Brightness contrast in the cat*

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Using both the method of paired comparisons and the method of constant stimuli, degree of brightness contrast was determined for two cats. Brightness contrast varied with relative luminance of various parts of the stimulus configuration in a manner comparable to that found in human Ss; brightness constancy was not obtained. The data indicate a fixed, nonadaptive basic visual process rather than a cognitive or adaptive perceptual constancy.

Brightness contrast is a phenomenon which occurs when an area of given luminance is surrounded or bordered by an area of different luminance. The apparent brightness of the central area, or test field, is found to be partially dependent on the luminance of the surrounding area, i.e., background. If the background is of lower luminance than the test field, the apparent brightness of the test field is increased; if the background is of higher luminance than the test field, the apparent brightness of the test field is decreased. This relationship is not a simple ratio (Kozaki, 1963); the exact form of the function has been the subject of numerous investigations (Freeman, 1967). If the brightness of the test field is constant when its luminance is a constant ratio to the luminance of its background, brightness constancy is observed. As Freeman (1967) remarks, perfect constancy has seldom been found.

While many psychophysical studies of brightness contrast have been conducted with human Ss, experimentation with animal Ss has been less precise. Early studies (Koehler, 1917; Klüver, 1933; Burkamp, 1923), while indicative of brightness constancy in the animals studied, are in the nature of demonstrations, lacking the stimulus control and procedural refinement of truly psychophysical investigations. Grether (1942) was able to show with a more precise methodology that color contrast in chimpanzees is similar in magnitude to that in humans. However, he was not able to obtain comparable data for brightness contrast because "the brightness discrimination habit had not been established firmly enough to persist throughout the magnitude measurements." The particular

procedure he used also seems at fault here, as there was no built-in safeguard to prevent the learned discrimination from extinguishing.

It is important to measure precisely the perceptual processes of animals so that the role of complex thought processes in perception may be better understood. For instance, Locke (1935) interprets his results as showing that humans may show differing amounts of brightness constancy, depending, in part, on whether they adopt an "artist" or "object" point of view. Monkeys, he found, show negligible individual differences and a larger degree of constancy than the human Ss. The finding may indicate that analytical activities on the part of human Ss confound measurement of their perceptual phenomena. A further example is the study of Davis, Masters, and Tjomsland (1965). In this comparative study, human beings were initially shown to exhibit more brightness contrast than monkeys. When, however, the design of the experiment was altered to eliminate labeling behavior on the part of the humans, the amount of contrast shown by the two species was almost identical.

The cat was selected as the S for the present investigation because it is the simplest animal that has a visual system anatomically similar to that of the primates. The primary differences are the relative simplicity of the striate cortex and a somewhat greater subcortical elaboration (Polyak, 1957). Precise measurements of its perceptual performance, comparable to measurements for humans, can determine the role of complex cognitive processes in brightness constancy and may also indicate whether or not physiological studies of this phenomenon are feasible. For these reasons, the present study was devised to apply the precise methods of psychophysical psychology to lower animals whose visual nervous system is similar to our own.

METHOD

Subjects

Two young cats, littermates, were trained. They were approximately 6

months old at the beginning of the training; the scaling and psychophysical measurements were made when the cats were between 12 and 16 months old.

Apparatus

The apparatus had two basic parts: an optical projection system and a response chamber. The essential features of the response chamber, a modified Sperry box, were a start chamber, a choice point from which the cat could view two stimulus display panels, response chambers in which the animal obtained food from behind the display panels, and return alleys leading back from the response chambers to the start chamber. The animals' movements through the box were communicated to the E by a bank of signal lights on the outside of the box, activated by microswitches under the floor of the start and response chambers. The box excluded all light, except that entering through the stimulus display panels. Two guillotine doors, an opaque one and a transparent Lucite one, separated the S in the start chamber from the stimulus display panels. The optical system of lenses and mirrors projected a 1-7/8 x 1-7/8 in. test patch of light on each of the two doors of the Sperry box. Each test patch was centered on a 5 x 5 in. field of background light. Luminance of the test and background fields were varied independently.

Experimental Procedure

The experimental procedure consisted of two parts. First the cats were subjected to a training procedure designed to train them to make a discriminative response to the central test squares appearing on the door panels of the apparatus. After this training procedure was completed, the second part of the experiment was begun, and the effect of brightness contrast was measured with a scaling method (Test 1) and with a psychophysical method (Test 2).

Training

The cats were trained by a series of gradual approximations to discriminate between test fields which differed in luminance by progressively smaller amounts. At the start of each trial the signal lights on the exterior of the Sperry box indicated when the cat had assumed a viewing position. The opaque door was then raised, and the cat was allowed to view the stimuli for 10 sec. The transparent door was next raised, and the cat was allowed to approach either of the display panels. A signal light flashed "on" when the animal had approached a panel closely enough to be scored as a response. If the response was to the positive

*This research was performed in partial fulfillment of the requirements of the degree of Master of Science at the Pennsylvania State University. The work was supported by USPHS Grant No. MH 10690-1 and Predoctoral Fellowship MH 32,272. The author wishes to thank Robert B. Freeman, Jr., for gracious and conscientious direction and support.

Fig. 1 PSEs obtained by the method of constant stimuli (Test 2).

stimulus, the cat could obtain a bit of cat food by pushing against the panel. If the cat responded to the negative stimulus, the panel was locked in place. After the response the cat returned to the start chamber; on every fourth trial it was given a bit of food for returning.

One cat was trained bright positive and the other dark positive. The position of the positive stimulus was varied from right to left, according to Gellerman's (1933) protocol. Each training session consisted of 25 trials; a criterion of 23 out of 25 trials correct was adopted. The cats were ultimately trained to discriminate between dark and bright test fields, differing in luminance by .2 log fL, whether presented on bright (1.62 log fL) or dark (.43 log fL) backgrounds.

Test 1. The next phase of the experiment involved the measurement of the effect of contrast on the cat's brightness discriminations. The first technique used was Thurstone's (1948) scaling method of equal sense distances, a variation of the method of paired comparisons.

To measure contrast, it was necessary to make background luminances unequal. On those trials on which backgrounds were unequal, responses to either test field were rewarded. Such trials were alternated with trials with backgrounds equal. On trials with backgrounds equal, the cats were rewarded only for responding to the correct test field.

The brightness of five central test squares, ranging from .8 to -.4 log fL, was scaled. These test squares were presented either on a "bright" background of .8 log fL or on a "dark" background of -.16 log fL. Every test square was paired with every other test square and with every possible combination of backgrounds.

This allowed two tests of brightness contrast on each test square, in one case when its background was brighter than that of the stimuli with which it was paired and in the other case when its background was darker. Ten measurements were made on each of the four background combinations of each stimulus pair during each 40-trial session. The scaling was completed after each cat had undergone 10 sessions of testing.

This procedure generated 12 brightness scales. One rated the apparent relative brightness of five test stimuli when all were compared on dark backgrounds, another when all were compared on bright backgrounds. The other 10 scales provided measures of brightness contrast. One rated the relative apparent brightness of the five test stimuli when the brightest was presented on a bright background and the other four on darker backgrounds. Likewise, a second scale rated the five test stimuli when the brightest was presented on a dark background and the others on lighter backgrounds. The remaining scales consisted of similar comparisons for the other four stimuli.

Test 2. When scaling had been completed, psychophysical measures of apparent equality of the test areas on the two stimulus panels were obtained, using the method of constant stimuli. In this method, a standard (St) test field, 1 x 3/4 in., was projected on a standard background. Five comparison (Co) test fields were projected either on identical backgrounds or on backgrounds of a different luminance. PSEs were calculated from the data obtained when backgrounds were equal and when they were unequal, giving a measure of brightness contrast.

Comparison stimuli on equal backgrounds and comparison stimuli

on unequal backgrounds were intermixed, randomly paired with the standard stimulus, and presented to the cat. Fifty pairings, or trials, made up a session. Correct responses were reinforced when backgrounds were equal; when backgrounds were unequal, all responses were reinforced so as not to bias the measure of brightness contrast. Two sessions were required to give 10 trials for each comparison stimulus. In all, eight measures of contrast were obtained.

RESULTS AND DISCUSSION

According to the rationale of Thurstone's scaling methods, the z score obtained for each of the test stimuli is an index of the subjective brightness of the stimulus. When all the test stimuli were paired on backgrounds of equal luminance, there was a linear relationship between the subjective brightnesses of the test stimuli and a logarithmic transformation of their luminances, except that the brightest stimulus was disproportionately bright. When each test stimulus was projected on a dark background and paired with the other test stimuli on light backgrounds, its brightness was enhanced. This contrast effect approached, but did not reach, significance ($t = 1.35$, $df = 4$, $p > .05$). When each test stimulus was projected on a bright background and paired with the other test stimuli on dark backgrounds, its brightness was decreased. This contrast effect was significant ($t = 3.30$, $df = 4$, $p < .025$). The finding that the change in test field brightness is greater when relative background luminance is increased than when it is decreased parallels findings with human Ss (Leibowitz, Mote, & Thurlow, 1953; Leibowitz, Myers, & Chinetti, 1955; Heinemann, 1955). In both cases, the amount of contrast obtained using the scaling method was not enough to result in constancy; instead, the subjective brightness was a compromise between a constancy match and a retinal illuminance match.

In Test 2, using the method of constant stimuli, the shapes of the psychophysical functions obtained during the measurements of contrast were similar to those obtained on the noncontrast measurements in most instances. Each of the four curves plotted in Fig. 1 represents the brightness matches of one of the standard test stimuli. The background luminance for each standard (St) test field is indicated by a large hash mark on the abscissa below the plot. The points plotted are PSEs, graphed as a function of the luminance of the backgrounds of the comparison (Co) stimuli.

A considerable contrast effect may

be seen in the data. In all cases but two, the brightness match is closer to a constancy match than to an absolute luminance match. In two instances, where the standard test stimulus was darker than its background and where the background of the comparison stimuli was darker than the background of the standard stimulus, there was a slight degree of overconstancy.

These findings parallel those obtained with human Ss which show a greater contrast effect when the central test field is darker than its surroundings, as opposed to when it is brighter than the surroundings. The finding of overconstancy, when the variable comparison (Co) test field luminance was lower than that of any other part of the stimulus configuration, is analogous to the condition necessary for overconstancy described by Jameson and Hurvich (1961). It is noteworthy that the cats never showed perfect constancy, which ordinarily requires a complex visual field. They responded to the four-field configuration in a manner consistent with the results usually obtained for humans. When St is darker than its background and the Co background is darker yet, overconstancy occurs. When St is brighter than its background and the

Co background is the darkest, the Co test field chosen as a match is close to a retinal luminance match. All other combinations produce a compromise which is nearer to a constancy than a retinal match. Even though none of the stimulus configurations used in the different experiments cited are identical to those used in the present experiment or to each other, this adaptation of two psychophysical methods for use with cats has made possible the demonstration that these animals respond to conditions of brightness contrast in somewhat the same manner as humans.

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(Accepted for publication December 12, 1970.)