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Strategies, context, and the mechanism of response inhibition

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A series of four experiments investigated Neill's (1977) claim that there are inhibitory mechanisms in selective attention. It was demonstrated that the evidence supporting the inhibitory theory, namely, the diminished availability of distractor responses during a discrete-trials version of the Stroop task is complicated by a number of strategic adaptations to various contingencies within the trial sequence. These results do not support a simple interpretation of response inhibition during the Stroop task.

Deployment of selective attention permits an observer to respond optimally to a chosen aspect of a multidimensional stimulus while disregarding or suppressing other unwanted aspects. Could the suppressive effects in selective attention arise from activity of inhibitory mechanisms? While broadly assenting answers to this question have been given from time to time (e.g., Greenwald, 1972; Treisman, 1964), a decidedly affirmative position has been taken by Neill (1977). The data base for Neill's position comes from experiments utilizing the Stroop (1935) color-word task.

Admirably suited for the study of inhibitory effects in selective attention, the Stroop task requires an observer to name the ink color of a letter display while suppressing the overwhelming tendency to read the color name spelled by the letters. Employing a series of discrete trials, Neill (1977) found that when two successive Stroop items were related so that the ink color of the second item matched the distracting word of the first, observers took longer to name the color than when the successive inputs were unrelated. In other words, a color name that was an incorrect response on Trial $n-1$ (by virtue of being the color name spelled by the stimulus word) became less readily available as the correct response on Trial n. Neill (1977) reasoned that the incorrect alternative had been actively inhibited in the temporally leading trial and that inhibition of that specific color name persisted into the following trial, resulting in diminished availability of that response (Dalrymple-Alford & Budayr, 1966).

Acceptance of Neill's (1977) suggestions would entail notable theoretical reorientation, in that no inhibitory mechanisms of cognitive control are explicitly postulated in current theories of attention (Kahneman, 1973; Keele, 1973; Norman & Bobrow, 1975). Closer scrutiny of Neill's results and of the inferences drawn from them may well be warranted for this reason alone; but there seem to be additional reasons for taking a closer look.

First, it is possible that subjects may not have treated successive trials as discrete; rather, they may have attempted to match successive stimuli. In the process, a strategy of sequential dependencies may have developed, much along the lines discussed by Tweedy, Lapinski, and Schvaneveldt (1977). These writers reported pronounced effects on response latencies under conditions in which preceding stimuli were employed as predictors of subsequent items. These results suggest that suppressive effects may not be ascribed unambiguously to activity of inhibitory mechanisms. Indeed, results reported below clearly reveal the dependence of suppressive effects upon subjects' strategies to match successive inputs.

A second difficulty in ascribing Neill's (1977) findings to inhibitory mechanisms lies in the fact that in Neill's experiments the successive inputs always consisted of difficult Stroop items. In this context, it is plausible that suppression effects may have arisen as a consequence of the subjects' attempts to cope with the demands of the task, and it is equally plausible that suppression effects may not arise with less demanding items. Were this to be so, Neill's notion of simple inhibition would require extensive review. The present work strongly implicates difficulty of material as a fundamental variable governing suppression effects.

In the present research, subjects were shown two successive colored stimuli and were required to name the ink colors of both leading (S1) and trailing (S2) items. Vocal naming latencies to S2 were recorded throughout. Experiment 1 was conducted to replicate the Stroop-stimulus suppression effect using the present paradigm. A second purpose of Experiment 1 was to provide additional evidence concerning other possible relationships between successive items. Three basic

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categories of response relationship were employed: (1) trials in which the colors of the stimuli were identical, permitting a repetition of appropriate color names, (2) trials in which the appropriate response for S2 was named by the distracting word for S1, requiring report of previously inappropriate responses, and (3) control trials in which the correct response for S2 bore no direct relationship to either aspect of S1.

EXPERIMENT 1

Method

Design and Materials. Fourteen examples of 12 different Stroop stimuli were prepared for presentation in a tachistoscope by centering the words RED, GREEN, BLUE, and YELLOW on white cards in uppercase 28-point Letraset Projectatype (PT102). The four words were painted in each of the above-named colors, except for that congruent with the named word. The visual angles subtended by the different stimuli varied approximately from 2.34 to 5.22 deg. Each configuration was paired once with all others, including itself, resulting in two packs of 84 stimuli each. The pairing of the stimuli resulted in seven experimental conditions, as defined by the following relationships between the items:[1] (1) Identical (IDENT)–Both stimuli were identical [e.g., RED (painted) in blue ink followed by (→) RED in blue ink]. (2) SAY-SAY–The colors of the stimuli were identical, and the distractor words were different (e.g., GREEN in blue ink → RED in blue ink). (3) Suppress-suppress (SUP-SUP)–The distractor words were identical for both stimuli, and the colors were different (e.g., RED in green ink → RED in blue ink). (4) Say-suppress (SAY-SUP)–The color for S1 and the distractor word for S2 had identical names, while the name of the distractor for S1 and the color for S2 were unrelated (e.g., GREEN in red ink → RED in blue ink). (5) Control (CONT)–The names of the distractors and colors for the pair were completely unrelated (e.g., YELLOW in green ink → RED in blue ink). (6) Reversal (REV)–The color for S1 and the distractor for S2 had identical names, and the distractor for S1 and the color for S2 also had identical names (e.g., BLUE in red ink → RED in blue ink). (7) Suppress-say (SUP-SAY)–The distractor for S1 and the color for S2 had identical names, while the names of the color for S1 and the distractor for S2 were unrelated (e.g., BLUE in green ink → RED in blue ink). Thus, for S2, conditions IDENT and SAY-SAY required report of S1 correct responses, conditions SUP-SUP, SAY-SUP, and CONT necessitated report of unrelated color names, and conditions REV and SUP-SAY involved naming of S1 incorrect responses. Since SUP-SUP and SAY-SUP sequences involved some degree of overlap of color names for the successive inputs, condition CONT was chosen as the appropriate baseline.

For all subjects, each condition was tested 24 times. The order in which the conditions appeared within the packs was randomly determined within the restriction that each condition appear three times in each block of 21 trials. All subjects received the presentation of the packs in both a forward and a reversed order, and for each subject, for each presentation, a different starting point was randomly determined. Forward and reversed orders of presentation ensured that all possible S1-S2 combinations of the different stimuli were achieved.

Procedure. All stimulus materials were presented by means of a Gerbrand's three-field tachistoscope. On each trial subjects first viewed a blank white preexposure field. They then initiated presentation of S1; responses to S1 initiated the presentation of S2 and simultaneously started a Hunter millisecond timer. Responses to S2 terminated the timer, and S2 remained in view for 1 sec before being replaced by the blank white field. At the end of each presentation of the packs, trials for which subjects responded incorrectly, or the apparatus failed, were re-presented. Data from the first 42 trials, during which each condition was tested six times, were discarded as practice. Subjects were instructed to name, as quickly as possible, the colors of the successive stimuli while ignoring the distracting words themselves.

Subjects. The eight subjects were male and female undergraduate students at Trent University who were paid $2.50 each for their participation.

Results and Discussion

For each subject, median reaction times (RTs) were calculated for the last 18 trials for each condition. These scores were submitted to a repeated-measures analysis of variance. Mean latencies and error rates are shown in Table 1.

As is evident in Table 1, there were large differences for RTs as a function of conditions [$F(6,42) = 27.22$, $MSe = 967$].[2] Using the error mean square from the analysis as the estimate of error, subsequent two-tailed t tests revealed that, relative to CONT sequences, RTs were significantly faster for both conditions IDENT and SAY-SAY [$ts(42) = 10.74$ and 7.64, respectively], while latencies for both REV and SUP-SAY trials were somewhat slower [$ts(42) = 2.0$ and 3.82, respectively, $ps < .05$]. Additional comparisons indicated that RTs for condition IDENT were faster than those for SAY-SAY [$t(42) = 3.09$], and SUP-SUP was improved relative to CONT [$t(42) = 2.82$]. Finally, performance for CONT and SAY-SUP [$t(42) = 1.18$] and for REV and SUP-SAY [$t(42) = 1.82$] did not differ.

The relative facilitation for both conditions IDENT and SAY-SAY suggests that, subsequent to the report of correct color names for S1, these responses were highly available, which is in keeping with the "repetition effect" reported by Bertelson (1963) and Keele (1969). In addition, the relative impairment for both REV and SUP-SAY sequences is indicative that the incorrect distractor-activated responses for S1 were especially difficult to report. These findings are fully consistent with Neill's (1977) suggestion that distractor responses were selectively inhibited prior to subjects' eventually attending appropriate color names for report.

The extra facilitation for conditions IDENT and SUP-SUP relative to SAY-SAY and CONT sequences, respectively, may be explained by assuming that subjects matched the successive displays on the basis of their

Table 1
Mean RT (in Milliseconds) and Error Rates for Seven Conditions in Experiment 1

Condition	RT	Error Rate
IDENT	521	1.9
SAY-SAY	555	1.3
SUP-SUP	608	2.0
SAY-SUP	626	2.4
CONT	639	2.6
REV	661	2.3
SUP-SAY	681	2.4

physical characteristics (Posner & Mitchell, 1967). According to this argument, following the response to S1, knowledge of the propriety of S1 ink color and the impropriety of S1 word form would enhance performance if that information were directly compared with S2. The greater the similarity of the stimuli, the more performance would be improved. Indeed, such comparison strategies may have been unavoidable if, as Keele (1973) suggests, subjects must utilize the available ink-color and word-form information for each presented item. In addition, the possibility of S1 information affecting S2 would be enhanced if the successive inputs were integrated. Since the successive stimuli were presented in the same spatial position, integration seems highly likely (Taylor, 1970).

Although the present paradigm was successful in yielding a suppression effect, the experiment itself was not designed to control for the possibility that this phenomenon depends upon the successive inputs being exclusively constructed of Stroop items. A second difficulty with the present findings was that, with extended practice, performance for conditions REV and SUP-SAY improved to the extent that RTs for these sequences were nearly equivalent to CONT trials. Prior to a demonstration in Experiment 3 that suppression effects cannot be obtained when processing difficulties are not associated with each successive input, Experiment 2 was conducted to further investigate the reasons for the eventual disappearance of the suppression effect.

EXPERIMENTS 2 AND 3

Considering that the basic categories of response relationship for appropriate, inappropriate, and unrelated color names made up 28%, 28%, and 44% of all trials, respectively, subjects were provided with little basis to expect that the first response would also serve as the second or, indeed, that any aspect of S1 would reliably predict S2. Consequently, having dealt with S1, subjects in Experiment 1 may not have been particularly motivated to make extended use of the information necessarily employed to sort out the conflicting color names for that stimulus. It is possible that the sustained presence of the suppression effect depends upon a continuous active employment of S1 as a predictor of S2 (e.g., Tweedy et al., 1977).

Experiment 2 was conducted to test these notions by manipulating the proportion of trials on which the different color names for S1 could serve as predictors of correct S2 responses. It was expected that when the proportion of predictably valid S1 trials was high, subjects would be more likely to employ the different S1 color names in order to relate or match the successive inputs. In turn, the latter matching strategy might increase the magnitude of the facilitatory and inhibitory effects. On the other hand, when the proportion of predictively useful S1 trials is low, suppression effects may be eliminated as subjects learn that successive inputs are seldom directly related and process the items discretely.

In Experiment 3 the generality of the suppression effect was tested by substitution of color-patch stimuli for Stroop items as S2. Since a consistently reported finding is that naming of the hues of these simpler stimuli is much easier than for Stroop items, the use of color patches represented an attempt to examine the suppression effect under conditions in which processing difficulties were not associated with each input. In addition, the validity of appropriate color information in reliably predicting subsequent responses was varied for different groups of subjects.

Method

General. The method and procedures were basically identical to those of Experiment 1 except that fewer conditions were employed in the present experiments. In Experiment 2, for 25% of the subjects (75-25 group), 75% of all trials consisted of conditions IDENT and SAY-SAY (37.5% each), and the remaining trials were composed of CONT and SUP-SAY sequences (12.5% each). For the remaining subjects (25-75 groups), the proportions were changed so that 25% of all trials were made up of conditions IDENT and SAY-SAY (12.5% each), the balance consisting of CONT and SUP-SAY trials. In all, there were three different 25-75 groups, for whom the proportions of CONT and SUP-SAY trials were 62.5% and 12.5%, 37.5% and 37.5%, and 12.5% and 62.5%, respectively. Twenty examples of each of the 12 different Stroop stimuli were prepared in order to produce five packs of 48 stimuli each. Within each of the packs, the items were ordered so that when Packs 1-2, 2-3, 3-4, and 4-5 were paired, the four conditions were produced in the required proportions for the different groups. In order to eliminate the possible influence of stimulus integration factors, the stimuli for the odd-numbered packs appeared in the upper portion of the visual field and those items for the even-numbered packs were presented in the lower portion. The separation between the near edges of the displays was approximately 1.44 deg of visual angle when the displays were viewed simultaneously. Each subject received the four different pairings of the packs twice, and data from the first 96 trials were excluded from analysis. All other aspects of Experiment 2 were identical to Experiment 1 except that, prior to the commencement of each block of 48 trials, subjects were informed of the relative positions of the successive inputs.

In Experiment 3, the odd-numbered packs were employed as S1 and were paired with color-patch stimuli that served as S2. The color patches, whose hues matched the colors employed for the Stroop items, were constructed by placing four horizontally aligned color dots (Letradots), subtending a visual angle of approximately 3.12 deg, in the lower portion of white cards. The separation between upper and lower stimuli was identical to that in Experiment 2. The pairing of these stimuli resulted in three conditions analogous to previous experiments: SAY-SAY, CONT, and SUP-SAY. For half of the subjects (75-25 group), these conditions comprised 75%, 12.5%, and 12.5% of all trials, respectively, while for the remaining subjects in the sole 25-75 group employed, the same sequences made up 25%, 62.5%, and 12.5% of all trials, respectively. All other aspects of Experiment 3 were identical to Experiment 2.

Subjects. The 20 subjects in Experiment 2 ($n = 5$/group) and the 16 subjects who served in Experiment 3 ($n = 8$/group) were selected from the same population as the subjects in Experiment 1 and were paid $3 each for their services.

Results and Discussion

Performance scores were calculated as in Experiment 1 except that in both experiments median RTs

Table 2
Mean RT (in Milliseconds) and Error Rate (ER) as a Function of Groups and Conditions in Experiment 2

	Condition							
	IDENT		SAY-SAY		CONT		SUP-SAY	
Group	RT	ER	RT	ER	RT	ER	RT	ER
75-25	438	1.2	456	2.0	672	2.1	748	1.8
25-75								
12.5% SUP-SAY	524	1.4	551	1.3	684	1.9	677	1.1
37.5% SUP-SAY	524	1.6	540	1.8	656	1.1	665	1.2
62.5% SUP-SAY	540	1.5	559	1.6	659	1.4	668	1.3

for each subject for those conditions comprising 12.5%, 25%, 37.5%, 62.5%, and 75% of all trials were based on 36, 72, 108, 180, and 216, or fewer, correct trials, respectively. As in Experiment 1, error rates were relatively low (1.5% and 1.9% of all trials for Experiments 2 and 3, respectively) and did not vary appreciably for the different groups or conditions. The median RT scores for Experiments 2 and 3 were submitted to 4 by 4 and 2 by 3 analyses of variance, respectively, in order to evaluate groups and conditions. Mean RTs and error rates for Experiment 2 are shown in Table 2, and the results of Experiment 3 are displayed in Table 3.

In Experiment 2, the analysis revealed that overall performance did not vary reliably for the different groups [$F(3,16) < 1$, MSe = 12,920], but there were large effects upon RTs as a function of conditions [$F(3,48) = 141.61$, MSe = 1,258]. It is evident from Table 2 that, as in Experiment 1, relative to condition CONT, average RTs for both IDENT and SAY-SAY sequences were much faster [$ts(48) = 20.3$ and 17.8, respectively], while latencies for SUP-SAY trials were somewhat slower [$t(48) = 2.78$]. A more important aspect of the data presented in Table 2, however, concerns the changed performance for conditions as a function of groups. The analysis revealed a significant Groups by Conditions interaction [$F(9,48) = 7.04$], and subsequent t tests revealed that RTs for both conditions IDENT and SAY-SAY were reliably faster for the 75-25 group relative to the different 25-75 groups [all $ts(16) > 5.44$ and 5.25, respectively]. In addition, latencies for condition SUP-SAY were significantly impaired relative to CONT sequences for the 75-25 group [$t(48) = 4.82$], while performance for the same conditions did not differ for the various 25-75 groups [all $ts(48) < 1$].

Table 3
Mean RT (in Milliseconds) and Error Rate (ER) as a Function of Groups and Conditions in Experiment 3

	Condition					
	SAY-SAY		CONT		SUP-SAY	
Group	RT	ER	RT	ER	RT	ER
75-25	401	1.6	587	2.3	544	1.9
25-75	539	2.2	586	1.7	586	2.0

Considering the results of Experiment 3, the analysis revealed that the effects of groups [$F(1,14) = 9.68$, MSe = 4,421], conditions [$F(2,28) = 109.9$, MSe = 558], and their interaction [$F(2,28) = 36.23$] were all statistically reliable. An inspection of Table 3 reveals that, although the results were somewhat similar to those of Experiment 2, in that the facilitation for condition SAY-SAY was somewhat greater for the 75-25 group than for the 25-75 group [$t(14) = 5.87$], unlike Experiment 2, RTs for SUP-SAY sequences were also facilitated relative to CONT trials, but only for the 75-25 group [$t(28) = 5.09$]. It is also evident from a comparison of the results presented in Tables 2 and 3 that overall performance was somewhat faster in Experiment 3 (mean = 540 msec) than in Experiment 2 (mean = 598 msec), thus verifying that the names of the color patches were easier to report than were those for the Stroop items.

The relative facilitation for condition SUP-SAY for the 75-25 group in Experiment 3 is in direct opposition to the suppression hypothesis, since it is evident that S1 distractor responses remained highly available when color patches were employed as S2. As Neill (1977) has pointed out, there are two possible ways to characterize this result. First, the redundant activation of the color name for S2 (via the continued availability of the preceding word-activated response) for condition SUP-SAY may accelerate its processing. The continued availability of distractor responses is also consistent with a "facilitatory" model of attention, as discussed by Posner and Snyder (1975a). If the attentional resources can simply be directed toward appropriate color names, while leaving the "pathway activation" for word-activated information unaffected, the residual activation for the distractor might then facilitate processing during SUP-SAY trials. On the other hand, Neill (1978) has introduced evidence that indicates that the efficiency of selective attention is affected by the number of simultaneously competing response alternatives. Since both the color- and word-activated responses for S1 remained available together with the S2 color response, a total of three recently activated responses was available on a CONT trial, whereas only two responses would be available during SUP-SAY sequences. The continued availability of an additional color name during CONT trials may have impaired subjects' ability to choose a response for S2, leading to increased RTs relative to SUP-SAY sequences.

Whatever the reasons for the relatively improved performance during SUP-SAY trials for the 75-25 group in Experiment 3, neither the "pathway-activation" nor the "number-competition" idea can be applied to the results of Experiments 1 and 2. According to both those notions, performance for condition SUP-SAY should have been improved relative to CONT sequences. Furthermore, the relatively delayed RTs for SUP-SAY sequences in Experiment 1 and for the 75-25 group of Experiment 2 cannot be attributed simply to selective inhibition of word-activated responses during S1. On that view, performance for condition SUP-SAY should have been uniformly impaired relative to the CONT trials. It is now apparent that the suppression effect requires another explanation that likely relies upon events that occurred during subjects' attempts to respond appropriately to the difficult color-word stimuli employed as S2. Further discussion of this matter is delayed until Experiment 4.

These results also demonstrate both that the proportion of predictive S1 trials successfully induced differential attending to the appropriate color names for S1 and that the influence of the distractors upon subsequent responses was especially dependent upon adaptive or strategic processes (Tweedy et al., 1977). The amount of facilitation for repetitions of appropriate color names was increased, and, as well, performance for subsequent report of distractor responses was impaired (Experiment 2) or improved (Experiment 3) only when subjects were motivated to continuously attend the color-activated information for S1 (i.e., for the 75-25 groups). It is also apparent that only color-activated information was actively employed during such stimulus comparison strategies. Since performance for condition SUP-SAY for the various 25-75 groups in Experiment 2 was virtually unaffected by progressive increments in the proportion of SUP-SAY trials, it appears that subjects in these groups were either unwilling or unable to employ distractor-activated information in order to facilitate subsequent responses. Moreover, since in Experiment 3 S1 distractor responses were able to facilitate report of subsequent color names, but only for the 75-25 group, it seems evident that only color-activated information, as compared with distractor information, was actively utilized during subjects' attempts to compare the inputs. While the available distractor information was included in subjects' attempted matches of the items, it is apparent that the available color names were not utilized as predictors of subsequent responses. Thus, the paucity of color-repetition trials for the various 25-75 groups in Experiment 2 caused subjects to treat the successive stimuli discretely, so that they were generally unaware of the possible utility of distractor information. These results may be employed to account for the elimination of the relatively delayed RTs during SUP-SAY trials in Experiment 1. It now appears that subjects in that experiment, as the subjects in the various 25-75 groups of Experiment 2, were forced to abandon any stimulus comparison strategies, since S1 was seldom directly relevant to S2.

EXPERIMENT 4

Since the implication of previous results is that the influence of the preceding distractor responses should generally have been to improve performance during SUP-SAY trials (or to impair performance for condition CONT), it is possible that delayed performance during SUP-SAY sequences may have occurred precisely because the distractor-activated information was continuously available during subjects' attempts to process S2. While such a suggestion appears initially to contradict "facilitatory" models of attention (e.g., Posner & Snyder, 1975a), this idea may have some merit if it is assumed that the availability of the preceding word-activated information impaired the normal processes involved in choosing a response for S2.

In keeping with the notion that suppression effects can be attributed to strategic factors, Experiment 4 was conducted to test the idea that suppression effects would occur only when subjects were set to expect processing difficulties during S2. In this experiment, all subjects were presented with Stroop items as S1, but for three different groups of subjects, S2 was made up of random presentations of all possible pairwise combinations of Stroop stimuli, color patches, or colored random letter sequences. It was expected that if the delayed performance for SUP-SAY sequences truly depends upon the impairment of subjects' adopted response-selection strategies during S2, then this effect should occur only when subjects expect Stroop interference for S2. Such expectations would be induced by random letter sequences, which physically resemble Stroop items and thus should promote an expectation of similar processing difficulties. On the other hand, when S2 had never been a Stroop item, or when the appearance of S2, itself, had indicated that responding difficulties would not be experienced (as for color patches), it was expected that RTs for SUP-SAY sequences would always be facilitated relative to CONT.

Method

General. The method and procedure were basically similar to the previous experiments, except that only the 75-25 condition was employed in the present study. As in Experiments 2 and 3, the Stroop items for Packs 1, 3, and 5 were employed as S1 and were paired with the different stimuli that served as S2. For all groups, the different S2 types were presented with equal probability so that, while the color of S2 was predictable from S1, the nature of the stimulus itself was not. The random letter stimuli were constructed by placing the letter sequences MTW, OMTTV, IHXT, and ATHHYO, which were meant to correspond to the words RED, GREEN, BLUE, and YELLOW, respectively, in the lower portion of the white cards using the same materials as for the color-word stimuli. Only conditions SAY-SAY, CONT, and SUP-SAY were employed in this experiment. For the random letter sequences, examples of these conditions were GREEN in blue ink → MTW in blue ink, YELLOW in green ink → MTW in blue ink, and BLUE in green ink → MTW in blue ink, respectively. The different S2 types for condition SAY-SAY each comprised 37.5% of all trials, while for CONT and SUP-SAY sequences, the different stimulus pairings made up 6.25% of all trials. All other aspects of the present experiment were identical to previous experiments.

Subjects. The eight subjects in each group were selected from the same population as in previous experiments and were paid $3 each for their participation.

Results and Discussion

Median performance scores for each subject for those conditions comprising 37.5% and 6.25% of all trials were based on 108 and 18, or fewer, correct scores, respectively. For the different groups, the median RT scores were submitted to separate 2 by 3 repeated-measures analyses of variance to evaluate the effects of S2 type and conditions. Mean RTs and error rates for all groups are presented in Table 4.

Stroop stimuli or random letters as S2. The analysis revealed that the effects of S2 type [$F(1,7) = 60.31$, MSe = 1,122], conditions [$F(2,14) = 32.66$, MSe = 7,080], and their interaction [$F(2,14) = 37.46$, MSe = 455] were all statistically reliable. As can be seen from the upper row of Table 4, overall latencies were somewhat faster for the random letter sequences than for the Stroop items. For both types of stimuli, average latencies for condition SAY-SAY were facilitated relative to CONT trials [$t(14) = 8.81$], while those for SUP-SAY sequences were marginally impaired [$t(14) = 1.95$, $p < .10$]. As is also evident from Table 4, latencies for both conditions CONT and SUP-SAY were much slower for the Stroop stimuli than for the random letter sequences [$ts(14) = 3.73$ and 3.87, respectively], while RTs for condition SAY-SAY were identical for the different S2 types [$t(14) < 1$].

Random letters or color patches as S2. For this group, the analysis revealed that neither the effects of S2 type [$F(1,17) < 1$, MSe = 2,669] nor the interaction of S2 type and conditions [$F(2,14) < 1$, MSe = 392] was statistically significant. The different conditions had a considerable effect upon RTs [$F(2,14) = 25.04$, MSe = 1,214], and, as can be seen from the middle row of Table 4 for both S2 types, average latencies for both conditions SAY-SAY [$t(14) = 11.14$] and SUP-SAY [$t(14) = 2.99$] were facilitated relative to CONT sequences.

Stroop stimuli or color patches as S2. The results for this group were basically similar to the first group, with the effects of S2 type [$F(1,7) = 44.0$, MSe = 2,433] and conditions [$F(2,14) = 31.23$, MSe = 3,826], and their interaction [$F(2,14) = 35.68$, MSe = 630] all being statistically reliable. As can be seen from the lower row of Table 4, the major difference between these results and those for the first group was that, although latencies for SUP-SAY trials were also impaired relative to CONT sequences for the Stroop items [$t(14) = 3.60$], RTs for the same condition for the color patches were improved relative to CONT trials [$t(14) = 2.42$].

These findings are in agreement with the suggestion that the relatively delayed RTs during SUP-SAY trials can be attributed to the impairment of subjects' response-selection strategies during S2. Relative performance for the random letter sequences for condition SUP-SAY was impaired when these stimuli were paired with Stroop items as S2, but RTs for the same inputs were facilitated when presented in the context of color patches. In addition, RTs for condition SUP-SAY for the color patches were uniformly facilitated. In other words, the delayed RTs during SUP-SAY trials were observed to occur only when subjects were set to expect and the appearance of S2 indicated that the response-selection difficulties would be encountered (i.e., S2 could be a Stroop item and a symbolic distractor was present). On the other hand, only relative facilitation effects were evident during SUP-SAY trials when experimental context or the appearance of S2 indicated that processing difficulties would not be experienced (i.e., S2 was never a Stroop item or a symbolic distractor was absent).

GENERAL DISCUSSION

The results of these experiments taken together do not support Neill's (1977) simple response inhibition

Table 4
Mean RT (in Milliseconds) and Error Rate (ER) as a Function of Groups, Stimulus Type, and Conditions in Experiment 4

	Stimulus (S2) Type																	
	Color Words						Random Letters						Color Patches					
	SAY-SAY		CONT		SUP-SAY		SAY-SAY		CONT		SUP-SAY		SAY-SAY		CONT		SUP-SAY	
Item Used as S2	RT	ER	RT	ER	RT	ER	RT	ER	RT	ER	RT	ER	RT	ER	RT	ER	RT	ER
Stroop Items or Random Letters	470	1.3	711	1.6	753	1.9	470	1.0	600	1.4	638	2.0						
Random Letters or Color Patches							511	2.0	616	1.9	587	1.8	507	2.0	596	2.4	573	2.6
Stroop Items or Color Patches	500	1.9	694	2.2	726	2.3							486	1.7	586	1.9	565	1.6

interpretation of the suppression effect. It is evident from these findings that this phenomenon is complicated by a number of strategic adaptations to various contingencies within the trial sequence. Most particularly, the present results make clear that task context is a significant factor and that the effect for a given type of sequence can be influenced both by the nature of other sequences (Experiment 2) and by stimuli (Experiment 4) that appear in the task.

Although the inadequacy of a simple inhibition account of the impaired performance for SUP-SAY sequences has been demonstrated, these experiments, themselves, do not suggest explanations for the occurrence of this phenomenon. While the results of Experiment 4 indicated that this effect may have occurred because the strategies that subjects employed to respond appropriately to S2 were disturbed, no precise mechanism was specified. However, as Keele (1973) noted, subjects must employ the available ink-color and word-form information in order to choose one response over the other. Second, the results of Experiment 3 suggested that during the resolution of Stroop interference, the appropriate color information was likely directly attended and reported, while the distracting word information was left unhampered. Finally, it is also evident from the present results that the available distractor information was also included in subjects' strategic attempts to match the colors of the inputs. If these tenets are accepted, the delayed RTs during SUP-SAY trials are, perhaps, not so difficult to understand. On such occasions, not only had the anticipated match of the color information failed to materialize, but, as well, in attending all of the concurrently available information within memory, it would be evident that the appropriate response for S2 was (1) associated with both a correct and an incorrect stimulus source and, assuming the operation of a facilitatory process, (2) unexpectedly highly available. The effect of this set of circumstances may be characterized in several ways. On one hand, any color name that was doubly represented would be highly ambiguous, temporarily qualifying as both appropriate and inappropriate until further, time-consuming analysis of the information within memory has verified its propriety. Alternatively, given that the correct response for S2 may have been unexpectedly highly available, and that reading has primacy over color naming (Fraisse, 1969), the response may have been temporarily rejected during SUP-SAY trials because the early availability of the response did not coincide with its usual source (i.e., color-activated responses usually become available for report somewhat later than word-activated responses). Further research may support either of these hypotheses.

While the preceding explanations of the suppression effect have dispensed with the notion of response inhibition altogether, a satisfactory account could also be one that couples a response inhibition interpretation with a fuller understanding of how S2 is processed under circumstances in which SUP-SAY sequences do not produce performance impairments. Whatever the outcome, a proper interpretation must be made consistent with the present findings.

Although these results clearly qualify the response inhibition interpretation, one additional difficulty remains. In both Experiments 2 and 3, RTs for condition CONT did not vary appreciably as a function of groups. This result is surprising, since, according to the cost-benefit theory of attention (Posner & Snyder, 1975a, 1975b), processing costs are expected to occur on those occasions when attention has been erroneously paid to processing inappropriate stimuli and/or responses. Accordingly, condition CONT RTs for the 75-25 groups should have been impaired relative to the 25-75 groups. For the former, continuous attention commitment to correct S1 color names should have caused misdirected attention for processing of unexpected colors during S2. While the absence of any costs associated with CONT sequences for the 75-25 groups is baffling, some consolation can be taken from results reported by Posner and Snyder (1975a, Experiment 1). These authors have also reported that response times were not substantially affected by a primary stimulus (S1) that was unrelated to a subsequent stimulus array (S2) when subjects were led to expect the successive inputs to match. The failure to produce any costs in this situation appears to be as problematic for the cost-benefit theory as are the present results.

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NOTES

1. Since Neill's (1977, 1978) related-unrelated terminology is obviously inappropriate here, a notation system similar to that devised by Dalrymple-Alford and Budayr (1966) has been employed.

2. The rejection region for all statistical tests reported in this paper is $p < .01$ or better, unless otherwise stated.

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