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Diffusion models of the flanker task: Discrete versus gradual attentional selection

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ABSTRACT

The present study tested diffusion models of processing in the flanker task, in which participants identify a target that is flanked by items that indicate the same (congruent) or opposite response (incongruent). Single- and dual-process flanker models were implemented in a diffusion-model framework and tested against data from experiments that manipulated response bias, speed/accuracy tradeoffs, attentional focus, and stimulus configuration. There was strong mimcry among the models, and each captured the main trends in the data for the standard conditions. However, when more complex conditions were used, a single-process spotlight model captured qualitative and quantitative patterns that the dual-process models could not. Since the single-process model provided the best balance of fit quality and parsimony, the results indicate that processing in the simple versions of the flanker task is better described by gradual rather than discrete narrowing of attention.

1. Introduction

The Eriksen flanker task has been extensively used to investigate the mechanisms underlying visual attention (Eriksen & Eriksen, 1974). In the standard task, participants must discriminate a single item (e.g., letter or arrow) that is surrounded, or flanked, by items that indicate the same or opposite response. For example, if participants had to decide whether the central arrow in a display faced right or left, a congruent trial would include flankers that faced the same direction as the central target (e.g.,

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> > > > >), whereas an incongruent trial would include flankers that faced the opposite direction (e.g., < < > < <). The standard finding is that the incongruent flankers produce interference that leads to slower and less accurate responses compared to the congruent condition, known as the flanker congruency effect (FCE).

The present study compares the ability of several integrated response time (RT) and attentional models to account for data from the flanker task. The primary aim was to discriminate theories of discrete and gradual narrowing of attention to determine which can best account for data from a range of experimental manipulations. The next section reviews critical findings from the flanker task, placing particular focus on how the decision evidence from the stimulus varies over time. This is followed by a brief review of models of visual attention that have been developed to account for data from the flanker task. Then the diffusion model is introduced with a focus on how it can be augmented to incorporate principles from theories of flanker processing. Two simple diffusion models are developed, one based on a single-process and one based on dual processes. These models are then tested along with the Dual-Stage Two-Phase Model (Hübner, Steinhauser, & Lehle, 2010) using a series of experiments in which different components of the decision process were manipulated. This battery of experimental data allows us to determine first, whether the models can adequately fit the data, and second, whether the model parameters appropriately reflect the experimental manipulations.

1.1. Processing in the flanker task

This study focuses on standard flanker tasks in which a stationary target with known location is flanked by congruent or incongruent items. Early studies involving flanker stimuli demonstrated that the visual system is not capable of infinitely fine selectivity. Even when participants knew the upcoming location of the target, they could not effectively constrain their attention to eliminate effects from the flankers (Eriksen & Eriksen, 1974). This finding also implies that the flanker interference is not due to inefficient search for the target or uncertainty about its location. Indeed, flanker interference has been shown with flankers over 2° from the target, meaning they were unlikely to be confused with the target location (Eriksen & Schultz, 1979). Perhaps the most salient finding from flanker experiments is that the interference is not constant over time. Gratton and colleagues (1988) examined this and found that most errors for incongruent trials occurred for fast responses. This is demonstrated in Fig. 1, which presents a quantile probability function (QPF) from a simple flanker experiment (Experiment 1 of this study). The QPF provides a summary of the entire data set, namely accuracy values and the distribution of RTs for correct and error responses. The position of a column on the *x*-axis indicates the probability of a response for a condition, with correct responses on the right and errors on the left.

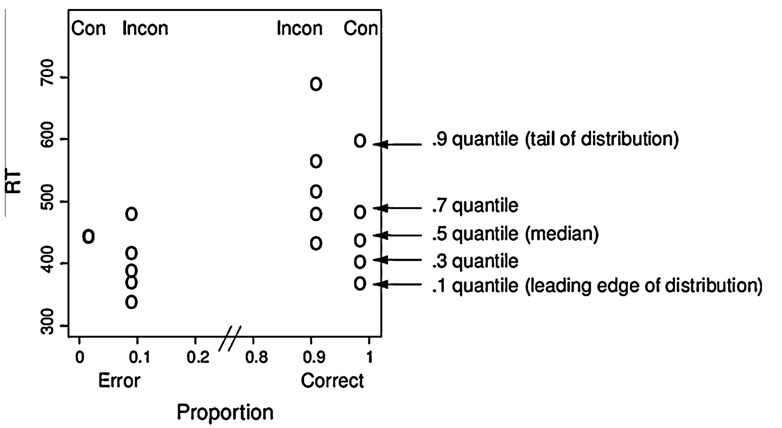

Fig. 1. Quantile probability function from a simpler flanker task (Experiment 1). The figure plots the accuracy and RT quantiles for correct and incorrect responses (see text for details).