Time Course of the Color-Color Stroop Task

Christopher Koch
George Fox University

Abstract

Traditional Stroop interference combines color and word dimensions to produce interference (Stroop, 1935). Stroop-like interference also occurs when two color blocks are presented together (Koch & Kubovy, 1996). Studies manipulating SOA in the traditional Stroop task have shown that interference is greatest when the two dimensions are presented within 100 msec of each other (cf., MacLeod, 1991). This study examines the time course of interference in the color-color (or color block) version of the Stroop task. Color block pairs were randomly presented to 16 subjects for 50, 100, 150, 200, and 250 msec in a within-subject design using neutral, congruent, and incongruent stimuli. The results show that RTs decline across stimulus conditions as stimulus duration increases. The results also indicate that the greatest interference occurs at 50 msec. Therefore, the interference obtained in the color-color version of the Stroop task occurs earlier in processing than in the color-word task.

Introduction

Stroop interference is produced when a color word is incongruent with a to be named color. Although Stroop (1935) originally used a series of words printed in different color ink (integrated stimuli), Stroop interference has also been demonstrated when individual color-words are presented (Dalrymple-Alford and Budayr, 1966) and when the word and color are separated (non-integrated) but presented closely together in space (Kahneman and Chajczyk, 1983). In fact, Dyer (1971; Dyer and Severance, 1973) manipulated the stimulus onset asynchrony between the color and word dimensions of the task to examine the time course of processing the color and word components of the Stroop stimuli. Theoretical explanations for Stroop interference differ yet al focus, to some degree, on the priority status of words in information processing (e.g., Posner and Snyder, 1975; Shiffrin and Schneider, 1977; Cohen, Dunbar, and McClelland, 1990). Koch and Kubovy (1996) modified the non-integrated version of the color-word Stroop task to examine whether or not Stroop-like interference can be obtained in the absence of word information. Specifically, they presented two color bars and asked participants to name the color one of the bars. Response times were fastest when the two bars were the same color (congruent) and slowest when the two bards were different colors (incongruent).

The present study was conducted to determine the time course of the color-color version of the Stroop task. MacLeod (1991) noted that interference in the color-word version of the Stroop task is greatest when the color and word are presented within 100 msec of each other. If the word information is removed, will the time course of Stroop processing remain the same or will it change in the color-color version?

Method

Participants

Fourteen upper division psychology students participated in the study for class credit. All participants had normal or corrected to normal visual acuity and normal color vision. Age of participants ranged from 22 to 52 with a median age of 23.

Instruments

Visual acuity was assessed using a Landolt C presented at the viewing distance for the experimental trials (70 cm). Color vision was examined using the Coren and Hakstian (1995, 1988) color vision screening. Short-term and working memory were measured using the forward and reverse digit span tasks, respectively, from the Wechsler Adult Intelligence Scale (WAIS).

Design

A 3 (condition) x 5 (duration) within-subject design was used. The color-color Stroop stimuli consisted of two color blocks presented either above or below fixation for a varying amount of time (50, 100, 150, 200, and 250 msec). The blocks were the same color for congruent trials and differed in color for incongruent trials. A single block was presented for neutral trials. The sequence of events for each trial is presented in Figure 1. Each trial was initiated with a key press (space bar). The block pair was presented followed by a mask which remained until a response was made. Each color was presented an equal number of times per condition and duration. Half of the trials appeared above fixation and half were below fixation. There were at total of 100 practice and 200 experimental trials. Sixty percent of the trials, in both the practice and experimental blocks, were incongruent.

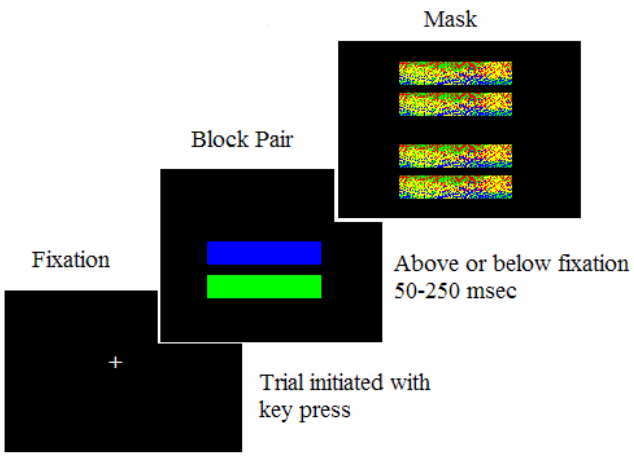

Figure 1. Sequence of stimuli for each trial.

Procedure

After being screened for visual acuity and color vision, participants completed the digit span task from the WAIS. They were then instructed to press the key corresponding to the color of the top block in a pair of color blocks. The “z” key coded red, “x” green, “.” yellow, and “/” blue. Therefore, participants used their middle and index fingers on both hands to respond to the color stimuli. Participants completed the 100 practice trials followed by the 200 experimental trials.

Results

Stroop RT Analysis

Table 1. Descriptive statistics for each condition by duration

	Neutral		Congruent		Incongruent	
Duration	M	SD	M	SD	M	SD
50	1010.75	278.58	908.93	266.73	1019.14	247.15
100	929.11	381.89	857.14	350.60	909.04	337.58
150	805.79	267.53	797.00	392.15	857.29	339.86
200	760.61	345.21	702.04	359.82	779.00	306.34
250	*799.75*	*382.70*	*740.00*	*386.67*	*714.29*	*312.42*

Descriptive statistics for the each condition by duration are presented in Table 1. An analysis of effect size shows that the largest effect size indicating Stroop interference occurs at 50 msec while a minimal effect size exists between the incongruent and congruent trials at 250 msec (Table 2). Therefore, the 250 msec duration was dropped from the analysis.

Table 2. Differences in RTs and effect sizes across durations.

	Incongruent-Neutral		Incongruent-Congruent	
Duration	difference	d	difference	d
50	8.39	0.03	110.21	0.41
100	-20.07	-0.05	51.89	0.15
150	51.50	0.19	60.29	0.15
200	18.39	0.05	76.96	0.21
250	*-85.46*	*0.22*	*-25.71*	*0.07*

A 3 (condition) x 4 (duration) repeated-measures ANOVA yielded a significant effect of condition ($F_{92, 26} = 4.01$, $p = .3$; eta-squared = .49) and duration ($F(3, 39) = 12.27$, $p < .001$; eta-squared = .24). The condition x duration interaction was not significant. Response times were faster as duration increased (Figure 2).

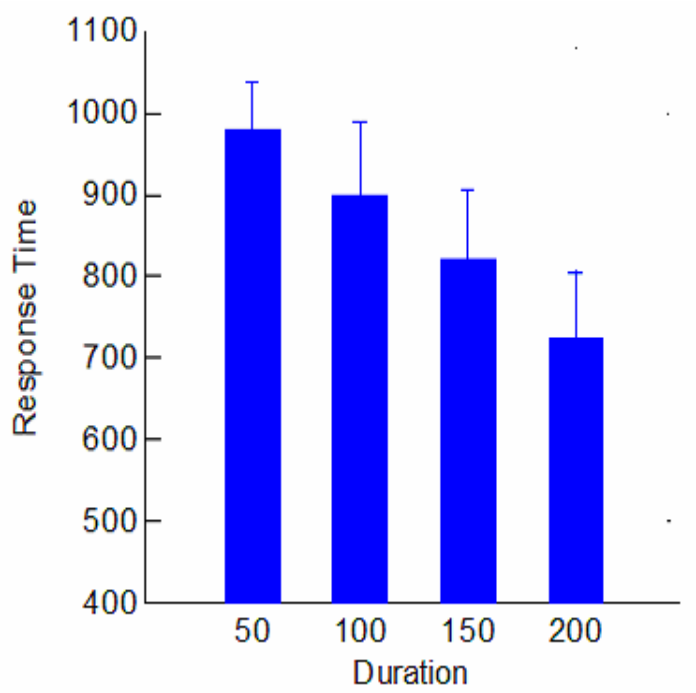

Figure 2. RT by duration

Response times for incongruent trials were significantly longer than RTs for congruent trials (Figure 2).

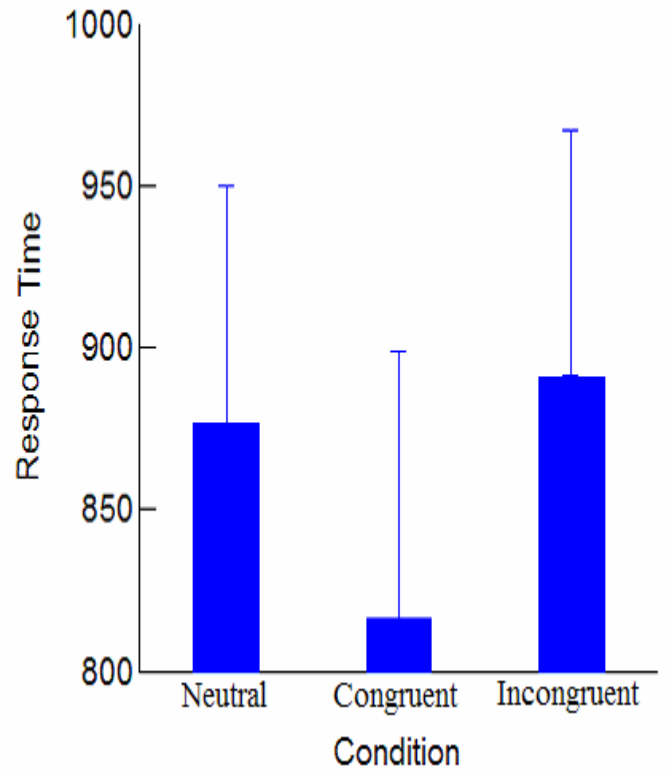

Figure 3. RT by condition

Relationship to Digit Span

A correlation analysis was conducted to determine if forward digit span (short-term memory marker) or reverse digit span (working memory marker) were related to RTs for the

different conditions of the color-color Stroop task at the various durations used in the study. These correlations were not significant.

Discussion

The time course of the color-word Stroop task is characterized by an S-shaped function in which the greatest amount of interference occurs when the color and word appear within 100 msec of each other (MacLeod, 1991). It has been shown that two color blocks can produce Stroop-like interference without the presence of word information (Koch and Kubovy, 1996). Examining the time course of the color-color variant of the Stroop task produces slightly different results from the traditional color-word version. Interference appears to be greatest at 50 msec, gradually declines as duration increases, and is essentially eliminated at 250 msec. Although the differences between the color-word and color-color Stroop tasks warrant further investigation, the difference found between the time course of the two versions is likely due to the presence and absence of word information. In addition, the current findings highlight that the various versions of the Stroop task (Table 3) can produce Stroop-like interference but the interference produced by these tasks may not represent the same underlying attentional process.

Table 3. Variations of the original Stroop task. The list is not comprehensive and does not include variations developed for clinical purposes.

Variation	Reference
Color-Word Sorting	Tecce and Happ (1964)
Picture-Word	Hentschel (1973)
Auditory Stroop	Hamers and Lambert (1972)
Flanker Task	Harms and Bundesen (1983)
Direction	Shor (1970, 1971); Seymour (1973, 1974)
Features (e.g., font, shape)	Warren and Lasher (1974); Compton and Flowers (1977)

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