Monoptic and dichoptic metacontrast[1]

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Metacontrast suppression was compared under conditions of monoptic and dichoptic presentation. It was found that interference was greater with dichoptic than with monoptic presentation, and that the point of maximum interference differed in the two conditions. The interference curve generated as a function of inter-stimulus interval (ISI) was also different; monoptically a "U"-shaped curve was found, whereas dichoptically the curve appeared to be more "J"-shaped. Theoretical implications are discussed, and it is suggested that binocular rivalry may play a role in dichoptic interference.

Metacontrast is one of several different types of temporal interference phenomena, the stimulus conditions of which are characterized by the use of nonoverlapping but spatially contiguous stimuli such as a disk and a ring. The interference effect is readily obtained with stimuli of equal intensity. Metacontrast suppression (the dimming or virtual disappearance of the first stimulus) is most pronounced with interstimulus intervals (ISI) of 50 to 100 msec. The effect decreases with both shorter and longer intervals.

A number of mechanisms have been proposed to explain the observed suppression. Some of these invoke peripheral mechanisms (Alpern, 1953) while others propose that central factors are involved (Werner, 1940; Baumgardt & Segal, 1942). Support for the latter view stems from experiments in which dichoptic interference has been reported (Kolers & Rosner, 1960; Werner, 1940). Monoptic and dichoptic metacontrast have not, however, been directly compared. Such a comparison is especially relevant in view of the fact that Alpern (1953) was unable to obtain dichoptic interference. It is possible that under monoptic and dichoptic conditions of presentation the effects obtained differ. If so, the assumption that the same mechanism is tapped would not be justified. The purpose of this experiment, therefore, was to make such a comparison.

Several different techniques have been employed for assessing the interference which occurs in metacontrast. Alpern (1953) has used a brightness matching procedure, in which the intensity of a test stimulus, which was followed by an interfering stimulus, was increased until it appeared equal to the standard. This method has several drawbacks, the main one being that the test stimulus appears quite different from the standard with which it is being compared. This leads to an artificial comparison which is difficult to make. Further, the data obtained with this method tend to be quite variable, especially at intermediate ISIs.

A detection method has also been employed (Werner, 1940; Kolers & Rosner, 1960), in which Ss report whether or not they have perceived the test stimulus. This method also introduces a great deal of variability. In addition, depending on the condition employed (forced choice vs free choice with or without catch trials), strikingly different functions can be generated (Schiller & Smith, 1966).

For this study we chose a brightness rating method which seems to have overcome some of the noted difficulties. We asked Ss to rate the apparent brightness of the test stimulus as it was followed, at various ISIs, by the interference stimulus. We found that this method produced consistent data within Ss, and reflected the phenomenon satisfactorily.

METHOD

Subjects

Three volunteer Ss, one male and two females, participated in this experiment. All Ss had 20-20 vision and were practiced in visual interference studies.

Apparatus

The apparatus consisted of a five-field tachistoscopic viewing box which permitted both monoptic and dichoptic presentation of stimuli. This apparatus has been described in detail elsewhere (Smith & Schiller, 1966). The electronic programmer was built by Sky Instrument Co. The light sources consisted of cold-cathode mercury-argon vapor lamps coated with magnesium-tungstate phosphor. The lights were covered by a 1/8 in. thick milk Plexiglas plate which served to diffuse the light. All stimuli were transilluminated.

The test stimulus consisted of a luminous disk with a visual angle of 1°. The interference stimulus was a luminous ring whose inner contour was adjacent to the contour of the disk. The areas of both disk and ring were 150 sq mm. The intensity of the stimuli was 20 ft-L. The focusing field consisted of four dimly illuminated dots arranged in the shape of a diamond, subtending a 5° visual angle. The Ss were instructed to fixate on the top dot, so that the stimuli fell 2.5° from the fovea.

Procedure

All Ss were given three days of training in the experimental situation, and were then tested for four consecutive days. Each session lasted approximately 1 h. Prior to each session Ss were adapted for 10 min.

Two methods of presentation were employed: monoptic and dichoptic. Under the monoptic condition,

both disk and ring were presented to the same eye, half the time to the left eye and half the time to the right eye. Under the dichoptic condition, the disk was presented to one eye and the ring to the other. Again, the disk was presented on half the trials to the left eye and on half the trials to the right eye. Under each of these four conditions, 20 measures (five per day for four days were taken at each of eight ISIs: 5, 20, 40, 60, 80, 100, 120, and 160 msec). In addition, there was a control condition in which the first stimulus was not presented. Each day five such control measures were taken with the ring presented to the left eye, and five with the ring presented to the right eye, giving a total of 40 control measures per S. The stimuli were presented in complete random order.

The S's task was to rate the apparent brightness of the first stimulus (disk) on a rating scale from 0 to 5, in which 5 was assigned to a stimulus disk of the same intensity as the ring, and the value of 0 was assigned if the first stimulus was not perceived at all.

RESULTS

The mean ratings for the three Ss under the two conditions of presentation (monoptic and dichoptic) at each of the eight ISIs, as well as in the control condition, are presented in Fig. 1.

The following observations may be made:

(1) Interference effects appear to be greater for dichoptic than for monoptic presentation with ISIs of 60 msec or less. At larger ISIs monoptic and dichoptic interference do not differ.

(2) Metacontrast interference is differentially affected by ISI in the monoptic and dichoptic conditions. Monoptically a U-shaped function is found with almost no interference at the shortest ISIs (5 and 20 msec). On the other hand, the dichoptic curve is more closely "J"-shaped, with considerable masking occurring with ISIs of 5 and 20 msec.

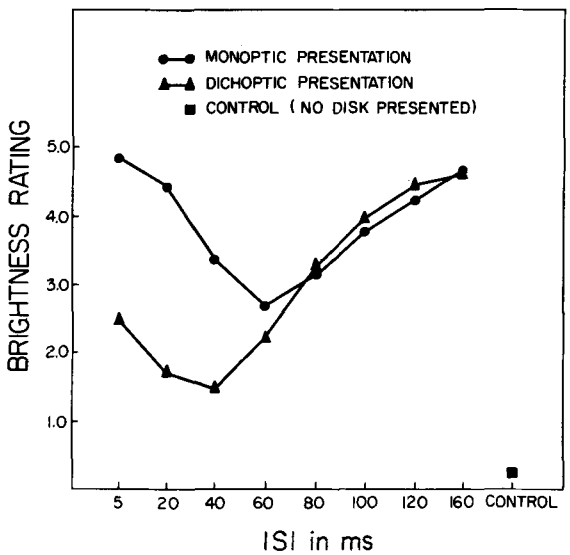

Fig. 1. Mean ratings for the three Ss under monoptic and dichoptic conditions of presentation.

(3) The ISI at which maximum interference occurs is not identical in the two conditions. Monoptically, maximum interference occurs with an ISI of 60 msec, whereas dichoptically the point of maximum interference appears to be 40 msec.

(4) Despite the darkening of the disk when it is followed by the ring, Ss appear able to distinguish the control condition in which no disk is presented from a disk-ring sequence which is presented either monoptically or dichoptically. This supports the earlier finding that even at the point of maximum interference it is possible to distinguish between the phenomenal darkening of the central disk and its actual absence (Schiller & Smith, 1966).

The results were analyzed by means of a five-way analysis of variance, using the five variables: ISI, monoptic vs dichoptic presentation, practice effect over days, presentation of disk to left or right eye, and Ss. Both practice effects and eye of presentation were found to be nonsignificant. The effect of ISI was found to be significant beyond the .001 level ($F = 62.05$, $df = 8/16$). Due to the fact that the assigned brightness values at the four highest ISIs overlapped, the observed difference between monoptic and dichoptic presentation was found to reach significance only at the .06 level ($F = 17.13$, $df = 1/2$). However, the interaction between ISI and modes of presentation was significant ($F = 33.06$, $df = 8/16$, $p < .001$). A separate analysis of variance carried out on the first four ISIs showed the monoptic-dichoptic effect to be significant beyond the .001 level of probability ($F = 672.3$, $df = 1/2$).

DISCUSSION

Dichoptically obtained metacontrast suppression in the past has been taken as evidence for central factors bringing about the interference. The fact that the dichoptic effects in this study are both greater than and different in function from the monoptic effects suggests, however, that the mechanisms underlying the two phenomena are not the same. This means that the source of interference obtained dichoptically reflects an entirely different process, or that there is an additional source of interference introduced under dichoptic modes of presentation. What could this source be? One possibility is that the dichoptic effect may, in part, be due to binocular rivalry. In conjunction with this hypothesis, two observations should be noted: (1) When a disk and a ring are presented to each eye at the same time, for a prolonged period, it is always the disk which is suppressed, suggesting that the ring is a more "compelling" figure. (2) When two brief stimuli,

such as a disk and a square, are presented in rapid succession to homologous retinal areas, the second stimulus is always much more clearly seen. This is not the case with monoptic presentation. This suggests that certain forms of binocular rivalry can take place even where two stimuli are presented in succession, with the second stimulus paradoxically producing interference upon the first.

These observations imply that some form of binocular rivalry may play an important role in metacontrast and may be responsible for the greater dichoptic effect.

The notion of binocular rivalry as a basis of dichoptic interference effects appears first to have been considered by Werner (1940) who discarded the idea primarily because he felt that if rivalry were the sole cause of the effect, interference in perception of the disk should occur if the ring *precedes* the disk, as well as when it follows it. In addition, if binocular rivalry were the total cause of the interference, one would expect to find a monotonic curve with interference decreasing as ISI is increased. Consequently, it would appear unlikely that binocular rivalry accounts entirely for the dichoptic effects. The "J"-shaped function which was observed for the dichoptic condition suggests that probably both forces play some role, and that the observed dichoptic interference results from an interplay of binocular rivalry and metacontrast.

References

Alpern, M. Metacontrast. *J. Opt. Soc. Amer.*, 1953, 43, 648-657.

Baumgardt, E., & Segal, J. Facilitation et inhibition parametres de la function visuelle. *Annee psychol.*, 1942-3, 43-44, 54-102.

Fehrer, E., & Biderman, I. A comparison of reaction time and verbal report in the detection of masked stimuli. *J. exp. Psychol.*, 1962, 64, 126-130.

Fehrer, E., & Raab, D. Reaction time to stimuli masked by metacontrast. *J. exp. Psychol.*, 1962, 63, 143-147.

Fehrer, E., & Smith, E. Effect of luminance ratio on masking. *Percept. mot. Skills*, 1962, 14, 243-253.

Kolers, P. A., & Rosner, B. S. On visual masking (metacontrast): dichoptic observation. *Amer. J. Psychol.*, 1960, 73, 2-21.

Schiller, P. H., & Smith, M. C. Detection in metacontrast. *J. exp. Psychol.*, 1966, 71, 32-39.

Smith, M. C., & Schiller, P. H. Forward and backward masking: a comparison. *Canad. J. Psychol.*, 1966, 20, 191-197.

Stigler, R. Chronophotische studien uter den Umgebungskontrast. *Pflug. Arch. ges. Physiol.*, 1910, 134, 365-435.

Werner, H. Studies on contour strobostereoscopic phenomena. *Amer. J. Psychol.*, 1940, 53, 418-422.

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