Learning and Motivation 56 (2016) 53–64

Contents lists available at ScienceDirect

Learning and Motivation

journal homepage: www.elsevier.com/locate/l&m

Stroop-like interference in a match-to-sample task: Further evidence for semantic competition?

Marshall L. Green, Lawrence Locker Jr., Ty W. Boyer, Bradley R. Sturz*

Georgia Southern University, United States

ARTICLE INFO

Article history:
Received 21 July 2016
Received in revised form
12 September 2016
Accepted 14 September 2016
Available online 30 September 2016

Keywords:
Stroop
Match-to-sample
Semantic competition
Response competition

ABSTRACT

Two explanations have emerged to account for the interference of word reading on color naming observed in the canonical Stroop task. Semantic competition suggests that interference results from competing semantic processes associated with the word and color dimensions of the stimulus. Response competition suggests that interference results from competition in articulating the word versus the color dimension. Recently, Sturz et al. (2013) attempted to reproduce a Stroop-like phenomenon within the context of a delayed match-to-sample (DMTS) task. Importantly, this task format provided an opportunity to isolate semantic versus response competition, through the manipulation of the congruence of the bi-dimensional samples' font color and word meaning and the relatedness of the foil to the irrelevant sample dimension. Findings indicated that incongruent samples produced Stroop-like interference, regardless of whether the foil was related with the irrelevant sample dimension or not, which was interpreted as support for semantic competition within the DMTS task. The present experiments further examine Stroop-like interference in the MTS task by manipulating the stimulus onset asynchrony (SOA). In Experiment 1, we presented the Stroop sample and response options sequentially, but without a retention interval, and in Experiment 2, we presented the sample and response options simultaneously. The results indicated increased reaction times on incongruent trials, independent of whether or not the foil was related to the irrelevant sample dimension. An asymmetrical Stroop-like pattern of interference, where the sample word interfered with color matching but not the reverse, was only observed in Experiment 2. Collectively, these results suggest that empirical and theoretical findings obtained in the traditional Stroop task may generalize to the DMTS task.

1. Introduction

In 1935, J.R. Stroop designed what is now widely known as the Stroop task. The task consisted of participants naming the ink colors of a list of color-words, and participants were much slower to respond when the words differed from the ink color they represented. Stroop's (1935) theoretical explanation of this effect was that associations between the word stimuli and the reading response were stronger than the associations between color stimuli and the naming response. At the time, Stroop suggested that reading a word was a strong association that overrode the relatively weak "to name" association.

* Corresponding author at: Department of Psychology, Georgia Southern University, P.O. Box 8041, Statesboro, GA 30460, United States.
E-mail address: bradleysturz@georgiasouthern.edu (B.R. Sturz).

http://dx.doi.org/10.1016/j.lmot.2016.09.003
0023-9690/

Since this initial interpretation was offered, the relative speed-of-processing account has been suggested to explain this "Stroop effect." Specifically, it is posited that word reading is faster than color naming. The advantage of this account is that it assumes a continuum of processing speed such that the faster process of reading provides a potential response that competes with, and thereby slows the color-naming process (MacLeod, 1991, 1992; Posner & Snyder, 1975). This relative speed of processing account has been examined through manipulations of stimulus onset asynchrony (SOA) – separating the bi-dimensional stimulus into separate word and color patch stimuli and systematically manipulating the time between presentation of the relevant color patch and the irrelevant word. The logic is that if the color naming process indeed takes longer than the word reading process, then an SOA between the presentation of the color and the color-word of sufficient length should allow for completion of the "naming" processes and eliminate slowed responding. Importantly, this does decrease the Stroop effect (see Glaser & Glaser, 1982; MacLeod & Dunbar, 1988), which has given rise to an automaticity and attention account that emphasizes that reading requires less attention than naming a color (MacLeod, 1991). Although the automaticity account is capable of explaining results from SOA manipulations, some argue that the effects are more parsimoniously characterized as contextually controlled rather than automatic (Besner, Stolz, and Boutilier, 1997; see also Kahneman & Henik, 1981; MacLeod & Dunbar, 1988).

An alternative explanation is that incongruent Stroop stimuli activate semantic representations of both color and word dimensions, producing semantic competition between these dimensions prior to response selection (Augustinova & Ferrand, 2012; Augustinova, Flaudias, & Ferrand, 2010; Klein, 1964; Schmidt & Cheesman, 2005; Luo, 1999). That is, one component of the Stroop effect results from attending to both the color and word dimensions that then activate competing semantic representations – generating a response along one dimension requires the active suppression of the other dimension. This additional suppression slows processing and thus responding. When both of the dimensions represent the same semantic code (*i.e.*, when the color and word are congruent), responding is not affected because suppression of the irrelevant semantic code is not required.

In contrast, response competition posits that incongruent dimensions of Stroop stimuli activate response units that produce interference at the point of response output (Luo, 1999; De Houwer, 2003). This explanation suggests that one component of the Stroop effect results from a bi-dimensional Stroop stimulus containing a 'respond' dimension (*e.g.*, name the color) as well as a 'do not respond' dimension (*e.g.*, read the word). Thus, the response can only be made by increasing attention to the 'respond' over the 'do not respond' dimension (MacLeod, Chiappe, & Fox, 2002). By definition, response competition occurs later in processing and places Stroop interference at the level of executive control.

Recently, Sturz, Green, Locker, and Boyer (2013) developed a delayed match-to-sample (DMTS) Stroop-like task in an attempt to isolate the effects of the activation of semantic codes during processing and response options at response selection. The task involved viewing one of three sample types: (1) a congruent sample (*e.g.*, a color word such as "red" in red font color), (2) an incongruent sample (*e.g.*, a color word such as "red" in blue font color), or (3) a baseline sample (*e.g.*, a color word such as "red" in black font color). The presentation of the sample was followed by a brief delay. After the delay, two unidimensional response option stimuli were presented: (1) a matching target, and (2) a non-matching foil. Using this approach, the task afforded a unique opportunity to examine responses to both the word and font color dimensions through manipulation of the response options presented on a given trial. Specifically, response options were either two words (*e.g.*, "red" and "blue" presented in black font) or two color patches (see Fig. 1 for example trials). Participants were instructed to select the word that matched the preceding sample word dimension if the options were words (*e.g.*, select the word "red" if the preceding sample had been the word "red," regardless of font color) or to select the color patch that matched the preceding sample font color if the options were two color patches. This task also provided an opportunity to systematically manipulate the relatedness of the foil response option to the irrelevant sample dimension. For example, on a trial where the sample was the word "red" in blue font, if two color patch options appeared, the match would be a blue color patch and the foil could be related to the irrelevant word dimension (*i.e.*, a red color patch). Alternatively, the foil could be unrelated to the sample (*i.e.*, a yellow color patch). Similarly, if two word options appeared, then the match would be the word "red" and the foil could be related to the irrelevant color dimension (*i.e.*, the word "blue"), or could be unrelated (*i.e.*, the word "yellow").

It is important to emphasize that in the DMTS Stroop task the relevant dimension, on which participants based their responses, was ambiguous prior to response option onset. Consequently, on incongruent sample trials, participants were required to attend to, and retain, both sample dimensions for the duration of the retention interval, and, therefore, the task demands differed from typical Stroop tasks, which require that the participant attend to only one dimension and explicitly disregard the other dimension (Besner et al., 1997; Cohen, Dunbar, & McClelland; 1990). Sturz et al. (2013) found that word targets were responded to more slowly than color targets, and, notably, that, for both color and word response options, reaction times were slower for the incongruent sample condition than congruent or baseline sample conditions, regardless of whether or not the foil was related to the irrelevant sample dimension. There was, however, a decrement in accuracy for incongruent conditions in which the foil was related to the irrelevant dimension for both word and color targets.

Although a traditional Stroop effect has been suggested to result from a combination of semantic and response competition (*e.g.*, Augustinova & Ferrand, 2012; Augustinova et al., 2010; De Houwer, 2003; MacLeod et al., 2002), Sturz et al. (2013) explained these findings in terms of semantic competition. As noted, the task required participants to attend to both sample dimensions on incongruent trials because the eventual response dimension remained ambiguous until the options appeared, thus requiring activation of semantic codes for both dimensions. Furthermore, on incongruent sample trials, the dimension rendered irrelevant by the appearance of the options must then be suppressed. By contrast, the lack of an effect of whether the foil was related or unrelated with the irrelevant sample dimension was taken as a failure to find evidence of response