Locating the Processing Bottleneck in Dual-Task Interference

Robert A. Kachelski (Robert.A.Kachelski@williams.edu)
Department of Psychology; Williams College
Williamstown, MA 01267 USA

Introduction

A modified version of the Stroop color-naming task was used to test theories of dual-task interference that propose a central bottleneck in processing either at the response-selection stage (e.g., Pashler, 1994) or at the response-production stage (e.g., Keele, 1973; Norman & Shallice, 1986). In considering the Stroop task from a dual-task perspective, the processing of the word was defined as the primary task (because of its obligatory and automatic nature) and color identification was defined as the secondary task. Following the locus-of-slack logic as it has been developed in the psychological refractory period (PRP) paradigm (Pashler, 1994; Schweickert, 1980), the difficulty in selecting a response to the color was manipulated, along with the stimulus onset asynchrony (SOA) between the word and the color.

Based on Pashler's (1994) principles of testing bottleneck models, different predictions follow from the two types of theories. Response-production bottleneck theories predict an interaction between response-selection difficulty and SOA, such that the manipulation of response-selection difficulty should have a greater effect on color-identification times at longer SOAs than at shorter SOAs. On the other hand, response-selection bottleneck theories predict that the effect of response-selection difficulty should be the same regardless of SOA, so that there should be no interaction between the two variables.

Method

On each trial, a single word appeared on a computer screen. It either appeared in color (red, blue, green, or yellow) from the beginning of the trial (SOA = 0) or initially appeared in gray and turned into one of the colors after an SOA of 50, 100, 150, 200, or 300 ms. None of the words used in the experiment were color words or words related to colors. Rather than naming the color in which each word was printed, the 33 participants responded by saying a number aloud that corresponded to the color (red = 1, blue = 2, green = 3, yellow = 4). The reaction times to identify the color by saying the appropriate number were recorded from the onset of the color.

Results

The 300 experimental trials were split into three equal blocks. The manipulation of response-selection difficulty was then defined by the amount of practice participants had in mapping the colors onto the correct number responses, based on the reasoning that the response selection would become easier for the participants with each block of trials. A two-factor, within-subjects ANOVA was conducted to test the effects of response-selection difficulty (Block 1, Block 2, Block 3) and SOA on the color-identification times. As can be seen in Figure 1, there was a significant effect of response-selection difficulty, F (2, 64) = 7.22, $p < .01$, with mean color-identification times significantly faster in Block 2 (M = 781 ms) and in Block 3 (M = 783 ms) than in Block 1 (M = 817 ms). There was also a significant effect of SOA, F (5, 160) = 30.10, $p < .0001$, with reaction times generally decreasing across SOAs from 0 to 150 ms and remaining fairly constant with further increases in SOA. The critical result was that there was no interaction between response-selection difficulty and SOA, F (10, 320) = 1.09, $p > .36$, which supports the idea of a bottleneck in response selection rather than in response production.

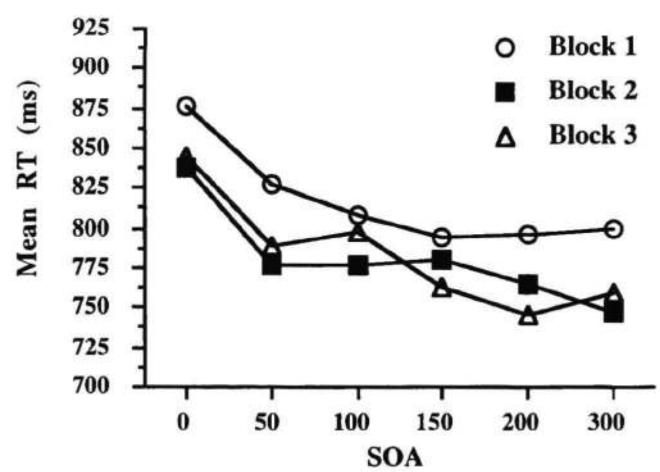

Figure 1: Mean color-identification times in each of the three blocks of trials as a function of the SOA between the word and the color.

References

Keele, S. W. (1973). *Attention and human performance.* Pacific Palisades, CA: Goodyear.

Norman, D. A., & Shallice, T. (1986). Attention to action: Willed and automatic control of behavior. In R. J. Davidson, G. E. Schwartz and D. Shapiro (Eds.), *Consciousness and self-regulation: Advances in research and theory (Vol. 4).* New York: Plenum.

Pashler, H. (1994). Dual-task interference in simple tasks: Data and theory. *Psychological Bulletin, 116,* 220-244.

Schweickert, R. (1980). Critical-path scheduling of mental processes in dual tasks. *Science, 209,* 704-706.