THE EFFECT OF THE PROPORTION OF INCONGRUENT STIMULI ON STROOP CONGRUITY

John S. Monahan
Central Michigan University, Mt. Pleasant Michigan, 48859 USA
monah1js@cmich.edu

Abstract

In five experiments, the proportion of incongruent stimuli was varied from .25 to. 75, with touch screen responding. In all cases there was significant Stroop congruity. With proportions of incongruent stimuli of .50 or less, there was considerable congruity, more than 100 ms. With proportions of more than .50, congruity was considerably less, between 50 and 65 ms. The effect seems to be related to a strategy based on probability: If incongruent stimuli are more probable, ignore the word. If incongruent stimuli are equally probable or less probable, use the word if possible.

Two lines of research indicate that the proportion of incongruent trials influences the level of congruity in Stroop tasks. Lindsay and Jacoby (1994) and Jacoby, Lindsay, and Hessels (2003) hypothesize that color naming and word reading are separate processes that influence Stroop interference and facilitation separately. They find that increasing the proportion of incongruent trials reduced Stroop interference and Stroop facilitation. Melara and Algom (2003) suggest that the proportion of incongruent trials allows a participant to understand the correlation between color and word. A greater proportion of incongruent trials informs one that word reading is not efficacious; strategy can be adjusted accordingly, causing faster incongruent reaction time (RT) and slower congruent RT. Conversely, a smaller portion of incongruent trials informs one that word reading can be helpful; the adjusted strategy should lead to slower incongruent RT and faster congruent RT.

Another way of looking at the problem comes from Garner's (1962) concept of uncertainty. Stimulus uncertainty can be divided into three related parts. Maximum uncertainty [$U_{max}(c,w)$] is the uncertainty that occurs if there is no correlation between aspects of the stimulus, i.e. if each potential stimulus is equiprobable. Contingent uncertainty [U(c:w)] is the uncertainty due to the correlation between aspects of the stimulus, in the case of Stroop stimuli, between color and word. Bivariate uncertainty [U(c,w)] is the actual uncertainty of a set of stimuli, including any reductions caused by contingent uncertainty. The relationship is shown below in Equation 1. The object of the current experiments was to determine whether there is a relationship between Stroop congruity [Incongruent RT - Congruent RT] and bivariate uncertainty.

$$U(c,w) = U_{max}(c,w) - U(c:w) \quad (1)$$

Method

Five groups of participants (numbering 35, 31, 26, 26, and 24 respectively) were tested to determine Stroop congruity (incongruent RT - congruent RT) under conditions of five levels of proportion of incongruent stimuli: .75, .60, .50, .375, and .25. All other stimuli were congruent. Participants were tested using PC's with touch screen monitors. Participants saw a color word in color on the screen and indicated the color the word was presented in by pressing a colored square on the screen. RT and accuracy were measured. The stimuli consisted of the words RED, YELLOW, GREEN, and BLUE presented in red, yellow, green,

	WR	WY	WG	WB
CR	N	1	1	1
CY	1	N	1	1
CG	1	1	N	1
CB	1	1	1	N

Figure 1. A generalized stimulus matrix. WR, WY, WG, and WB are the four color words. CR, CY, CG, and CB are the four colors of the letters. N represents the number of congruent stimuli of that type in the matrix. For the five proportions of incongruent stimuli, the number of congruent stimuli represented by each N are as follows: .75 - 1; .60 - 2; .50 - 3; .375 - 5; .25 - 9. The corresponding U(c:w) are: 0, .08, .21, .45, .79.

and blue. There was a block of practice trials followed by four blocks of data collection trials. Trial blocks consisted of 12 incongruent trials, one each of all possible incongruent color and word combinations, plus congruent trials to reach the desired proportion of incongruent trials. Congruent trials consisted of equal numbers of each possible congruent stimulus. There were 4, 8, 12, 24, and 36 congruent trials respectively. Trials were presented randomly without replacement. Participants were debriefed. An example of a stimulus matrix is shown below.

Results

RT was significantly slower and Stroop congruity significantly greater for first trial blocks than for subsequent trial blocks. Thus only data from the second, third and fourth blocks are reported. Mean RT, mean Stroop congruity, and mean accuracy as a function of the proportion of incongruent stimuli are reported in Table 1.

Table 1. RT and Congruity by Proportion of Incongruent Stimuli

Stroop	Proportion of Incongruent Stimuli				
Measure	.75	.60	.50	.375	.25
$U_{(c,w)}$	4.00	3.92	3.79	3.55	3.21
Congruent RT	582 (.98)	519 (.95)	586 (.98)	626 (.97)	592 (.97)
Incongruent RT	646 (.94)	568 (.91)	693 (.89)	777 (.76)	768 (.86)
Congruity	64	50	108	151	175

Note: U(c,w) in bits; RT and congruity in ms; Proportion correct responses in parentheses.

The bivariate correlations between uncertainty and the proportion of incongruent stimuli ($r = .960$, $p < .01$), uncertainty and congruity ($r = -.946$, $p < .015$), and proportion of incongruent stimuli and congruity ($r = -.930$, $p < .022$) were significant.

The greater the proportion of congruent trials, the greater the level of the Stroop congruity. In general, the increase in congruity came at the expense of incongruent RT. There is a similar decrease in incongruent accuracy as the proportion of congruent stimuli increases.

Discussion

Both Lindsay and Jacoby's (1994) and Melara and Algom's (2003) hypotheses predict that congruity is negatively correlated with the proportion of incongruent stimuli. Both also predict that at high proportions of incongruent stimuli, congruity is eliminated. In the current experiment, that did not happen. Even with as much as 75% incongruent stimuli, there was significant Stroop congruity.

Possibly the reason that significant congruity was found even at the highest proportion of incongruent stimuli has to do with the response modality. Lindsay and Jacoby (1994) used vocal responding, a mode that often leads to a great deal of Stroop interference and congruity as well as facilitation. Key press responding typically leads to considerably less Stroop interference and congruity and usually not to facilitation. Of course, Lindsay and Jacoby measured accuracy in relation to response time rather than RT. Thus the differences in results could be due to response effects of to time restraint effects.

An alternate way to envision the processes that produced the results is to consider the probability that a responding will be speeded or slowed by considering the word as well as the color when responding. When the proportion of incongruent stimuli is greater than .50, it is advantageous to try to ignore the word or suppress responding to it. There is a condition conducive to response competition. This process is much easier with touch screen than with vocal responding. When the proportion of congruent items is .50 or greater, it can be helpful to use the word as well as the color when responding. There is a condition conducive to addressing response conflict. If there is no conflict, respond quickly. There appears to be a discontinuity between congruity with incongruent proportions above .50 and congruity with incongruent proportions at .50 or less.

References

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