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Differences Between Mentally Retarded and Nonretarded Persons' Efficiency of Auditory Sentence Processing

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Mentally retarded adolescents and MA-matched nonretarded children participated in three experiments designed to examine differences in language-processing efficiency. A compressed speech technique was used in Experiments 1 and 2. Experiment 3 relied on a sentence–picture vertification procedure. Our results suggest that retarded and nonretarded individuals differ in the speed with which they are able to execute the semantic–analytic processes but not necessarily the phonological encoding processes that are involved in auditory language comprehension. In addition, the data suggest a possible group difference in the quality of the semantic representation encoded during sentence processing.

Researchers have demonstrated that there are large and highly consistent differences between mentally retarded and nonretarded individuals in the speed with which even the most basic information processing operations can be executed (see Sperber & McCauley, 1984). Retarded individuals are slower at executing such fundamental processes as encoding stimulus information (e.g., Merrill et al., 1985; Nettelbeck & Lally, 1976), searching the contents of short-term memory (e.g., Dugas & Kellas, 1974; Harris & Fleer, 1974; McCauley, Kellas, Dugas, & DeVellis, 1976), retrieving information from long-term memory (e.g., Sperber, Merrill, McCauley, & Shapiro, 1983), and making simple semantic decisions (Davies, Sperber, & McCauley, 1981; Sperber, Davies, Merrill, & McCauley, 1982).

Individual differences in processing efficiency may be related in some fundamental way to differences in the performance of more complex cognitive activities. For example, there is evidence suggesting that skilled and less-skilled reading comprehenders differ in the speed with which they are able to code discourse units (Perfetti & Lesgold, 1977). When input is presented continuously and rapidly, the deeper levels of memory and comprehension (Craik & Lockhart, 1972) may only be achieved if sufficient time is allowed for the processing of one unit prior to the presentation of the next. Our goal in the present series of experiments was to examine differences between retarded and nonretarded persons in processing efficiency within the context of auditory language comprehension.

EXPERIMENT 1

Experiment 1 was designed to determine whether retarded and nonretarded persons differ in the speed with which they are able to code discourse units during auditory comprehension activities. The general procedure involved the use of a compressed speech technique (see, e.g., Carver, 1973a, 1973b). This technique allowed us to increase the overall rate of presentation in such a way as to leave the normal speech pattern relatively unchanged, with minimal distortion in tone and pitch. Retarded and nonretarded subjects listened to a series of short prose passages and answered questions about each passage follow-

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ing its presentation. The passages were presented at six different speech rates: 150, 200, 250, 300, 350, and 400 words per minute. We expected that increases in speech rate would result in decreases in comprehension performance for all subjects. To the extent that the retarded subjects were slower at coding discourse units than were the equal-MA nonretarded subjects, however, we expected that the retarded subjects would exhibit a greater rate of decline in comprehension performance due to increases in presentation rate than would the nonretarded subjects.

Method

Subjects

The subjects were 18 retarded adolescents and 18 nonretarded fourth-grade children selected from classes in the New York City Public Schools. The retarded subjects had a mean IQ of 63.1 (standard deviation [*SD*] = 9.1) and a mean chronological age (CA) of 16.4 years (*SD* = 1.2). Their IQs were based on recent administrations of the Stanford-Binet Intelligence Scale or Wechsler Intelligence Scale for Children. Mean mental age (MA) for the retarded sample, estimated by the formula MA = CA × IQ/100, was 10.4 years (*SD* = 1.5). The nonretarded sample had a mean CA of 10.3 years (*SD* = .6). Their MAs were estimated to be roughly equivalent to their CAs on the basis of their placement in the appropriate school grade and the absence of any major learning problems, as indicated by their teachers.

Design and Materials

The variables in the experiment were population (retarded and nonretarded) and speech rate (150, 200, 250, 300, 350, and 400 words per minute). Speech rate was manipulated within-subjects.

Presentation materials consisted of 30 four-sentence prose passages. These passages were randomly divided into six sets of five passages, with each set individually recorded. Using a speech compressor, we constructed six versions of each passage set corresponding to the six different levels of speech rate. Speech rate was measured by the method described by Carver (1973a) as an average across the five passages within each set. The assignment of individual subjects to specific versions of the passage sets was made such that: (a) each subject received only one version of each set of passages, (b) each subject received one set of passages at each presentation rate, and (c) across all subjects within each group, each set of passages was heard an equal number of times at each presentation rate.

Test materials consisted of 10 yes–no questions for each set of passages (2 about each passage), with half requiring a "yes" response and half requiring a "no" response. Questions were presented at normal speech rate, and the same questions were asked following each version of a given passage set.

For all subjects the presentation order for speech rate was fixed in ascending order, beginning with 150 words per minute and ending with 400 words per minute. This was done to maximize performance at the faster speech rates, while maintaining practice requirements at manageable levels. The dependent variable was the number of correct responses to the questions.

Procedure

Subjects were tested individually. They were asked to listen to a series of short stories at different speeds and to answer questions about each story when it was over. At the beginning of the session, the subjects received one practice passage at 150 words per minute, followed immediately by the presentation of the first set of experimental passages. Subjects were presented one practice passage with each increase in speech rate in order to familiarize them with the new speech rate prior to the initiation of experimental trials at that speed.

Results and Discussion

The mean number of correct responses in each condition are presented in Figure 1. Preliminary analysis revealed no effect of passage sets; therefore, this variable was not included in the main analysis. The primary analysis was a 2 (population) × 6 (speech rate) mixed analysis of variance.

As expected, the anaylsis revealed a significant main effect of speech rate, $F(5, 170), = 69.24$, $p < .001$, with subjects exhibiting

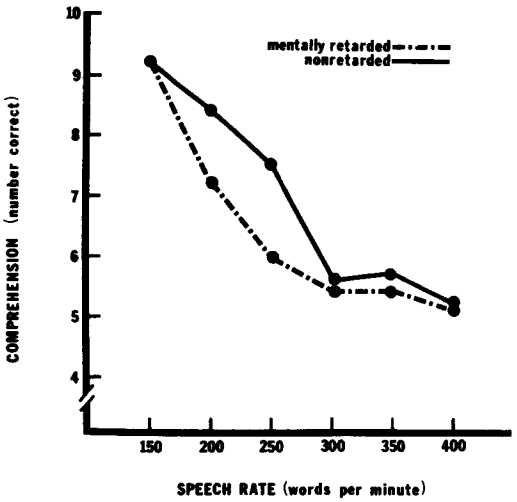

Figure 1. Mean number of correct responses to questions of Experiment 1 as a function of population and speech rate.

decreases in the number of correct responses obtained with increases in speech rate. Newman-Keuls analysis yielded the following pattern of results due to the speech rate variable: 150 words per minute (wpm) > 200 wpm > 250 wpm > 300 wpm = 350 wpm = 400 wpm, all significant *ps* < .05. This result is fairly consistent with previous experiments using the compressed speech technique. Our subjects, however, reached minimum performance levels at 300 wpm whereas earlier research suggests that minimum performance levels are generally reached between 350 and 400 wpm (e.g., Carver, 1973a, 1973b; Foulke & Sticht, 1969). This difference between experiments is likely due to the nature of the experimental passages used in the different studies. The passages used in earlier studies were generally longer than the passages used here. The greater context provided by longer passages probably enabled subjects to process the materials faster than could the subjects of the present study.

The analysis also revealed a significant Population × Speech rate interaction, $F(5, 170) = 2.32$, $p < .05$. Tests of simple effects indicated that the nonretarded subjects answered more questions correctly than did the retarded subjects at both 200 wpm, $F(1, 34) = 8.22$, $p < .05$, and 250 wpm, $F(1, 34) = 14.54$, $p < .05$. The two groups did not differ at any other speech rate. Thus, although the performance of both groups declined as a function of increased speech rate, the rate of decline in comprehension performance observed for the retarded subjects was greater than that observed for the nonretarded subjects. We therefore concluded that the equal-MA nonretarded subjects were able to code discourse units more rapidly than were the retarded subjects.

EXPERIMENT 2

Experiment 1 provided a global analysis of the relationships between processing speed, mental retardation, and comprehension ability. Even during relatively short passages, however, there are a number of cognitive processes involved in comprehension. Word names must be phonologically analyzed and placed in working memory, relevant conceptual information must be retrieved from long-term memory, and higher order semantic analysis must be executed in order to construct meaningful configurations of the discourse units in memory (cf. Perfetti & Lesgold, 1977). In the context of reading comprehension, Perfetti and Lesgold argued that verbal coding speed differences have two basic components. One component is the phonological analysis and storing of a word name. The second component is the retrieval of contextually constrained semantic properties (i.e., semantic analysis). Although these two components may not be identical to the processes involved in auditory comprehension, we reasoned that analogous phonological and semantic-analytic processes are likely to be present. Experiment 2 was designed to examine the extent to which the differences observed in the previous experiment could be attributed to differences between retarded and nonretarded individuals in the speed with which auditorally presented prose can be phonologically analyzed and stored in working memory.

In this experiment, retarded and nonretarded subjects listened to a series of single sentences (e.g., "Helen had to talk to her class on Monday") presented at the same six levels of speech rate used in Experiment 1. Immediately following the presentation of each sentence, we presented a single word probe (e.g., "talk" or "walk"). The subjects were simply required to respond "yes" if the probe was in the sentence and "no" if it was not. Because semantic

analysis is not required to perform this task, we assumed that this procedure would primarily measure the amount of time required to execute the phonological analysis and word-storage component of verbal coding speed. We again expected that both retarded and nonretarded subjects would exhibit decreases in the number of correct responses made with increases in presentation rate, with group differences in phonological encoding speed being evidenced by differing rates of decline in performance as a function of speech rate.

Method

Subjects

The subjects in this experiment were 18 retarded adolescents and 18 nonretarded fourth-grade students selected so as to be comparable to those of the previous experiment. The retarded subjects had a mean CA of 16.6 years (SD = 1.1), a mean IQ of 61.7 (SD = 8.7), and a mean estimated MA of 10.2 (SD = 1.3). The nonretarded sample had a mean CA and estimated MA of 10.4 (SD = .5).

Design and Materials

The design was identical to that of Experiment 1. The presentation materials consisted of 60 sentences (e.g., "Helen had to talk to her class on Monday") randomly divided into six sets of 10 sentences each. Again, six versions of each set were recorded, one at each speech rate. Counterbalancing procedures and presentation order were identical to those used in the previous experiment.

Test stimuli consisted of one single-word probe stimulus for each presentation sentence (e.g., "talk" or "walk" for the previous example). For each set of 10 sentences, one-half of the probe stimuli were words that appeared in the sentences, and half were words that did not appear in the sentences. Probe stimuli that were not in the original sentences were selected to rhyme with a word in the sentence and to be a grammatically appropriate replacement for that word. This was done to ensure that subjects could not respond correctly to the probe on the basis of partial information. Probe stimuli were presented at normal speech rate.The dependent variable in the experiment was the number of correct responses to the probe stimuli.

Procedure

Subjects, who were tested individually, were informed that they would hear a series of sentences at different speeds. They were instructed to listen to each sentence carefully and told that immediately following the presentation of each sentence, the experimenter would read a word to them. The subjects were instructed simply to respond "yes" if the word read was in the sentence they had just heard and "no" if it was not. Subjects received all 10 sentences at a single speech rate before proceeding to the next faster rate of speech. Two practice trials were presented to the subjects prior to the start of experimental trials at each speed rate.

Results and Discussion

The mean number of correct responses obtained by subjects in each condition are presented in Figure 2. Preliminary analysis again revealed no effect of stimulus set, and this variable was excluded from the main analysis. The primary analysis was a 2 (population) × 6 (speech rate) mixed analysis of variance.

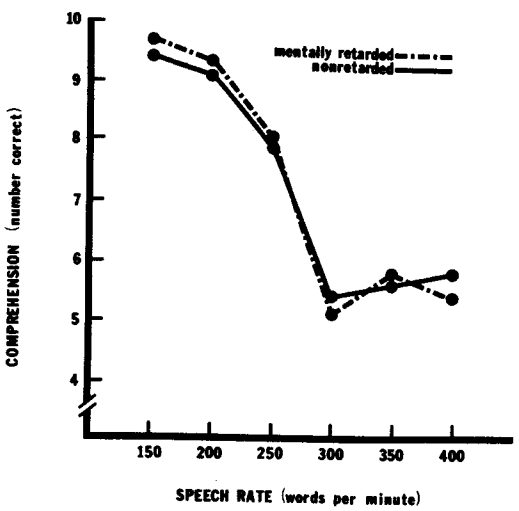

Figure 2. Mean number of correct responses to probes of Experiment 2 as a function of population and speech rate.

As in the previous experiment, the main effect of speech rate was significant, $F(5, 70) = 64.12$, $p < .001$, with performance decreasing with increases in speech rate up to 300 wpm, at which point performance approached chance-level responding (150 wpm > 200 wpm > 250 wpm > 300 wpm = 350 wpm = 400 wpm, all *ps* < .05 using Newman-Keuls). Unlike the previous experiment, however, the Population × Speech Rate interaction did not even approach significance. Thus, it appears that the population difference observed in Experiment 1 could not be attributed to differences in the execution of the phonological coding and storage processes involved in auditory language comprehension.

EXPERIMENT 3

Experiment 3 was designed to investigate differences between retarded and nonretarded subjects in the speed with which discourse units can be semantically analyzed. Measuring the amount of time required to conduct the semantic analysis of discourse is not a straightforward task, however, because semantic analysis can begin before the entire sentence has been presented and phonological analysis has been completed (cf. Marslen-Wilson, 1975; Marslen-Wilson & Welsh, 1978). Nevertheless, because we can assume that the semantic analysis of a discourse unit such as a sentence cannot be completed until all units of the sentence have been presented (under conditions in which the last word is critical to the interpretation), it is possible to obtain a relative measure of the time required to analyze discourse semantically by measuring the amount of time that is needed to complete these analyses following the presentation of the last word of the sentence. Indeed, it may be the inability to complete the semantic analysis of one discourse unit (even though phonological codes haave been temporarily stored in working memory) prior to the presentation of the next unit that represents a fundamental source of individual differences in language comprehension performance.

The general procedure used in this experiment was a modified version of the encoding function methodology developed by Posner (1978). Posner's procedure essentially involves the successive presentation of two stimuli, with subjects being required to make same–different judgments about these stimuli as rapidly as possible. The critical manipulation is to vary the time given to subjects between the presentation of the first stimulus and the presentation of the second stimulus, the interstimulus interval (ISI). Assuming that the subjects must encode the first stimulus prior to making their same–different judgments, Posner reasoned that increasing the ISI would facilitate performance on the task (as indexed by decreases in response time) up to the point at which sufficient time had been given to encode that first stimulus. Additional time should not help subjects perform the task because nothing further need be done with the first stimulus, and what can be done with the second stimulus is identical across all remaining ISIs. Under these conditions the time required to encode the first stimulus of the pair is assumed to be the ISI at which maximum response time performance levels are first observed.

In our experiment, the first stimulus of each pair was an auditorally presented sentence. The second stimulus was a black and white line drawing that either accurately or inaccurately depicted the meaning of the sentence. The subjects' task was to respond "yes" if the sentence and picture were semantically identical and "no" if they were not, as rapidly as possible. Following the general logic of this procedure, we varied the ISI with the expectation that response times would decrease with increases in ISI up to the point at which the sentence had been semantically analyzed and encoded into working memory. Our primary interest was in examining whether retarded and nonretarded individuals reached maximum performance levels at different ISIs, thereby suggesting group differences in the amount of time necessary to complete the execution of the semantic-analytic processes involved in the comprehension of auditorally presented sentences.

Method

Subjects

Subjects were 15 retarded adolescents and 15 nonretarded fourth-grade children selected in a manner similar to that used in the previous experiments. The retarded subjects had a CA of 16.0 years (*SD* = 1.3), a mean IQ of 64.6 (*SD*

= 9.6), and a mean estimated MA of 10.8 years (*SD* = 1.7). The nonretarded sample had a mean CA (and estimated MA) of 10.5 years (*SD* = .6).

Design and Materials

The variables in the experiment were population (retarded and equal-MA nonretarded), ISI (0, 200, 400, 600, and 1000 msec), and response type (yes and no). The ISI and response type were manipulated within subjects.

Fifty sentences were generated for use. These sentences were of the agent–action–object variety (e.g., The boy held the cat). The sentences were randomly divided into five sets of 10 sentences, and each set was recorded for presentation. An inaudible tone was placed at the onset of the last word of each stimulus sentence. This tone was used to initiate presentation of the target picture and start the timing cycle of the response timer at the specified ISI for each sentence–picture pair. Response times were measured from the onset of the target picture to the subjects' depression of a response key indicating their semantic–identity judgment.

Target pictures consisted of photographic slides of black and white line drawings. For one–half of the sentences within each set of 10, the drawings accurately depicted the intended meaning of the sentence. For the remaining sentences, the drawings accurately depicted both the agent and the object of the sentence but misrepresented the action stated in the sentence (e.g., a drawing of a boy sitting next to a cat for the previous example).

Each subject received all five sets of stimulus pairs, one set at each ISI condition. The presentation order of ISI conditions was counterbalanced across subjects within each group. The assignment of stimulus sets to ISI conditions was made such that, across subjects within each group, each set appeared at each ISI an equal number of times.

Response times to making semantic identity decisions served as the major dependent variable.

Procedure

Subjects were tested individually in one 30–minute session. They were asked to listen carefully to each stimulus sentence and then to verify whether the picture (presented at the designated ISI following the sentence) was an accurate representation of that sentence. Subjects were instructed to respond using a two–button response key. "Yes" responses were always made using the preferred hand. The experimental session began with 25 practice trials that were identical in format to the experimental trials, with the exception that all ISIs during practice were set at 0 msec. Practice was immediately followed by the experimental trials. One practice trial preceded each ISI condition in order to familiarize the subject with changes in the ISI. Response times for semantic–identity decisions were recorded to the nearest msec.

Results and Discussion

Mean response times (excluding errors) for each condition are presented in Figure 3. Errors were rare (less than 6.0% for both groups), and analysis revealed no reliable trend in error rates as a function of groups or conditions. Because the variable of response type was defined by the nature of the second stimulus of the pair, we assumed that the amount of time required to encode the sentences would not vary as a function of this manipulation. Preliminary analysis of the date supported our assumption,

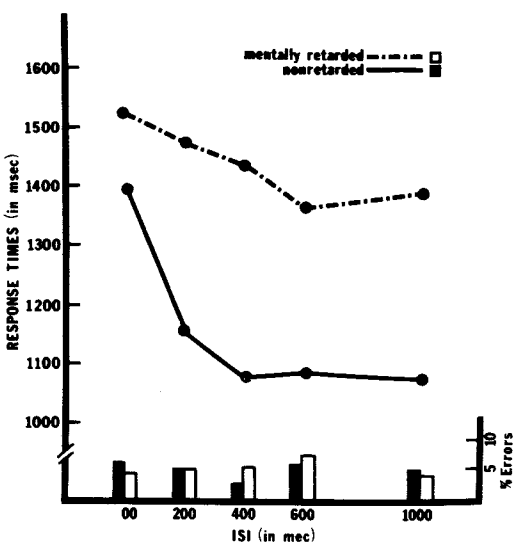

Figure 3. Mean response times of semantic identity judgments of Experiment 3 as a function of population and ISI.

and the data were collapsed across this factor for the primary analyses.

The primary analyses were designed to determine statistically the ISI at which the response-time function of each group first reached maximum performance levels. This was done in the following manner. On the basis of visual inspection of the data, response times obtained at the 1,000-msec ISI were selected as our estimate of maximum performance. The mean response time for this condition was then compared (using correlated t tests: $df = 14$, alpha = .05) with that obtained at each of the shorter ISIs, starting with the 0-msec ISI and running through the 600-msec ISI. Encoding time for each group was defined as the shortest ISI tested for which the obtained mean response times did not differ significantly from our estimate of that group's maximum performance levels.

The results of these analyses were quite consistent with the shapes of the functions presented in Figure 3. The nonretarded subjects reached maximum performance levels at an ISI of 400 msec, and the retarded subjects reached maximum performance levels at an ISI of 600 msec. These data lend support for the hypothesis that retarded individuals are slower at semantically analyzing discourse units than are nonretarded individuals of equal-MA. Other aspects of our data, however, revealed that quantitative differences between groups in the execution of these semantic–analytic processes may not represent the entire story.

Looking again at Figure 3, it can be seen that in addition to differences in the ISI at which maximum performance was reached, there was also a difference in the magnitude of the decrease in response times across ISIs between the retarded and nonretarded subjects. Response times for the nonretarded subjects improved by 321 msec, whereas those of the retarded subjects improved by only 149 msec (as indexed by the differences between the 0- and 400–msec ISIs for the nonretarded subjects and the 0- and 600–msec ISIs for the retarded subjects). Analysis revealed that the difference between these means was reliable, $F(1, 29) = 4.77$, $p < .05$, suggesting a second difference in the manner in which retarded and nonretarded individuals semantically analyze auditorally presented sentences.

Because the group difference in the magnitude of improvement across ISIs was essentially an interaction of Population × ISI, it cannot be viewed as simply reflecting differences between retarded and nonretarded individuals in the amount of time needed to reach a decision once the picture appears. The interpretation of this effect must take into account the fact that the difference was smaller at the shorter ISIs than at the longer ISIs. Two general interpretations are applicable. One possibility is that either or both groups of subjects changed their criterion for making match/nonmatch decisions as the length of the ISI increased. Because error rates did not vary systematically with response times, however, as would be expected with a criterion shift, this is not the preferred explanation. The second possibility is that the quality of the semantic representations encoded for the sentences by the two groups may differ, with the representations encoded by the nonretarded subjects enabling this group to make more rapid comparisons between the sentence and the picture. Future researchers should focus on this possibility.

General Discussion

The experiments reported here examined differences between retarded and nonretarded persons in general processing efficiency within the context of language comprehension activities. Taken together, the results of these experiments suggest that: (a) retarded individuals are slower at processing discourse units during comprehension activities than are nonretarded individuals of equal-MA, (b) differences in the efficiency of processing auditorally presented prose reside primarily in the speed with which retarded and nonretarded individuals are able to execute the semantic–analytic processes (relative to the phonological encoding processes) involved in language comprehension activities, and (c) retarded and nonretarded individuals differ not only in the speed with which they are able to execute the semantic–analytic processes of sentence comprehension but also in the quality of the semantic representations that result from the execution of these processes.

The finding that differences between retarded and nonretarded persons in processing speed were only observed in the execution of the semantic–analytic component of verbal

coding speed is quite consistent with the conclusions reached by Davies et al. (1981; see also Cody & Borkowski, 1977; Sperber, Ragain, & McCauley, 1976). In that study, Davies et al. assessed intelligence-related differences in the speed with which individuals process semantic category information under conditions that required the active, deliberate processing and manipulation of that information relative to conditions that required only the more passive processes associated with the simple activation of stored semantic knowledge. Their results suggested that retarded and nonretarded subjects' differences in semantic processing speed were primarily associated with processes involved in the active retrieval and manipulation of semantic knowledge. In the present study, it is reasonable to assume that the semantic–analytic component of verbal coding speed required the execution of more active, albeit nonstrategic, processes than did the phonological analysis and memory-storage component. Therefore, the differences between retarded and nonretarded subjects emerged only under conditions in which the use of these semantic–analytic processes were required for performance of the experimental task (i.e., Experiments 1 and 3).

Although the focus of these experiments was on intelligence-related differences in processing speed, we also found evidence suggesting group differences in the quality of the semantic representation encoded for the sentences of Experiment 3. Our nonretarded subjects constructed semantic representations that enabled them to show twice the magnitude of improvement in response-time performance compared to the retarded subjects between simultaneous presentation conditions and conditions that permitted optimal performance levels; that is, the retarded individuals not only took longer to encode the sentences, but they also did not get as much out of processing the sentences. One possible explanation of this particular combination of results is that it is necessary for prose to be processed very rapidly in order for the deeper levels of comprehension to be achieved and, hence, better quality semantic representations to be constructed (cf. Perfetti & Lesgold, 1977). In this way, the construction of the semantic representation may depend on the speed of processing. On the other hand, it may simply be that retarded and nonretarded individuals differ in processing speed as a by-product of processing sentences in a different manner. An important goal of future researchers may be to examine the precise nature of the relationship between processing speed and quality of encoding.

References

Carver, R. P. (1973a). Understanding, information processing, and learning from prose materials. *Journal of Educational Psychology, 65*, 72–75.

Carver, R. P. (1973b). Effect of increasing the rate of speech presentation upon comprehension. *Journal of Educational Psychology, 65*, 118–126.

Cody, W. J., & Borkowski, J. G. (1977). Proactive interference and its release in short-term memory of mildly retarded adolescents. *American Journal of Mental Deficiency, 82*, 305–308.

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior, 11*, 671–684.

Davies, D., Sperber, R. D., & McCauley, C. (1981). Intelligence-related differences in semantic processing speed. *Journal of Experimental Child Psychology, 31*, 387–402.

Dugas, J. L., & Kellas, G. (1974). Encoding and retrieval processes in normal children and retarded adolescents. *Journal of Experimental Child Psychology, 17*, 177–185.

Foulke, D., & Sticht, T. G. (1969). Review of research on the intelligibility and comprehension of accelerated speech. *Psychological Bulletin, 72*, 50–62.

Harris, G. J., & Fleer, R. E. (1974). High speed memory scanning in mental retardates: Evidence for a central processing deficit. *Journal of Experimental Child Psychology, 17*, 452–459.

Marslen-Wilson, W. D. (1975). Sentence perception as an interactive parallel process. *Science, 189*, 226–228.

Marslen-Wilson, W. D., & Welsh, A. (1978). Processing interactions and lexical access during word recognition in continuous speech. *Cognitive Psychology, 10*, 20–63.

McCauley, C., Kellas, G., Dugas, J., & DeVellis, R. F. (1976). Effects of serial rehearsal training on memory search. *Journal of Educational Psychology, 78*, 474–481.

Merrill, E. C. (1985). Difference in semantic processing speed of mentally retarded and nonretarded persons: Comparison of short- and long-term memory processing. *American Journal of Mental Deficiency, 90*, 71–80.

Merrill, E. C., McCauley, C., Sperber, R. D., Littlefield, J., Rider, E. A., & Shapiro, D. (1985). *Age- and intelligence-related differences in semantic processing speed.* Paper presented at the annual meeting of the Society for Research in Child Development, Toronto, Canada.

Nettelbeck, T., & Lally, M. (1976). Inspection time and measured intelligence. *British Journal of Psychology, 67*, 17–22.

Perfetti, C. A., & Lesgold, A. M. (1977). Discourse comprehension and sources of individual differences. In M. A. Just & P. A. Carpenter (Eds.), *Cognitive*

processes in comprehension (pp. 141–183). Hillsdale, NJ: Erlbaum.

Posner, M. I. (1978). *Chronometric explorations of mind.* Hillsdale, NJ: Erlbaum.

Sperber, R., Davies, D., Merrill, E. C., & McCauley, C. (1982). Cross-Category differences in the processing of subordinate-superordinate relationships. *Child Development*, 1249–1253.

Sperber, R., & McCauley, C. (1984). Semantic processing efficiency in the mentally retarded. In P. H. Brooks, R. Sperber, & C. McCauley (Eds.), *Learning and cognition in the mentally retarded* (pp. 141–163). Hillsdale, NJ: Erlbaum.

Sperber, R. D., Merrill, E. C., McCauley, C., & Shapiro, D. (1983). *Intelligence-related differences in the efficiency of semantic encoding.* Paper presented at the annual meeting of the Society for Research in Child Development, Detroit.

Sperber, R. D., Ragain, R. D., & McCauley, C. (1976). Reassessment of category knowledge in retarded individuals. *American Journal of Mental Deficiency, 81*, 227–234.