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CONTRAST DETECTION AND DIRECTION DISCRIMINATION OF DRIFTING GRATINGS

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Abstract—Observers performed simple detection and left/right discrimination of drifting sinusoidal gratings. Ratio of detection to discrimination sensitivities was measured under variations in several experimental parameters. In the first experiment, it was found that combinations of spatial and temporal frequency which resulted in the same velocity produced similar detection/discrimination ratios. At an exposure duration of 800 msec, the relationship between the ratio and velocity described a power function with the intercept at 0.6°sec^{-1}. Decreasing duration shifted the curve to higher velocities. I examined the effect of grating orientation in a second experiment. Visual sensitivity was poorer for oblique than for vertical gratings with detection and discrimination exhibiting similar size anisotropies. In a third experiment, observers viewed gratings presented to different retinal loci. Visual performance in both detection and discrimination fell with greater eccentricity. However, motion discrimination fell more steeply resulting in an increase in the ratio. The results demonstrate that form and motion analyzing mechanisms cannot be distinguished by their response to changes of spatial frequency, orientation or retinal locus.

Motion   Orientation   Eccentricity   Sustained-transient

INTRODUCTION

Contrast sensitivity for detection of gratings has frequently been used to determine human visual sensitivity. In early grating studies, the criterion for threshold was usually defined as the minimum contrast required to barely distinguish that the display was no longer a uniform field. The exact appearance of the target at threshold was not considered when making determinations of sensitivity. More recent experimenters (Van Nes *et al.*, 1967; Keesey, 1972; Kulikowski, 1971) have noted that with each set of parameters, separate contrast thresholds may be recorded for the perception of temporal (motion/flicker) and spatial (pattern) structure. Results showed that changes in the values of experimental variables differentially affected the two classes of threshold. This has led some (e.g. Keesey, 1972; Tolhurst, 1973; Kulikowski and Tolhurst, 1973; Breitmeyer and Ganz, 1976) to suggest that the human visual system contains separate pattern/flicker ("transient") and pattern ("sustained") analyzing systems. A survey of the literature shows that previous authors have suggested three parameters which differentially affect the two mechanisms.

(1) *Spatial frequency*

Studies of the relationship between flicker/motion and pattern thresholds have been primarily concerned with the effects of spatial and temporal frequency. Many studies (e.g. Van Nes *et al.*, 1967) have demonstrated that threshold for spatial structure was lower than that for temporal structure when the target contains high spatial and low temporal frequencies. Under these conditions, a drifting grating can appear as a set of stationary stripes at detection threshold. The stripes seem to move only after contrast is increased to a higher level. Higher temporal and low spatial frequencies produce the opposite result: temporal structure is seen at detection threshold with a greater contrast necessary for perception of distinct light and dark bars. This result has led to the conclusion (Tolhurst, 1973; Kulikowski and Tolhurst, 1973) that the transient system is tuned to low spatial frequencies while the sustained system is more sensitive at higher spatial frequencies.

However, the greater sensitivity for temporal structure at low spatial frequencies may have an alternate explanation. Most investigators who employ grating stimuli specify rate of motion in terms of temporal frequency of the target. This means that when spatial frequency of the grating is varied, temporal frequency is held constant. As a result, high spatial frequency gratings move at a lower velocity than low spatial frequency targets. This follows from the fact that velocity is equal to the temporal frequency divided by the spatial frequency of the target gratings. Therefore, the greater sensitivity for temporal change at low spatial frequencies may actually represent a greater sensitivity at high velocities.

This possibility was examined by Harris (1980), who conducted an extensive study of the relationship between pattern and flicker thresholds. Observers used method of adjustment to set both types of threshold for test gratings covering a wide range of spatial and temporal frequencies. The experimental results showed greater sensitivity to flicker at high velocities and greater sensitivity to pattern at low velocities. Moreover, Harris concluded that combinations of spatial and temporal frequencies which produce the same velocity resulted in a similar ratio of flicker to form thresholds. However, this conclusion was based on the mean of seven observers. Data from different subjects varied greatly, and the group mean curve did not reflect the behavior of individual observers.

In most studies of pattern and flicker/motion thresholds (such as Harris'), observers adjust contrast of the test grating until "distinct" spatial or temporal structure is seen. This task is both difficult and highly subjective in nature. As an alternative, several experimenters (Green, 1982b; Lennie, 1980; Watson *et al.*, 1980) have employed a two alternative forced-choice detection–discrimination paradigm. Observers were tested for both simple detection and left–right discrimination of the same drifting gratings. All three experiments showed that detection was better than discrimination at high spatial frequencies but similar at low spatial frequencies. However, these studies used only a few combinations of spatial and temporal frequencies. Moreover, temporal frequency was held constant when spatial frequency was varied. It is therefore not possible to conclude whether the better motion discrimination was due to lower spatial frequency or to higher velocity.

(2) *Orientation*

It has also been suggested that grating orientation has a differential effect on the sustained and transient mechanism. The influence of grating orientation on pattern and flicker/motion thresholds has been examined in two studies which used similar techniques but reported different conclusions. Camisa *et al.* (1977) and Essock and Lehmkuhle (1983) instructed observers to set both classes of threshold for vertical and 45° oblique gratings. Camisa *et al.* concluded that pattern sensitivity was lower for oblique gratings but that orientation had no effect on flicker/motion thresholds. It was suggested therefore that retinal anisotropy is restricted to the sustained system. They ignored, however, the fact that one of their two observers actually exhibited a small but statistically significant 1 dB oblique effect for flicker (Essock, personal communication). Essock and Lehmkuhle, on the other hand, concluded that there is an oblique effect for both pattern and flicker, although the patsotropy was considerably greater.

(3) *Retinal Locus*

Primarily on the basis of physiological evidence, it has frequently (e.g. Breitmeyer and Ganz, 1976) been suggested that the transient system is more sensitive than the sustained system when the peripheral retina is stimulated. The view that the peripheral retina is specialized for motion perception is quite old (Exner, 1875; Granit, 1930), but psychophysical evidence is based mostly on anecdotal observations. Quantitative studies (e.g. Leibowitz *et al.*, 1972; Tyler and Torres, 1972; Tynan and Sekuler, 1982) have demonstrated that motion sensitivity (defined in terms of liminal velocity or exposure duration) decreases with greater eccentricity of stimulation. One possible explanation is that although both pattern and motion perception are impaired with eccentric viewing, the disruption of pattern perception is greater. Therefore, motion sensitivity might decrease in absolute terms but improve relative to form.

The purpose of the present experiment was to employ the more rigorous detection–discrimination paradigm to test whether form and motion/flicker analyzing systems can be differentiated on the basis of their response to variations in spatial frequency, orientation and retinal locus. In the first experiment, detection and discrimination thresholds were measured over a wide range of spatial and temporal frequencies. My results generally support Harris' (1980) conclusion that the ratio of motion to pattern sensitivity is determined solely by velocity. In a second experiment, observers were tested with both vertical and oblique gratings. Retinal anisotropies of equal magnitudes were found for both detection and discrimination. This result fails to support the contention that there is a difference between pattern and motion oblique effects. In a third experiment, ratios were measured at different retinal eccentricities. Absolute sensitivity to both pattern and motion declined with peripheral stimulation, but motion sensitivity fell faster than pattern performance.

METHODS

Observers

Four observers served in different phases of the study. D.G. and D.M. are emmetropes while W.S. and E.E. are myopes and wore appropriate spectacle correction. Only E.E. was aware of the purpose of the experiment.

Apparatus and procedures

Observers binocularly viewed sine-wave gratings which were presented on the face of a Tektronix 608 display by means of the standard television technique. For the first (spatial and temporal frequency) and a second (orientation) experiment, the screen was masked down to a 6.1° circular field. A small black circle was placed in the center of the screen to aid in fixation. Grating orientation was changed by rotating the entire CRT display in a wooden cradle, and no optical devices were employed. For the third experiment (retinal locus) the field was 2° high and 4° wide. During threshold determinations, observers viewed either the center of the display or small red fixation lights located at various distances below the midline of the screen. Viewing distance was 91 cm and mean luminance of the display was always 45 cd/m². Unless otherwise specified, grating exposure was 800 msec in duration.

To start each session, the observer first was adapted to dim illumination for 5 min and then to the unmodulated CRT screen for 3 min. Contrast thresholds for both detection and discrimination were measured by means of a staircase procedure where target detectability was altered in manner contingent upon accuracy. If correct responses were made on three consecutive trials, contrast was decreased by a 0.1 log unit step. An error at any time resulted in a similar size contrast increment. A detection level corresponding to the 79.6% correct level on a psychometric function was found by averaging the reversal points in each staircase (Wetherill and Levitt, 1965). Final data usually represented the mean of two staircases consisting of 6 or 8 reversals each. Ninety percent of the estimated standard errors fell between 0.43 and 0.57 dB.

Detection and discrimination data were collected in separate staircases. In detection situations, the observer was only required to identify which of the two intervals contained the test grating and no direction information was required. To produced discrimination thresholds, the observer merely responded "left" or "right" after each trail, and no indication of the correct interval was necessary. My method differs from that previously employed since I obtained detection and discrimination thresholds from separate sets of trials while others (Lennie, 1980; Watson *et al.*, 1980) have used a simultaneous detection–discrimination procedure. However, the two methods seem to produce similar results (Green, 1982b).

RESULTS

Experiment 1. *Spatial and temporal frequency*

In the first experiment, detection and discrimination thresholds were measured for drifting gratings which varied in spatial and temporal frequency. Figures 1 and 2 show the detection–discrimination ratios of gratings presented for a duration of 800 msec. Each set of points represents ratios obtained for a range of spatial frequencies at a single temporal frequency. For clarity of presentation, data from increasingly lower temporal frequency conditions have been displaced upward by 4 dB. As has previously been reported (Watson *et al.*, 1980; Green, 1982b; Lennie, 1980) detection and discrimination sensitivities are similar with coarse gratings but diverge with increasing spatial frequency. The growth of the detection discrimination ratio describes a power function at all temporal frequencies.

It is apparent from Figs 1 and 2 that data from the four different temporal frequencies lie along approximately parallel lines and are displaced horizontally by 1 octave of spatial frequency. This is exactly what would occur if detection–discrimination ratios are the same at each velocity. In Fig. 3, the ratios for all combinations of spatial and temporal frequency are plotted on a common velocity axis. The data for each observer fall on a straight line, confirming that equal velocities produce similar detection–discrimination ratios. At low velocities, there is a slight but systematic trend for 0.6 Hz rates to produce lower ratios than 0.3 Hz gratings. The detection and discrimination thresholds of the two observers reach equality at about 0.6 /sec⁻¹. This is slightly faster than the value suggested by Lennie (1980), possibly because of

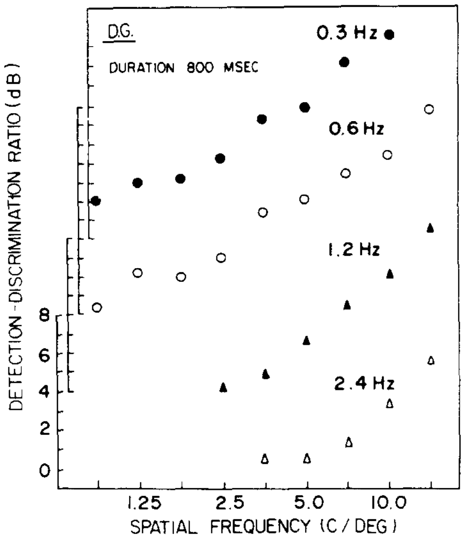

Fig. 1. Ratio of detection to discrimination as a function of spatial frequency. Each set of points represents data obtained at a particular temporal frequency. Sets of points have been displaced upward 4 dB. Observer D.G.

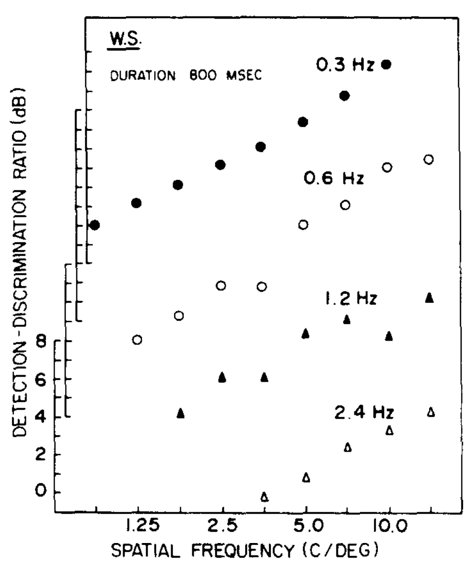

Fig. 2. Ratio of detection to discrimination as a function of temporal frequency. Details are the same as Fig. 1. Observer W.S.

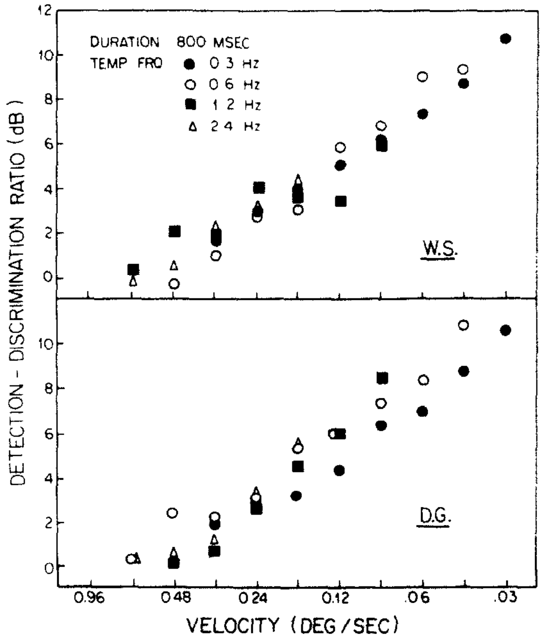

Fig. 3. Ratio of detection to discrimination as a function of velocity. Each symbol represents data obtained at a particular temporal frequency. Gratings were exposure for a duration of 800 msec. Upper panel, observer W.S.; lower panel, observer D.G.

the longer exposure durations (2 sec) that he employed (see below).

Figure 4 shows the results for a similar experiment except that exposure duration was shortened to 200 msec. The points again fall on a single line if plotted on a velocity scale. The critical velocity required for discrimination of direction increased to about 1 sec^{-1}. However, at low velocities, the ratios obtained with the 0.6 Hz drift rate begin to fall systematically above the data obtained with the other two temporal frequencies. This suggests that there may be other factors besides velocity which determine direction sensitivity at low spatial frequencies and low velocities.

The experiment was repeated with the durations reduced further to 100 msec. As shown in Fig. 5,

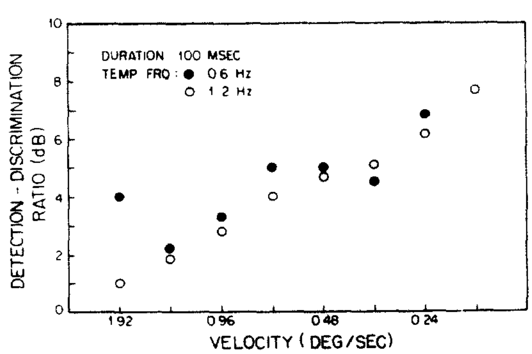

Fig. 4. Ratio of detection to discrimination as a function of velocity. Details are the same as in Fig. 3 except that duration was 200 msec Observer W.S.

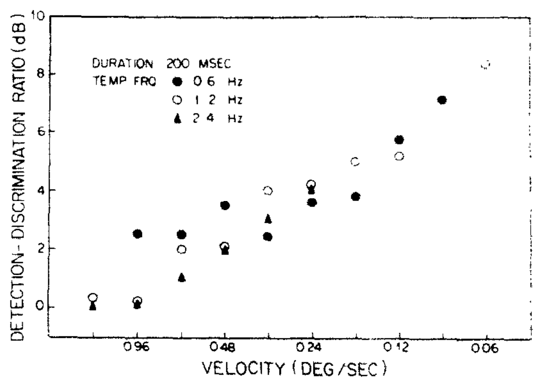

Fig. 5. Ratio of detection to discrimination as a function of velocity. Details are the same as Fig. 3 except that duration was 100 msec. Observer D.M.

points from the two temporal frequencies fall on the same line with the critical velocity occurring at a speed well over 2 sec^{-1}. The tendency for low velocity ratios with the 0.6 Hz temporal frequency to be greater than expected on the basis of velocity alone is again evident.

In addition to the lower limit for discrimination of direction at threshold, I also attempted to determine the upper limit. Van Nes *et al.* (1967) reported that at very high velocities, the threshold percept of drifting gatings was that of simple flicker and that direction of motion was not evident. I attempted to measure the velocity at which this effect occurs. However, I was not able to accomplish this because observers could discriminate direction at threshold when I used the 61.4 sec^{-1} (0.44 c/deg at 27 Hz) maximum velocity that my apparatus could produce.

Discussion

The major finding of the experiment is that combination spatial and temporal frequency which give rise to the same velocity also produce similar ratios of detection to discrimination. The previous assertion (Tolhurst, 1973; Kulikowski and Tolhurst, 1973) that motion sensitivity is detected by a transient system tuned to low spatial frequencies apparently resulted from the practice of maintaining a constant temporal frequency when spatial frequency was varied. However, the simple relationship between ratio and velocity failed at brief exposure durations when spatial and temporal frequencies were low. Under these conditions, more contrast was required for discrimination than would be expected on the basis of velocity alone. Subjects noted that the source of the difficulty was an apparent counterphase flicker (180 phase shift) that was seen at grating offset. This greatly impaired the ability to discern motion. In a previous experiment (Green, 1982b) I have similarly noted that uniform flicker backgrounds disrupted motion perception.

The resuts of the present experiment, along with those of Harris (1980), suggest that motion sensitivity is better at low spatial frequencies because these targets move at a higher velocity. Further evidence that velocity, and not temporal frequency, is the code for motion was reported by Thompson (1981) in a study of velocity aftereffects. He found that the size of the effect depended solely on the velocity of the adaptation grating. However, his conclusions are weakened by conflicting data (Pantle, 1974) which demonstrates that the motion aftereffect depends on temporal frequency.

Although my data show that *ratio* of detection to discrimination depends on velocity, other evidence suggests that detection *per se* is determined by temporal frequency. Studies have shown that the optimal sensitivity of human observers (Crook, 1937; Watanabe *et al.*, 1968; Tolhurst *et al.*, 1973) and of single units (Ganz, 1978) is obtained when gratings of different spatial frequency move at the same temporal frequency. The optimal frequency depends on several factors but is usually in the 4–6 Hz range (see Tolhurst *et al.*, 1973). Since I employed drift rates only as fast as 2.4 Hz, it was not possible to determine whether this relationship held true in my experiment.

The present results also exhibit some indication that the detection–discrimination ratio exhibits a velocity × time tradeoff. Doubling the exposure duration from 100 to 200 msec halved the velocity required for the observers to discriminate direction at threshold from 2 sec^{-1} to 1 sec. The tradeoff is likely to occur only at brief durations since a further increase to 800 msec (a factor of four) only decreased the required velocity to 0.60 sec^{-1}. Any assertion of a tradeoff is tentative, however, since I have so little data at brief durations.

Experiment 2. *Orientation*

Detection and discrimination thresholds were measured for vertical and oblique gratings with a drift frequency of 0.6 Hz for 500 msec. Both 45 left and 45 right oblique gratings were employed. Since there was no difference in sensitivity to the left and right tilts, these data were combined to produce a single threshold for the oblique gratings. Figure 6 shows that a detection oblique effect was not obtained with spatial frequency values of 5.0 c/deg and below. At high spatial frequencies, sensitivity to oblique gratings dropped 4–5 dB below that for verticals. These data are similar to those reported in previous studies (Camisa *et al.*, 1977; Essock and Lehmkuhle, 1983; Campbell *et al.*, 1966). Motion discrimination thresholds show a 1 dB oblique effect for spatial frequencies up to 10 c/deg where there is a jump to 6–7 dB. The small effect at low spatial frequencies is surprising since there are no previous reports of anisotropy at such low spatial frequencies. The main point, however, is that the oblique effect for motion discrimination is as large or larger than that of simple contrast detection.

Camisa *et al.* concluded that increasing rate of temporal frequency decreased the size of the oblique effect. With a 15 c/deg grating, two of three observers

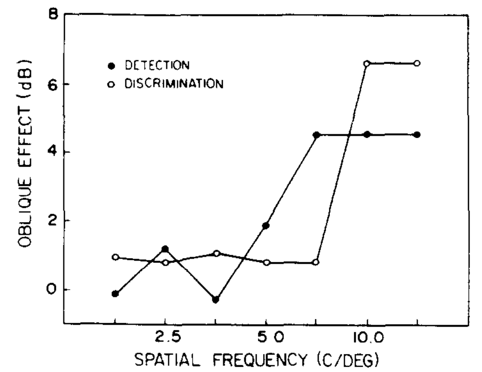

Fig. 6. Magnitude of the oblique effect as a function of spatial frequency. Solid symbols show results obtained for detection and open symbols represent data for discrimination. Temporal frequency was held constant at 0.6 Hz for each spatial frequency. Observer W.S.

showed no anisotropy at 8 Hz, and the third exhibited none at 12 Hz. This presumably occurred becuase the stimuli were then detected by the transient system. To test the validity of this claim, we measured detection and discrimination thresholds for a 14 c/deg grating which drifted at rates ranging from 0.6 to 9.6 Hz. The 0.6, 1.2 and 2.4 Hz gratings appeared stationary at detection threshold while the 4.8 and 9.6 Hz gratings could be seen to move. The magnitudies of the obtained oblique effects are shown in Fig. 7. The data from both observers failed to demonstrate any pronounced decline in the oblique effect with increasing temporal frequency. Discrimination oblique effects were slightly larger at slow temporal frequencies while

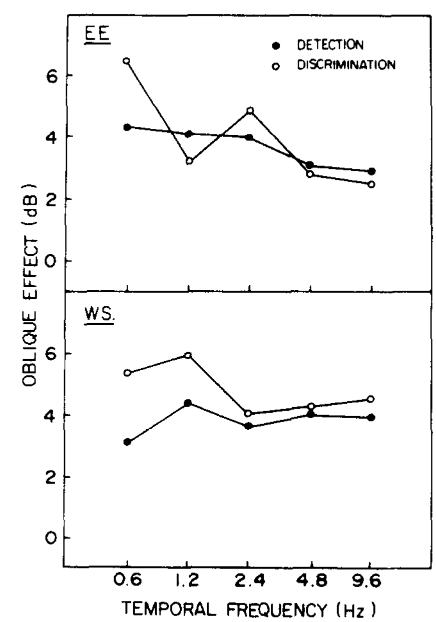

Fig. 7. Magnitude of the oblique effect as a function of temporal frequency. Solid symbols show detection data and open symbols represent data for discrimination. Spatial frequency was 14 c/deg. Upper panel, observer E.E.; lower panel, observer W.S.

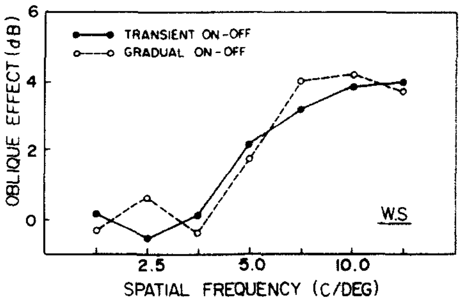

Fig. 8. Magnitude of the oblique effect for detection as a funtion of spatial frequency for two types of on/offset. Solid symbols show results obtained with sharp on/offset while open symbols represent data resulting from gradual on/offset. Gratings were stationary. Observer W.S.

detection and discrimination anisotropies were similar at fast drift rates. This result confirms the data in Fig. 6 which showed that the motion discrimination oblique effect can be larger than that obtained for detection.

As a further test of the effect of temporal transients on the oblique effect, an additional experiment was performed. Detection thresholds were measured for two second presentations of gratings which were switched on and off in two different ways. One method employed a sharp rectangular pulse which produced a highly transient on–off. The second method was to switch the grating on and off with a gradual cosine temporal envelope. Based on the inferences drawn by Camisa *et al.*, it would be expected that the gradual on and offset would (1) lower the spatial frequency at which the oblique effect would be obtained, and (2) increase its magnitude. The results, shown in Fig. 8, indicate that the presence of absence of sharp transients had little influence on the oblique effect. This is consistent with my previous demonstration that high rates of motion did not significantly alter the magnitude of the anisotropy.

Discussion

Sensitivities for both detection and discrimination were poorer with oblique gratings. The magnitude of the anisotropy was rougly equal for the two classes of threshold and was little affected by rate of temporal modulation. The data fail to support the view (Camisa *et al.*, 1977) that the oblique effect can dissociate sustained and transient mechanisms. These authors claimed that the oblique effect is restricted to the sustained system. However, I found that at 4.8 and 9.6 Hz (Fig. 7) direction of motion could be discriminated at threshold. Even though this suggests that detection was mediated by the transient system, a large oblique effect was still obtained. One is forced to conclude that the transient system does exhibit anisotropy or that at high spatial frequencies, motion is not processed by the sustained system.

The present data are not in good agreement with previous method of adjustment results which exhibited little or no flicker/motion anisotropy (Camisa *et al.*, 1977) or a flicker/motion anisotropy which was smaller than that obtained with pattern (Essock and Lehmkuhle, 1983). Moreover, these studies also reported that increasing rate of temporal modulation greatly decreased the oblique effect for both criteria. The difference between our data and those of previous studies is not likely due to individual observer differences since one subject (E.E.) served in Essock and Lehmkuhle (1983) as well as here. In addition to psychophysical method, previous studies also differed from ours in the use of counterphase flickering rather than drifting gratings. It is not obvious which, if either, of these differences can account for the disparity in data. Levinson and Sekuler (1980) and Ball and Sekuler (1980) also failed to find evidence of motion anisotropy in an isotropic dot display. Their failure may have been due to the fact that individual dots contain low spatial frequencies, which do not typically exhibit anisotropy. Another possibility is that motion oblique effects are only found in stimuli which possess a well-defined orientation. This would suggest a connection between form and motion detecting mechanisms. Ball and Sekuler (1980) found an oblique effect for direction discrimination of highly suprathreshold dots. Whether this is due to visual factors or the use of gravitation cues is not clear.

Experiment 3. *Retinal locus*

In the third experiment, I investigated the effect of retinal locus on detection and discrimination of a drifting 3.5 c/deg grating presented for 500 msec. Figure 9 shows absolute sensitivities for observer W.S. who fixated at or below the midline of the display. For all three temporal frequencies, performance in both detection and discrimination declined monotonically with increasing eccentricity. The slow 0.6 Hz temporal frequency resulted in better detection than discrimination at all eccentricities. When fixation was 6° or less from the center of the screen, the 1.2 Hz rate produced a small superiority of detection while detection and dicrimination were the same at 4.8 Hz. Curves diverged at greater eccentricity, however, due to a relative loss of motion sensitivity.

Ratios of detection to discrimination are shown in Fig. 10. The ratios obtained with central viewing change little as fixation is moved a few degrees away from the target. This was true whether discrimination thresholds greatly exceed those for detection (0.6 Hz = 0.17 sec^{-1}) or direction could be discriminated at detection threshold (4.8 Hz = 1.37° sec^{-1}). At more eccentric locations, however, the ratio begins to climb steeply, indicating that left/right sensitivity decreases faster than detection sensitivity. The loss of notion sensitivity with eccenticity is remarkably rapid. Each curve was run to the maximum eccentricity at which direction could be discriminated. With observer D.G. in the 4.8 Hz condition, for example, detection and discrimination thresholds

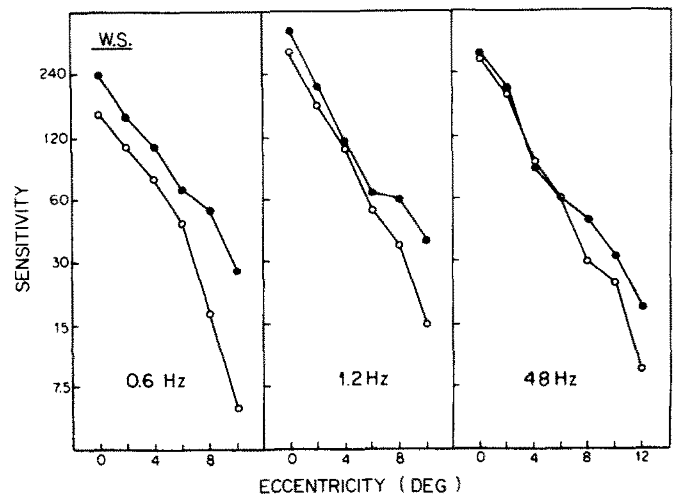

Fig. 9. Contrast sensitivity as a function of retinal eccentricity for three different temporal frequencies. Gratings were exposed for 500 msec and had a spatial frequency of 3.5 c/deg. Observer W.S.

were similar at 10°, but at 14° direction could not be discriminated even at maximum contrast (50%).

Discussion

My finding that contrast sensitivity decreases with greater retinal eccentricity is hardly surprising. Previous studies have shown that visual performance is poorer in a number of tasks when the peripheral retina is stimulated. Both contrast thresholds for stationary (Hilz and Cavonius, 1974) and drifting gratings (Sharpe, 1974), as well as motion thresholds as defined by liminal velocity (Aubert, 1886; Leibowitz *et al.*, 1972; Tynan and Sekuler, 1982) are higher in the periphery. While both detection and discrimination are disrupted by eccentric viewing, it is clear from my results that motion sensitivity was impaired more. This result appears to refute the notion (Exner, 1875; Granit, 1930; Sharpe, 1974) that the periphery is specialized for motion perception.

Data from other studies also support the view that motion/flicker sensitivity falls rather quickly in the periphery. Harris (1980) compared pattern and flicker thresholds with central and 5° eccentric fixation. The velocity required to obtain equal sensitivities for flicker and pattern was 1° sec^{-1} in the fovea and over 4° sec^{-1} in the periphery. Virsu and Rovamo (1979) obtained thresholds for left/right discrimination and detection at various eccentricities but only one velocity. The results from this experiment are difficult to relate with mine because the data were not analyzed to directly compare detection and motion thresholds. By picking off points from different graphs (Fig. 2A and C), it is possible to make a rough estimation of detection–discrimination ratios. Virsu and Rovamo's results are extremely noisy, with several seemingly impossible instances where motion sensitivity exceeds detection by a wide margin. Overall, however, the general trend is for discrimination performance to fall relative to detection as retinal locus is more eccentric. However, other data suggest that under some conditions the periphery may be as good as the central field in motion perception. Tynan and Sekuler (1982) found that the apparent speed of moving dots was lower in the periphery only when low velocities were used. At high velocities, apparent speed was independent of retinal locus. Presumably, the effect of retinal locus was found in the present study because only low velocities were employed. Low and high velocities may be coded by different mechanisms (Green, 1982a).

The apparent contradiction between my results and the many anecdotal reports of superior peripheral motion sensitivity might also be explained by Troxler fading. Prolonged steady viewing of a visual scene may result in objects fading from view, especially in the peripheral field. Fading can be prevented and faded objects returned to view by temporal modulation of the target. Motion would then appear to be a highly salient visual cue. When a target is viewed for a very short time, as in my experiment, fading does

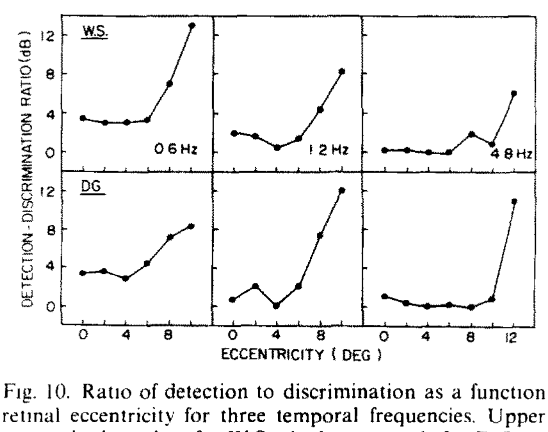

Fig. 10. Ratio of detection to discrimination as a function retinal eccentricity for three temporal frequencies. Upper panels show data for W.S., the lower panels for D.G.

not have time to occur so that target motion is relatively less important. Under these conditions, motion perception in the periphery might be limited by some factor such as "cortical magnification" (Rovamo *et al.*, 1978).

CONCLUDING REMARKS

Previous authors (Keesey, 1972; Tolhurst, 1973; Kulikowski and Tolhurst, 1973) have asserted that the human visual system contains one mechanism (the transient system) which signals flicker/motion but no distinct form information while a second mechanism (the sustained system) codes pattern but cannot signal motion. Moreover, it has been suggested that these systems differ in that (1) the transient system is tuned to lower spatial frequencies (Tolhurst, 1973; Kulikowski and Tolhurst, 1972), (2) the sustained but not transient system exhibits retinal anisotropy (Camisa *et al.*, 1977), and (3) that the transient system is relatively more sensitive in the periphery (Breitmeyer and Ganz, 1976). I found no evidence to support the validity of any of these three proposed differences between motion and pattern processing. My results showed that (1) when velocity rather than temporal frequency is the motion parameter, there was no special sensitivity to motion at low spatial frequencies, (2) comparison of vertical and oblique gratings revealed similar anisotropies for detection and discrimination, and (3) peripheral stimulation produced relatively *poorer* sensitivity to motion.

I do not take these results to necessarily suggest that the sustained-transient dichotomy itself is invalid. Evidence in favor of the dichotomy has been found in experiments employing spatial frequency masking (Legge, 1978), subthreshold summation (Wilson, 1980), detection of on-off and counterphase flickering gratings (Kulikowski, 1971) and uniform field flicker adaptation (Green, 1981) and masking (Green, 1982a, 1982b). Rather than totally discarding the idea of separate sustained and transient mechanisms, the dichotomy might be retained by supposing that either system can detect motion. Several authors (Exner, 1875; Leibowitz, 1955; Tyler and Torres, 1972; Anstis, 1978) have suggested that the human system contains two distinct mechanisms for motion detection. One operates at high velocities and "directly" senses motion without processing form while the second responds to slower motion and "infers" motion from change in the position of form. It has been suggested (Bonnet, 1977; see also Kulikowski, 1978) that these correspond to sustained and transient motion detection processes. In the present experiment, I may have failed to find evidence of a dichotomy because of the relatively low velocities employed. As a result, only the sustained-like mechanism was studied.

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