

Visual selective attention among persons with schizophrenia: The distractor ratio effect

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Abstract

The current study investigated whether impaired visual attention among patients with schizophrenia can be accounted for by poor perceptual organization and impaired search selectivity. Twenty-three patients with schizophrenia and 22 healthy control participants completed a conjunctive visual search task where the relative frequency of the two types of distractors was manipulated. It has been shown that, when the total number of items in a display is fixed, search performance depends on the relative frequency of the types of distractors (i.e., as the ratio becomes more discrepant search time decreases). This modulation of search efficiency reflects participants' ability to group items by their perceptual similarity and then search only the smaller group of items that share a feature with the target. Results show that patients modulate their response time normally as a function of the distractor ratio – that is, they benefit from the presence of a smaller distractor subset in the display. This suggests that patients with schizophrenia, group items according to their perceptual similarity and flexibly deploy their attention to the smaller subset of distractors on each trial. These results demonstrate that search selectivity as a function of the relative frequency of distractors is unimpaired among patients with schizophrenia.

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1. Introduction

1.1. The visual search paradigm

In the past three decades, the visual search paradigm has been widely used in the study of visual attention. In

a typical “conjunctive” visual search task, participants are required to search for a target item among a number of nontarget items (i.e., distractors). Each of the distractors shares one of its features (e.g., color) with the target item and there exists an equal number of each type of distractor in the display. Often the total number of items in the display (i.e., display size) is manipulated and search efficiency is determined by measuring the change in response time (RT) or error rate (ER) as a function of display size. When search is highly efficient, plotting RT as a function of display size yields a flat

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slope, suggesting that search is executed in parallel across the whole display. Search slopes increase as search becomes more serial and elaborate, that is, less efficient (see Treisman, 1988 for a review). It has been demonstrated that the discriminability of the target from the distractors is the main factor in search efficiency (Duncan and Humphreys, 1989). However, visual search also achieves efficiency through other mechanisms. For example, studies have shown that, during conjunctive visual search, display items are often parsed into groups of items. This phenomenon has been referred to as *perceptual grouping* and is defined as the preliminary perceptual segregation of the stimulus field prior to the application of focused attention (Treisman, 1982). Items in a display can be grouped based on different principles such as similarity (Baylis and Driver, 1992; Kramer and Jacobson, 1991), contiguity (Moore et al., 1998), and co-linearity (Lavie and Driver, 1996). Perceptual grouping improves search efficiency by enabling a person to focus attention on groups rather than single items in the display and select the most informative items for further search. This reduces the need to scan each individual item in a conjunctive search display. So, for example, in the search for a green 'X' among red 'X's and green 'O's a person might limit their search to either the green items that share the target color or the 'X's that share the target shape. When there is an equal number of each type of distractor, often search is limited to the subset of items that has the more dominant feature. For example, if their color is more discriminable, search is limited to the same-color items. However, previous studies have also shown that subset selection can occur based on the relative frequency (i.e., ratio) of the two types of distractors. That is, when the relative frequency of distractors is manipulated during conjunctive visual search tasks, there is a bias to search through the smaller subset of distractors (Shen et al., 2000). Shen et al. investigated the eye movements of participants during a conjunctive visual search task in the attempt to explain the *distractor ratio effect* - the finding that when the total number of items in a search display is fixed, search performance in a conjunctive visual search task depends on the relative frequency of the two types or subsets of distractors (Bacon and Egeth, 1997; Egeth et al., 1984; Kaptein et al., 1995; Poisson and Wilkinson, 1992; Zohary and Hochstein, 1989). The distractor ratio effect results in optimum search efficiency for displays with extreme distractor ratios (i.e., one of the distractors is rare), but search efficiency decreases as the ratio of distractors approaches one (i.e., the two types of distractors are equally represented). Consequently

when RT is plotted as a function of the number of one type of distractor, an inverted U (or V) pattern emerges. The distractor ratio effect is an excellent example of visual selective attention and visual guidance flexibility during visual search. It has also been found that this type of visual guidance is mostly under the control of lower level, bottom-up, factors and is affected but not overridden by top-down factors such as contextual or instructional manipulations (Shen et al., 2007).

1.2. Visual search in schizophrenia (SCZ)

The majority of studies investigating visual search performance among SCZ patients have found that patients are less efficient on visual search tasks. That is, patients demonstrate steeper search slopes compared to controls on conjunctive search tasks (Carr et al., 1998; Fuller et al., 2006; Mori et al., 1996). As noted above, visual search efficiency in the context of a conjunctive search task depends, in part, on the ability to group perceptually similar items together and direct attention to the most relevant and informative group of items in the display. Therefore, impairment in perceptual grouping may be one mechanism underlying impaired visual search performance among SCZ patients.

1.3. Perceptual grouping in SCZ

Empirical evidence suggests that SCZ is associated with an impairment in the early stages of perceptual information processing, specifically a deficit in perceptual organization (Place and Gilmore, 1980; Wells and Leventhal, 1984). In general, these findings suggest that patients with SCZ fail to perform an initial global structuring of the stimulus field and, therefore, their performance is not affected by the gestalt information present in the display. However, others have found that patients with SCZ group items normally based on perceptual attributes (Carr et al., 1998; Chey and Holzman, 1997; Rief, 1991). For example, Carr et al. investigated the relationship between RT and the number of groups in a display among SCZ and healthy individuals. According to Treisman and Gelade (1980), as a result of perceptual grouping, RT increases in a linear fashion as the number of groups in a display increases. Carr et al. found that patients with SCZ were influenced by the increase in the number of groups in a manner similar to controls. As such, they concluded that perceptual grouping was intact in patients with SCZ.

As reviewed above, the distractor ratio effect is the result of perceptual grouping with the additional component of selectivity based on the relative frequency

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