Spatial interval discrimination in the presence of flanking lines

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Abstract—Spatial interval discrimination was studied in the absence or presence of distractors. In the latter case, two flanking lines surrounded two vertical lines delimiting the spatial interval. Using a temporal 2AFC technique with a method of constant stimuli we measured the accuracy of performance (discrimination thresholds) and biases (points of subjective equality) depending on the separations between the target and the flanking lines. For separations less than or comparable to the size of the spatial interval we found both a reduction of precision and the increase of perceived sizes of the spatial intervals: the discrimination thresholds were increased, the size of the spatial interval was overestimated. For larger separations, the size of the spatial interval was underestimated, but the precision of performance was not affected by the presence of flanking lines. We discuss the possible mechanisms underlying spatial interval discrimination in the presence of flanking lines.

1. INTRODUCTION

Human performance is remarkably accurate in a set of spatial visual tasks where observers are required to detect changes in the relative position of stimuli in space. This kind of tasks fall into the hyperacuity range (Westheimer, 1975) and include Vernier acuity (Westheimer and McKee, 1977b), bisection acuity (Burbeck and Yap, 1990; Levi and Klein, 1990), alignment and spatial interval discrimination (Hirsch and Hylton, 1982).

This surprising accuracy is significantly influenced by the presence of additional objects which alter observer’s performance by inducing perceptual shifts in localisation judgements or changing discrimination thresholds (Levi et al., 1985; Badcock and Westheimer, 1985a, b). For localisation judgements, within a small restricted region of several minutes of arc (2–4 min, Westheimer and McKee, 1977a; Badcock

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and Westheimer, 1985a, b) the target location may be assigned to the location of a weighted centroid of the pattern luminance distribution. The addition of one flank within the relevant region moves the centroid and thus changes performance (Watt et al., 1983). With increasing separations (4–10 min) the test line was repelled from the flank. These repulsion effects revealed behaviour different from that expected from the centroid hypothesis: the observers’ performance was independent of the contrast polarity. Thus, authors conclude that two mechanisms are involved in localisation judgements: one for small separations estimating local luminance distribution and another one for large separations involving spatial interactions between the features of the stimuli. The precision of performance (discrimination thresholds) was not dependent on the separations tested.

Less is known about large separations between the test stimuli and distractors. Hess and Badcock (1995) studied spatial interval discrimination using spatially bandpass targets and distractors (Gaussian blobs) and showed that the presence of one flank induces shifts in the points of subjective equality (which were zero in the absence of flanks) for all tested separations between the target and the flank. The largest separations tested were 1.2 of the base spatial interval of 2.8 deg measured between the centres of the Gaussian blobs. Removing the additional blob this far from the targets did not eliminate completely the influence of the flank, thus providing evidence of long-range processes underlying these interactions. In the paper by Hess and Badcock (1995) shifts in perception of the sizes of spatial intervals are reported, but there is no indication of any changes in the precision of spatial interval discrimination. The same pattern of results was reported in the earlier study by Burbeck and Hadden (1993): subjects overestimated the size of the spatial interval in the presence of one additional flanking line, but the discrimination thresholds were not significantly affected. However, Morgan et al. (1990) studied two-dot vernier acuity and showed that two noise dots inserted between the two target squares raised the discrimination thresholds for the separation 4.4 min, but not for the separation 21 min. Thus, there are somewhat contradicting data on discrimination thresholds in the presence of flanks, which may reflect the different sizes of the spatial intervals employed in the different studies, different separations between the targets and flanks, or different kind of objects delimiting the spatial intervals. But all the above mentioned studies agree in that the addition of flanks introduces perceptual shifts in judgements of the sizes of the spatial intervals.

The absence of reports of decreasing precision when observers discriminated ‘crowded’ spatial intervals is somehow surprising as there is a lot of experimental data on the reduction of the visual acuity in the presence of distractors (for review, see Flom, 1991).

Earlier we showed (Bondarko and Danilova, 1996) that in simultaneous presentations, size comparisons depend on the distances between the compared objects. This visual task became independent of the separation when it exceeded 1.5 sizes of the objects showing that up to such large separations, we still may observe interactions between objects influencing size perception processes.