Contribution of Cognitive and Semantic Control to Performance on Stroop Tasks

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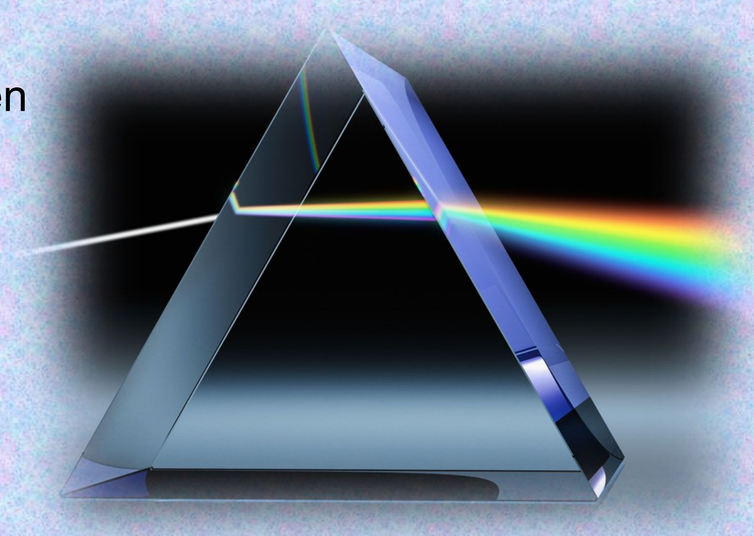
Background

The Stroop effect occurs when people have difficulty naming the ink color of letters that spell color names. For example, looking at the word **BLUE** and saying 'red'. Since its first description over 90 years ago, the Stroop effect has been widely applied as an experimental research method,



Despite the sustained attention on the Stroop effect, the cause of the effect remains unclear. While some theories suggest perceptual interference early in processing, others suggest that the effect is caused by response selection late in processing.

We developed a novel form of the Stroop task that requires a divergent response, increasing the cognitive load at the response selection stage. In this *Choice Condition* a correct response to the word **BLUE** would be to say 'red' or 'green', either response would be considered correct.

Methods

An experiment was conducted on time taken to complete a range of color reading tasks.

A sample of 91 participants was recruited, all Thai university students, with a mean age of 22.2 years (SD = 1.0). All performed in four separate conditions (see Figure 1).

The Incongruent Condition is the traditional way to show a Stroop effect. The Choice Condition is of particular interest, as this contains additional cognitive load at the response stage.

For each trial, participants were presented with 50 words on a card and time to complete responding to all 50 was measured as the dependent variable. Two trials were performed within each condition.

In addition, all participants performed a separate test of general cognitive control, the Color Trails Test. This is a standard, paper-and-pen measure of executive function.

Figure 1: Examples of stimuli types in the four conditions. These are shown in English, however, the actual version applied used Thai words.

Color Naming Condition:
"Say the color of each rectangle"

Word Reading Condition:
"Say each word aloud"

RED GREEN BLUE GREEN

BLUE RED GREEN RED

Incongruent Condition:
"Name the ink color of each word"

GREEN RED BLUE RED

BLUE GREEN BLUE GREEN

Choice Condition:
"For each word say a color that is different to what you are looking at"

BLUE GREEN RED GREEN

BLUE RED BLUE GREEN

Results

Figure 2: Mean task completion times in the four experimental conditions.

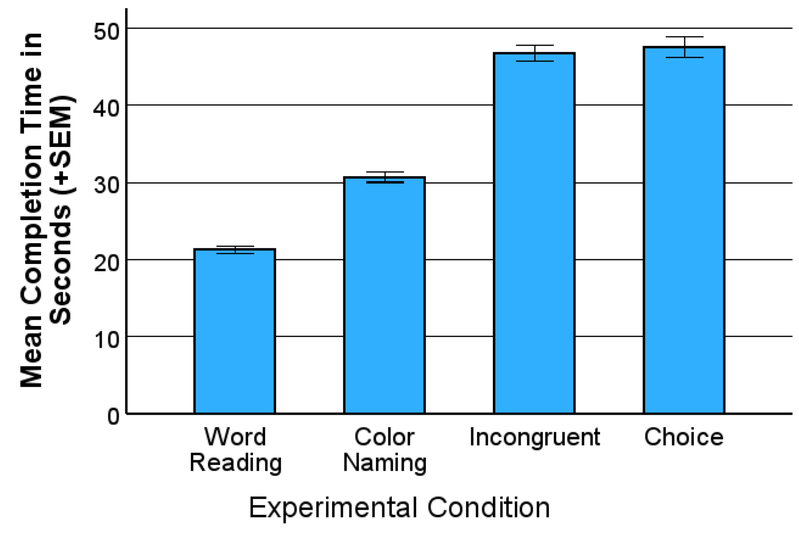


Table 1. Linear regression to predict performance in the *Incongruent Condition.*

Variable	*B*	*t*	*p*-value
Constant		1.69	0.10
Word Reading	-0.02	-0.17	0.86
Color Naming	0.69	7.16	<.01
Color Trails Test	0.19	2.54	.01

Table 2. Linear regression to predict performance in the *Choice Condition.*

Variable	*b*	*t*	*p*-value
Constant		0.81	0.42
Word Reading	0.23	2.00	0.05
Color Naming	0.37	3.15	<.01
Color Trails Test	0.11	1.17	0.25

Conclusions

- The standard Stroop *Incongruent Condition* and the novel *Choice Condition (*created specifically for this experiment), both produced robust statistically significant Stroop effects, p <.001 (see Figure 2).
- This suggests that Stroop interference effects are produced late in processing, at response selection. We infer this because our *Choice Condition* contained no early perceptual conflict.
- However, the Stroop effect in the *Choice Condition* was dependent on word reading and color naming speed (see Table 2), suggesting that limited resource semantic cognitive control may be an important factor.
- In contrast, the Stroop effect in the *Incongruent Condition* is not explained by word reading ability, but is by domain-general cognitive control resources.
- We suggest that semantic cognitive control and domain-general cognitive control processes may differentially affect performance on these two Stroop-effect-inducing tasks