

# Interference produced by modified Stroop stimuli

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The present research attempted to determine whether the typical pattern of responding found with Stroop stimuli is also found when the stimuli are printed vertically, printed vertically with three-letter abbreviations, and printed horizontally with three-letter abbreviations. Response times were recorded for reading, color naming, and conflict (interference) tasks, with the primary performance measure being the ratio of the conflict score to the color naming score. Three groups of subjects responded to modified Stroop stimuli and one group was presented conventional Stroop stimuli, thereby serving as the reference, or control, group. No significant difference was found among the groups on the ratio measure. These results were interpreted as evidence that Stroop stimuli can be modified in several ways, while still retaining inference qualities. Implications of this research, particularly with regard to investigations of hemispheric asymmetry and sex differences, are discussed.

The Stroop (1935) color-word test has been utilized in a variety of areas in psychology (for reviews of the literature, see Dyer, 1973; Jensen & Rohwer, 1966). This test has been investigated not only for the information it yields concerning color naming, word reading, and interference, but also as a methodological tool for the investigation of other psychological processes.

Recently, several investigators have sought to study hemispheric asymmetry by means of the Stroop measure. Dyer and Harker (cited in Dyer, 1973) presented vertically printed Stroop stimuli to one visual field at a time. Two peripheral locations, at 45 min and 2 deg horizontal displacement from the fovea, were utilized. The authors reported no hemispheric differences in amount of interference or in response times.

Another study aimed at a better understanding of the relationship between Stroop performance and possible hemispheric asymmetry was done by Tsao, Feustel, and Soseos (Note 1). Like Dyer and Harker (cited in Dyer, 1973), these investigators presented vertically printed Stroop stimuli to one hemisphere at a time, with subjects performing the usual three Stroop tasks. While a significant hemispheric difference was found in the interference condition for the error rate measure, there was no significant hemispheric difference for the reaction time measure. Within conditions, the only significant difference found was in the interference conditions, with no hemispheric difference found either

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for the reading or for the color naming conditions.

While the Stroop measure appears to hold promise for the investigator interested in hemispheric differences, these modifications of it have not been adequately standardized. There are no published data directly comparing the strength of the Stroop phenomenon with stimuli other than normal ones. In short, then, it is necessary to demonstrate that the pattern of results typically found with the normal Stroop stimuli is also found with modified (e.g., vertical) Stroop stimuli.

Another problem in hemispheric research is that the stimuli are presented peripherally, and visual acuity falls off very rapidly as a function of distance from the fovea. Words presented horizontally will vary considerably in legibility from beginning to end. This difference in legibility can affect performance on Stroop stimuli. Research done by Schmit and Davis (1974), for example, is difficult to interpret due to the use of standard Stroop stimuli. Vertical presentation alleviates this problem in terms of the (presumably more important) horizontal dimension, but even under poor acuity conditions, the subject may be recognizing the color word more by noting its length than by discriminating the individual letters. Better stimulus control could be achieved by presenting all words in a standard length, such as limiting all words to three letters.

The purpose of this research was to compare performance on the standard Stroop task with performances on three variants of the task: vertical presentation, horizontal abbreviations, and vertical abbreviations. The differences, if any, among these conditions will indicate the extent to which it is appropriate to modify the standard Stroop task for use in hemispheric research.

## METHOD

## Subjects

Subjects were male and female undergraduate students drawn from psychology classes at Texas Christian University. All participated in the research either for extra credit or to fulfill a course requirement.

## Apparatus and Procedure

Pseudo-Isochromatic plates (American Optical Company, Model 1940) were utilized as a screening device for color deficiency. A Texas Instruments Datachron calculator/clock (Model 1977) served as the timing instrument. A Viewlex projector (340 W) was utilized to present the stimuli to the subjects.

The stimuli consisted of 20 verbal items (or colored patches) arranged in four horizontal rows. The verbal items were constructed of 5-mm-high rub-on letters, and the color patches were 2.5 x 3.8 mm. The four stimulus sets were converted to slides and presented to the subject at a viewing distance of 1.38 m.

Each subject performed three tasks under one of four formats for the stimulus materials. These tasks, always performed in the same sequence, were: (1) reading—the subject was required to read 20 color words (or abbreviations) printed in black ink; (2) naming—the subject was required to name the colors of the 20 colored patches; and (3) conflict—the subject was required to name the colors of the 20 printed color words or abbreviations. The meaning of the word and the color of its ink were incongruent in this condition.

The four stimulus formats, which corresponded to the four experimental conditions, were: (1) standard Stroop (SS)—the stimuli viewed by the SS group were five standard color words (RED, BLUE, GREEN, PURPLE, and YELLOW); (2) abbreviated Stroop (AS)—the stimuli viewed by the AS group were RED, BLU, GRE, PUR, and YEL; (3) vertical full (VF)—the stimuli for this group were the standard color words printed vertically; and (4) vertical abbreviated (VA)—subjects in the VA group viewed vertical presentations of the same stimuli viewed by the AS group.

Upon entering the laboratory, each subject first responded to 12 stimuli from the Pseudo-Isochromatic plates. If incorrect responses were given to four or more of the plates, that subject's data were collected but not used. This criterion was established in order to rule out any effects that a color deficiency might exert on the data. Four subjects fell into this category.

After responding to the color plates, each subject was seated in an acoustically shielded booth. The instructions to the subject were delivered in a standard, yet informal, manner, with the experimenter emphasizing both speed and accuracy in responding. The times were recorded by the experimenter.

## RESULTS

Analysis of variance performed on the reading,

color naming, and conflict tasks showed no significant differences among the four groups of subjects. While performance differences on the reading task approached significance [ $F(3,96) = 2.25, p < .086$ ], there was no difference among the groups on the color naming task [ $F(3,96) = 1.09, p < .358$ ] or the conflict task [ $F(3,96) = .84, p < .476$ ]. On the three basic, conventional Stroop measurements, then, there were no significant differences among the experimental groups.

Since the conflict task is essentially the same as color naming with the stimuli in a different format, the most sensitive measure of conflict is a ratio of the scores achieved on the two tasks. Each subject's conflict time was divided by his or her color naming time, yielding a conflict measure that was independent of intersubject differences in color naming ability. Table 1 summarizes these data.

A 2 (abbreviation-full) by 2 (vertical-horizontal) analysis of variance performed on the ratio measure found no significant differences among the four groups. The F values and probability values were as follows:  $F = .171 (p < .682)$  for the horizontal-vertical manipulation;  $F = 2.698 (p < .10)$  for the abbreviated-full variable, with longer response times occurring with the full presentations; and  $F = .226 (p < .641)$  for the interaction.

A t test was done on the ratio measure to test for the presence of a sex difference. The test indicated no significant difference between males and females. The mean and standard deviation for the males were 1.71 and .33, respectively; for females, the mean score was 1.72, and the standard deviation was .34.

Significant differences were found between males and females on the color naming task [ $t(98) = 2.272, p < .024$ ] and the conflict task [ $t(98) = 2.053, p < .04$ ]. Table 2 summarizes these data.

Since these analyses argue for acceptance of the null hypothesis, it is necessary to demonstrate that such acceptance can be justified and that the assertion of no differences among the groups is a meaningful conclusion. The percentage of variance accounted for by each factor confirms the true similarity of the groups: Neither the combined effect (i.e., the interaction) nor the individual (main) effects accounted for as much as 3% of the total variance. A discriminant function analysis, utilized to

Table 1  
Summary Statistics by Condition

Task	Condition							
	Standard Stroop		Abbreviated Stroop		Vertical Full		Vertical Abbreviated	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Read	8.03	1.31	8.47	1.18	8.44	1.75	9.06	1.23
Name	10.71	2.00	11.56	1.88	11.16	2.13	10.68	1.81
Conflict	18.61	3.37	18.56	3.17	19.74	5.47	17.90	3.91
Ratio	1.78	.36	1.63	.32	1.77	.33	1.69	.32

Note—Ratio = conflict/name.

Table 2  
Summary Statistics by Sex

	N	Read		Name		Conflict		Ratio	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Males	39	8.68	1.24	11.53	1.52	19.74	3.60	1.73	.32
Females	61	8.36	1.36	10.67	2.00	18.13	3.90	1.73	.31

Note—Ratio = conflict/name.

examine the pattern of reading, color naming, conflict, and ratio scores, also revealed nonsignificant differences ( $p < .07$ ) among the four groups. Although this probability value is close to the conventional (.05) level of significance, the discriminant function accounted for only 12% of the variance between the groups. Clearly, the data show a Stroop phenomenon in all four groups.

### DISCUSSION

The failure to reject the null hypothesis should not be interpreted as a failure to obtain meaningful results. The primary aim of the present research was to discover whether the Stroop interference occurs with three modifications of the stimuli. The pattern of scores within each experimental condition is quite similar to that of traditional Stroop research: In all groups, the reading task was performed fastest and the conflict task slowest, with the latter task requiring approximately 70% more time than the color naming task. This difference between the conflict and color naming times is well within the range of traditional Stroop research. In addition, the variances for each group were small relative to the corresponding means, indicating that the similarity among the groups is genuine and not the result of large measurement error. The present results are valuable in that they provide norms justifying the use of modified stimuli that promise to be more useful than the standard stimulus format in certain kinds of research. Particularly with respect to the use of the Stroop as a means for studying functional differences between the hemispheres, the present research carried important implications.

One study in which the use of modified Stroop stimuli would have proven advantageous was done by Schmit and Davis (1974), who presented single stimulus items, both congruent and incongruent, to one hemisphere at a time. Subjects then responded manually, pressing buttons with their fingers. The results were as predicted: Reactions to incongruent stimuli were longer than reactions to congruent stimuli, with this difference being greater for the left (dominant) hemisphere.

The use of standard Stroop stimuli, however, confounds the

results of the study. When the subjects were responding to the word, rather than to the color of the ink, it is possible that word length served as the salient cue, since each of the three stimulus words contained a different number of letters. When the subjects were responding to the color of the ink, rather than to the word meaning, it is again possible that the words were not read; this, of course, would decrease the amount of interference. In fact, these researchers reported a faster reaction time in their interference condition than in their reading condition. These findings are the reverse of those found in most research utilizing Stroop stimuli.

The results reported by Schmit and Davis (1974) are not readily interpreted. If these investigators had utilized modified Stroop stimuli (e.g., vertically printed, abbreviated color words), then the problems in interpreting their results would be eliminated. Subjects could not possibly have utilized word length as a cue in responding, and the stimuli could have been more precisely presented to the retina of the subject.

The present research has empirically demonstrated that the Stroop phenomenon occurs even when the stimuli are modified in several ways: An equal amount of Stroop interference occurs with vertical words, vertically printed abbreviations, horizontal abbreviations, and (normal) unabbreviated color words. These results help validate other research that has utilized vertically printed Stroop stimuli. Based on the present data, an investigator can utilize such modifications of the Stroop stimuli and remain confident that the same pattern of behavior will occur when subjects perceive these modified stimuli as when they perceived normal Stroop stimuli.

### REFERENCE NOTE

1. Tsao, Y., Feustel, T., & Soseos, C. *Stroop interference in the left and right visual fields*. Paper presented at the annual meeting of the Psychonomic Society, San Antonio, Texas November 1978.

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