THE EFFECT OF OBJECT-BASED SELECTION ON THE SEPARATED STROOP TASK

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The Stroop Effect (SE) documents the failure to ignore the carrier color word when people report its ink color (Stroop, 1935). Despite the vast amount of Stroop research, a few studies only investigated the effect of input selection—object-based or space-based—on the SE. The results were inconclusive. Moreover, the studies showing object-based modulation of the SE used the classic, integrated Stroop task, whereas studies showing space-based modulation typically used the spatially-separated version of the Stroop task. In this study we employed spatially separated Stroop displays to study the effect of object-based selection on the SE. The results showed larger SEs when the word and the color patch were part of the same object. This suggests improved processing of all features of an attended object, even if irrelevant to the task.

The Stroop (1935) task is widely used to measure selective attention. The paradigm and the associated effect are well known. A single color word in color is presented on a trial, and the participant's task is to name, while timed, the print color. The stimuli divide into congruent (the word naming its color as in the word RED printed in red) and incongruent (word and color conflict as in RED printed in green) combinations. The Stroop effect is the difference in performance across congruent and incongruent combinations. The presence of the Stroop effect shows that the task-irrelevant words were noticed, thereby indicating the failure of selective attention to the target print color (see MacLeod, 1991, for a review). This study focuses on a relatively neglected aspect of the Stroop phenomenon: The influence of object-ness on the SE. Are the word and the color perceived as components of the same single object? Does the SE remain invariant when the word and color are separated onto different objects?

Selective attention enables prioritization of components of the visual input. In the literature, selective attention is discussed both in the context of *input selection* (i.e., whether the visual field is parsed into specific regions or objects) and in the context of the *dimensional selection* (i.e., which dimension of a single object is processed first). The first process refers to the notion of visual field or space. Attention parses the visual field into well-processed and less well-processed chunks, the parsing governed by physical proximity (as space-based models hold) or by shared figural, temporal, or other physical features (as object-based models hold). With the object selected, attention becomes an intra-object process, decomposing the stimulus into task-relevant and task-irrelevant dimensions. Given the color-word stimulus in the classic Stroop task, input selection is irrelevant because a single object is considered (hence the absence of object-based selection) whose attributes inhere in the same location (hence the absence of space-based selection). However, in the spatially separated version of the task, input selection is important. The separate components can still belong to the same object or to different objects. Is the SE affected by object affiliation? We used a variation on the Stroop stimuli to empirically test this question.

We used the spatially separated version of the Stroop task (Kahneman & Chajczyk,1983). The display contained a colored bar and a color word in black presented above or below the bar. The participant's task was to name the color of the bar. Kahneman and Chajczyk (1983) found that the SE also obtained in such a separate preparation.

Recently, Wuehr and Waszak (2003) tested the role of object-based selection on the SE. The participants were presented with two partially overlapping rectangles each appearing in a different color. Clearly, each rectangle formed a separate well-delineated object. Color words in black appeared on each rectangle. The participant's task was to name the color of the occluding rectangle (the relevant object) and to ignore the occluded rectangle. The main result was that color words in the relevant object produced larger Stroop effects than color words in the irrelevant object. So, object affiliation did make a difference.

In this study, our goal was to take another look at the effect of object-based selection on the SE, while controlling for confounding in earlier research. Our manipulation entailed previously separated Stroop displays as parts of the same object or as parts of different objects. We predicted that the SE will be affected by object affiliation and that it will be larger for same-object perception.

Method

Participants

Eight undergraduate students from the Tel-Aviv University participated in the experiment for course credit.

Apparatus, Stimuli and Design

Displays were generated by an Intel Pentium 4 computer attached to a 15-inch CRT monitor, using 1024 × 768 resolution graphics mode. Viewing distance was set at 70 cm. A solid bar of color, 4.6 cm in length and 1 cm in width, was presented in the center the screen and the words were presented in 20-point David font. Three colors were used: red, green, and blue. The color words were presented at a distance of 1 mm above or below the color bar. Half of the color words were congruent and half were incongruent with the color of the bar. There were four experimental blocks: (a) the color word on the top or bottom of the bar on a homogeneous background; (b) the same as (a) but the entire stimulus (bar and word) appear on a well-formed gray rectangle; (c) the same as (b) but the big gray rectangle includes the only the word or only the bar; (d) spatially integrated display with the color word appearing on the colored bar. These experimental conditions were presented in separated blocks of trials. Each block included 48 trials presented in a random order. The first 5 trials were considered buffer trials and were not included in the analysis. Timed responses were made orally to a microphone. Because errors were few, we report RTs for correct responses.

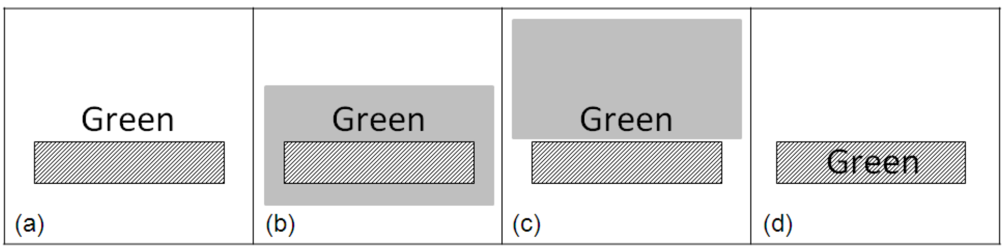

Figure 1: Illustration of the displays in each of the four conditions. See text for details. = red, green or blue; = gray.

Results and Discussion

Table 1 gives the results. The overall effect of congruency confirms the presence of SE in the data [F(1, 7)=39.924, p=.0004]. Absolute RT differed across conditions with the integrated condition (d) yielding longer latencies than the other three conditions (a), (b) and (c). The two effects did not interact (F<1). However, what is most revealing about the present data is the differences in the SE across conditions. Planned comparisons showed that the SE in condition (a), the typical display of spatially separated components (cf. Kahneman and Chajczyk, 1983), differed from that in condition (b) and in condition (d), but not from that in condition (c).

What does this pattern tell us? Take another look at Figure 1. Again, display (a) is the prototypical Stroop stimulus presented is spatially separated preparations ever since the classic study by Kahneman and Chajczyk (1983). What we did not know is whether the separated components are still perceived as parts of one object or that they are perceived as separate objects. The present results tell us that the latter is the case. The SE in condition (a) did not differ from the SE in condition (c), the latter clearly containing two separate objects. In a complementary fashion, the SE in condition (b) and (d) did not differ from one another. These two conditions clearly entail a single object.

Collectively, the SE obtained in conditions (a) and (c) tended to be smaller than the SE obtained in conditions (b) and (d). In other words, the SE tended to be larger when color and word belonged in one object, than when each belonged to a separate object. The most illuminating contrast perhaps is that between condition (a) and condition (b) with the single, yet consequential difference being the placement of the color and word under a single object umbrella in (b). This seemingly innocuous change made the SE in (b) significantly larger than that in (a) [F(1, 7)=6.07, p=.022].

We conclude that the object affiliation of Stroop components affect the SE. It is easier to ignore the task irrelevant word when it belongs to a different object than does the target color. We also learned that the manipulation of Kahneman and Chajczyk (1983) accomplished more than spatially separate the components. What Kahneman and Chajczyk did is also separate the components object-wise.

From a wider point of vantage, one must be careful to separate between spatially separated and object separated Stroop displays. Spatially separated components may or may not be object-wise separated. Only when the components truly belong to two separate objects, does the SE diminish or selective attention improves.

Table 1: Mean RTs and SEs (both in ms) for the four experimental conditions

	Condition			
Stimuli	(a)	(b)	(c)	(d)
Congruent	675	658	673	724
Incongruent	773	771	778	848
Total	724	714	725	786
	SE			
	98	113	105	124

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