

# Reverse Stroop effect with concurrent tasks

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Variations in irrelevant ink color impaired the processing of color words in a card-sorting task, demonstrating the occurrence of a reverse Stroop effect in a task without a spoken response. The magnitude of the reverse Stroop effect was not significantly affected by whether the card sorting was carried out in isolation, while irrelevantly articulating, while retaining digits, or while irrelevantly imaging.

The well-known Stroop effect occurs when a person is asked to name the colors of patterns of ink that spell out the names of other, conflicting colors (Stroop, 1935). Performance is reliably found to be worse than in a control condition in which conflicting color names do not occur. It has been proposed by Cohen and Martin (1975) and Morton and Chambers (1973) that the effect may be thought of in terms of a race between color processing and word processing leading to response competition. Delay will be caused when the verbally derived information becomes available first and has to be rejected. Evidence supporting this hypothesis was reported by Martin (1978). It was found that the addition of an irrelevant articulation condition to a normal Stroop task resulted in a significant decrease in the size of the Stroop effect, presumably because a selective impairment in the processing of the verbal information made its intrusion less likely; replication of this result has been reported by Naish (Note 1) and Wilhite (Note 2). Complementarily, Gough and Cosky (1977) demonstrated the occurrence of speech recoding in a Stroop task using not color words themselves but pseudo-homophones of them (e.g., "bloo," "grene"), although Naish (1980) found this effect for female but not for male subjects.

It is possible also to demonstrate the occurrence of a reverse Stroop effect, in which the naming of written color words is impaired by the occurrence of different ink colors. The size of this reverse effect is, however, considerably smaller than that of the standard effect (see Dyer, 1973), a result that the race model can accommodate most simply by positing that the proportion of times in which ink color information becomes available before color word information is less than the reverse (Morton & Chambers, 1973).

Furthermore, the model implies that while the effect of impairing the processing of written information in the

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standard Stroop task is to decrease the magnitude of the observed Stroop effect, the effect of the same operation in the reverse Stroop task should be to increase the magnitude of the corresponding effect. Impairing the processing of written information using a visual mask has in fact been found to have this effect by Gumenik and Glass (1970), and Dyer and Severance (1972) have shown that this is not due to differences in simple legibility.

The present experiment was carried out in order to investigate, first, whether a reverse Stroop effect could be obtained using a task in which the response was a manual one rather than a spoken one (cf. Simon & Sudalaimuthu, 1979) and, second, whether its magnitude would be increased by the carrying out of a variety of additional tasks that might impair processing of the written word. The three additional tasks used were irrelevant articulation (as in Martin, 1978), maintaining three digits in memory (postulated by Baddeley, 1976), to fill the articulatory loop component of working memory), and, for comparison, maintaining an irrelevant mental image.

## METHOD

### Subjects

Thirty-two subjects from the Oxford subject panel participated in this experiment. There were equal numbers of males and females, and their ages were between 18 and 40 years.

### Materials

The stimuli were words in capital letters each .5 cm tall and .3 cm wide, written in six different colored inks (black, blue, green, purple, orange, and yellow) at the centers of 7.6 x 12.7 cm blank white cards. Two categories of card pack were prepared, neutral and incongruent. Each pack contained 30 cards. For the neutral condition, there was one pack, with each of its cards having a color name written on it in brown ink; each of the six color names occurred five times. For the incongruent condition, there were two packs. Pilot observations had indicated that the largest reverse Stroop effects were obtained not when all color names differed from the ink in which they were written, but rather when approximately one-half did. Thus one pack in the incongruent condition had three color names that occurred three times in inconsistent color inks and twice in consistent color inks and three color names that occurred twice in inconsistent color inks and three times in consistent color inks. The second pack in

the incongruent condition consisted of the complement of the first; color names previously paired with three inconsistent color inks (and twice with consistent color inks) were paired with the remaining two inconsistent color inks (and three times with consistent color inks), and vice versa.

#### Procedure

In order to increase the magnitude of the reverse Stroop effect, all subjects first carried out a standard Stroop task for 30 min before this experiment (see Stroop, 1935).

Subjects were tested individually. They were instructed to sort each pack as fast as possible into a set of piles with one color name to each pile. The two categories of pack were combined with four types of task instruction. Subjects sorted the cards in isolation, said "blah" continuously while sorting, recalled after the sort three varying digits spoken by the experimenter before the sort, or maintained a visual image of a wine glass (selected for colorlessness). Each subject performed all eight conditions of the experiment, and the order of cards within the pack was randomized for each subject. The order in which each subject carried out the eight conditions was determined by two 8 by 8 digit-balanced Latin squares. Equal numbers of subjects of the same sex received each of the two varieties of packs in the incongruent condition, and the balancing was the same for the male and for the female subjects.

#### RESULTS

Sorting times were subjected to a four-way analysis of variance (stimulus type by additional task by sex by subjects). The mean sorting time for incongruent stimuli, 41.7 sec, was significantly longer than that for neutral ones, 38.3 sec [ $F(1,30) = 30.67$ ,  $p < .001$ ]. However, the magnitude of this reverse Stroop effect did not interact significantly with the type of additional task (if any) [ $F(3,90) = .18$ ], as can be seen in Table 1. There was, though, a significant main effect of type of task [ $F(3,90) = 10.85$ ,  $p < .001$ ]; mean times for sorting in isolation, while articulating, retaining digits, and imaging were 37.6, 40.5, 39.1, and 42.7 sec, respectively. There was no other significant main effect or interaction.

A similar analysis of variance was carried out upon the number of errors occurring in each condition. The only significant result was that more errors were made with incongruent stimuli, .78%, than with neutral ones, .29%, confirming the reverse Stroop effect [ $F(1,30) = 4.56$ ,  $p < .05$ ].

#### DISCUSSION

The results demonstrate that a reverse Stroop effect may be observed even when the response is a sorting rather than a spoken one. The magnitude of the effect in the unaccompanied condition of the present experiment, calculated as the ratio of the difference in mean times between incongruent and neutral stimuli to the mean time for neutral stimuli, was 8.7%. This compares with values of 3.2% (Session 1) and .4% (Session 2) reported by Dyer and Severance (1972) and 16.1% reported by Gumenik and Glass (1970).

However, the size of the reverse Stroop effect here was not significantly affected by the occurrence of additional tasks of articulating, retaining digits, or imaging. The elementary point must be borne in mind that absence of significance of an effect

Table 1  
Mean Sorting Times (in Seconds)

Additional Task Type	Neutral Stimuli	Incongruent Stimuli	RSE
Unaccompanied	36.03	39.16	3.13
Articulation	38.83	42.08	3.25
Digit Recall	37.08	41.16	4.08
Visual Imagery	41.18	44.25	3.07

Note—RSE = reverse Stroop effect.

does not demonstrate the absence of the effect; it demonstrates only that the presence of the effect has not been detected by an experiment of a particular design and size. Thus a possible reason why a significant effect was not obtained in the present experiment is suggested by the race model. The visual masks used by Dyer and Severance (1972) and Gumenik and Glass (1970) increased mean latencies by 33% (first session), 19% (second session), and 119%, respectively, and increased the magnitude of the reverse Stroop effect from 3.2% to 13.0%, from .4% to 4.1%, and from 16.1% to 44.1%, respectively. In contrast, articulating, retaining digits, and imaging increased mean latencies in the present experiment by only 8%, 3%, and 14%, respectively. It is thus possible that the failure of these manipulations to significantly affect the magnitude of the reverse Stroop effect is a consequence simply of their failing to slow the processing of the written information to a large enough extent.

#### REFERENCE NOTES

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