Psychology and Aging
2000, Vol. 15, No. 1, 9–17

0882-7974/00/$5.00 DOI: 10.1037//0882-7974.15.1.9

Further Evidence That Negative Priming in the Stroop Color–Word Task Is Equivalent in Older and Younger Adults

Deborah M. Little and Alan A. Hartley
Scripps College

In 2 experiments, possible adult age differences in negative priming were explored using several variants of the Stroop color–word task. Negative priming was at least as high in the older adults as in the younger adults in every variant. Negative priming varied as a function of condition, but the age equivalence was unaffected. This result was true even when the possibility of general slowing was taken into account. Across conditions, interference and negative priming were positively correlated. The results do not permit a clear choice between the 2 major theoretical explanations of negative priming, inhibition and memory retrieval; they do show that negative priming can be systematically manipulated within an experimental paradigm.

Hasher and Zacks (1988, 1997) have theorized that the ability to inhibit the processing of distracting information is compromised in old age. Much of the support for this theory comes from studies that use negative priming as an operational marker for inhibitory functioning. Negative priming is measured over pairs of trials in which both a target and a distractor are present. The distracting information on the prime trial (n) then becomes the target information to which the participant must respond on the probe trial ($n + 1$).[1] Inhibition plays a central role in each of the theoretical explanations that have been offered for negative priming. Researchers have proposed negative priming as a benchmark for the intactness of inhibitory functioning (Kane, May, Hasher, Rahhal, & Stoltzfus, 1997; May, Kane, & Hasher, 1995). One theoretical account is that selection of the target on the prime trial can be accomplished efficiently by inhibiting processing of the distractor. The inhibition will have effects that will carry over to the probe trial: If the distractor from the prime trial becomes the target on the probe trial, the processing of the previously inhibited target will be suppressed and the response slowed. The second theoretical account, episodic retrieval, postulates that the presentation of a stimulus automatically elicits information from previous presentations (see May et al., 1995; Neill & Valdes, 1992). If the previous presentation of the current target was as a distractor, then the information recalled is that this target had previously been tagged with the instruction *do not respond.* This remembered information conflicts with the requirement on the current trial for a response to the target and must be inhibited to allow a correct response. (Conversely, if the target had also been a target on a prior trial, the remembered instruction to respond would facilitate responding on the current trial, resulting in positive priming.) It is important to note the implicit assumption that only information from the immediately preceding stimulus is retrieved (or less restrictively, information from trials more than one back is severely attenuated). If participants retrieved information for the last two or more stimuli with equal strength, in most balanced sequences, any particular stimulus aspect would have an equal weight of *respond* and *do not respond* tags. Malley and Strayer (1995) and Strayer and Grison (1999) have proposed an alternative to the simple assumption of instance retrieval. They found that negative priming occurs only for stimuli that repeatedly occur as targets. They proposed that only stimuli that have a high level of activation from prior presentations elicit the processing that leads to a *do not respond* tag.

Several studies have found negative priming in young adults but not older adults: For young adults but not older adults, responses slow on trials in which the previous distractor becomes the target (Connelly & Hasher, 1993; Hasher, Stoltzfus, Zacks, & Rypma, 1991; Kane, Hasher, Stoltzfus, Zacks, & Connelly, 1994; McDowd & Oseas-Kreger, 1991; Stoltzfus, Hasher, Zacks, Ulivi, & Goldstein, 1993; Tipper, 1991; also see Fox, 1995; May et al., 1995; and Neill, Valdes, & Terry, 1995, for recent reviews). Other studies, however, have reported that negative priming in elderly adults is the same or even greater than in young adults (Kieley & Hartley, 1997; Kramer, Humphrey, Larish, Logan, & Strayer, 1994; Schooler, Neumann, Caplan, & Roberts, 1997; Sullivan & Faust, 1993; Sullivan, Faust, & Balota, 1995). Researchers have used a variety of different target and distractor stimuli, including overlapping letters (e.g., McDowd & Oseas-Kreger, 1991), overlapping pictures (e.g., Sullivan & Faust, 1993), adjacent letters (Kramer et al., 1994), picture–word combinations (Schooler et al., 1997), and Stroop color words (Kieley & Hartley, 1997). The absolute levels of negative priming—the difference between probe

Editor's Note. Joan M. McDowd served as the action editor for this article.—LLL

Deborah M. Little and Alan A. Hartley, Department of Psychology, Scripps College.

Deborah M. Little is now at the Volen National Center for Complex Systems, Brandeis University.

Correspondence concerning this article should be addressed to Alan A. Hartley, Department of Psychology, Scripps College, Claremont, California 91711. Electronic mail may be sent to ahartley@scrippscol.edu.

[1] We use negative priming here to refer only to the identity of the stimulus. Researchers have also studied location negative priming (e.g., Connelly & Hasher, 1993). In location negative priming procedures, the target appears at the location previously occupied by a distractor.

trial reaction time (RT) and prime trial RT—have also varied considerably across studies. Studies from the research program of Hasher and Zacks reported an average negative priming effect of 9.6 ms for younger adults and 1.3 ms for older adults (unweighted means across studies: Connelly & Hasher, 1993; Hasher et al., 1991; Kane, Hasher, et al., 1994; Kane, May, et al., 1997; Stoltzfus et al., 1993). At the other extreme, Kieley and Hartley (1997) found average negative priming effects of 55.3 ms for both younger and older adults across their three experiments. The conflation of different outcomes with different methods makes it difficult to interpret the existing findings. The present experiments attempted to produce different levels of negative priming in different conditions of within-subjects designs in an effort to resolve some of the uncertainty and explore age effects as the size of the negative priming effect varied.

There is no direct evidence for manipulations that affect the level of negative priming. Inhibition, however, is central to both major theoretical explanations, distractor suppression and episodic retrieval. Inhibition is thought to be directly related to the interference caused by distractors.[2] There is good evidence for manipulations that affect the amount of interference. In the present experiments, then, to affect the amount of negative priming, we created conditions that were expected to vary the amount of interference using alternate versions of the Stroop color–word task (Stroop, 1935). We expected that the amount of interference would affect the activation of inhibitory processes that would, in turn, affect the amount of negative priming. In the Stroop task, experimenters present words and colors and participants are to identify the color. The word may be the name of the color presented, in which case the color and word are congruent and responses are typically speeded. The word may be the name of a different color, in which case the color and word are incongruent and responses are typically slowed. The neutral condition is one in which experimenters present color-unrelated or nonsense words. The Stroop task is ideal to investigate the relationship between negative priming and interference not only because it has been used to elicit negative priming (Dalrymple-Alford & Budayr, 1966; Kieley & Hartley, 1997; Lowe, 1979, 1985; Neill, 1977), but also because variables that affect interference have been studied extensively (see MacLeod, 1991, for a review). In Experiment 1, we used the original task and four variants. In the combined condition (i.e., the standard Stroop task), the color and word were a single, integrated stimulus. In the superimposed condition, we presented the word in light gray, centered on a block of color (cf. Kamlet & Egeth, 1969). There were also near-adjacent and far-adjacent conditions, in which the word appeared above or below a colored bar. Kahneman and Chajczyk (1983) presented a color word randomly above or below a bar of color. They found that interference was reduced relative to the standard condition when the word was separated from the color and that when the word was moved further above or below the color bar, interference was lowered even more. We predicted that Stroop interference—the difference between RT for incongruent trials in which the color and word disagreed and RT for neutral trials in which the word was neutral with respect to color—would decrease systematically from the standard condition to the superimposed condition to the near-adjacent condition to the far-adjacent condition.

Verhaeghen and De Meersman (1998a) have recently reported the results of a meta-analysis of a small number of studies of aging and negative priming. They concluded that there was a reliable negative priming effect across studies. They also concluded that negative priming has a multiplicative rather than an additive effect on the processing stages it affects. Specifically, they found that the aggregate data were well fit by a model in which

$$RT_{\text{negative priming}} = b_0 + b_1(RT_{\text{baseline}}), \quad (1)$$

with b_0 equal to −0.036 ms for both age groups and b_1 very slightly smaller for older adults (1.08) than for younger adults (1.10). They also found that the heterogeneity in effect sizes was not significant; there were no moderator variables to be accounted for. The inferred homogeneity of multiplicative effect sizes led Verhaeghen and De Meersman to the conclusion that the findings of the extant studies could be explained by general slowing. That is, across experiments, greater or lesser negative priming was no more than would be expected from the higher or lower RTs in the baseline comparison conditions. The conclusions from Verhaeghen and De Meersman's meta-analysis have a direct implication for the present experiments: Differences in negative priming—either differences between age groups or differences among conditions within an age group—should be largely accounted for by general slowing, although the negative priming effect may be slightly smaller in older adults than in younger adults. To test this prediction, in addition to analyses carried out on the negative priming effect as it is usually defined—the difference between RT on negative priming trials and RT on baseline trials—we also carried out analyses on the negative priming effect expressed as the ratio of the RT on the negative priming trials to the RT on the baseline comparison trials for each participant in each condition. This transformation is not perfect, inasmuch as the value Verhaeghen and De Meersman found for the intercept, b_0, was significantly different from zero. Nevertheless, the estimated value was very close to zero, and it was the same for younger and older adults; hence, the ratio provides an a priori transformation that can be calculated from the data of individual participants and that is unlikely to be biased. Because Verhaeghen and De Meersman (1998b) concluded in a separate meta-analysis that general slowing can also account for age-related differences in the Stroop interference effect, we also applied ratio transformations to the interference data in analyses of the present experiments.

[2] The two principal theoretical explanations for negative priming, distractor suppression and episodic retrieval, both assign a central role to interference and inhibition. In the usual suppression account, greater interference indicates that the individual is less successful at suppressing processing of the distractor. Reduced suppression, then, results in reduced negative priming when the distractor becomes the target on the subsequent trial. In the usual episodic retrieval account, greater interference should result in stronger *do not respond* tagging, which should, in turn, produce greater negative priming on the subsequent trial. Other predictions could be drawn for each position (Fox, 1995). For example, an alternate suppression account holds that conditions producing greater interference will elicit greater efforts to suppress it, resulting in greater negative priming. An alternative episodic retrieval account holds that greater interference indicates the individual was less successful in applying the *do not respond* tag, so greater interference should be accompanied by reduced negative priming. The important point for the present research is that both theoretical positions predict a relationship between interference and negative priming, although the direction of the relationship is a matter for debate.

Experiment 1

Method

Participants. Thirty-one younger adults participated in Experiment 1 as one of several options for extra credit in an undergraduate introductory psychology course. Mean age was 18.4 years (range = 18–20), mean years of education completed was 12.9 (SD = 0.57), mean self-rating of current health status was 8.3 (on a 10-point scale, with 10 as *excellent; SD* = 1.37), and mean visual acuity using a Snellen chart viewed binocularly at 20 ft (6.1 m) was 23.4/20 (SD = 8.10). Thirty-one community-dwelling older adults participated in Experiment 1. Mean age was 74.2 years (range = 65–87), mean years of education completed was 16.3 (SD = 3.39), mean self-rating of current health status was 9.0 (SD = 1.21), and mean visual acuity was 28.8/20 (SD = 9.44). Five participants were dropped from each group because their responses failed to trip the voice-operated relay on more than 25% of the trials; thus, the final sample size was 26 participants in each age group.

Design. Each participant completed four experimental conditions; the order of the conditions was randomly determined for each participant. In each condition, the task was to name the color (other than light gray) that appeared in the display. In the standard condition, the words themselves were presented in colors. In the superimposed condition, the word was presented in light gray, superimposed on a block of color. In the near-adjacent condition, the word was printed in light gray directly above or below a horizontally oriented color block. In the far-adjacent condition, the word was positioned near the top or bottom of the screen, with a horizontally oriented color bar at fixation.

Displays and procedure. Stimuli were presented on a 33-cm (13-in.) SVGA monitor driven by an Intel-486 personal computer. Stimulus presentation and voice response collection were controlled by the Micro Experiment Laboratory software and response box (Schneider, 1995). Typical viewing distance was 46 cm, although head position was not constrained. Stimuli were presented against a dark background. The colors used were red, green, blue, and yellow. The names of those colors were the color words used; the neutral words were *rug, boat, glove,* and *yeoman.* There were 132 trials in each condition, run in a single block. The sequence of trials began with a randomly ordered mix of 36 trials consisting of 12 congruent trials (a color word presented in the corresponding color), 12 incongruent trials (a color word presented in some other color), and 12 neutral trials (a neutral word presented in one of the four colors). The order of trials was random except that in no case was the color word on one trial the target color on the following trial. Sixty incongruent trials followed these 36 trials. On half of the 60 incongruent trials, the color word on the one trial became the target color on the next trial (negative priming trials). On the other half of the trials, there was no relation between the color and word on one trial and those on the next; that is, neither the color word nor the color on one trial could appear as either the color word or color on the next trial (no-relation trials). These two types were randomly intermixed. The 60 incongruent trials were followed by another 36 trials that randomly mixed congruent, incongruent, and neutral trials.[3] The words, printed in capital letters, subtended approximately 1.6° vertically and 4.6° to 9.8° horizontally. In the superimposed, near-adjacent, and far-adjacent conditions, the color was presented as a block subtending 2.5° vertically and 10.8° horizontally, centered in the display. In the superimposed condition, the word was centered on the color block. In the near-adjacent condition, the nearest contours of the letters were 0.3° above or below the color block (randomly determined); in the far-adjacent condition, the nearest contours were 2.9° above or below the color block (again, randomly determined). Each trial began with a white, outline rectangle subtending 2.5° by 10.8°, which was presented for 500 ms at the location in which the color block would appear (except for the standard condition, in which case the rectangle outlined the area in which the word would appear). This was followed by the word and, if appropriate, the color block, which remained for 1,500 ms or until a voice response was sensed. The participant was instructed to name the color as quickly as possible but without making errors, ignoring the words that appeared. The intertrial interval was 1,000 ms. There was a rest break midway through each condition. The experimental session was tape-recorded so that the correctness of responses could be determined later. The session began with a practice block of 128 neutral trials, 32 from each experimental condition, with a short break after each set of 32. The practice trials were followed by the four experimental conditions, with the order randomly chosen for each participant.

Results

In both experiments, we set the alpha level at .05. We carried out tests for sphericity when it was appropriate. For cases in which the test was significant, we applied a Greenhouse–Geisser correction; we report the conservative probability here.

Stroop interference: RTs. Conventionally, Stroop interference is calculated as the difference in RT between incongruent trials and neutral trials. We used RTs from the 72 mixed trials for this analysis.[4] Age group was a between-subjects variable in the analysis of variance; condition (standard, superimposed, near-adjacent, and far-adjacent) and trial type (incongruent and neutral) were within-subjects variables. Mean RTs appear in Table 1. There were significant main effects of age group, $F(1, 50) = 5.78$, $p = .020$, $MSE = 72{,}380.77$, and of trial type, $F(1, 50) = 185.66$, $p < .001$, $MSE = 2{,}263.18$. Average RTs were shorter for younger adults (M = 694 ms) than for older adults (M = 757 ms). There was significant Stroop interference, with RTs on neutral trials (M = 694 ms) shorter than those on incongruent trials (M = 757 ms). There was a significant main effect of experimental condition, $F(3, 150) = 81.00$, $p < .001$, $MSE = 3{,}459.73$, and there were significant interactions of age group and condition, $F(3, 150) = 4.12$, $p = .014$, $MSE = 3{,}459.73$, of age group and trial type, $F(1, 50) = 5.06$, $p < .001$, $MSE = 2{,}263.18$, and of trial type and condition, $F(3, 150) = 18.82$, $p < .001$, $MSE = 966.04$. The interaction of age group with trial type and condition did not achieve significance, $F(3, 150) = 0.33$, $p = .806$, $MSE = 966.04$.

---

[3] We included the block of incongruent trials because pairs of trials permitting assessment of negative priming occur very infrequently in a normal mix of congruent, incongruent, and neutral trials. Further, Kane, May, et al. (1997) argued that pairs of trials on which the target is the same may specifically encourage a strategy of holding the last prior stimulus in immediate memory. For these reasons, it was necessary to have a segment of trials with a very high proportion of incongruent trials, during which there would be no repeated targets. We elected to embed the segment between two segments of mixed stimuli, with no obvious break from one segment to the next. We felt that participants would be less likely to notice the uniform block after 36 trials of developing concentration on the color-naming task. Because this method formed a type of ABBA design, it provided the additional advantage that measures of Stroop interference would be based on a combination of trials early and late in a set. We make no claim that the participants would not have noticed that there were a large number of incongruent trials in the middle of a condition. We note, however, that the rational strategy if one were to notice the disparity would be to make every effort to ignore the word, because there could be no benefit to reading it (as there is when congruent trials may occur).

[4] Normally, the analysis would have been based only on trials with correct responses. Because of problems in recording, reliable error data were not available for some participants in some conditions. For participants with complete error data, we compared RTs for all trials and for correct trials only. In no case was there a significant difference between the two, so we used RTs from all trials for the analyses reported here.

Table 1
Reaction Times (RTs), Interference, and Negative Priming in Experiment 1

	Standard		Superimposed		Near-adjacent		Far-adjacent	
Age and measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Younger								
Incongruent	793	96	722	87	694	83	672	86
Neutral	709	65	666	73	652	73	643	74
Interference[a]	84	63	56	45	42	43	29	39
Congruent	682	79	639	78	599	79	597	74
Suppression	839	79	755	101	750	94	723	71
No-relation	792	79	747	88	730	89	705	76
Negative priming[b]	47	47	8	44	20	40	18	47
Older								
Incongruent	901	125	793	125	770	135	715	124
Neutral	787	110	719	125	705	120	671	103
Interference	114	70	74	49	65	46	44	41
Congruent	735	123	660	104	635	103	634	90
Suppression	939	149	792	143	803	141	750	131
No-relation	896	138	785	142	757	123	733	122
Negative priming	43	46	7	36	46	47	17	41

[a] Interference = $RT_{incongruent} - RT_{neutral}$. [b] Negative priming = $RT_{suppression} - RT_{no\ relation}$.

Tests of simple main effects for the interaction of age group and condition showed that RTs were significantly longer for the older adults than for the younger adults in the standard, superimposed, and near-adjacent conditions but not in the far-adjacent condition. To explore the interactions with trial type, we calculated a Stroop interference score for each participant in each condition. Mean interference scores appear in Table 1. Interference was greater for older adults (M = 74 ms) than for younger adults (M = 53 ms). Paired comparisons using Bonferroni t tests showed that interference was greatest in the standard condition. The superimposed and near-adjacent conditions did not differ from one another, nor did the near- and far-adjacent conditions, although the superimposed condition resulted in greater interference than did the far-adjacent condition. A set of ancillary analyses determined that Stroop interference was significantly greater than zero for both age groups in all conditions (the smallest t value was 3.77, $p < .001$, for younger adults in the far-adjacent condition).

Stroop interference: Ratio-transformed RTs. In order to test the conclusions offered by Verhaeghen and De Meersman (1998b), we also calculated the ratio of the RTs from incongruent and neutral trials. Analysis of variance on this measure with age group and condition (standard, superimposed, near-adjacent, and far-adjacent) produced only a significant main effect of condition, $F(3, 150) = 15.95$, $p < .001$, $MSE = 0.057$. Interference was greatest in the standard condition (M = 1.14) and progressively lower in the superimposed (M = 1.10), near-adjacent (M = 1.08), and far-adjacent (M = 1.06) conditions. Paired comparisons using Bonferroni t tests showed that all differences were significant except those between superimposed and near-adjacent conditions and between near-adjacent and far-adjacent conditions. Neither the main effect of age group nor the interaction of age group and condition were significant, $F(1, 50) = 3.27$, $p = .077$, $MSE = 0.028$, and $F(3, 150) = 0.11$, $p = .957$, $MSE = 0.057$, respectively. The Stroop interference ratio was significantly greater than 1.00 for each age group in every condition (the smallest t value was 3.62, $p < .001$, for younger adults in the far-adjacent condition).

Stroop interference: Proportion correct. We could determine the proportion of trials with correct responses for 49 participants. Analysis of variance on these proportions produced a significant main effect of the type of trial, $F(1, 47) = 33.32$, $p < .001$, $MSE < 0.01$. The proportion correct was higher on the neutral trials (M = .993) than on the incongruent trials (M = .965). There was also a significant main effect of the experimental condition, $F(4, 141) = 4.29$, $p = .006$, $MSE < 0.01$, and an interaction of the trial type and condition, $F(3, 141) = 4.95$, $p = .003$, $MSE < 0.01$. The proportion correct was significantly lower in the standard condition (M = .969) than in the superimposed condition (M = .983) or in the far-adjacent condition (M = .984). The difference between the standard condition and the near-adjacent condition (M = .981) approached significance (p = .053), but no other comparisons were significant. The difference between incongruent and neutral trials was greatest in the standard condition (mean difference = 0.049), smaller in the near- and far-adjacent conditions (mean difference = 0.028 and 0.021, respectively), and smallest in the superimposed condition (mean difference = 0.017). No other effects were significant in the analysis of proportion correct.

Negative priming: RTs. Conventionally, negative priming is calculated as the difference in RT between trials on which the word from the preceding trial becomes the color on the subsequent trial (negative priming trials) and trials on which there is no relation between the words and colors on the preceding and subsequent trials (no-relation trials). We used RTs from the 60 incongruent trials in the middle of each experimental condition for this analysis. Age group was a between-subjects variable in the analysis of variance; condition (standard, superimposed, near-adjacent, and far-adjacent) and trial type (negative priming and no-relation) were within-subjects variables. Mean RTs appear in Table 1. There was a main effect of trial type, $F(1, 50) = 62.58$, $p < .001$, $MSE = 1{,}074.21$, indicating a significant negative priming effect. There was also a significant main effect of condition, $F(3, 150) = 64.73$, $p < .001$, $MSE = 5{,}728.62$, and significant interactions of age group and condition, $F(3, 150) = 5.13$, $p = .004$, *MSE* = 5,728.62, and trial type and condition, $F(3, 150) = 7.65$, $p < .001$, *MSE* = 899.82. Younger and older adults differed significantly only in the standard condition. Although older adults were 35 ms slower on average in the other conditions, none of the differences was significant. We calculated a negative priming score for each participant in each condition; means appear in Table 1. Paired comparisons of the negative priming effect between experimental conditions showed that negative priming was greatest in the standard and near-adjacent conditions and lower in the superimposed and far-adjacent conditions. Neither the main effect of age group, $F(1, 50) = 3.21$, $p = .079$, *MSE* = 86,287.77, nor the interaction of age group and trial type, $F(1, 50) = 0.62$, $p = .435$, *MSE* = 1,074.21, was significant. The interaction of age group, trial type, and condition was not significant, $F(3, 150) = 1.39$, $p = .252$, *MSE* = 899.82. The overall negative priming effect was very similar for older adults ($M = 24$ ms) and younger adults ($M = 20$ ms). Negative priming was significantly greater than zero (with a one-tailed test) for both younger and older adults in the standard, near-adjacent, and far-adjacent conditions. Negative priming was not significantly greater than zero in the superimposed condition, $t(50) = 1.21$, $p = .119$.

Negative priming: Ratio-transformed RTs. We calculated a second negative priming effect as the ratio between RTs on negative priming trials and no-relation trials. Analysis of variance on these ratios produced only a significant effect of condition, $F(3, 150) = 6.32$, $p < .001$, *MSE* = 0.019. Negative priming was greatest in the standard condition ($M = 1.05$), next largest in the near-adjacent condition ($M = 1.04$) and the far-adjacent condition ($M = 1.03$), and smallest in the superimposed condition ($M = 1.01$). Paired comparisons using Bonferroni *t* tests showed significant differences between the standard and superimposed conditions, between the standard and far-adjacent conditions, and between the superimposed and near-adjacent conditions. The other differences were not significant. Neither the main effect of age group nor the interaction of age group and condition were significant, $F(1, 50) = 0.18$, $p = .670$, $MSE < 0.001$, and $F(3, 150) = 1.60$, $p = .19$, *MSE* = 0.005, respectively. One-sample *t* tests showed that the mean ratio was significantly greater than 1.00 for both age groups in all conditions except the superimposed condition.

Negative priming: Proportion correct. Analysis of variance on the proportion correct produced a significant main effect of the type of trial, $F(1, 47) = 26.80$, $p < .001$, $MSE < 0.01$. The proportion correct was higher on the negative priming trials ($M = .978$) than on the no-relation trials ($M = .965$). There was also a significant main effect of the experimental condition, $F(3, 141) = 6.78$, $p < .001$, $MSE < 0.01$, and an interaction of the trial type and condition, $F(3, 141) = 10.80$, $p < .001$, $MSE < 0.01$. The proportion correct was lowest in the standard condition ($M = .958$) and successively larger in the superimposed condition ($M = .969$), the near-adjacent condition ($M = .977$), and the far-adjacent condition ($M = .980$). The difference between negative priming and no-relation trials was largest for the standard condition (mean difference = 0.034) and the superimposed condition (mean difference = 0.025) and smallest for the far-adjacent condition (mean difference = 0.002). In the near-adjacent condition, proportion correct was lower on negative priming trials than on no-relation trials (mean difference = −0.008).

Discussion

The attempt to manipulate Stroop interference was successful: Interference dropped systematically from the standard condition to the superimposed to the near-adjacent and then far-adjacent conditions. Negative priming also changed as a function of condition, but not in the same way as interference changed. (We discuss the relationship between interference and negative priming after reporting the results of Experiment 2.) These conclusions held regardless of whether we used difference measures or ratio measures. With difference measures, interference was higher in older adults than in younger adults but there was no difference for negative priming. With ratio measures, there were no age differences in either interference or negative priming.

These results replicate the findings by Kieley and Hartley (1997) that negative priming in the Stroop task is as great or greater in older adults as in younger adults. The results are consistent with the conclusion by Verhaeghen and De Meersman (1998a) that the age differences in negative priming as well as in interference were no greater in their study than would have been expected from general slowing. These results are clearly at odds with the assertion that the negative priming effect is homogeneous—that experimental manipulations will have no effect on negative priming conditions beyond what would be expected from the lengthening of RT in the corresponding baseline conditions.

Experiment 2

In the near-adjacent and far-adjacent conditions of Experiment 1, the location of the distracting word was unpredictable, randomly appearing either above or below the color block. Experiment 2 added new conditions to explore the effects of presenting the distractors in a fixed and therefore, predictable position. In Experiment 2, there were two near-adjacent conditions. One condition was identical to that in Experiment 1: the word appeared in a randomly varying (and therefore, unpredictable) location above or below the color block. In the second near-adjacent condition, the word appeared in a fixed (and therefore, predictable) location either above or below the color block. The assumption is that with a predictable location, both younger and older adults should be able to block the shift of attention to the word. With an unpredictable location, attention should be drawn to the word, resulting in processing in which effects carry over to the next trial. This might be particularly true for older adults, because they are differentially hurt by unpredictable distractors in visual search (Hartley, 1992). We added two other conditions in which the word partially overlapped the color block, again appearing in either a fixed or varying location. We retained the superimposed condition from Experiment 1, but we dropped the standard condition.

Method

Participants. The participants were drawn from the same populations as in Experiment 1. The 31 younger adults had an average age of 19.8 years (range = 17–28) and an average of 13.8 years of education ($SD = 1.63$). The average health rating was 8.4 ($SD = 1.92$). Average visual acuity was 20/18.9 ($SD = 5.83$). The 31 older adults had an average age of 73.5 years (range = 58–87) and an average of 15.5 years of education ($SD = 3.20$). The average health rating was 8.6 ($SD = 1.21$). Average visual acuity was 20/25.2 ($SD = 6.99$). Visual acuity was measured using the Vision Contrast Test System (Vistech Consultants, Dayton, OH) viewed at 10 ft (3.05

m). The contrast sensitivity function was obtained and then converted to standard Snellen chart units.

Design. There were five conditions. The superimposed condition was identical to that in Experiment 1. In the partial overlap conditions, the word was positioned so that either the upper half or lower half overlapped the color block. In the fixed partial overlap condition, the words were in the same location on all trials. Overlap on the upper or lower half was randomly determined for each participant. In the random partial overlap condition, trials with the upper half of the word overlapping the color block and trials with the lower half overlapping the color block were randomly intermixed. The random-adjacent condition was identical to the near-adjacent condition in Experiment 1. In the fixed-adjacent condition, all of the words were either above the color block or below the color block, with the location randomly determined for each participant. The order of the five conditions was also randomly determined for each participant.

Displays and procedure. The sizes and characteristics of the displays were very similar to those in Experiment 1. One change was that the color (and color word) purple was substituted for yellow, both because the color was easier to discriminate and because the word *purple* triggered the voice-operated relay more reliably than the word *yellow.* The neutral words used were *cat, seed, fight,* and *lumber.* The composition of the experimental conditions was the same as in Experiment 1, with 36 mixed trials followed by 60 incongruent trials followed again by 36 mixed trials. The instructions and the timing of events were identical to those in Experiment 1.

Results

There are two ways to organize the experimental conditions. First, in three of the conditions, the word appeared in a fixed location: superimposed, fixed partial overlap, and fixed-adjacent. Second, four of the conditions—fixed and random partial overlap, and fixed- and random-adjacent—form a 2 × 2 design varying the location of the word (partial overlap and adjacent) and the predictability of the word's location (fixed or random). In the following analyses, we analyze each of these organizations separately.

Stroop interference: RTs. The first analysis of variance on the untransformed RTs from the fixed word location conditions (superimposed, fixed partial overlap, and fixed-adjacent) produced significant main effects of age group, $F(1, 60) = 7.50$, $p = .008$, $MSE = 35{,}348.42$, type of trial (incongruent and neutral), $F(1, 60) = 126.21$, $p < .001$, $MSE = 1{,}935.73$, and condition (superimposed, partial overlap, and adjacent), $F(2, 120) = 27.84$, $p < .001$, $MSE = 2{,}875.31$. Mean RTs appear in Table 2. Older adults ($M = 742$ ms) were slower than younger adults ($M = 688$ ms), and RTs on incongruent trials were longer ($M = 740$ ms) than those on neutral trials ($M = 689$ ms). RTs were longer in the superimposed condition ($M = 743$ ms) than in the partial overlap ($M = 707$ ms) or adjacent ($M = 694$ ms) conditions, which did not differ from each other. There was a significant interaction of trial type and condition, $F(2, 120) = 28.88$, $p < .001$, $MSE = 1{,}169.55$. To explore the interaction, we calculated interference effects for each participant in each condition. Paired comparisons of the conditions showed that interference was greater in the superimposed condition ($M = 78$ ms) than in the partial overlap ($M = 42$ ms) or the adjacent ($M = 34$ ms) conditions, which again, did not differ. The second analysis of variance, comparing the fixed and random versions, resulted in significant main effects of age group, $F(1, 60) = 7.26$, $p = .009$, $MSE = 46{,}333.38$; type of trial, $F(1, 60) = 110.38$, $p < .001$, $MSE = 2{,}505.13$; and word location (partial overlap or adjacent), $F(1, 60) = 4.36$, $p = .041$, $MSE = 1{,}999.12$. Again, older adults were slower than younger adults ($Ms = 730$ ms and 678 ms, respectively), and incongruent trials were slower than neutral trials ($Ms = 728$ ms and 681 ms, respectively). There was a significant interaction of trial type and fixed versus random word location, $F(1, 60) = 16.08$, $p < .001$, $MSE = 770.06$. Mean interference effects appear in Table 2. Interference was greater in the random conditions ($M = 57$ ms) than in the fixed conditions ($M = 38$ ms). Interference was not significantly higher in older adults ($M = 57$ ms) than in younger adults ($M = 49$ ms), nor did any other interactions involving age group approach significance (largest $F = 1.99$, $p = .164$). The interference was significantly greater than zero for both age groups in every condition.

Table 2
Reaction Times (RTs), Interference, and Negative Priming in Experiment 2

	Superimposed		Overlap fixed		Overlap random		Adjacent fixed		Adjacent random	
Age and measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Younger										
Incongruent	747	105	703	92	708	92	683	90	704	100
Neutral	677	82	667	84	653	69	650	85	659	83
Interference[a]	70	48	36	52	55	49	33	34	45	46
Congruent	654	85	631	84	619	76	612	76	611	81
Suppression	775	118	738	106	735	111	715	110	749	95
No-relation	755	98	734	105	722	104	708	99	730	110
Negative priming[b]	20	53	4	38	13	42	7	37	19	57
Older										
Incongruent	818	97	753	87	772	103	737	99	764	97
Neutral	730	64	705	61	708	70	706	74	699	69
Interference	88	52	48	47	64	50	31	47	65	51
Congruent	673	60	644	55	631	60	642	71	632	65
Suppression	841	91	795	97	820	112	768	105	826	105
No-relation	827	92	787	83	786	95	764	94	790	96
Negative priming	14	34	8	39	33	43	4	40	36	35

[a] Interference = $RT_{incongruent} - RT_{neutral}$. [b] Negative priming = $RT_{suppression} - RT_{no\ relation}$.

Stroop interference: Ratio-transformed RTs. The first analysis of variance on the ratio-transformed RTs for the fixed conditions yielded only a significant main effect of condition, $F(2, 120) = 23.78$, $p < .001$, $MSE = 0.069$. Interference was greatest in the superimposed condition ($M = 1.11$), lower in the fixed near-adjacent condition ($M = 1.06$), and lowest in the fixed far-adjacent condition ($M = 1.05$). The second analysis on the transformed RTs with age group, condition (near-adjacent or far-adjacent), and location (fixed or random) as independent variables yielded only a significant effect of location, $F(1, 60) = 14.58$, $p < .001$, $MSE = 0.049$, with random location producing greater interference ($M = 1.08$) than fixed location ($M = 1.05$).

Stroop interference: Proportion correct. A single analysis of variance was carried out on the proportion correct as a function of condition (superimposed, fixed and random partial overlap, and fixed- and random-adjacent), trial type (incongruent and neutral), and age group. Intelligible, complete recordings were available for 30 younger adults and 25 older adults. There were significant main effects of condition, $F(4, 212) = 9.63$, $p < .001$, $MSE < 0.01$, and trial type, $F(1, 53) = 45.30$, $p < .001$, $MSE < 0.01$, and a significant interaction of trial type and condition, $F(4, 212) = 17.24$, $p < .001$, $MSE < 0.01$. The proportion correct was highest in the fixed partial overlap condition ($M = .99$), lower in the superimposed and fixed-adjacent conditions (*M*s = .98) and the random partial overlap condition ($M = .97$), and lowest in the random-adjacent condition ($M = .96$). Accuracy was higher on neutral trials than on incongruent trials (*M*s = .99 and .97, respectively). The difference between incongruent and neutral trials was greater in the superimposed and random conditions (mean difference = 0.04) than in the fixed conditions (mean difference = 0.01).

Negative priming: RTs. The first analysis of variance on the fixed conditions produced significant main effects of age group, $F(1, 60) = 7.05$, $p = .010$, $MSE = 46{,}419.06$; trial type (negative priming or no-relation), $F(1, 60) = 9.23$, $p = .004$, $MSE = 898.03$; and condition, $F(2, 120) = 20.21$, $p < .001$, $MSE = 5{,}688.07$. The mean RTs appear in Table 2. Older adults were slower than younger adults (*M*s = 797 ms and 738 ms, respectively), and negative priming trials were slower than no-relation trials (*M*s = 772 ms and 763 ms, respectively). The superimposed condition ($M = 800$ ms) was slower than the partial overlap condition ($M = 763$ ms), which was, in turn, slower than the adjacent condition ($M = 739$ ms). No interactions were significant. Specifically, there was no interaction of trial type and condition that would have indicated a difference among conditions in negative priming, $F(2, 120) = 1.49$, $p = .229$, $MSE = 782.09$. Most important, negative priming as indicated by the interaction of age group and trial type was no different in older adults than in younger adults, $F(1, 60) = 0.20$, $p = .656$, $MSE = 898.03$. The second analysis of variance, on the fixed and random versions, produced significant main effects of age group, $F(1, 60) = 7.98$, $p = .006$, $MSE = 61{,}762.18$; trial type, $F(1, 60) = 27.34$, $p < .001$, $MSE = 1{,}097.34$; and fixed versus random location, $F(1, 60) = 6.01$, $p = .017$, $MSE = 6{,}925.21$. Older adults were slower than younger adults (*M*s = 792 ms and 729 ms, respectively); negative priming trials were slower than no-relation trials (*M*s = 768 ms and 753 ms, respectively); and trials with the words in randomly varying locations were slower than those with the words in a fixed location (*M*s = 770 ms and 751 ms, respectively). The interaction of word location with fixed versus random was significant, $F(1, 60) = 5.72$, $p = .020$, $MSE = 5{,}906.83$, as was the interaction of trial type with fixed versus random, $F(1, 60) = 13.40$, $p = .001$, $MSE = 861.34$. The three-way interaction of age group with trial type and fixed versus random was significant, $F(1, 60) = 4.57$, $p = .037$, $MSE = 861.34$. Means for the negative priming effect (RT on negative priming trials less RT on no-relation trials) appear in Table 2. For the fixed conditions, negative priming was virtually identical in the older adults ($M = 5$ ms) and in the younger adults ($M = 6$ ms), whereas in the random conditions, it was much larger in the older adults ($M = 34$ ms) than in the younger adults ($M = 17$ ms). The negative priming effects were significantly greater than zero for both age groups in the superimposed condition, the random partial overlap condition, and the random-adjacent condition.

Negative priming: Ratio-transformed RTs. The first analysis of variance, on the fixed conditions, yielded no significant effects. The second analysis, on the transformed RTs with age group, condition (near-adjacent or far-adjacent), and location (fixed or random) as independent variables, yielded only a significant effect of location, $F(1, 60) = 14.35$, $p < .001$, $MSE = 0.043$, with random location producing greater interference ($M = 1.03$) than fixed location ($M = 1.01$).

Negative priming: Proportion correct. As with proportion correct in the Stroop interference analysis, we included all five experimental conditions in a single analysis of variance. The only significant effect was a main effect of trial type, $F(1, 53) = 12.75$, $p = .001$, $MSE < 0.01$, with accuracy lower on negative priming trials than on no-relation trials (*M*s = .98 and .99, respectively).

Comparisons of Experiments 1 and 2. Because two of the conditions from Experiment 1 were replicated in Experiment 2, the superimposed condition and the near-adjacent (random) condition, the results can be compared to determine whether comparable levels of interference and negative priming occurred. We subjected both interference and negative priming effects to analysis of variance, with age group and experiment (1 or 2) as between-subjects factors and condition (superimposed or adjacent) as a within-subject factor. For the difference measure of interference, there were significant main effects of condition, $F(1, 110) = 12.40$, $p = .001$, $MSE = 1{,}421.37$, and age group, $F(1, 110) = 6.88$, $p = .01$, $MSE = 3{,}130.69$. Stroop interference was greater in the superimposed condition ($M = 73$ ms) than in the near-adjacent condition ($M = 55$ ms), and it was greater for older adults ($M = 62$ ms) than for younger adults ($M = 60$ ms). For the difference measure of negative priming, only the main effect of condition was significant, $F(1, 110) = 10.50$, $p = .002$, $MSE = 1{,}685.98$, with the near-adjacent condition eliciting greater negative priming ($M = 30$ ms) than the superimposed condition ($M = 13$ ms). Results for ratio measures were similar. For interference, there were significant main effects of condition, $F(1, 110) = 10.48$, $p = .002$, $MSE = 0.003$, and age group, $F(1, 110) = 4.28$, $p = .04$, $MSE = 0.006$. Stroop interference was greater in the superimposed condition ($M = 1.10$) than in the near-adjacent condition ($M = 1.08$), and it was greater for older adults ($M = 1.10$) than for younger adults ($M = 1.08$). For the ratio measure of negative priming, only the main effect of condition was significant, $F(1, 110) = 12.26$, $p = .001$, $MSE = 0.003$, with the near-adjacent condition eliciting greater negative priming ($M = 1.04$) than the superimposed condition ($M = 1.02$). Most important, for all of these analyses, there were no significant main effects or interactions involving the experiment factor.

Discussion

As in Experiment 1, with difference measures, there was no indication that negative priming was lower in older adults. In fact, negative priming was virtually identical in younger and older adults when the location of the word was predictable. When the location of the word was unpredictable, negative priming was significantly higher in older adults than in younger adults. Interference was higher in older adults, and the difference was exaggerated with unpredictable distractor locations. With ratio measures, the age differences vanished. An unpredictable location produced both more interference and more negative priming, but it did so equally in both age groups. The comparisons of the superimposed and near-adjacent (random) conditions in Experiments 1 and 2 showed no differences between experiments in the results for those conditions: Interference was higher and negative priming lower in the superimposed condition than in the adjacent condition.

Interference and Negative Priming

Both the inhibition and the episodic retrieval theories predict a relationship between interference and negative priming. Finding either a positive or negative relationship would not provide decisive evidence against either theory, as both can be made to predict either outcome (as noted in Footnote 2). Failure to find a relationship would be problematic for either position.

In Experiment 1, the average correlation within a condition between interference and negative priming was .11. (The individual correlations were as follows: standard, −.14; superimposed, .07; near-adjacent, .35; far-adjacent, .16.) In Experiment 2, the average correlation within a condition between interference and negative priming was .15. (The individual correlations were as follows: superimposed, .00; overlap-random, .27; overlap-fixed, .30; adjacent-random, .14; adjacent-fixed, .04.) Because the correlational analyses yielded equivalent results for difference and for ratio measures, we only present results for difference measures, in the interests of simplicity. These results suggest that the correlation between interference and negative priming is negligible. However, these correlations are between difference scores. The reliability of difference scores can be quite low, so the correlations may reflect little other than measurement error (Cohen & Cohen, 1975). This may account for the wide range of values reported in other research (see McDowd, 1997, for a review).

There is an alternative approach. Because interference and negative priming were measured in a number of different conditions across the two experiments, it is possible to calculate a meta-analytic correlation, using the experimental condition as the unit of measurement rather than the participant within a condition. This should reduce or eliminate the attenuation of the correlation by measurement error. Across experiments, we obtained the mean for each age group in each condition of each experiment. We calculated difference scores for interference and for negative priming. The correlation between interference and negative priming was significantly greater than zero, $r(16) = .60$, $p = .008$.

The positive correlation is consistent with two of the theoretical explanations for negative priming. It is consistent with the suppression explanation, which posits that conditions with greater interference will elicit greater efforts to suppress the distractor and that suppression will carry over as inhibition of the target. The correlation is inconsistent with the other suppression account, which suggests that greater interference is a sign of failure to suppress and should be related to reduced negative priming. This account predicts a negative correlation between interference and negative priming. The version of the episodic retrieval explanation that is consistent with the positive correlation holds that greater interference produces stronger *do not respond* tagging. Inhibiting the *do not respond* tag when the item becomes a target, then, results in greater negative priming.

General Discussion

In the present experiments, negative priming was at least as large in older adults as in younger adults. The results after ratio transformation were also consistent with the assertion of Verhaeghen and De Meersman (1998a) that the differences that are seen are no larger than would be expected on the basis of general slowing. Verhaeghen and De Meersman plotted the functional relationship between mean RTs in negative priming conditions and in baseline conditions and found that the data were best fit by a regression with an age by condition (negative priming or baseline) interaction term (i.e., a slope dummy variable reflecting a different slope for younger and older adults). The intercept was the same for the two age groups; no age-group dummy variable was needed. We repeated Verhaeghen and De Meersman's analysis using the 18 data points from our two experiments (two age groups in each of nine conditions). The results were well fit by Equation 1, with $b_0 = -90$ ms and $b_1 = 1.14$, $R^2 = .94$. Adding intercept and slope dummy variables to allow for different functions for younger and older adults produced no significant improvement, $F(2, 14) = 0.72$, *ns*. Thus, our meta-analysis failed to replicate Verhaeghen and De Meersman's conclusion that the negative priming effect (b_1 in Equation 1) was slightly smaller in older adults.

Verhaeghen and De Meersman (1998a) also concluded that the negative priming effects in the experimental conditions they surveyed were homogeneous. This implies that experimental manipulations do not matter, at least beyond the effects they have on baseline condition RTs. This implication is clearly wrong. We found small but reliable differences among conditions in negative priming, even after a ratio transformation, although the meta-analyses do not reflect these differences. In Experiment 1, negative priming was higher in the standard condition than in others; in Experiment 2, negative priming was higher with words appearing randomly above or below the color block than with words appearing in a fixed position. Across experiments, the near-adjacent (random) condition produced more negative priming than was produced by the superimposed condition. Both the integration of the target color and distracting word into a single stimulus in the standard condition and the unpredictable onset of the distractor in the near-adjacent condition may serve to capture attention, leading to more extensive processing of the distractor, perhaps even after the response has been generated. The greater processing could result in greater negative priming, as Kramer et al. (1994) and Kieley and Hartley (1997) have also argued. Nevertheless, a ratio transformation removed age differences, so the most parsimonious interpretation is that there is no differentially greater attention capture in older adults.

Are the present results in some way idiosyncratic to the Stroop task? Taken broadly, the answer must be no. We reached essentially the same conclusion as Verhaeghen and De Meersman (1998a), who surveyed results from a variety of procedures: Negative priming is similar in younger and older adults. We obtained a slightly higher slope value (1.14) for the function relating negative priming and baseline RTs than did Verhaeghen and De Meersman, who also found slightly different values for younger (1.10) and older (1.08) adults, but these are minor differences. We disagree with the conclusion of Verhaeghen and De Meersman that the negative priming effect is homogeneous; we found reliable differences even across closely related conditions. We do note, however, that the small number of studies and the homogeneity of the procedures used to study negative priming may limit the generality of their conclusions.

References

Cohen, J., & Cohen, P. (1975). *Applied multiple regression/correlation analysis for the behavioral sciences.* Hillsdale, NJ: Erlbaum.

Connelly, S. L., & Hasher, L. (1993). Aging and inhibition of spatial location. *Journal of Experimental Psychology: Human Perception and Performance, 19,* 1238–1250.

Dalrymple-Alford, E. C., & Budayr, B. (1966). Examination of some aspects of the Stroop color-word test. *Perceptual and Motor Skills, 23,* 1211–1214.

Fox, E. (1995). Negative priming from ignored distractors in visual selection: A review. *Psychonomic Bulletin & Review, 2,* 145–173.

Hartley, A. A. (1992). Attention. In F. I. M. Craik & T. A. Salthouse (Eds.), *Handbook of aging and cognition* (pp. 3–49). Hillsdale, NJ: Erlbaum.

Hasher, L., Stoltzfus, E. R., Zacks, R. T., & Rypma, B. (1991). Age and inhibition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 163–169.

Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. In G. G. Bower (Ed.), *The psychology of learning and motivation* (Vol. 22, pp. 193–225). San Diego: Academic Press.

Hasher, L., & Zacks, R. T. (1997). Cognitive gerontology and attentional inhibition: A reply to Burke and McDowd. *Journals of Gerontology: Psychological Sciences, 52,* P274–P283.

Kahneman, D., & Chajczyk, D. (1983). Tests of the automaticity of reading: Dilution of Stroop effects by color-irrelevant stimuli. *Journal of Experimental Psychology: Human Perception and Performance, 9,* 497–509.

Kamlet, A. S., & Egeth, H. E. (1969). Note on construction of Stroop-type stimuli. *Perceptual and Motor Skills, 29,* 914.

Kane, M. J., Hasher, L., Stoltzfus, E. R., Zacks, R. T., & Connelly, S. L. (1994). Inhibitory attentional mechanisms and aging. *Psychology and Aging, 9,* 103–112.

Kane, M. J., May, C. P., Hasher, L., Rahhal, T., & Stoltzfus, E. R. (1997). Dual mechanisms of negative priming. *Journal of Experimental Psychology: Human Perception and Performance, 23,* 632–650.

Kieley, J. M., & Hartley, A. A. (1997). Age-related equivalence of negative priming in the Stroop color-word task. *Psychology and Aging, 12,* 22–29.

Kramer, A. F., Humphrey, D. G., Larish, J. F., Logan, G. D., & Strayer, D. L. (1994). Aging and inhibition: Beyond a unitary view of inhibitory processing in attention. *Psychology and Aging, 9,* 491–512.

Lowe, D. G. (1979). Strategies, context, and the mechanism of response inhibition. *Memory & Cognition, 7,* 382–389.

Lowe, D. G. (1985). Further investigation of inhibitory mechanisms in attention. *Memory & Cognition, 13,* 74–80.

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin, 109,* 163–203.

Malley, G. B., & Strayer, D. L. (1995). Effect of stimulus repetition on positive and negative identity priming. *Perception & Psychophysics, 57,* 657–667.

May, C. P., Kane, M. J., & Hasher, L. (1995). Determinants of negative priming. *Psychological Bulletin, 118,* 35–54.

McDowd, J. M. (1997). Inhibition in attention and aging. *Journal of Gerontology: Psychological Sciences, 52B,* P265–P273.

McDowd, J. M., & Oseas-Kreger, D. M. (1991). Aging, inhibitory processes, and negative priming. *Journal of Gerontology: Psychological Sciences, 46,* P340–P345.

Neill, W. T. (1977). Inhibitory and facilitory processes in selective attention. *Journal of Experimental Psychology: Human Perception and Performance, 3,* 444–450.

Neill, W. T., & Valdes, L. A. (1992). Persistence of negative priming: Steady state or decay? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* 565–576.

Neill, W. T., Valdes, L. A., & Terry, K. M. (1995). Selective attention and the inhibitory control of cognition. In F. N. Dempster & C. J. Brainerd (Eds.), *Interference and inhibition in cognition* (pp. 207–261). San Diego: Academic Press.

Schneider, W. (1995). *MEL professional: User's guide.* Pittsburgh, PA: Psychology Software Tools.

Schooler, C., Neumann, E., Caplan, L. J., & Roberts, B. R. (1997). Continued inhibitory capacity throughout adulthood: Conceptual negative priming in younger and older adults. *Psychology and Aging, 12,* 667–674.

Stoltzfus, E. R., Hasher, L., Zacks, R. T., Ulivi, M. S., & Goldstein, D. (1993). Investigation of inhibition and interference in younger and older adults. *Journal of Gerontology, 48,* P179–P188.

Strayer, D. L., & Grison, S. (1999). Negative identity priming is contingent on stimulus repetition. *Journal of Experimental Psychology: Human Perception and Performance, 25,* 24–38.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18,* 643–662.

Sullivan, M. P., & Faust, M. E. (1993). Evidence for identity inhibition during selective attention in old adults. *Psychology and Aging, 8,* 589–598.

Sullivan, M. P., Faust, M. E., & Balota, D. A. (1995). Identity negative priming in older adults and individuals with dementia of the Alzheimer type. *Neuropsychology, 9,* 537–555.

Tipper, S. P. (1991). Less attentional selectivity as a result of declining inhibition in older adults. *Bulletin of the Psychonomic Society, 29,* 45–47.

Verhaeghen, P., & De Meersman, L. (1998a). Aging and the negative priming effect: A meta-analysis. *Psychology and Aging, 13,* 435–444.

Verhaeghen, P., & De Meersman, L. (1998b). Aging and the Stroop effect: A meta-analysis. *Psychology and Aging, 13,* 120–126.

Received May 13, 1998
Revision received April 7, 1999
Accepted April 30, 1999 ■