Visual noise causes tunnel vision'

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Abstract

Subjects had quickly to detect similarities between two uppercase letters presented peripherally and one other central letter falling on the fovea. These three characters were so legible that this task was very easy when the three letters were flashed on by themselves. But the addition of extra letters to this display seriously impaired performance. The periphery of the retina could no longer accurately detect at a glance whether items were similar. Foveal performance was also affected to some extent by extra items in the periphery of the retina.

Introduction

People usually select the information they want from a general background of unwanted material. Pattern recognition often involves peripheral matching in the sense that comparisons are made between one foveal item and many others placed in the periphery. Alternatively, similarities and differences are noted between two or more entirely peripheral items. This process of peripheral matching also guides eye movements which are by no means random walks, as Boynton (1960) and others have recently made clear. Selective visual attention usually involves direct movements of the fovea from one rich source of data to another. The most frequent choice ever made is where to look next. The fovea is such a busy sensor that it has to sample only essential data almost continuously. To reduce random search, eye movements must often be planned from data acquired by the peripheral retina. The main contention is that the addition of visual noise in the form of unwanted signals can destroy this vital peripheral matching. Pattern recognition is impaired because similarities can no longer be recognized quickly between wanted foveal and peripheral items—and the fovea must therefore be used more often.

Method

Twenty Harvard and Radcliffe undergraduates were tested individually and all had normal vision or corrected normal vision. After dark adapting for 10 min., the S was instructed to fixate the small dot in the center of the screen and to attend to the entire width of the screen. He inspected successive patterns of uppercase letters briefly flashed on for 100 msec. at 2.5 ft.-L. and centered on his fixation point. Between displays the field was less than 0.1 ft.-L. He was asked to report "Yes" when the center also occurred on both sides.

In order to vary the amount of visual noise, three kinds of displays were prepared. In all displays the three matched letters were always halfway up the screen and occupied the same positions relative to the fixation point. The *Three Letter* displays showed only three letters for recognition and this was the No Noise condition in Fig. 1. Both of the Noise conditions in Fig. 1 presented extra unwanted letters in addition to the matched letters. The *Line* displays showed one line of 17 letters, and the *Page*

displays showed 22 lines of letters consisting of altogether 374 letters covering the whole display area. The second main variable was the width subtended by the row of recognition stimuli. In the *Three Letter* displays, the three recognition letters were close together, slightly spread or widely scattered. In both Noise displays, these matched letters were similarly distributed. With viewing distances of 28 and 56 in, the three recognition widths subtended 1, 3 and 5 degrees, or 2, 6 and 10 degrees respectively. Only the 1 or 2 degree presentations were entirely foveal; the other widths required peripheral and foveal discrimination. The letters were 0.25 in high and 0.5 in between centers: they were of high contrast on 8.5 x 11 in white backgrounds. Each of the nine arrangements of displays and widths was prepared in two different versions—with the three recognition letters as N or C. The resulting 18 cards were randomly mixed with an equal number of catch displays which had either no matching letters at all or only one matching letter to one side of the central letter.

Results and Discussion

Figure 1 shows that the extra unwanted letters or visual noise gave the main effect. Virtually perfect scores were made with the *Three Letter* (No Noise) at all widths of recognition display. But the addition of unwanted letters to these identical patterns of three wanted letters gave a catastrophic reduction in recognition scores. These Noise conditions were harmful either as *Line* or as *Page* displays. The worst impairment was found when the recognition letters stretched into the peripheral retina. These Noise displays subtending 3 to 10 degrees averaged only 10 per cent correct. Foveal recognition was also, however, definitely impaired by peripheral visual noise, even when the three matching letters were adjacent to each other. Recognition scores for material in the fovea fell to three-quarters or two-thirds of achievement at the

Fig. 1.

Table 1. Percentage Correct Recognition of Matched Trios

Display Type			Recognition	Display Width
			3° - 6°	5° - 10°
RN	N	NS	43	41
NT	N	ZN	79	81

noise-free level when extra unwanted letters fell on the periphery of the retina. The displays, the widths, and also the interaction between these variables were all significant ($p < 0.01$) by analysis of variance, but individual differences, viewing distances, and the nature of the recognition letter had no effect. Bringing the matching letters near the end of the line of letters was established as a second-order benefit in the Line display in which the widest recognition patterns were the least accurately read.

This end-of-the-line effect was followed up in another study with 20 further Harvard and Radcliffe Ss. The tachistoscopic conditions were identical except that now only five letters were presented in 100 msec. Even two extra noise letters can drastically reduce recognition scores for three wanted letters—provided the two noise letters are added just outside the wanted letters. They have much less effect when they are placed just inside the wanted letters; the recognition score doubles when the wanted letters are outside the unwanted. This suggests that the scanning of the visual image once it has been formed may be undertaken from the outside inward towards the fovea (see also the results of Haselrud & Clark, 1957).

Both investigations show that visual noise impairs peripheral matching. These considerable changes in performance partly depend on retinal confusions, but they also appear to involve non-retinal factors since even doubling the viewing distance did not alter recognition scores. The possible disadvantages of moving back, such as smaller visual angles between the visually smaller letters, might conceivably have been balanced by benefits from these being read by less peripheral parts of the retina, but the No Noise evidence in Fig. 1 makes this rather unlikely.

The concept of the useful field of view helps to understand the results. The useful field of view is the area around the fixation point from which information is being briefly stored and read out during a visual task. When there is too much information, the useful field contracts to prevent over-loading of the visual system, just as the pupil constricts with too much light. The useful field of view is therefore varying in width from moment to moment according to the amount of information on the display. The useful field cannot exceed the normal physiological limits set by the ordinary visual acuity fields. But these experiments show that information overload from too many unwanted signals can prevent the useful field from reaching the size of the normal plotted fields, as Teuber et al (1960) and Sanders (1963) have also mentioned. The Page displays here are believed to resemble the massive

overload conditions used by Volkmann (1964), as well as by Chaikin et al (1962). There was not enough time to form the visual image. These investigators have demonstrated that allowing more time broadened the effective tachistoscopic fields. This suggests that with considerable overloading the visual image is formed from the center outwards; visual noise would therefore produce a temporary tunnel vision. The Line displays only slightly overload the visual system so that here the visual image was fairly well-formed according to the evidence of Sperling (1963); the difficulty was now in scanning the visual image because this recognition of items such as letters is the slowest part of the process. This kind of scanning appeared to be inwards towards the center.

In both circumstances, extraneous visual stimuli destroyed peripheral recognition because the whole stimulus pattern was so complex; as Hake (1957) comments, the limited exposure times were no longer sufficient to process the main signals in addition to this extra information. Mackworth & Mackworth (1959) had noted this visual overload effect as also have Kaplan & Carvellas (1965), unlike Neisser (1963). Tunnel vision occurred because priority was given to foveal items. Even foveal performance was, however, definitely impaired by the addition of unwanted peripheral stimuli.

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Note

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