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Modeling selective attention: Not just another model of Stroop (NJAMOS)

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Abstract

The Stroop effect has been studied for more than sixty years, and yet it still defies a complete theoretical account. The model presented here offers a new approach that integrates several explanations of the Stroop phenomenon into a hybrid model. Because this model is built within the ACT-R cognitive architecture (Anderson & Lebiere, 1998), it applies a generic, pre-specified set of mechanisms for learning and performance to the particulars of the Stroop task. Besides fitting a variety of already published experimental results, the model offers the potential to capture strategic variation in what is typically considered a low-level attentional phenomenon. © 2002 Elsevier Science B.V. All rights reserved.

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1. Modeling selective attention: not just another model of Stroop (NJAMOS)

The Stroop effect has been studied for more than sixty years (Stroop, 1935), and yet it still defies a complete theoretical account. One explanation for the apparent lack of progress is that so much empirical research has been conducted using this basic paradigm that what we now call the 'Stroop effect' is actually a compendium of results derived from a multitude of manipulations applied to a family of Stroop-like tasks! The current article focuses on a select set of Stroop results in order to introduce the model NJAMOS. NJAMOS offers a new theoretical account that integrates several explanations of the Stroop phenomenon into a hybrid model. Specifically, NJAMOS performs competitive, parallel retrieval of information within a goal-based, sequential cognitive processor. NJAMOS is built within the ACT-R cognitive architecture (Anderson & Lebiere, 1998), so it applies a general, pre-specified set of learning and performance mechanisms to the particulars of the Stroop paradigm. Moreover, NJAMOS is unique among models of ('low level') attentional phenomena in that it allows for ('high level') strategic variability.

The organization of the paper is as follows. First a description of the Stroop phenomenon is presented. Then, major theoretical features of other computational models are reviewed. Next, the NJAMOS model is described and fit to a selection of relevant data. Finally, the potential of NJAMOS for accommodating other results is discussed along with a more general view on evaluating Stroop models.

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1.1. The basic phenomenon

The Stroop effect offers a window onto the processes of selective attention in that stimuli with two prominent dimensions are presented in a task where one dimension must be processed and the other ignored. Typically, the stimuli are words, and the two dimensions are the form of the word and the color of the ink in which it is written. The task, then, is either to name the ink color or to read the word. The basic Stroop manipulation varies the relationship between the meaning of the word and the color of the ink to be congruent (e.g., the word 'red' printed in red ink), conflicting (e.g., the word 'blue' printed in red ink), or neutral (e.g., the word 'dog' or a string of 'X's printed in red ink). A robust result emerges: for color naming, there is interference in the conflicting case and (usually) facilitation in the congruent case, but for word reading, there is no (or very little) effect of the congruency of this relationship.

Fig. 1 shows a typical data set (along with the NJAMOS predictions to be discussed later). The interference and facilitation in color naming can be seen by the shifts in the color-naming curve as a function of congruency. The lack of such effects for word reading are shown by the relatively flat line for this condition. These results suggest an asymmetry in selective attention, namely, that participants are strongly influenced by the word when naming the ink color but that they can ignore the ink color when reading.

2. Theoretical accounts of the Stroop effect

Two different views of the Stroop effect cover much of the theoretical work in this area. The 'horse-race' view highlights the overall difference in speed of processing for words versus colors (see Fig. 1, separation of the two curves) and assumes a response bottleneck. This view implies that the pattern of interference depends on the relative arrival of word versus color information to the response stage: whichever kind of information arrives first will produce interference for the other. Because word reading is, on average, faster than color naming, this view predicts the asymmetry of words interfering with colors but not vice versa.

The other view of the Stroop effect highlights the different levels of automaticity people have acquired for processing the two stimulus dimensions. Because word reading is so highly practiced among typical Stroop experiment participants, it is more automatic than color naming. This greater automaticity implies that reading requires fewer attentional resources and hence interferes more easily with color naming.

The key similarity between the two views is that they both emphasize parallel processing of the two stimulus dimensions. Not surprisingly, then, the dominant computational accounts of Stroop phenomena have been implemented within connectionist models. The key difference between the two views is whether relative speed or automaticity is considered the main determiner of interference effects. Note that

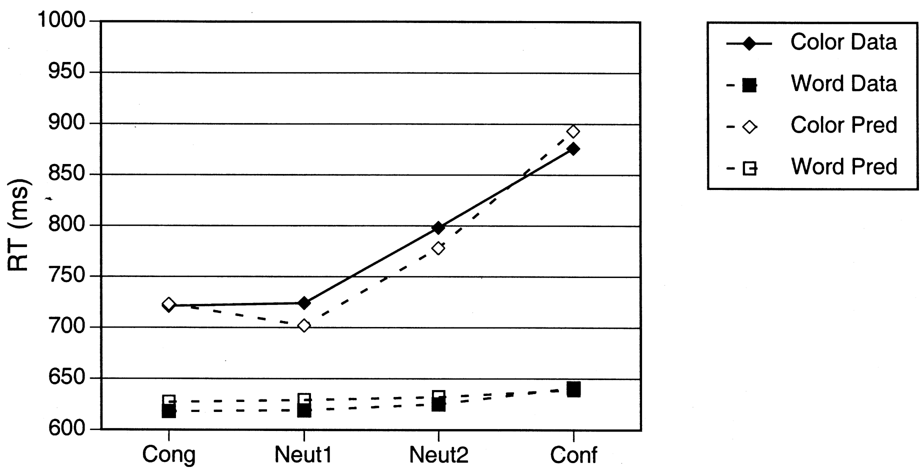

Fig. 1. Reaction times for standard Stroop experiment. 'Neut1' refers to a string of 'X's in colored ink for color naming and a word printed in black ink for word reading; 'neut2' refers to a non-color word in colored ink for color naming.