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Similarities in Negative Priming Between Persons With and Those Without Mental Retardation of Equal Chronological Age

Edward C. Merrill, Steven M. McCown, and Shirley Kelley
University of Alabama

Adolescents with and those without mental retardation participated in a negative priming procedure in two experiments. They identified letters to stimulus displays presented in pairs. Negative priming was observed as the slowing of response times when the distractor in the first display (prime) became the target in the second display (probe). In the standard procedure, all displays include one target and one distractor. In our modification, prime displays occasionally included a distractor without a target. Although adolescents with mental retardation typically do not exhibit negative priming when responding on the basis of stimulus identity, they did so with single letter primes in these experiments.

Results of studies of visual selective attention processes indicate that efficient selection of one stimulus over another is likely to involve not only excitation directed toward the selected stimulus, but also inhibition that minimizes response tendencies to the stimulus that is not selected for further processing (e.g., Lowe, 1979; Neill, 1977; Tipper, 1985; Tipper & Cranston, 1985). This has been most evident in studies investigating the phenomenon of "negative priming" (e.g., Neill, 1977; Tipper, 1985). Negative priming is observed when individuals are presented visual displays containing two stimuli and must select and respond to one stimulus on the basis of some designated physical characteristic. For example, the display may contain two stimulus letters, each presented in a different color (e.g., the target is designated the red letter and the distractor is designated the blue letter). The experimental task is to identify the red letter and ignore the blue letter on a series of trials. Of primary interest is what happens when a distractor in one display becomes a target in the next display. The typical result is that response times are slower when identifying a target that was a distractor in the previous display relative to identifying that target if it was not in the previous display.

Active inhibition processes such as those presumed to be reflected in the negative priming paradigm are assumed to be important components of many cognitive activities, including memory, reasoning, and language comprehension (see Dempster & Corkill, 1999a, 1999b).

For example, when ambiguous words are encountered in text, comprehension depends on the active inhibition of context-inappropriate word meanings (e.g., Tanenhaus, Leiman, & Seidenberg, 1979). Because comprehension suffers when context-inappropriate meanings of words remain active during discourse processing (LeFever & Erhi, 1976), we would expect that individuals who exhibit difficulty using inhibition processes would also exhibit difficulties comprehending discourse. More generally, because inhibition processes are assumed to play a prominent role in a variety of cognitive activities, we would expect to observe cognitive performance difficulties associated with a failure to use inhibition processes efficiently across many cognitive tasks. It is, therefore, important that we carefully examine the use of inhibition processes of selective attention by individuals with mental retardation.

Studies of selective attention conducted on persons with mental retardation have shown that adolescents with mental retardation do not exhibit negative priming under all of the same conditions in which negative priming is observed for individuals without mental retardation matched on chronological age (CA). More specifically, when the participant's response is based on stimulus identity, individuals with mental retardation do not exhibit negative priming (e.g., Cha & Merrill, 1994; Merrill & Taube, 1996) whereas individuals without mental retardation typically do exhibit negative priming. In the experiments reported here, we wanted to further our understanding of selective attention in persons with mental retardation by attempting to create conditions in which adolescents with mental retardation would exhibit negative priming under stimulus identity instructions.

Recent research conducted on adults without mental retardation has indicated that attentional mechanisms play an important role in facilitating the inhibition that is observed with negative priming. For example, Engle, Conway, Tuholski, and Shisler (1995) reported that negative priming is resource dependent and can be disrupted by an attention demanding secondary task. In addition, MacDonald, Joordens, and Seergobin (1999) reported that manipulations focusing attention on distractor stimuli in the prime display increase the magnitude of negative priming. Further, Richards (1999) has demonstrated that manipulations designed to focus attention on the target stimuli and away from the distractor stimuli decrease the magnitude of negative priming. Based on these results, we reasoned that persons with mental retardation would be more likely to exhibit negative priming if we could increase their attention to the distractor stimuli. To accomplish this, we modified the standard identity negative-priming procedure (e.g., Cha & Merrill, 1994; Tipper, 1985) in one important way. In the standard procedure, each trial consists of a prime display followed by a probe display, with each display containing two letters. The target letter is presented in one specific color (e.g., red) and the distractor is presented in a second color (e.g., blue), with the participant identifying the target in each display. In our modification of the procedure, we only presented one stimulus in half of the prime displays (the probe displays always had two stimuli). Half of the time the single stimulus was a target (presented in red) and half of the time it was not a target (presented in blue). Participants were instructed to identify the red letter and withhold responding when only a blue letter was in the display. We expected that participants would attend to the distractor more when there was not a target in the prime display. Further, we believed that requiring participants to withhold responding when only a distractor appeared in the display would encourage the use of inhibition processes.

EXPERIMENT 1

In Experiment 1, we constructed three priming conditions in which the

prime display had a single stimulus or a double stimulus. In the positive-priming condition, the target in the probe display was the same letter as the target in the prime display. In the negative-priming condition, the target letter in the probe display was the same letter as the target in the prime display. Participants did not respond to the prime display when only a single letter appeared in the negative-priming condition. In the neutral condition, the target and distractor in the probe display were different from the letter or letters in the prime display. In the neutral condition, participants responded to half of the prime displays (when the single letter was a target). If our manipulation induced the participants with mental retardation to inhibit the distractor stimuli, then we expected to observe negative priming under conditions in which the prime display contained a single stimulus but not when the prime display contained two stimuli.

It is important to mention that even if we observe inhibition in our experiment, it will not be identical to the standard negative-priming effect observed for adolescents and adults without mental retardation in previous studies (e.g., Cha & Merrill, 1994; Neill, 1977; Tipper, 1985; Tipper & Cranston, 1985). When the typical effect is observed, it is generally assumed that participants are unaware of the relation between the distractor in the prime and the target in the probe. This will not be the case in Experiment 1. Hence, any effect we observe may involve somewhat different mechanisms than the standard effect. Nevertheless, we believe that any demonstration of inhibition of identity responses by persons with mental retardation will further our understanding of the relative similarities and differences between persons with and those without mental retardation.

Method

Participants

Participants were 16 adolescents with and 16 adolescents without mental retardation. The adolescents with mental retardation were recruited from the local schools systems. They had an average IQ of 66.3 (standard deviation [*SD*] = 7.3) and chronological age (CA) of 17.2 (*SD* = 1.1). The adolescents without mental retardation were recruited from introductory psychology classes and had an average CA of 17.5 years (*SD* = .4). The adolescents with mental retardation received $5.00 for participating and the adolescents without mental retardation received course credit.

Materials

Each trial consisted of two displays, a prime display followed by a probe display. The prime displays could contain either one or two letters. When the prime display included one letter, it could be printed in either red or blue. When the prime display included two letters, one was printed in red and one was printed in blue. Probe displays always included two letters, one in red and one in blue. Red letters were designated as targets in all displays. Single letters appeared in the center of the screen. Targets appeared to the right or left of center an equal number of times in two-letter displays. The letters *A, B, C,* and *D* (both upper- and lowercase) were used as stimuli. Letters were approximately 5 cm high and 4 cm wide. When two letters appeared in the display, they were separated by approximately 2 cm. The stimuli subtended no greater than 1.25 degrees of visual angle. There were a total of 120 trials, 60 in which there was one letter in the prime and 60 in which there were two letters in the prime. In both the one-letter prime and the two-letter prime conditions, there were 20 positive-priming trials, 20 negative-priming trials, and 20 neutral trials. In the positive-priming trials, the target in the probe was the same letter as the target in the prime. In the negative-priming condition, the target in the probe was the same as the distractor in the prime. In the neutral condition, both letters in

the probe were different from the letter or letters in the prime. The neutral condition with single primes was constructed such that the letter in the prime was a target half of the time and a distractor for the remaining trials. Trials were presented in random order.

Design and Procedure

The variables in the experiment were participant groups (mentally retarded, nonretarded), number of prime letters (one, two), and type of prime (positive, negative, neutral). Number of prime letters and type of prime were manipulated within participants. The primary dependent variable was probe target identification time. These times were recorded to the nearest msec.

Participants, who were tested individually, were seated approximately 50 to 60 cm from the display. They were informed that they would view a series of displays containing either one or two letters and that the letters would be printed in either red or blue. Participants were instructed to identify the red letters as quickly and accurately as possible and ignore the blue letters. They were explicitly told that if a display only had a blue letter that they were not to respond to that display. We presented stimuli via a Macintosh LC computer using the software program *Superlab* (Cedrus Corp). Responses were made manually on the computer keyboard, with the *A, S, K,* and *L* keys relabeled *A, B, C,* and *D,* respectively. Participants were asked to rest the middle and index fingers of each hand on the keyboard to facilitate rapid responding. They received up to 20 practice trials to familiarize them with the equipment and experimental procedure. Participants who did not or could not perform the task as instructed were not included in the experiment. Three participants with and one participant without mental retardation were excluded for this reason. During the experiment, each display was presented for a maximum of 2 seconds. When a response was made, the current display was removed and the next display was presented 250 msec later. If a response was not made before 2 seconds had elapsed, the current display was removed and the next display was presented. If responses were not made for displays in which a target was presented, the participant's failure to respond was counted as an error. This is the only procedural difference of substance between this experiment and previous experiments. Response times and errors in responding were automatically recorded.

Results and Discussion

Mean probe target identification times were calculated for each participant in each condition, excluding trials in which errors were made. Because the procedure limited response times to less that 2000 msec, there were no outliers to exclude from the calculation of means. The data are presented in Table 1. Error rates were low and did not vary systematically as a function of participant groups or conditions. Errors of responding (i.e., responding with the incorrect letter name) are also reported in Table 1. Errors of commission (responding to a distractor) were 1.8% for the participants without mental retardation and 2.2% for the participants with mental retardation. Errors of omission (not responding to a target) were less than 0.5% for both groups of participants. The primary analysis was a 2 (participant groups: mentally retarded, nonretarded) $\times$ 2 (number of prime letters: one letter, two letter) $\times$ 3 (type of prime: positive priming, negative priming, neutral) multivariate analysis of variance (MANOVA), with number of prime letters and type of prime treated as within participant variables. Results for the repeated measures are reported in terms of Wilks' lambda, with significance tested at .05.

The analysis revealed a significant main effect of participant groups, $F(1, 30) = 76.30$, $p < .001$, a significant main ef-

Table 1
Mean Response Times and Standard Deviations for Identifying Targets as a Function of Groups and Stimulus Conditions

	Group					
	Mentally retarded			Nonretarded		
Prime	Mean	*SD*	Errors (%)	Mean	*SD*	Errors (%)
Single						
Positive	868	151	1.1	623	78	1.3
Negative	1128	185	2.0	755	93	1.5
Neutral	1072	150	1.5	651	81	1.6
Double						
Positive	812	127	1.8	568	79	1.5
Negative	1129	195	1.7	751	101	1.9
Neutral	1058	170	1.8	600	104	1.3

fect of number of prime letters, $F(1, 30) = 5.59$, $p < .05$, and a significant main effect of type of prime, $F(2, 29) = 121.12$, $p < .001$. There was also a significant interaction of participant groups and type of prime, $F(2, 29) = 18.15$, $p < .01$. Neither the main effect of number of prime letters nor any other interaction effect was significant. The main effect of group indicated that the participants with mental retardation responded more slowly than did the participants without mental retardation (1013 msec vs. 658 msec, respectively). The main effect of number of primes indicated that response times were longer in the single prime condition than in the double prime condition (850 msec vs. 821 msec, respectively). The main effect of type of prime was evaluated using Tukey's HSD, indicating that response times in the positive prime condition were significantly faster than responses times in the neutral condition (720 msec in the positive condition and 845 msec in the neutral condition, $p < .01$), and that response times in the negative-priming condition were significantly slower than response times in the neutral condition (941 msec in the negative condition and 845 msec in the neutral condition, $p < .01$). Because this result was somewhat surprising (we expected negative priming in the one-letter but not the two-letter condition for the participants with mental retardation), we decided to test whether or not there was significant negative priming separately in each condition for each group. The results of the four *t* tests comparing the negative and neutral response times in each group by number of prime letters conditions revealed that negative priming was, in fact, observed in each of the negative-priming conditions, all ps $< .05$. Hence, we found evidence of significant inhibition in both the one-letter prime condition and the two-letter prime condition for our participants with mental retardation. This is the first time that identity negative priming by adolescents with mental retardation has been reported.

Tests of simple effects were conducted to evaluate the Participant Group × Type of Prime interaction. The analyses revealed that this interaction was due to significantly greater positive priming being observed for the participants with mental retardation than for the participants without mental retardation (220 vs. 30 msec, respectively). This group difference has been observed in all of the studies of negative priming conducted on adolescents with mental retardation reported in the literature (Cha & Merrill, 1994; Merrill, Cha, & Moore, 1994; Merrill & Taube, 1996). However, the magnitude of the difference was much greater in this experiment than in previous experiments, which may have been due to the go versus no-go nature of the single-stimulus prime trials. More specifically, we suspect that participants were relatively more rapid in the positive-priming condition in this experiment because they engaged in a "matching-to-prime" type task that was discovered and encouraged by our use of single letter targets in the prime displays. This process should be relatively faster than identifying the letters, as would be necessary in the neutral priming condition, and would result in larger priming in the positive condition. Assuming that persons with mental retardation benefit more from the comparison of "matching" vesus "identifying" (because persons without mental retardation are considerably faster with identification), we believed a greater difference in positive priming

would result from using this procedure. The difference between groups in the magnitude of negative priming was not significant, although the difference was fairly large (64 msec vs. 127 msec for the participants with and those without mental retardation, respectively). Negative-priming effects for both groups were, in fact, much larger than is typical when letters are used as stimuli (i.e., the typical effect is about 20 msec). The failure to reach significance with this size difference may have been due to variability introduced by the procedure. However, the most important result was that identity negative priming was observed for persons with mental retardation using this procedure where it had not been observed previously. A second experiment was conducted to pursue this in more detail.

EXPERIMENT 2

Persons with mental retardation exhibited identity negative priming in Experiment 1; however, we could not conclude that it was due to our manipulation because negative priming was evident in both the single-stimulus and double-stimulus prime conditions. We conducted a second experiment to determine whether the single-prime manipulation created the conditions for negative priming to be exhibited by our participants with mental retardation. In Experiment 2, the single- and double-stimulus prime conditions were presented in homogeneous blocks using an ABA reversal design. First, participants received a block of double-stimulus primes, followed by a block of single-stimulus primes, and then followed by a second block of double-stimulus primes. If the single-prime manipulation led to participants with mental retardation exhibiting negative priming in Experiment 1, then we expected these participants to exhibit negative priming only after they were switched to the single-stimulus prime condition. In addition, by employing a second block of double-stimulus primes, we could evaluate the degree to which any negative priming that is encouraged by the single-stimulus prime generalizes to a subsequent double-stimulus condition.

We made one other procedural change in Experiment 2. We did not include the positive-priming condition. Our primary reason was that we wanted to eliminate the value of participants engaging in the matching strategy discussed earlier. In addition, the positive-priming trials were not necessary for addressing the primary issues of the experiment, and we wanted to keep the overall number of trials to a manageable size.

Method

Participants

Participants were 15 adolescents with and 15 adolescents without mental retardation who were recruited in the same manner as in Experiment 1. The adolescents with mental retardation had a mean IQ of 62.1 (SD = 8.8) and a mean CA of 17.2 years (SD = 1.4). The adolescents without mental retardation had a mean CA of 17.8 (SD = .5).

Materials

Materials were identical to Experiment 1 except that positive-priming trials were not included in Experiment 2. This change was made because positive-priming trials were not needed to address the primary questions of the experiment, and we wanted to decrease the number of trials and time to test individual participants.

Design and Procedure

The variables were group (mentally retarded, nonretarded), type of prime (neutral, negative), and trial block (first double, single, second double). Type of prime and trial block were manipulated

within subjects. Data collection proceeded in a manner analogous to Experiment 1.

Results and Discussion

Mean probe target identification times were calculated for each participant in each condition, excluding trials in which errors were made. These data are presented in Table 2. Errors of responding were low and did not vary systematically as a function of participant groups or conditions (see Table 1). Errors of commission were 2.0% for the participants without mental retardation and 2.2% for the participants with mental retardation. Errors of omission were again less than 0.5% for both groups. We first conducted a preliminary analysis using a 2 (participant groups: mentally retarded, nonretarded) × 3 (trial block: first double, single, second double) MANOVA, with number of prime letters and trial block treated as within-participant variables. This analysis was conducted on negative-priming effects calculated by subtracting response times of the neutral condition from the negative condition for each trial block (see Table 3).

The analysis revealed a marginal main effect of group, $F(1, 28) = 3.03$, $p < .09$, with the participants who did not have mental retardation exhibiting greater negative-priming effects than did the participants with mental retardation (36.5 msec vs. 12.4 msec, respectively). There was also a significant main effect of trial block, $F(2, 28) = 8.67$, $p < .01$, with larger negative-priming effects being observed in the single-stimulus condition (45.6 msec) than in either the first double (4.0 msec) and second double (14.7 msec) conditions. The interaction of group and trial block was not significant.

Because the third trial block (second double stimulus) could not have influenced performance in the first two trial blocks, we decided to reanalyze the data without including the last block to address our primary question. This analysis yielded a significant effect of trial block, $F(1, 28) = 15.9$, $p < .01$, and a significant interaction of group and trial block, $F(1, 28) = 4.52$, $p < .05$. Tests of simple effects indicated that the participants without mental retardation exhibited greater negative priming in the first double trial block than did the participants with mental retardation, $F(1, 28) = 6.34$, $p < .05$. However, the two groups were virtually identical in the single-stimulus trial block. Participants with and without mental retardation exhibited large and equal negative-priming effects in the single prime condition, whereas only the participants without mental retardation exhibited negative priming in the first double prime condition.

To assess the maintenance/generalization of negative priming, we compared negative priming in the first double condition with negative priming in the second double condition. This analysis revealed a significant main effect of

Table 2
Mean Response Times and *SD*s for Identifying Targets in Experiment 2 by Group and Stimulus Condition

	Group					
	Mentally retarded			Nonretarded		
Prime	Mean	*SD*	Errors (%)	*SD*	Mean	Errors (%)
First double						
Neutral	1168	163	0.9	676	111	1.2
Negative	1150	179	1.4	650	102	0.8
Single						
Neutral	1153	154	1.1	685	124	1.0
Negative	1298	142	1.5	639	116	1.3
Second double						
Neutral	1135	171	1.3	655	101	0.8
Negative	1145	151	1.2	628	93	1.1

Table 3
Mean Negative Priming Effects and *SD*s in Experiment 2 as a Function of Groups and Stimulus Conditions

Group	First double	Single	Second double
Mentally retarded			
Mean	−18	45	10
Standard deviation	53	52	56
Not mentally retarded			
Mean	26	46	37
Standard deviation	43	38	51

group, $F(1, 28) = 8.87$, $p < .05$, and a significant main effect of trial block, $F(1, 28) = 5.44$, $p < .05$. The interaction was not significant. Persons without mental retardation exhibited greater negative priming than did persons with mental retardation (32 msec vs. −4 msec), and both groups exhibited some residual effect associated with the single-stimulus primes. Hence, there was some amount of maintenance/generalization from the second to the third block of trials, but this did not differ for the two groups. Of course, we cannot rule out the possibility that practice alone might account for the increase in negative priming. However, previous research with similar numbers of trials has not indicated any increase in negative priming for persons with mental retardation.

One big difference between results in the two experiments was the size of the negative-priming effects. In Experiment 1, negative-priming effects were huge (over 100 msec). In Experiment 2, they were still larger than normal (about twice as big as the standard effect with letters) but were less than half the size of those in Experiment 1 (40 msec). It is reasonable to think that the difference in conditions led to this discrepancy. In Experiment 1, the trials in which no response was made occurred less often and less predictably. This may have had a greater disruptive effect on overall response times in all conditions. Indeed, a look at the overall response times in the two experiments indicates that they were relatively slower in Experiment 1 than in Experiment 2. Previous research has demonstrated that negative-priming effects are larger when the selection task is more difficult (e.g., Ruthruff & Miller, 1995). Assuming that larger response times reflect task difficulty, then observing larger negative-priming effects in Experiment 1 than in Experiment 2 would be consistent with previous research. We also believe that the letter-matching strategy may have influenced the magnitude of negative priming.

General Discussion

In these experiments, we created conditions in which persons with mental retardation exhibited inhibition under instructions to respond on the basis of stimulus identity. This is in contrast with previous research in which researchers have failed to demonstrate identity negative priming by adolescents with mental retardation (Cha & Merrill, 1994; Merrill & Taube, 1996). We believe that this is an important result because it indicates that individuals with mental retardation can exhibit inhibition that is similar to individuals without mental retardation. Hence, the difference between groups observed in earlier studies appears to reflect a difference in the generality with which identity negative priming is observed rather than a deficiency in a basic ability. It is also important that we observed negative priming in both the one-letter and two-letter prime conditions of Experiment 1 and slightly more negative priming in the second block of double-stimulus primes (following the single-stimulus prime trials) in Experiment 2. Both results suggest that the tendency to inhibit distractors carried over from the single-stimulus prime trials to conditions that did not usually elicit negative priming from persons with mental retardation. What remains to be explained is why they do not inhibit distractors spontaneously in the standard negative-priming experiment and yet do so when "encouraged" by task conditions to attend to the distractor.

One issue that has not been addressed adequately in the experimental literature concerning negative priming is how it develops. Tipper and colleagues (e.g., Tipper, Bourque, Anderson, & Brehaut, 1989) have reported that negative priming is observed developmentally earlier for choices based on stimulus location than for choices based on stimulus identity. Indeed, persons with mental retardation have also exhibited negative priming in a location-based task (Merrill et al., 1994). However, recent research

has indicated that processes other than inhibition may be responsible for negative priming of location (see Milliken, Tipper, & Weaver, 1994; Park & Kanwisher, 1994). It is, therefore, unlikely that negative priming for location develops first and then generalizes to identity decisions. We think that we may have tapped into the developmental progression with our manipulations. Perhaps inhibition occurs initially when attention is directed to an object for which a response must be withheld without there necessarily being a "target" object in the area. In the case of our experiments, we did this with the single-stimulus distractors. With sufficient experience in this form of inhibition, the process may eventually generalize and be more or less spontaneously observed in conditions in which a target object is also present. We know from past research that persons with mental retardation may not benefit from practice and experience of this sort to the same degree as do persons without mental retardation (e.g., Merrill, Goodwyn, & Gooding, 1994). Hence, persons with mental retardation may be less likely to engage spontaneously in the processes that result in negative priming even after much practice than are persons without mental retardation.

The results of Experiment 1 suggest that another way that attention can be directed to the distractors might be to increase the salience of some important dimension of the distractor. This may have been how we encouraged the generalization of the negative-priming effect to the double-stimulus condition in the first experiment. Presenting some blue stimuli alone may have enhanced the salience of the distractors and encouraged additional attention to them even when a target was also presented in the prime. To the extent that distracting stimuli are more salient, the selection between distractor and target would be more difficult. As mentioned previously, Ruthruff and Miller (1995) found that difficulty of selection increases the likelihood that negative priming will be observed. Perhaps the training of mechanisms of selective attention requires that salient distractors be placed prominently in the environment rather than strategically removed.

One additional result was observed in this experiment. Consistent with previous research (Cha & Merrill, 1994; Merrill et al., 1994; Merrill & Taube, 1996), the participants with mental retardation in Experiment 1 exhibited significantly greater positive priming than did the participants without mental retardation. Cha and Merrill suggested that this effect may be due to an exclusive attentional focus on the target on the part of the participants with mental retardation that required greater activation for a response to be made in the absence of inhibiting the distractor. In essence, they posited that participants needed to reach an optimum signal to noise ratio to initiate a response. In their study, the ratio included only activation for the participants with mental retardation but both activation and inhibition for the participants without mental retardation. Hence, reaching a response threshold would require greater activation for the participants with mental retardation. It now appears that this hypothesis may not be entirely correct. In Experiment 1, we did observe negative priming for the participants with mental retardation, and yet they still exhibited significantly greater positive priming than did the participants without mental retardation. Therefore, the explanation for the larger positive-priming effect may be relatively independent of whether or not negative priming is observed. However, it was still the case that persons without mental retardation did exhibit negative priming that was twice as large as the effect observed for persons with mental retardation in Experiment 1. So, we cannot rule out this explanation altogether.

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