) = 582.61$, with sentences at the 600-msec delay being verified faster than sentences at the 0-msec delay; and a significant main effect of association level, $F(1, 56) = 5.12$, $p < .05$, with high-association sentences being responded to faster than were low-association sentences. However, the main effects were qualified by the significant interaction of Group × Association Level × Delay, $F(1, 56) = 12.52$, $p < .01$.

Table 2
Mean Sentence Verification Times (in msec) by Subjects as a Function of Level of Association and Delay

Group/Delay	Level of association: Low	High
Mentally retarded		
0	1236	1228
600	1147	936
Nonretarded		
0	1021	998
600	725	684

The interaction was further analyzed by looking at the effects of association level and delay separately by group. For the subjects with mental retardation, there was a significant main effect of association level, $F(1, 28) = 5.87$, $p < .05$, a significant main effect of delay, $F(1, 28) = 100.88$, $p < .001$, and a significant interaction of Association Level × Delay, $F(1, 28) = 19.02$, $p < .01$. The subjects with mental retardation exhibited more improvement in verification times as a function of the increase in delay of the picture in the high-association condition (293 msec) than in the low-association condition (89 msec). As in Experiment 1, the subjects with mental retardation were better able to access contextually relevant relations between the words of the sentences when the words had an a prior association than when they did not. For the subjects without mental retardation, the analysis revealed only a main effect of delay, $F(1, 28) = 478.86$, $p < .01$, with verification

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Level of association	
Low	High
1236	1228
1147	936
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725	684

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times in the 600-msec delay condition being faster than those in the 0-msec delay condition (704 msec vs. 1,009 msec). Neither the main effect of association level nor the Association Level × Delay interaction was significant. The subjects without mental retardation exhibited a similar improvement in verification times for low- and high-association sentences as the delay increased from 0 to 600 msec. By implication, it seems likely that the subjects without mental retardation were encoding and comprehending the low- and high-association sentences in a similar fashion. It is important that the magnitude of improvement exhibited by the subjects with mental retardation in the high-association condition (293 msec) was very similar to the magnitude of improvement exhibited by the subjects without mental retardation overall (305 msec).

Discussion

The results of Experiment 2 are consistent with those of Experiment 1. When presented with low-association sentences, the subjects without mental retardation appeared to access the contextually relevant information about the words in the sentences and incorporate that information into their semantic representations more than did the subjects with mental retardation. This was indicated by the greater degree of improvement in verification times exhibited by the subjects without mental retardation relative to those with mental retardation in the low-association condition. When presented with high-association sentences, the degree of improvement associated with the increase in the delay interval was essentially identical for both groups. We therefore concluded that both groups were accessing the contextually relevant information about the words of the sentences and incorporating this information into the semantic representations of the sentences when the sentences were constructed from words that were highly associated with each other.

In addition to revealing a point of equivalence between persons with and without mental retardation, the data of Experiment 2 indicate that the group difference in sentence processing observed in these experiments reflect differences in sentence encoding and comprehension processes rather than memory retrieval processes because they were observed in the sentence verification task as well as the cued recall task. This is consistent with most current models of sentence comprehension suggesting that an important component of initial comprehension processes involves establishing cohesive relations among the individual words of a sentence and focusing on the contextually relevant aspects of the meanings of the words (see, e.g., Kintsch, 1988; Waltz & Pollack, 1985). A failure to efficiently accomplish this goal would lead to semantic representations of sentences that would include both context-appropriate and context-inappropriate meanings of the words in the sentence (cf. Conrad, 1974; Kintsch & Mross, 1985; Swinney, 1979; Till, Mross, & Kintsch, 1988). The meaning of the sentence would therefore be specified less precisely, with the consequences likely to include a more shallow level of understanding of the sentences and, by implication, a less durable memory representation of the sentence (Craik & Lockhart, 1972).

We generally view the difference in performance observed between our groups of subjects in this series of experiments to reflect a difference in their level of developmental functioning. Indeed, the factors that we think are operating as a result of the primary manipulation used in the studies reported here—degree of associative relatedness and meaningfulness—have been shown to be very sensitive to differences in developmental level (e.g., Frasure & Entwisle, 1973; Rosenberg, Jarvella, & Cross, 1971; Weener, 1971). For example, the ability to use syntax in the absence of associative relatedness to recall verbal messages is a relatively late developing skill, emerging as late as the age of 9 or 10 (Weener, 1971). To

the extent that it is possible to view our low-association sentences in these experiments as sentences with good syntax and low-associative relatedness, then our results parallel these age-related differences. It is important to note, however, that our earlier work (Merrill & Bilsky, 1990; Merrill & Marr, 1987) indicated that persons with mental retardation perform at a level below what would be expected on the basis of MA. Nevertheless, we believe that the results of our studies reflect individual differences in focusing on contextually relevant aspects of the meanings of words in sentences. Persons who are young and persons with mental retardation seem to exhibit difficulty in performing the cognitive operations involved when the contextual relations between the words are less obvious, as was the case with sentences constructed from words that are low associates. However, the difficulty appears to be one of generalizing a mental process that our subjects with mental retardation were able to use rather than their not having or being able to use the process at all. This is indicated by the finding that the subjects with mental retardation performed at the level of the subjects without mental retardation when the degree of association between words in the sentence was high. Our speculation is that this is related to the ease with which contextually relevant information can be retrieved from memory. This information is likely to be easier to retrieve for high-association than for low-association sentences.

There are two important implications of our results. First, it is necessary to recognize that there are important comprehension operations that take place beyond a level of "understanding" a sentence or a text. They may result in apparently small changes, but they are associated with a more specific semantic representation of the text, which should lead to a more precise degree of comprehension, and a more durable representation, which should lead to better memory. Second, it is possible to manipulate the level of understanding of persons with mental retardation by changing the degree of linguistically appropriate context available in the environment. In Merrill and Jackson (in press), this was done by the less than subtle manipulation of adding a picture as context. In the studies reported here, we manipulated the context linguistically. It may be interesting to determine the range of contextual manipulations that are possible in support of language comprehension and to determine the degree to which normal language opportunities of persons with mental retardation are contextually supported by their environment.

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