On the independence assumption in the span of perception¹

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Abstract

Using the customary methodology, the probability of detecting a dot was examined as a function of the number of dots contained in a circular array and the spatial dispersion of the dots. The independence hypothesis in the span of perception was shown to be limited and of tenuous validity since both hit rate (HR) and false alarm rate (FAR) were joint functions of the two independent variables.

Introduction

With respect to a study by Hunter & Sigler (1940), Schlosberg (1948) proposed that the detection of a single dot was independent of the number of other dots simultaneously presented in the stimulus array, and that the decline in accuracy observed as a function of the total number of dots presented (Woodworth & Schlosberg, 1954) was a matter of simple probability. While this view has received some support (Restle, Rae, & Kiesler, 1961), signal detection theory (Tanner & Swets, 1954) and the finding that the degree of spatial dispersion functions in localizing stimuli (Flavell & Dragnus, 1957; Kaswan, 1958; Kaswan & Young, 1963; Leibowitz, Myers, & Grant, 1955) suggest that this might be too narrowly conceived.

Hence, the purpose of the present investigation was to assume the experimental orientation of previous studies but to re-examine the independence assumption (1) considering both hit rate (HR) and false alarm rate (FAR), (2) varying spatial dispersion by arranging the dots in circular patterns of differing diameters, and (3) keeping the stimuli within a maximum visual angle of $2^{\circ}39'$, assuming acuity apart from spatial dispersion to be a constant within that angle.

Method

Subjects.

Nine males and 15 females from introductory psychology courses serving a class requirement were Ss. Glasses were permitted.

Apparatus.

Stimuli were presented with a Gerbrands-type tachistoscope in conjunction with a Hunter timer. The masking stimulus was composed of eight rays emanating at 45° intervals from a fixation point, covering a total visual angle of 4° .

The stimuli were from one to eight black dots ($8'$ of visual angle) on a white background located in positions corresponding to the rays of the mask which was absent during the stimulus exposure. Within each pattern, all dots were equidistant from the focal point of the mask, and all patterns had a luminance of .37 apparent ft c.

While the mask permitted up to eight dots in one exposure, only the data from three-, four-, and five-dot groupings were analyzed. Eight arrangements of each of these dot groupings were composed so that within each dot grouping (1) two of the dots in each arrangement were on the ends of an undrawn diagonal passing through the focal point, (2) each of the four possible diagonals was represented in two different arrangements, (3) each of the eight potential dot positions appeared an equal number of times, and (4) each particular arrangement was made three times, once each so that the major diagonal subtended a visual angle of $53'$ (D1), $1^{\circ}46'$ (D2), and $2^{\circ}39'$ (D3).

Over the entire experiment each of the nine stimulus classes (3, 4, and 5 dots each at the three diameters) was represented 120 times with eight different pattern arrangements each appearing 15 times. Each S viewed five replications of the nine classes and one fill-in (a 1-, 2-, 6-, 7-, or 8-dot grouping). The stimulus-class sequence was random and particular patterns were different for every block of three Ss.

Procedure.

The S viewed the stimuli in a self-paced manner in a dim room after listening to 10 min. of instruction and practicing on four to eight non-test patterns which served to indicate the exposure speed which was neither too difficult nor easy. Perceived dots were written by the S on a set of blank patterns like the mask in the tachistoscope.

Results

The mean speed of presentation was 56 msec., which factor accounted for an insignificant amount of the HR and FAR variance ($F_s < 1$). Unfortunately, the cutting points used by Ss were so homogeneous that meaningful ROC curves could not be drawn. Since neither normality nor homogeneity assumptions could be met, Friedman non-parametric analyses of variance were used.

HR. Figure 1 presents HR and FAR for the various stimulus classes. The traditional method of assessing the independence assumption has been to deal with HR only (but see Restle et al, 1961). In accordance with the hypothesis, there was no general difference in the probability of detecting a single dot for the 3-, 4-, and 5-dot groupings ($\chi_r^2 = 2.69$; $\chi_r^2 = 5.99$, $df = 2$, $p = .05$) nor was there a main effect for diameter ($\chi_r^2 = 3.52$, $df = 2$). However, Fig. 1 shows that there was a Dot by Diameter interaction, HR going from a slightly increasing to a slightly decreasing function of the number of dots as the diameter increased. An indirect test of this observation

Fig. 1. HR and FAR as a function of the number of dots and their spatial dispersion (diameter).

was made by performing a repeated measures analysis of variance comparing diameters for differences between 3- and 5-dot groupings ($F = 5.78$, $df = 2/46$, $p < .01$). Additionally, a t test showed that the spread of the different diameters was greater at three dots than at five ($t = 3.77$, $df = 23$, $p < .001$). Only a slight learning trend occurred over the five blocks of trials ($\chi^2_r = 8.07$, $df = 4$, $p < .10$).

FAR. In contrast, FAR increased as the number of dots increased ($\chi^2_r = 22.94$, $df = 2$, $p < .001$), particularly for the smallest diameter over the other two ($F = 3.27$, $df = 2/46$, $p < .05$). FAR declined over blocks of trials ($\chi^2_r = 21.53$, $df = 4$, $p < .001$).

Discussion

The general findings were that although HR was not a uniform function of the number of dots, FAR was; spatial dispersion (diameter) interacted with the number of dots for both HR and FAR; and there was some tendency to improve detection over time, despite the fact that no feedback was given during the experiment.

While it is tempting to conclude that HR was indeed independent of the number of dots, such a main effect appeared to be a fortuitous result of the particular dot-diameter combinations chosen, since an interaction between these variables was present. Moreover, FAR was definitely a function of the number of dots, particularly for small diameters, and HR and FAR are inseparable components of detection. The contrast between these results and those of Restle et al (1961) is probably due to the fact that the latter experiment used only one to four dots and a simpler localization task determined by both fewer and easier categories (Leibowitz et al, 1955).

Thus, the evidence presented here hardly provides a confirmation of the independence assumption, even when consideration is restricted to the usual HR test. Rather, the data imply that FAR be considered jointly with HR and that spatial dispersion is also a variable in the span of perception. Consequently, the traditional independence hypothesis may be oversimplified and of dubious general validity.

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Notes

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