1977

Reduced stereopsis due to binocular masking

Robert J. Olin
Pacific University

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Abstract

Reduced stereopsis due to binocular masking

Degree Type

Thesis

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Master of Science in Vision Science

Committee Chair

Clifton M. Schor

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Optometry

REDUCED STEREOPSIS
DUE TO
BINOCULAR MASKING

By

Robert J. Olin

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Approved by

Clifton Schor

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INTRODUCTION

The phenomenon of depth perception arises from many aspects of sensory information in the form of monocular and binocular clues. Of the three binocular clues to depth at the near distance, namely stereopsis, vergence, and correlative accomodation, stereopsis is by far the strongest. Stereopsis is based on the geometrical fact that objects ahead or behind the fixation point have images that fall on non-corresponding retinal areas in the two eyes. This horizontal shift between corresponding points in the retinal images is referred to as retinal disparity. The terms binocular parallax, binocular shift, or disparity apply equally. The discovery of the stereoscope by Wheatstone (1838) first demonstrated the phenomenon of stereopsis arising from retinal disparity. As early as 1841, Dove, using exposures too brief to initiate convergence movements, demonstrated stereopsis resulting from disparity alone.

Stereopsis is a relative cue to depth discriminations and allows us to rank the order of near and far objects around a fixation point. Stereo-acuity (the smallest discernible difference in binocular parallax) varies generally as does monocular visual acuity (Ogle, 1950; Richards and Foley, 1971). The area of greatest sensitivity is within the macula where correct judgements of within two seconds of arc can be made (Anderson and Weymouth, 1923). As does visual acuity, stereo-acuity is reduced considerably in the peripheral retina (Blakemore, 1970). When the disparities are within Panum's fusional area the disparate points are seen as a single fused image in depth. Fusion is not a prerequisite, however, because diplopic images beyond Panum's fusional area can also be seen in depth (Ogle, 1952). Stereopsis can also occur without simultaneous presentation of the right and left views. Stereopsis with interstimulas intervals of up to 100 ms has been reported by Ogle (1963).

Conclusive evidence is not final, but stereopsis appears to be an inherited trait of autosomal dominant variety (Richards, 1970). Recent studies (Richards, 1970,1971) have shown a surprising number of individuals with normal visual acuity and binocular fusion seem to lack normal stereopsis. The investigation reported 15% of the 150 random subjects tested had some form of stereo-anomaly. Most of these individuals fell into two groups, namely those who were unable to make crossed disparity discriminations, and those who were unable to detect uncrossed disparities. The rest of the remaining stereo-anomalous observers appreciated the differences in relative magnitude, but failed to distinguish if disparity was crossed or uncrossed. Further investigations led

Richards to believe there are three independent pools of disparity detectors that are each individually inherited. These " pools " would correspond to crossed, uncrossed, and zero disparity sensory systems that are lacking in the discrete types of observed stereo-anomalies.

Stereo-blind individuals are not normally picked up on standard tests for stereopsis because these tests include other cues to stereopsis than disparity alone (Jones,1972). Richards testing procedure involved flashing disparities for only 80 ms to avoid disjunctive eye movements rather than allowing continuous viewing. The utilization of eye movements can allow stereo-anomalous individuals to pass standard stereo tests. Stereo-anomalies are not only a phenomenon of short duration stimuli however. Richards (1970) has developed Julesz-type random dot cards which stereo-anomalous observers are unable to pass. These cards do not possess any monocular cues and stereoscopic responses cannot be faked.

Even if an individual is blessed with all types or " pools " of disparity detectors, ultimate stereopsis is achieved only with sufficient stimulation of the visual cortex (Julesz, 1971). Work by Barlow, Blakemore and Pettigrew (1967) established a class of binocularly driven cortical units in area 17 of the cat that respond maximally for specified disparity values. Evidence submitted by Blakemore (1960) showed conplementary cortical organization of binocular neurons of each eye corresponding to a single line of gaze. Work reported by Hubel and Wiesel (1970) showed evidence of binocular depth cells in area 18 of the Macaque monkey cortex. Half of the cells in area 18 responded to anatomically corresponding points of the right and left retina. The remaining cells respond maximally when non corresponding (disparate) retinal areas are simultaneously stimulated. These binocular depth cells have very fine organization and only respond to specific disparities.

Studies of masking and metacontrast (Kahneman, 1968) show delay of information or differences in processing time can have a masking effect in the visual cortex. This masking has the effect of wiping out the perception of a visual event. In recent experiments (Merikle, Coltheart and Lowe, 1971; Lowe, 1975) results obtained indicated masking activity is different for central and peripheral areas of fixation, and also varies greatly with presentation time of the masking stimulas.

Assuming that transmission times of the two visual channals could be different due to anatomical length or processing time, it is also reasonable to assume masking at the cortical level could take place due to an asyncronous stimulation of binocular depth cells by the visual channals.

This masking of one visual channals information by the other could in effect prevent stereoscopic judgements and render the subject stereo-blind. This research is undertaken to confirm the psychophysical findings of Richards (1970,1971) and to investigate the possibility that stereo-blindness may be due to unequal transmission times of the two visual channals.

EXPERIMENTAL METHOD

Random dot stereograms are used initially to identify subjects with absent or reduced stereoscopic vision, (see figs. 1, 2a and 2b). The testing stereograms and technique of Julesz (1971) were utilized to reveal stereo-blindness and stereopsis deficiency. Random dot stereograms were used because they provide a very pure test for stereopsis in the absence of monocular depth cues present in many other clinical tests for stereopsis (Frisby, Mein, Saye, and Stanworth, 1975).

Pulsed vertical lines were delivered independently to each eye with the use of a Keystone backlighted stereoviewer. The inside lighting was removed and replaced with disparity variable vertical line masks $\frac{1}{4}^{\circ}$ wide and 2° high. Each mask was illuminated by a row of light emitting diodes (L.E.D.s). The variable line disparities were encased behind an opaque white glass screen containing a fixation reticule (see fig. 3). The vertical lines were only visible when the L.E.D.s were activated.

The subject was corrected for his phoric or tropic posture and instructed to fixate the center of the reticule. Random vertical line stimuli were delivered with crossed, uncrossed, and zero disparity in a pulsed fashion lasting

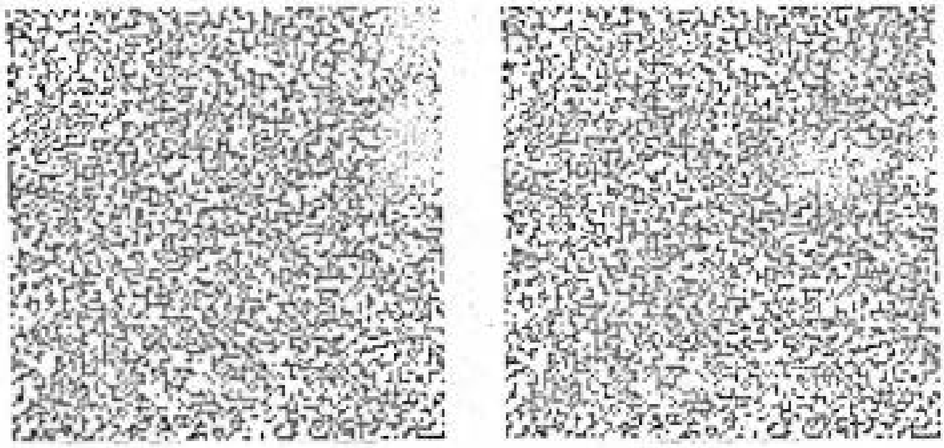
Fig. 1 Julesz test figures for stereopsis

A. Square

B. Cross

C. Diamond

D. Disk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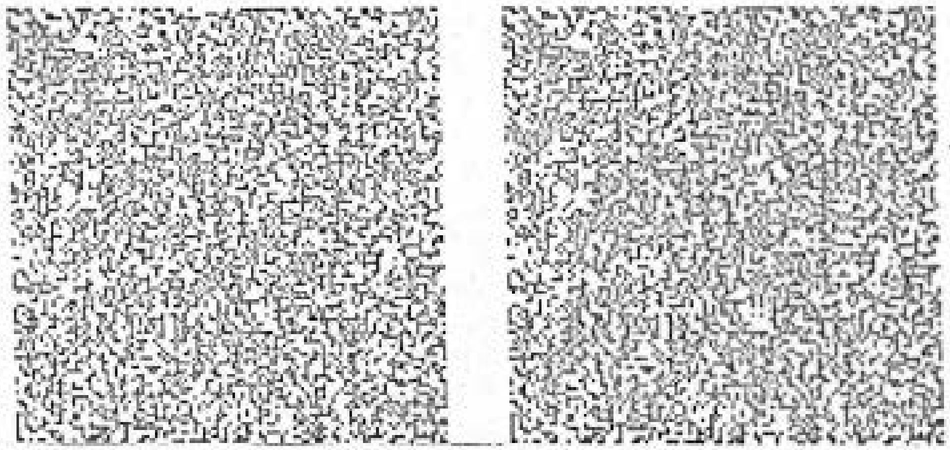
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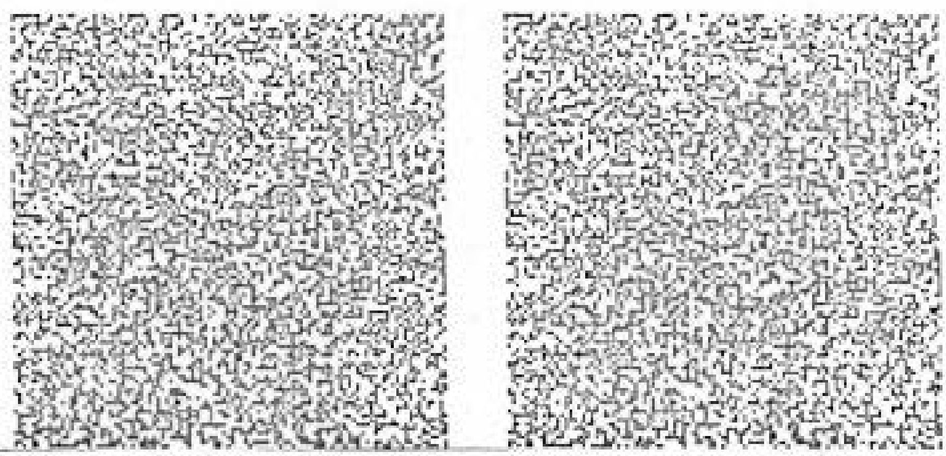
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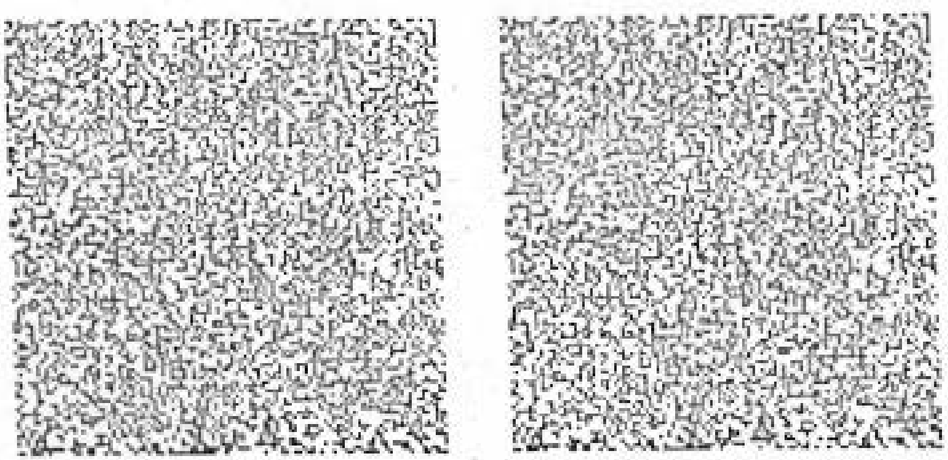

D

Fig. 2a,b Julesz test figures for stereopsis with diminished binocular correlation.

A. 100% intact

B. 90% intact

C. 80% intact

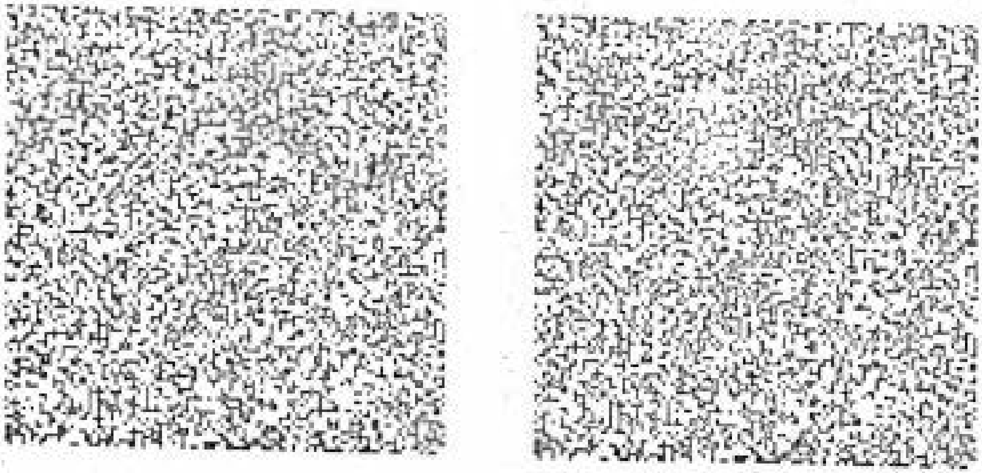
D. 70% intact

E. 60% intact

F. 50% intact

G. 40% intact

Used for quantification of stereopsis loss.



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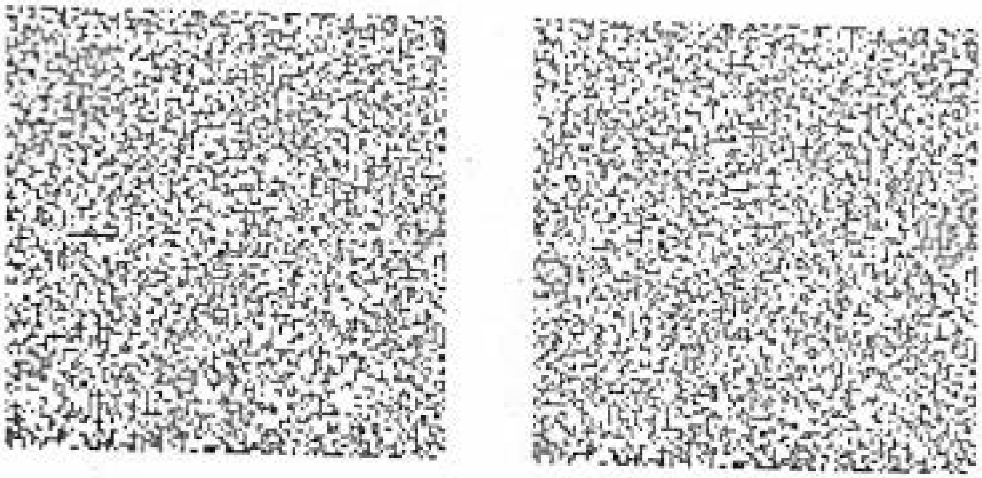

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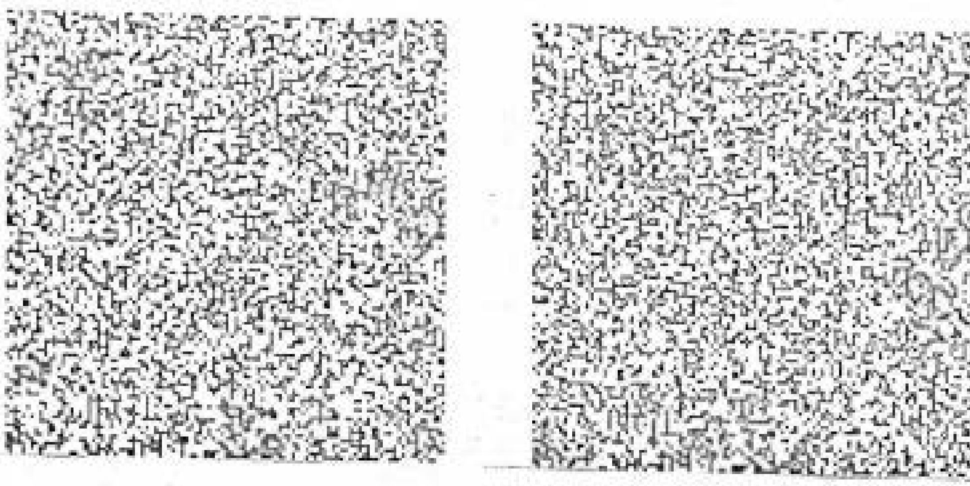

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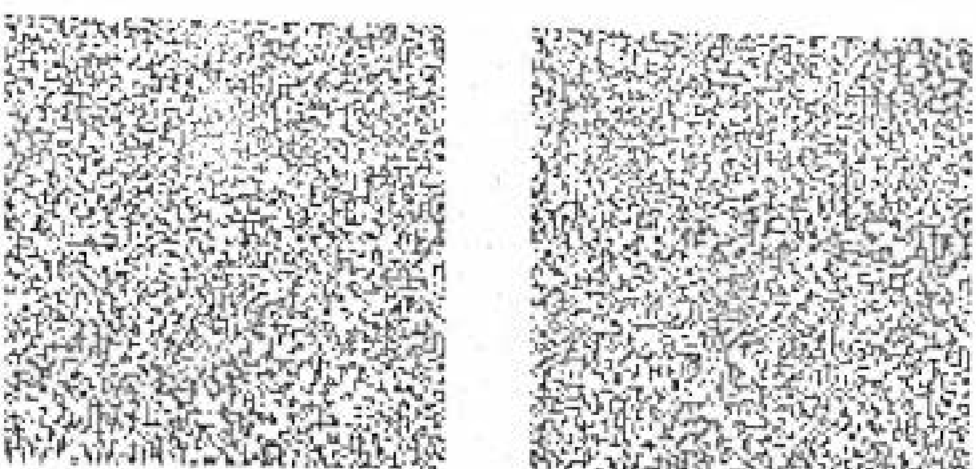

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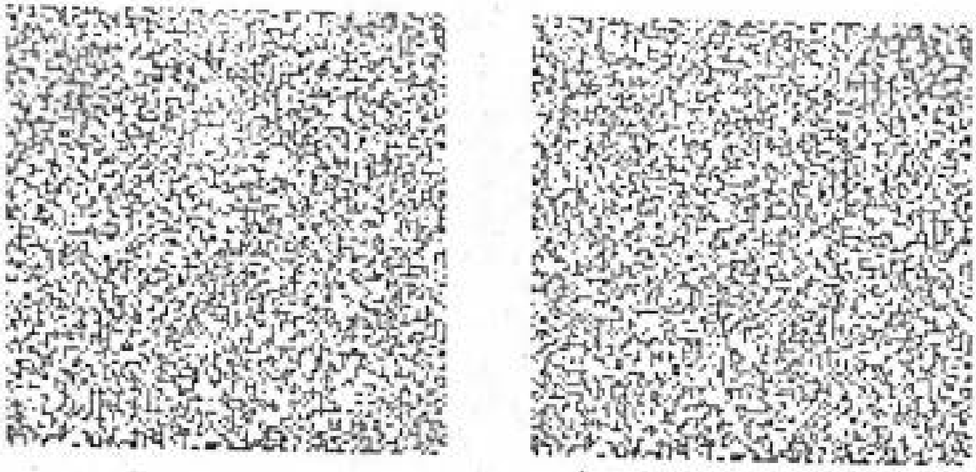

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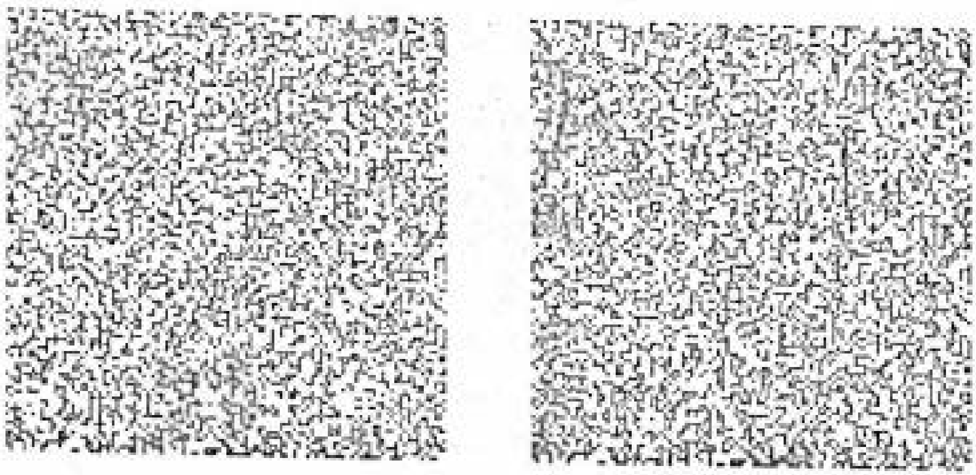

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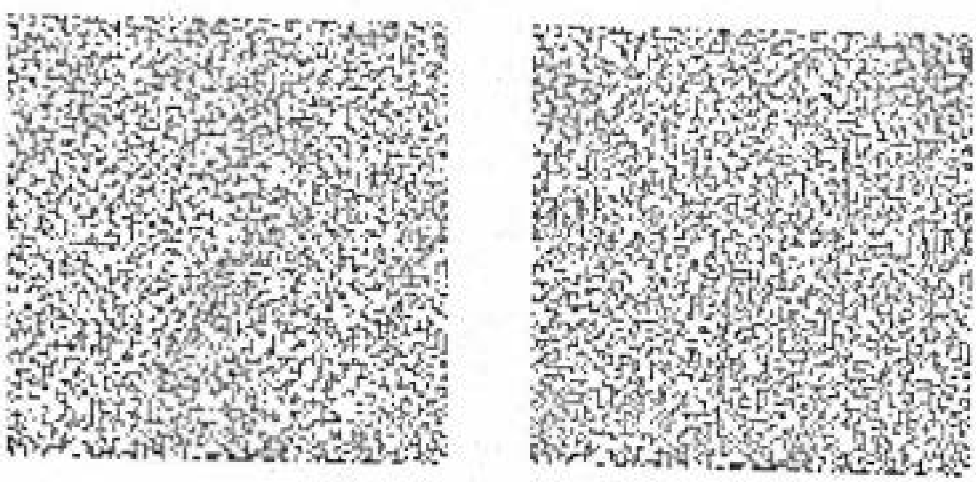
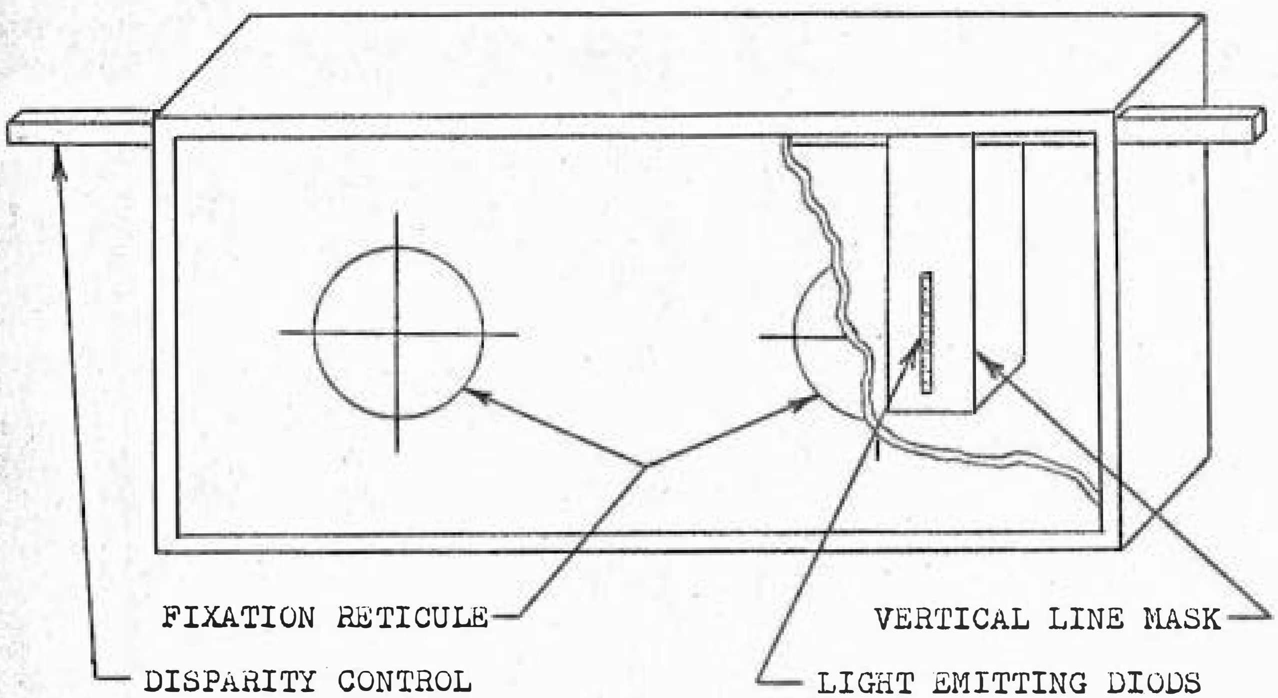


G

Fig. 3 Schematic of variable disparity apparatus


FIXATION RETICULE
VERTICAL LINE MASK
DISPARITY CONTROL
LIGHT EMITTING DIODS

80 ms. The subjects task was to report the disparity of the stimulas relative to the fixation plane as in front, behind, or on the plane. Stimuli were presented to the subject approximately every 10 seconds by means of a toggle switch controlled by the subject. A minimum of 75 stimuli were presented to each subject in the first part of the investigation.

In the zero disparity (null) case, the stimulas of the two vertical lines was delivered to only one eye. The lines were symetrical about the fixation point and appeared essentially the same as the disparate stimuli. The separation of the lines in all three cases was randomly delivered in values of 1°, 2°, and 4°.

The second part of the experiment involved delivering asyncronous stimuli by delaying the stimulas to one eye. The time delay could be varied from 5 ms to 1,000 ms via electronic delay timers in each channal. The time delay utilized was 50 ms. The disparity values were 1° and 2°. This procedure was then repeated to the other eye. It is anticipated the asyncronous stimuli will provide an improvement in stereoscopic depth judgments for the anomalous observer.

Screening results from the random dot stereograms identified five subjects with reduced or absent stereoscopic vision. Further evaluation with pulsed vertical line disparities was undertaken and is reported here.

RESULTS

The results of the data from the five subjects are presented here in graphical form with the data separated into three distinct areas. The first two graphs in fig. 4a show the data of stimuli presented with equal time duration to each eye. The data in 4b shows a delay to the left visual channal, while fig. 4c shows a delay to the right visual channal. In all cases, the top graph on each page represents the ratio correct while the bottom graph represents the frequency of response in each catagory (in front, on the plane, and behind). The number of stimuli in each disparity case and each null case was the same in order to statistically evaluate the results. The monocular or null stimuli are plotted as zero in the graphs because they do not contain any disparity information.

The method used for calculating the ratio correct is simular to that used by Richards (1971). This involves totaling the number of identical responses to stimuli having the same spatial separation, and determining the ratio that were in fact correct. For example, subject M. O. (fig. 4a) gave 8 correct behind responses to the 4° uncrossed disparity. The subject also indicated 1 incorrect behind response to the crossed 4° disparity

Fig 4 Response data of M.O.

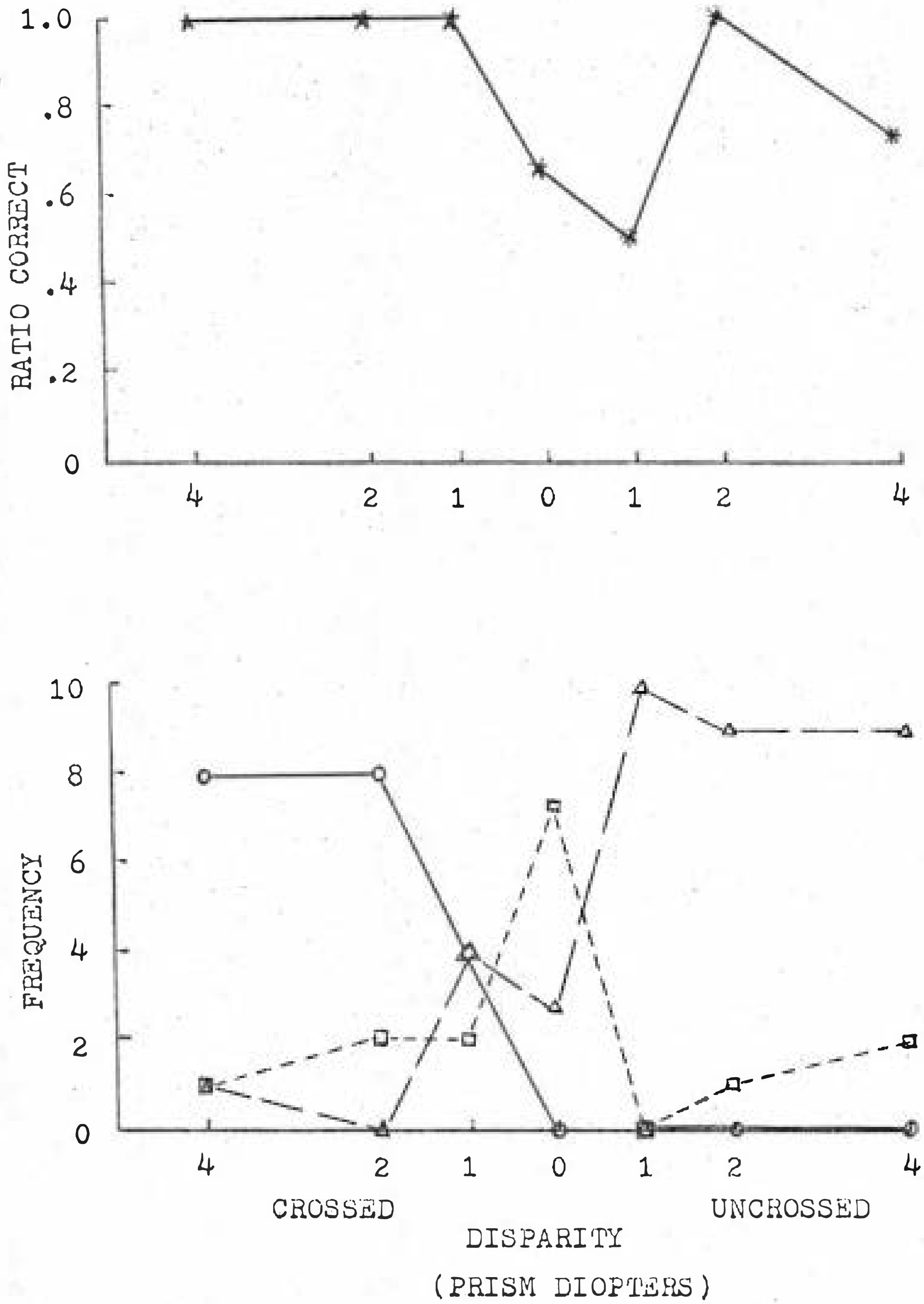
Fig. A Syncronous stimuli

Fig. B Left delay

Fig. C Right delay

In the lower graph in each figure, the open circles represent " in front"; the squares represent " on the plane "; and the triangles represent " behind" responses.

Fig. A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RATIO CORRECT
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FREQUENCY
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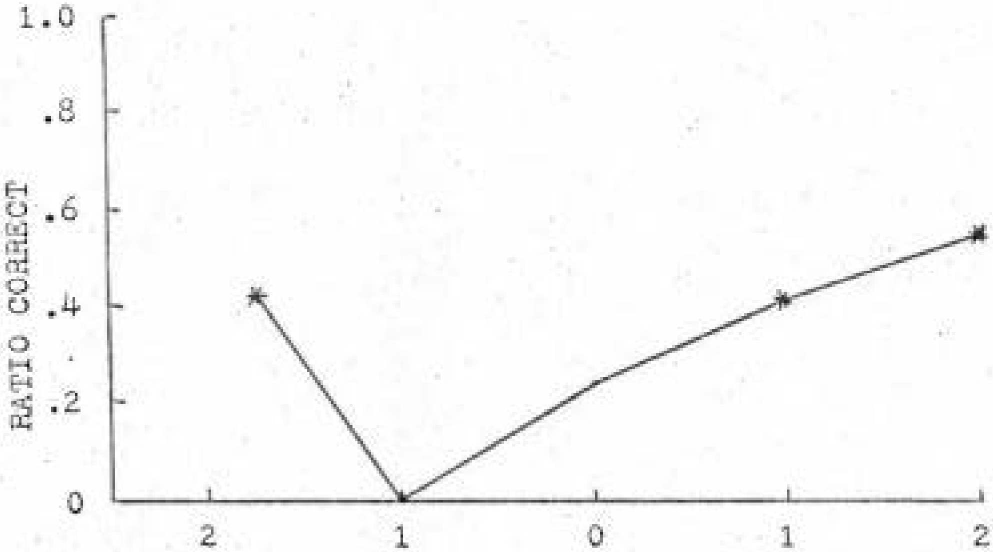
CROSSED
UNCROSSED
DISPARITY
(PRISM DIOPTERS)

Fig. B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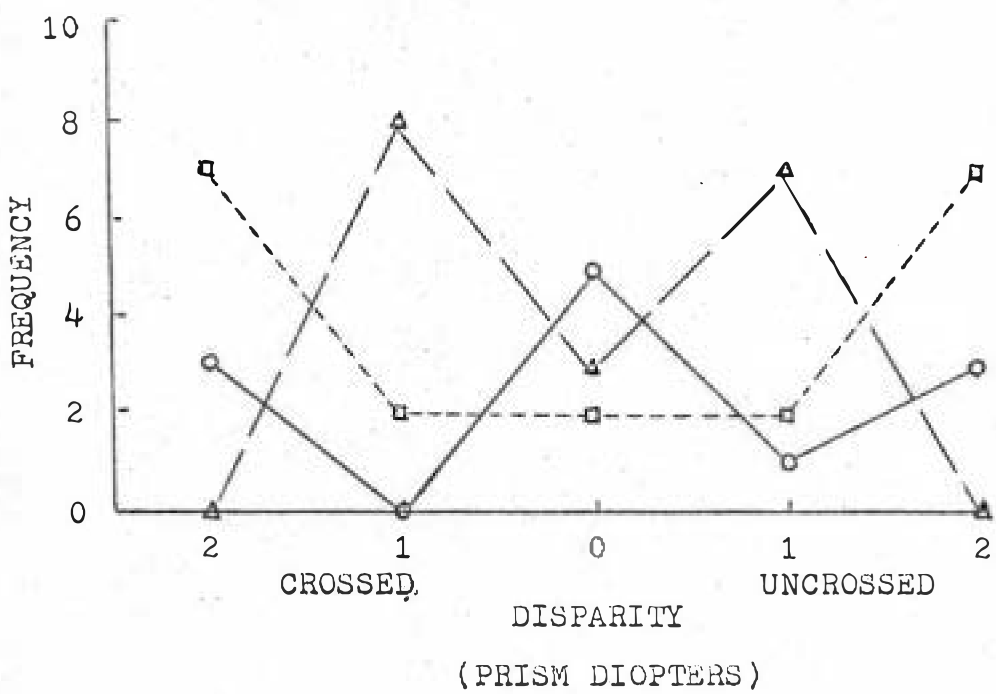
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DISPARITY
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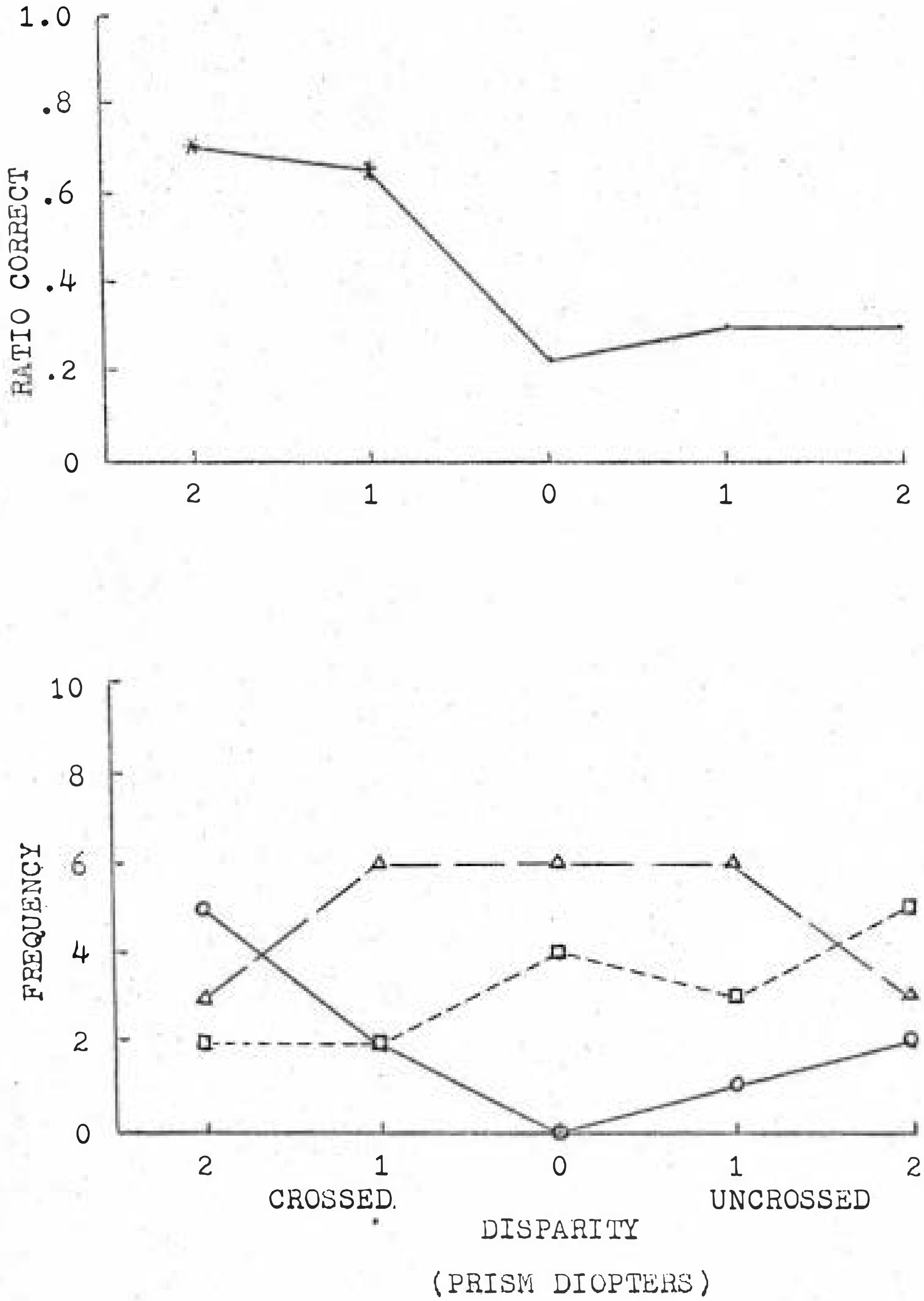
Fig. C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DISPARITY
(PRISM DIOPTERS)

and 2 behind response to the zero disparity (null) case. The ratio correct for the 4 uncrossed disparity would therefor be;

$$\frac{8}{8 + 1 + 2} = .73$$

The ratio correct is somewhat different from the classical version, in that it allows each stimulas condition to be assessed more acurately. For instance, if the subject had reported behind for all stimulas conditions, the classical measure would score 100% correct for the uncrossed disparities. In fact, the subject has not made a relative depth discrimination, but the classical measure shows high discrimination for uncrossed disparities. The modified measure determines the subjects ability to pair the uncrossed responses to the actual uncrossed disparity. In the case where the subject always reported behind for all stimulas conditions, the ratio correct would be only .33 or 33%. This is the chance level in a three-alternative forced choice situation.

The ratio correct was statistically compared to the .33 level of chance utilizing the binomial distribution. Those points on the graph which were deemed significant at the 99% level of confidence are indicated by a star.

Fig. 5 Response data of D.M.

Fig. A Syncronous stimuli

Fig. B Left channal delay

Fig. C Right channal delay

Fig. A

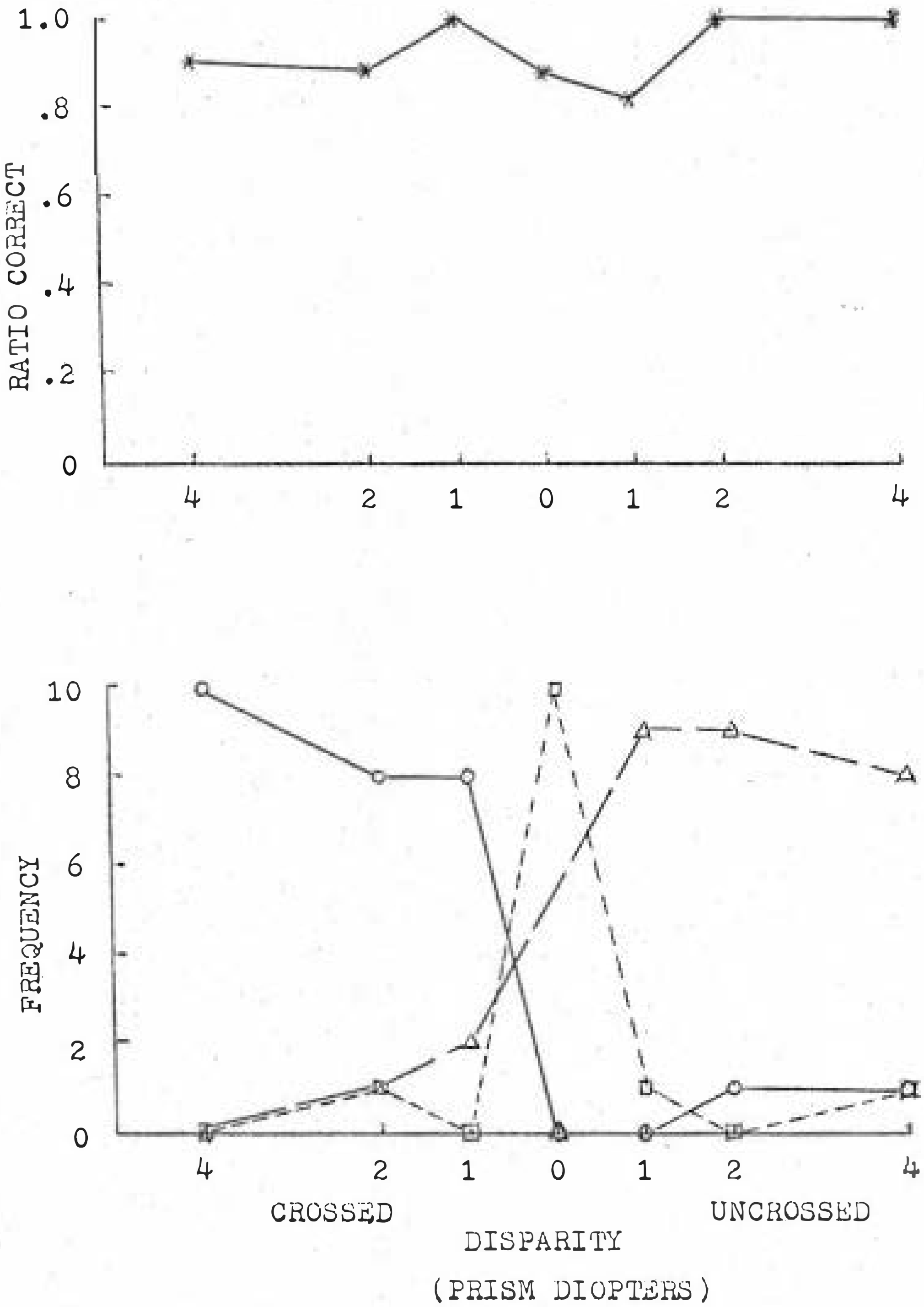
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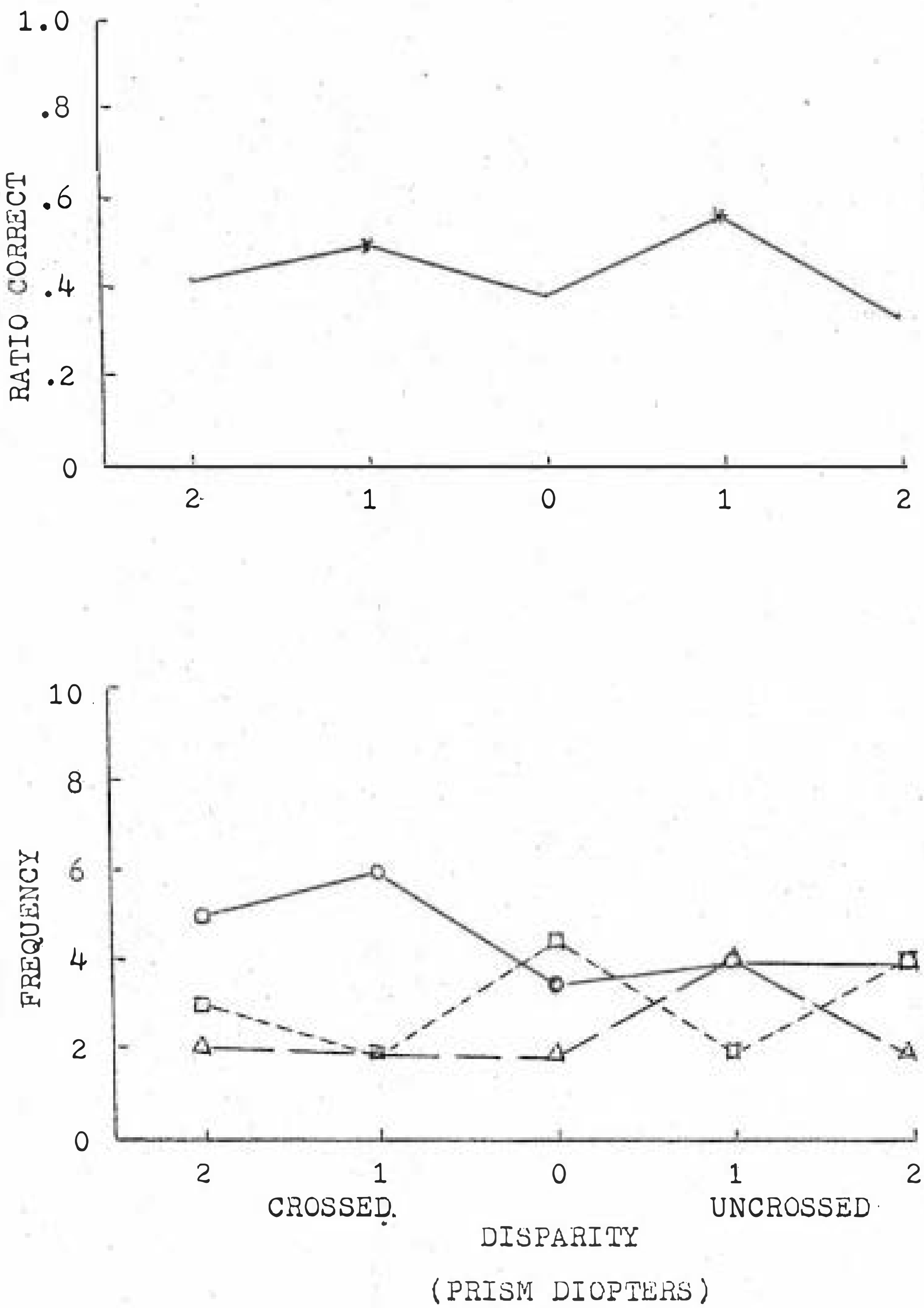
Fig. B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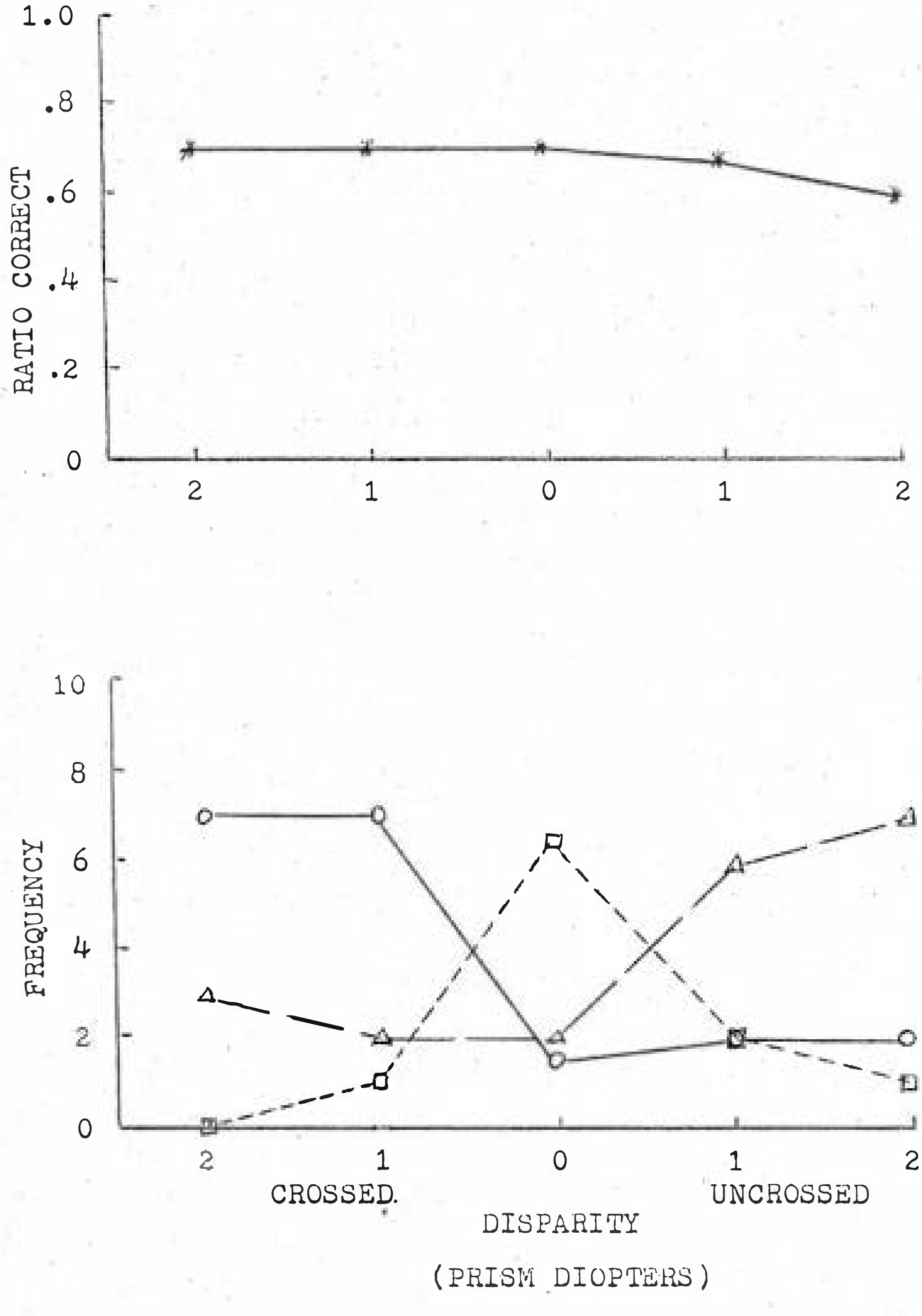
DISPARITY
(PRISM DIOPTERS)

Fig. C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DISPARITY
(PRISM DIOPTERS)

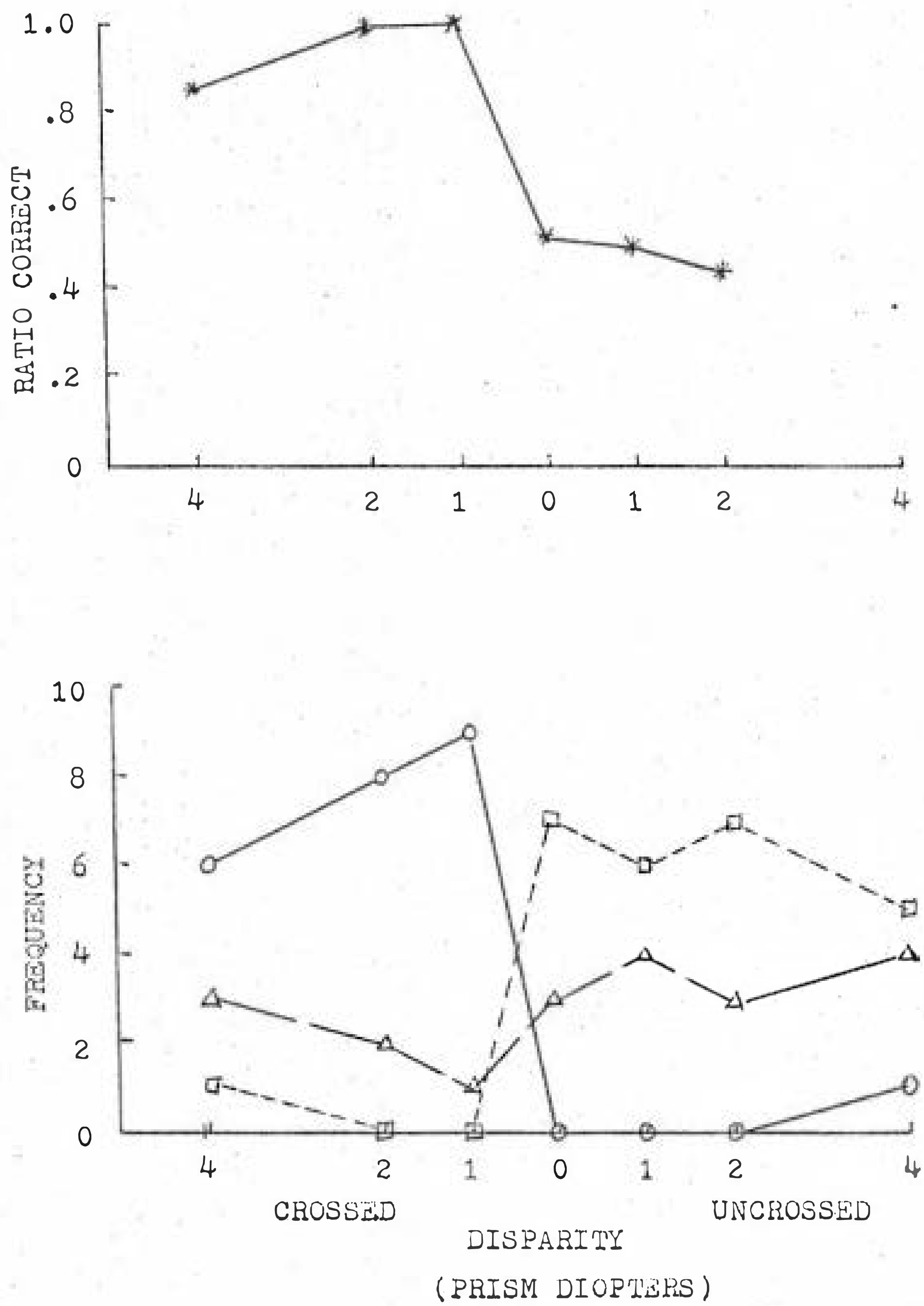
Fig. 6 Response data of G.S.

Fig. A Syncronous stimuli

Fig. B Left channal delay

Fig. C Right channal delay

Fig. A



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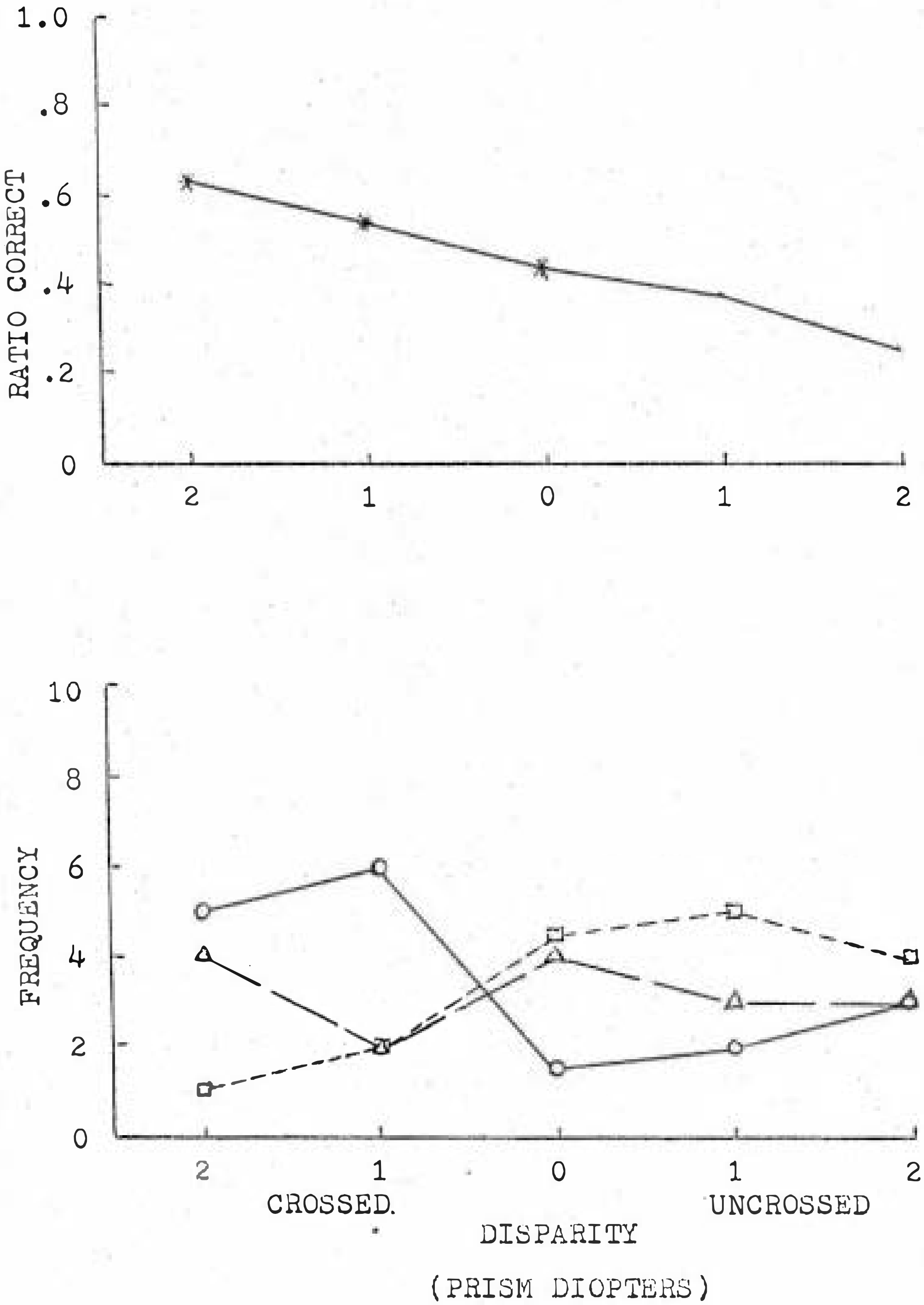
DISPARITY
(PRISM DIOPTERS)

Fig. B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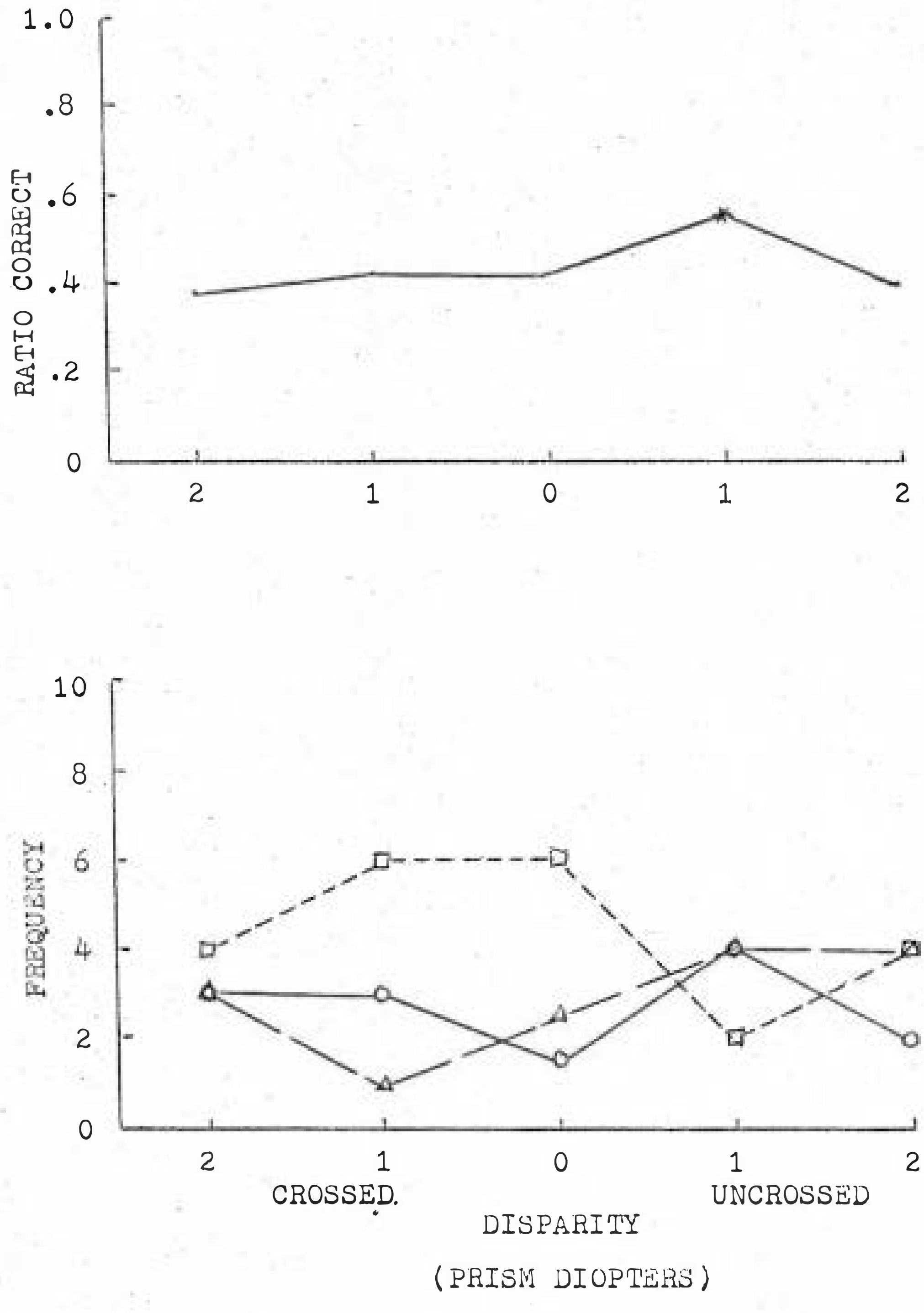
(PRISM DIOPTERS)

Fig. C



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UNCROSSED
DISPARITY
(PRISM DIOPTERS)

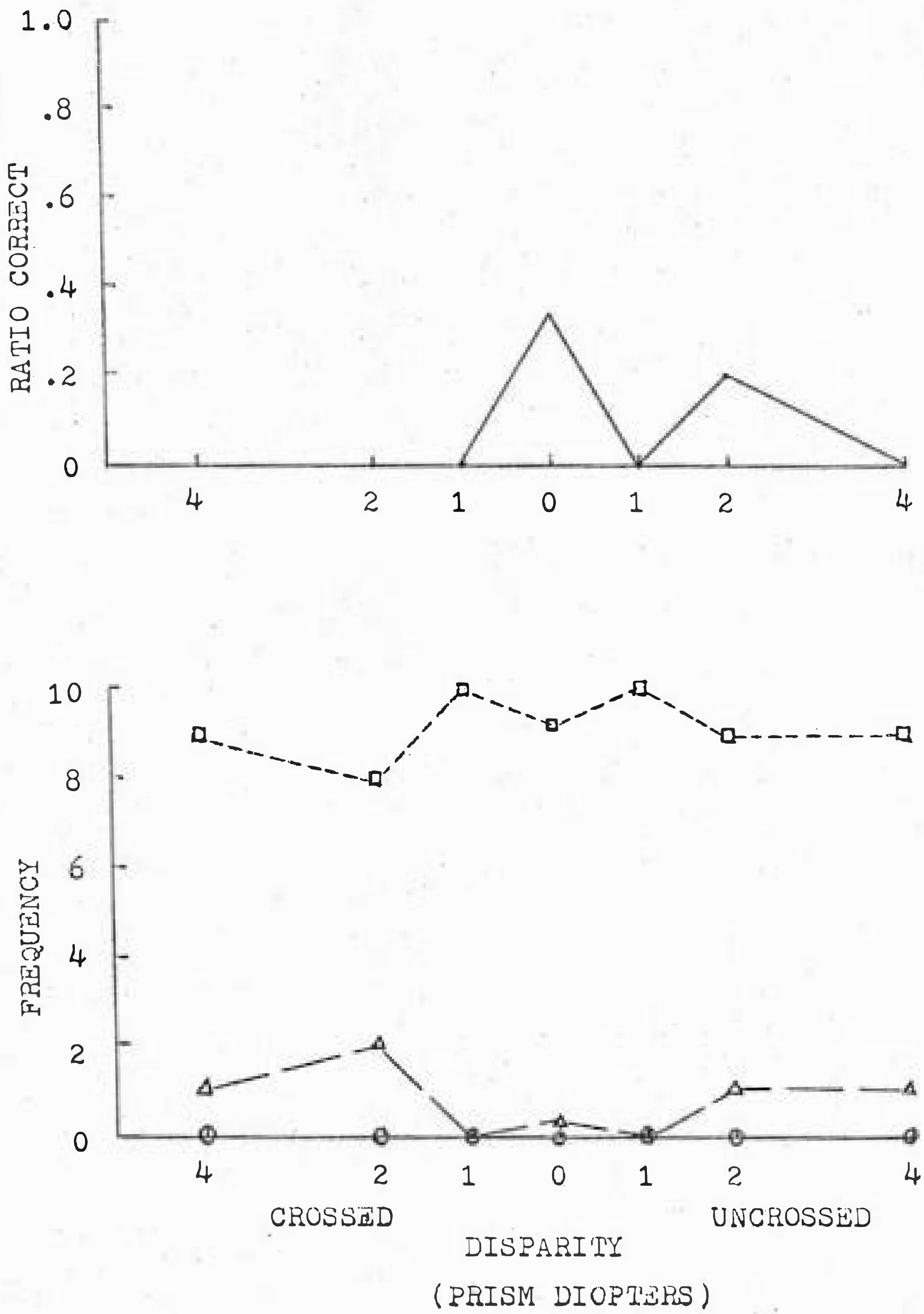
Fig. 7 Response data of P.S.

Fig. A Syncronous stimuli

Fig. B Left channal delay

Fig. C Right channal delay

Fig. A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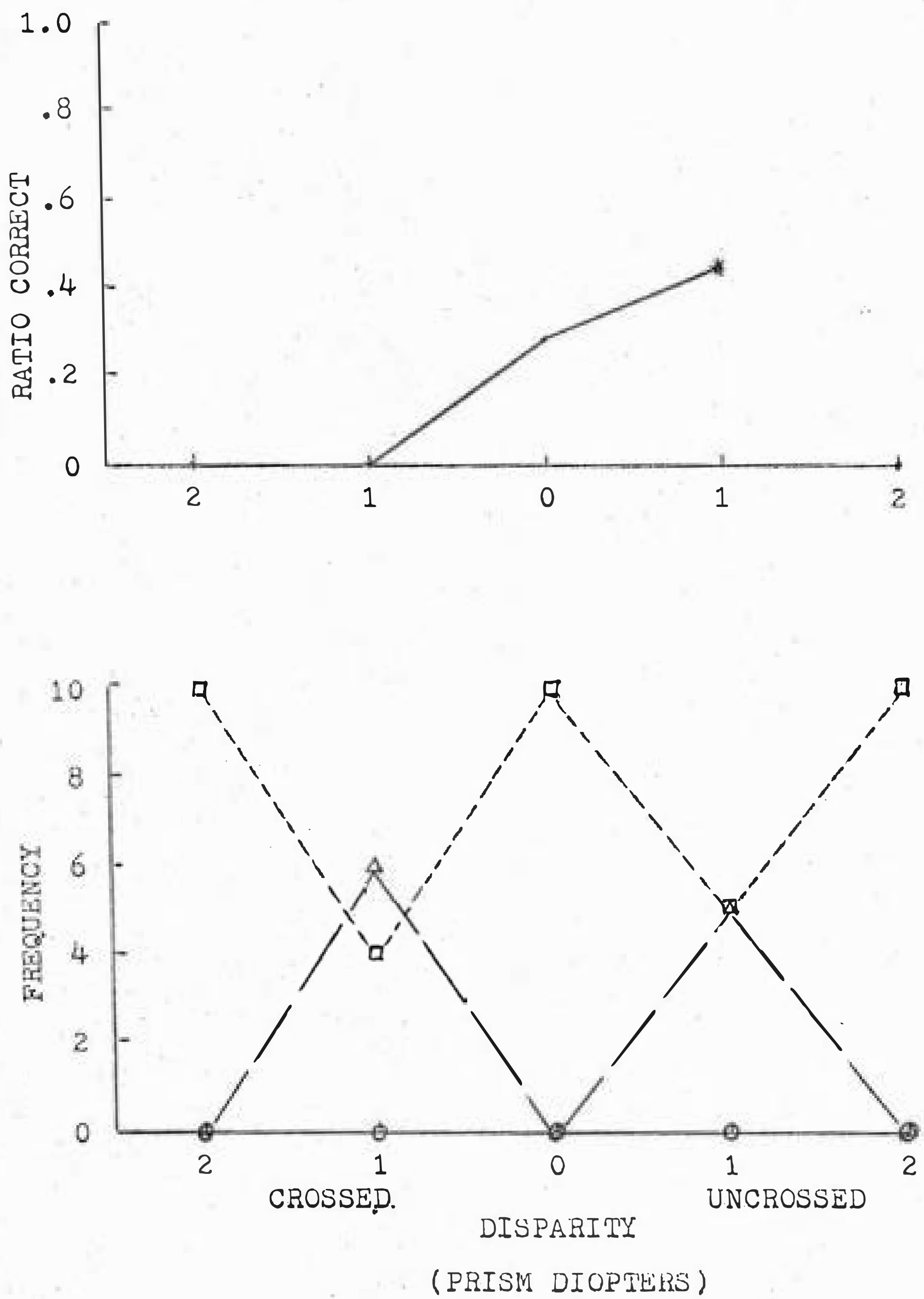
DISPARITY
(PRISM DIOPTERS)

Fig. B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DISPARITY
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Fig. C

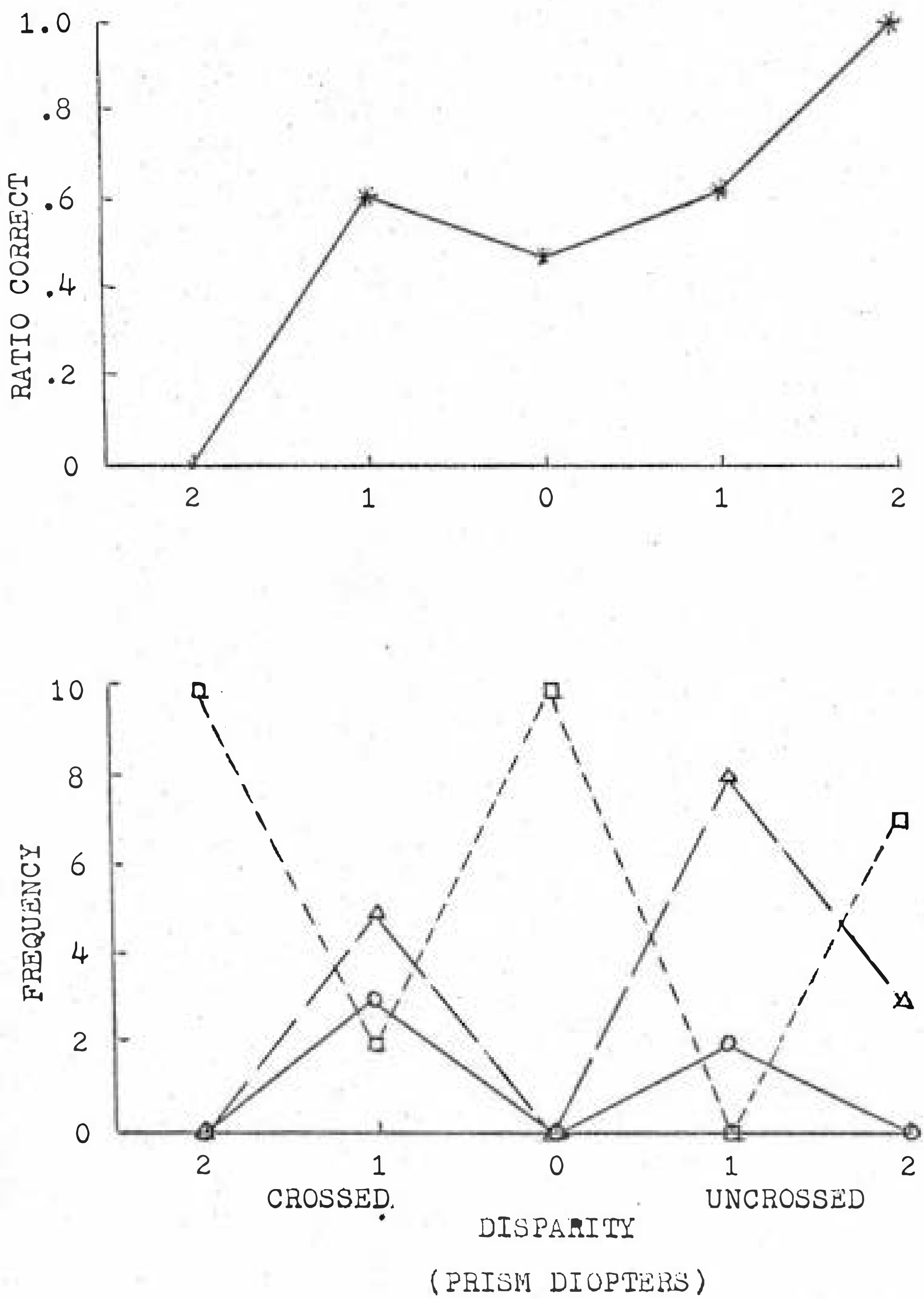
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Fig. 8 Response data of R.E.

Fig. A Syncronous stimuli

Fig. B Left channal delay

Fig. C Right channal delay

Fig. A

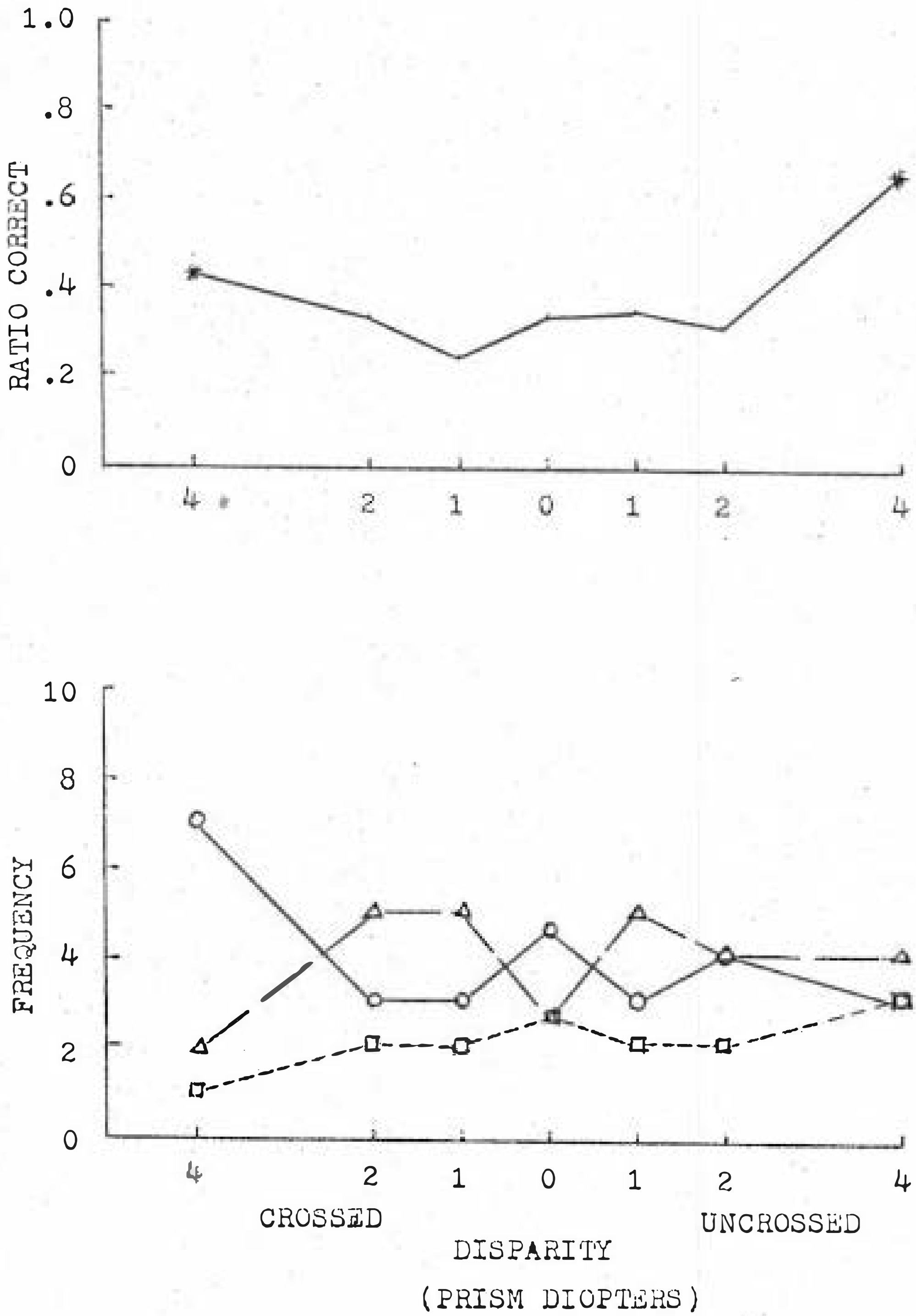
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Fig. B

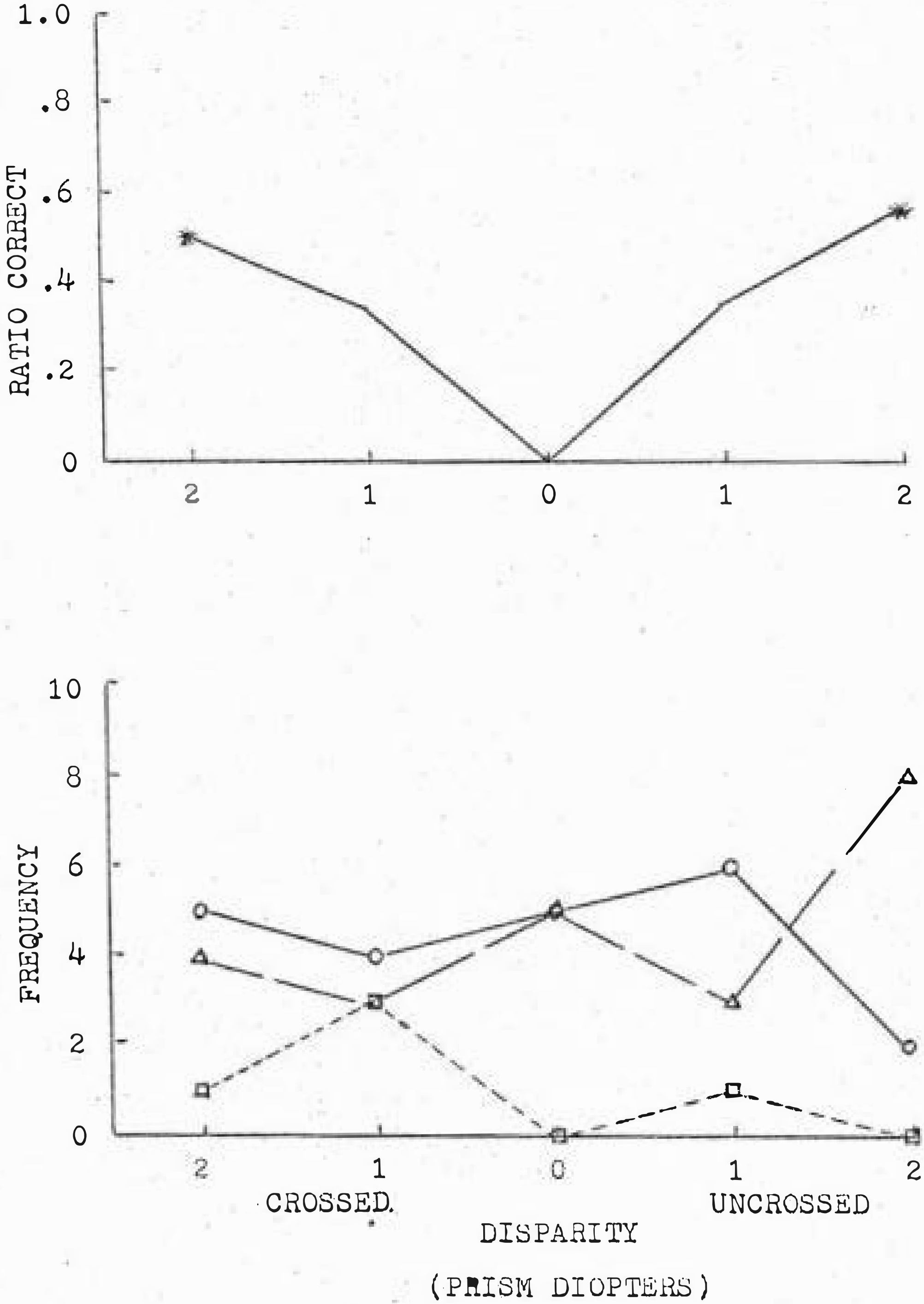
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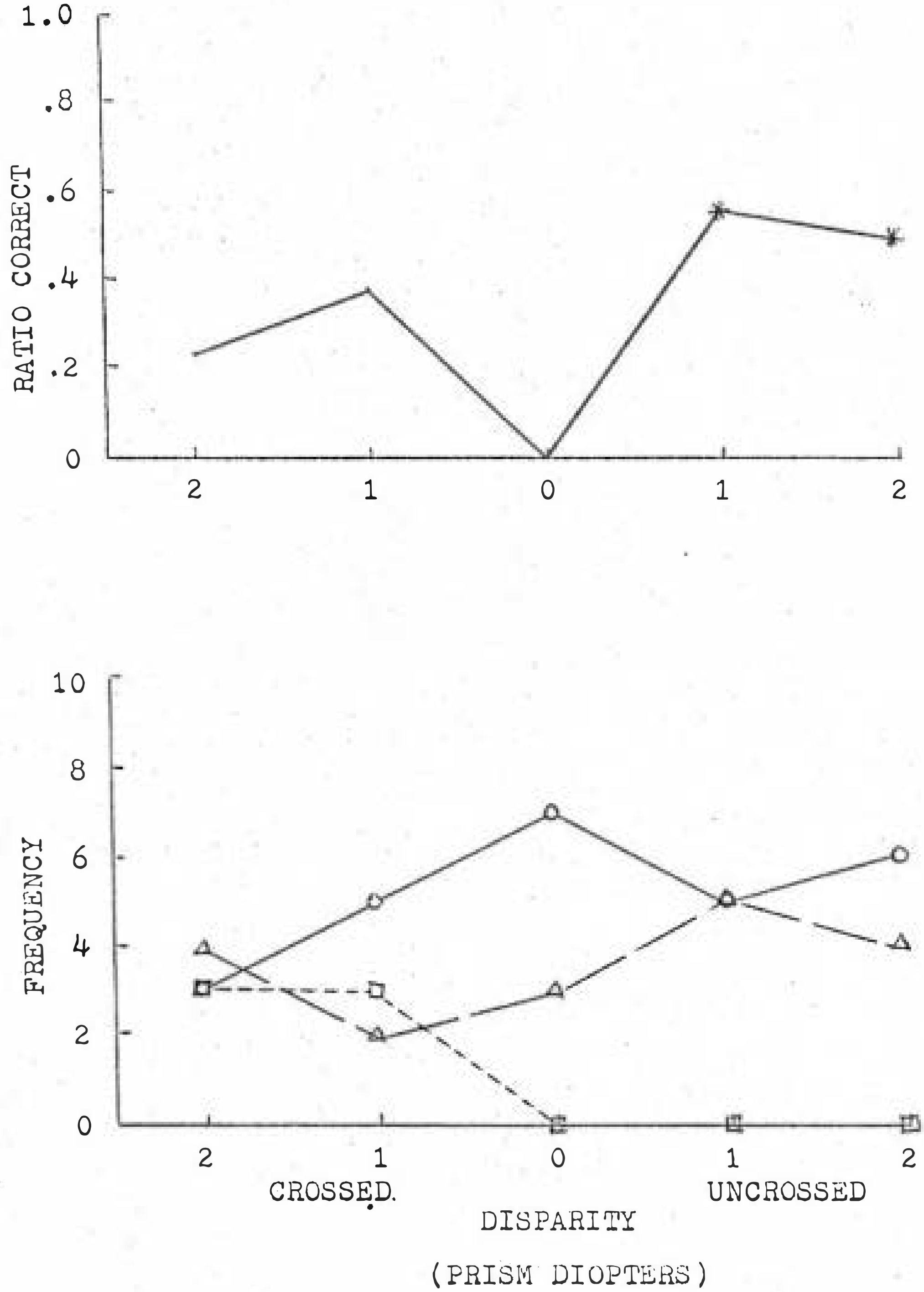
Fig. C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SUMMARY AND CONCLUSIONS

Thirty-two subjects were screened with random dot stereograms to determine stereopsis deficiency or stereo blindness. Five subjects of this group went through further evaluation by the use of pulsed vertical line disparities. Two of the five were determined to have normal stereopsis by the random dot stereograms, but were included as normal subjects. The remaining three exhibited some form of stereopsis deficiency.

Only one stereo deficient subject showed a significant improvement in stereoscopic judgements with the use of an asyncroness stimulas. This subject responded with an average response ratio of 0.12 (well below chance) with simultanious stimuli, but with an asyncroness stimulas the average response ratio increased to 0.58 .

Data from the two normal subjects and one stereo deficient subject showed an asymetric loss in stereoscopic judgements. This loss was greatest when the stimulas to the non dominant eye was delayed.

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