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Random-dot picture sampling by optical projection

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An optical projection technique for controllable and quantifiable degradation of any two-dimensional test slide is described. The technique provides many of the features of electronic methods at low cost.

For many experiments in vision, it is necessary to control the visual input. For example, tachistoscopic presentation gives controlled stimulus duration. The technique described here provides controlled spatial sampling of any two-dimensional stimulus figure. The optical random-dot sampler projects samples of pictures as small intensity-modulated dots whose density can be controlled and quantified. An example of a picture sampled at four dot densities is shown in Figure 1.

Random-dot sampling produces degradation of spatial information that is rather similar to the fragmented line-drawing pictures of Gollin (1960). These have been used by several workers to investigate processes of memory, perception, and brain function.

The optical projection device described here is derived from a video-sampler developed by Williams (1972, 1973), in which the signal from a TV camera is sampled. Each sample is a .1-μsec signal pulse produced by a Schmitt trigger operated by a gated noise generator. These pulses appear on the TV monitor as dots of a picture, and they are electronically counted. Similar computer-generated displays have been developed by Barlow (1978). These electronic solutions are expensive The present device provides many of the same features at low cost.

METHOD

An optical solution is adopted, using standard slide projectors and photographic film. Test slides are projected through one of a sequence of calibrated hole masks. Each hole in the mask provides a dot of the test picture, each of which is effectively featureless. Since it is often necessary to change the picture and the number of dots independently, the hole masks are kept separate from the pictures, which are projected through the masks and are independently selected. This is achieved by imaging the selected test slide, with a standard projector, onto the selected hole mask, which is a 35-mm transparency. A further projection lens images the samples of the test picture onto a screen for viewing. The optical arrangement, with dimensions using readily available slide projectors and lenses, is given in Figure 2.

It would, of course, be possible to mount the test picture slides each with a hole mask slide, as "sandwiches" (Figure 3), but this would require expensive and cumbersome duplication of pictures and hole masks. It is also possible to adapt the method to give dynamic displays with a pair of synchronized cine projectors arranged in tandem: one providing the (moving) picture, and the other, the (dynamic) hole masks for the dot sampling.

APPLICATIONS

This device can be used to test the ability of observers to use limited visual positional information to give form perception. It is envisaged to have clinical applications in the assessment of spatial abilities of patients with right parietal cortical damage (Warrington & Taylor, 1973) and for measuring the cued recall of patients with memory defects (Warrington & Weiskrantz, 1968). The fragmented words used in the latter study can be produced using the random-dot picture sampling device by replacing the picture slides and hole masks with slides of words and their "patchwork" masks.

The technique may also have more general applications for investigating visual function; for example, in determining the effects on recognition of various types of contextual cuing or the importance of color information on the recognition of different types of picture.

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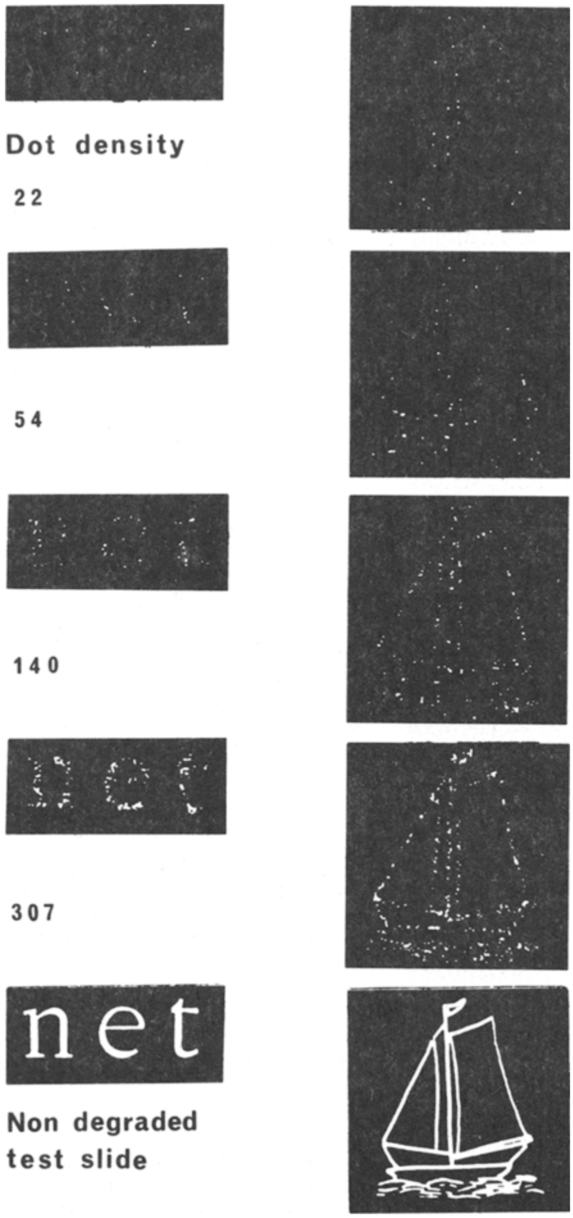

Figure 1. A line drawing and a word degraded by random-dot sampling. The "dot density" is the number of sampling holes per square centimeter.

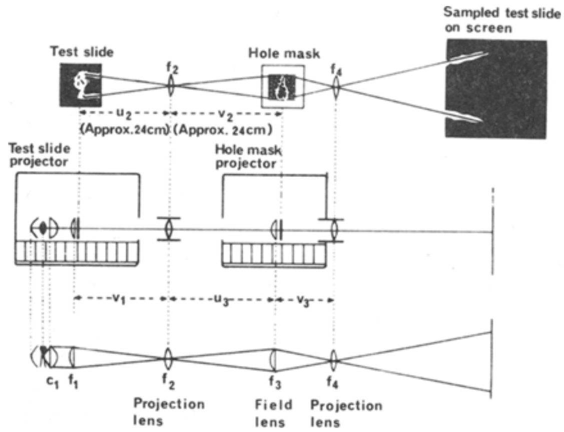

Figure 2. The tandem projection technique. Test picture slides are projected by the rear standard slide projector and imaged on the hole masks in the front modified projector. (This has its light source and back removed.) The projectors and lens f_2 are adjusted for exact registration of the picture slide onto the hole mask slide, as shown in the top ray diagram. The focal length of the lens f_2 was chosen to be as long as 120 mm to provide a 200-mm gap between the projectors, which allows the full range of a longitudinal slide magazine to be accommodated. (Registration can be checked using a pair of identical slides in the gates of the projectors.) Evenness of the illumination can be maximized by focusing the images of the projector lamp at the nodal points of lenses f_2 and f_4, as shown in the lower ray diagram. This is achieved by selecting lenses f_1 and f_3 with appropriate focal lengths (f_3 is the more critical). These can be calculated from the simple lens formula, $1/f = 1/u + 1/v$, where f = focal length of lens, u = object to lens distance, and v = image to lens distance. It is the case that when there is unity magnification between the picture slide and the dot-mask slide the focal length of f_1 should be twice that of f_2. (The focus of the images of the projector bulb can be checked by placing a screen at the nodal points of lenses f_2 and f_4.) Satisfactory results have been obtained using both the Leitz Pradovit Colour 250 and Rollei P.35A projectors. The internal shutter in the Leitz projector is advantageous, but an external shutter can be fitted to the Rollei projector to occlude the moving slide during slide change.

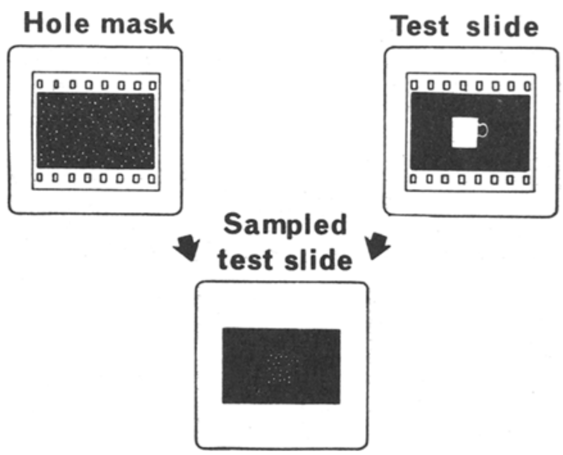

Figure 3. The sandwich slide technique. A hole mask and a picture transparency are mounted (emulsion sides together) in the same slide holder. A similar result to that achieved with the "sandwich slide" picture is given by the tandem projection technique, in which the slides are selected separately.

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