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Relationship between central and peripheral visual tendencies and center of balance responses to yoked prism

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Abstract

Peripheral vision has been shown to help stabilize subjects on a balance task more than central vision. Lenses and prisms have been shown to affect a person's center of balance. A study by Jeske demonstrated significant shifts in center of balance upon the application of yoked prism. The question posed by this study is, " do subjects who tend to pay more attention to peripheral visual information respond differently to 12 prism diopters of vertically yoked prism than do those subjects who pay more attention to central visual information?" Replication of the results found by Jeske was also attempted. Subjects were 25 non-optometry students. The subject's tendency to pay attention to peripheral or central visual information was measured using a combination of the scores on a distance maddox rod phoria, peripheral visual response speed as measured by the Wayne Peripheral Awareness Tester and Trainer, and score on the rod and frame apparatus. The subject's center of balance response to vertically yoked prism was measured using the BALANCE SYSTEM: from the Chattecx corporation. It consists of a computerized balance platform from which footplates take rapid samples of percent of body weight shift based on an X-Y coordinate system. The X values quantified leftward or rightward center of balance position (X COB). The Y values quantified the forward or rearward center of balance positions (YCOB). Postural sway, dispersion, was also measured (PS). No significant differences were found between the prism conditions in the XCOB or PS analysis. Significant differences were seen in the YCOB variable when the base-down yoked prism condition was compared to the base"'UP prism condition. The central or peripheral processing characteristics did not show a significant relationship to YCOB response to yoked prism. Effects of refractive error and habitual standing posture on YCOB response to yoked prism was also measured. The myopes and the emmetropes responded significantly ($p < 0.05$) more to the base-up prism than did the hyperopes, and the hyperopes and emmetropes responded signiticantly ($p < 0.05$) more to the base-down yoked prism. Signiticant differences ($p<0.05$) between subjects with a forward habitual posture and those with a rearward habitual posture were found for the base-down and baseup conditions, as well as the post base-up condition. Jeske's study was only partially replicated. The center versus peripheral processing characteristics are not predictors of an individual's response to yoked prism. Better predictors of center of balance response to yoked prism are refractive error and habitual standing posture.

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RELATIONSHIP BETWEEN CENTRAL AND PERIPHERAL VISUAL TENDENCIES AND CENTER OF BALANCE RESPONSES TO YOKED PRISM

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About The Authors

Suzanne D. Scott grew up in Lake Oswego, Oregon. She graduated from Lakeridge High School in 1986 and then went to the University of Oregon, Eugene, Oregon to pursue a degree in General Science. She graduated with a Bachelors of Science in 1990. Suzanne spent the last two summers of college working for the Occupational Safety and Health Administration (OSHA) in Washington D.C. as a research assistant and industrial hygienist. She started optometry school in the fall of 1990 at Pacific University College of Optometry, Forest Grove, Oregon. While in optometry school, Suzanne was active in the local Student Optometric Association and the American Optometric Student Association. Suzanne will receive her doctorate of optometry degree on May 22, 1994. Her future plans include participating in a post-graduate residency in Vision Training at State University of New York.

Michael J. Glanzer spent his childhood in Madison, South Dakota, where he grew up with a twin brother and two sisters. In 1987 Michael traveled to Minneapolis, Minnesota to attend Northwestern University. One year later he returned to South Dakota to attend South Dakota State University where he completed the pre-requisites for entrance into optometry school. Michael started his optometric career at Pacific University College of Optometry in Forest Grove, Oregon. Here he was able to complete his bachelors degree in Vision Science while pursuing the O.D. degree. Michael will graduate on May 22, 1994 with a doctorate of optometry degree. He is then planning to participate in a post-graduate residency program at the Portland Veteran's Administration Hospital.

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ABSTRACT

Peripheral vision has been shown to help stabilize subjects on a balance task more than central vision. Lenses and prisms have been shown to affect a person's center of balance. A study by Jeske demonstrated significant shifts in center of balance upon the application of yoked prism. The question posed by this study is, " do subjects who tend to pay more attention to peripheral visual information respond differently to 12 prism diopters of vertically yoked prism than do those subjects who pay more attention to central visual information?" Replication of the results found by Jeske was also attempted.

Subjects were 25 non-optometry students. The subject's tendency to pay attention to peripheral or central visual information was measured using a combination of the scores on a distance maddox rod phoria, peripheral visual response speed as measured by the Wayne Peripheral Awareness Tester and Trainer, and score on the rod and frame apparatus. The subject's center of balance response to vertically yoked prism was measured using the BALANCE SYSTEM™ from the Chattecx corporation. It consists of a computerized balance platform from which footplates take rapid samples of percent of body weight shift based on an X-Y coordinate system. The X values quantified leftward or rightward center of balance position (XCOB). The Y values quantified the forward or rearward center of balance positions (YCOB). Postural sway, dispersion, was also measured (PS). No significant differences were found between the prism conditions in the XCOB or PS analysis. Significant differences were seen in the YCOB variable when the base-down yoked prism condition was compared to the base-up prism condition. The central or peripheral processing characteristics did not show a significant relationship to YCOB response to yoked prism. Effects of refractive error and habitual standing posture on YCOB response to yoked prism was also measured. The myopes and the emmetropes responded significantly ($p< 0.05$) more to the base-up prism than did the hyperopes, and the hyperopes and emmetropes responded significantly ($p< 0.05$) more to the base-down yoked prism. Significant differences ($p<0.05$) between subjects with a forward habitual posture and those with a rearward habitual posture were found for the base-down and base-up conditions, as well as the post base-up condition.

Jeske's study was only partially replicated. The center versus peripheral processing characteristics are not predictors of an individual's response to yoked prism. Better predictors of center of balance response to yoked prism are refractive error and habitual standing posture.

INTRODUCTION

Why is it more difficult to stand on one foot with the eyes closed than with the eyes open? Human research studies have shown the human body tends to increase the amount of postural sway, that is, the normal center of balance variation, shown on a standing task when visual cues are removed or made to be confusing[1]. It has also been shown that one's normal body sway is more related to peripheral vision cues than to central cues. In a 1984 study by Paulus, Straube and Brant it was demonstrated that anterior-posterior sway increased by 185% when only foveal vision was allowed as compared to a baseline open-eyed condition. In a peripheral vision only condition, sway was increased only 15% from the open-eyed baseline. This shows that peripheral visual cues stabilized the subjects almost as well as full field cues[1]. A possible explanation for this phenomenon is that foveal vision causes a state of over-dependence on visual input that does not necessarily give adequate information for maintaining balance[2]. This is demonstrated by the fact that one's body sways more when eyes are open in a dark room than when the eyes are closed. With eyes closed there is no expectation of visual input that will aid in the balance reference. With eyes open, even in a dark room, there are expectations of receiving visual information that coincides with the somatosensory and vestibular inputs. When this doesn't happen, a mismatch is perceived and balance is more disturbed than in the eyes closed condition[2]. This information could lead to the following question: Could a person who has a tendency to pay more attention to peripheral visual information, and thereby learns to depend upon peripheral information, behave differently on a balance task than a person who tends to pay more attention to and depends upon central information?

Some papers have indicated certain optometric and non-optometric tests have the ability to determine a person's ability to attend to peripheral or central information. In a chapter of *Problems in Optometry,* authors Coffey and Reichow say, " Peripheral visual response speed is dependent upon peripheral visual sensitivity, attentional focus, and visual motor response speed." They use the Wayne Peripheral Awareness Tester/Trainer (PATT) to test this skill in the Pacific Sport Visual Performance Profile, a protocol for testing the visual performance of athletes[3]. This apparatus requires subjects to respond to a stimulus randomly presented in the periphery while they maintain fixation at a central point. It could be hypothesized that a person who is more aware of the periphery will have better peripheral visual sensitivity and peripheral attentional focus, and thus a better score on the PATT, than a person who is more aware of the central information. If this is indeed the case, subjects could be categorized into those having central or peripheral processing tendencies based on PATT response times.

Elliott B. Forrest, O.D. has described that refractive findings and fusional states are indicators of the visual system's adaptations to the individual's environmental interactions. He understands high esophoric or exophoric deviations to be adaptations by individuals who have difficulty organizing peripheral and central information simultaneously. The esophore and the exophore, however, have adapted to this inability differently. Despite the difficulty for simultaneous central and peripheral perception, the exophoric individual still has a desire to get information from all areas of his/her visual world. His/her adaptation is to alternate attentional focus between peripheral and central information. The exophoria is a visuo-motor compensation for this alternation tendency[4]. The esophoric individual, on the other hand, has adapted to the inability to simultaneously process central and peripheral information by relying only on central information. Turning the eyes inward makes the periphery very confusing, as it produces highly disparate stimuli. The confusion makes it easier for the esophoric individual to suppress the periphery. The esophoric individual uses primarily central information and ignores the peripheral information[4]. In following Forrest's model it is possible to make inferences about an individual's central or peripheral processing tendency by assessing his/her phoria. The esophore tends to be influenced by central information and the exophore, who alternates between central and peripheral processing, is able to pay attention to peripheral information.

This view is corroborated in a study performed by Martin Birnbaum, O.D. In 1981, Birnbaum found that esophoric males scored higher on the Children's Embedded Figure Test (CEFT) than did male exophores. The Embedded Figures Test provides a task where the subject is to locate a hidden figure in a complex background. The EFT has been found to relate to visual information-processing style[5]. This study supported Birnbaum's hypothesis that esophores tend to demonstrate a visual information-processing style that is more analytical and highly differentiated. He explained the more highly differentiated processing style as emanating from the esophore's tendency to pay more attention to figure, detail, and small areas of space than the exophore. Birnbaum hypothesized exophores may demonstrate visual information processing which is more peripheral and less differentiated because they tend to be more global and simultaneous in gathering information[6]. These data support the categorization of subjects into central and peripheral processors based on phoria.

Many studies in the psychological literature have dealt with an individual's ability to sense gravitational upright in a visually and/or posturally conflicting environment. The quantification of this effect can be accomplished using the rod and frame apparatus[7]. The rod and frame task requires a subject to position a rod vertically despite a tilted visual surround. Subjects who are accurate at aligning the rod are considered to be field independent. That is, they are not affected by the conflicting visual information. Subjects who are less accurate in the alignment task are considered to be field dependent. That is, they are greatly affected by the visual surround[8]. It has been hypothesized that the differences in the alignment task stem from the relative importance assigned to visual versus vestibular information. Field independent individuals rely more upon the vestibular and proprioceptive information while field dependent individuals rely more upon visual information. Interestingly, it is the peripheral visual information that affects the field dependent individuals[9]. The results of the rod and frame test could give an indication of the individual's processing style. A field dependent subject tends to be more affected by the frame which is considered to be peripheral information; therefore, s/he would be categorized as a peripheral processor and the field independent subject would be considered central because s/he is not as influenced by the peripherally placed frame.

The three measures discussed, PATT, phoria, and rod and frame, have all been suggested to measure some form of a person's tendency to pay attention to central or peripheral information. Taken together these measures could give representation of the type of visual processing tendencies the subject favors.

Lenses cause a locational shift in visual information which can lead to body postural shifts. In 1970, Steven B. Greenspan demonstrated that children showed significant shifts from a habitual nearpoint posture when plus lenses were worn. In his study, posture was photo-documented and analyzed. The most consistent change seen was an increase in the subject's working distance[10]. Dr. John Pierce later studied the physiological effects of lenses by recording heart rate, electromyographic response, the basal resistance level of the skin and respiration rate. He found that heart rate, electromyographic amplitude and respiration rate increased when inappropriate lenses were worn for a near task. It was further concluded that inappropriate posture induced by the inappropriate lenses was a cause of this stress response[11]. Pierce demonstrated increased physiological activity in subjects wearing small amounts of vertical prism. It was found that as prism value increased, the physiological activity during the near-point task also increased. In this study it was primarily a change in head posture, a head tilt induced by the vertical prism, that caused the increase stress and thus, the increased physiological activity[11].

Yoked prisms, or prisms that are oriented in the same direction, have also been described as able to cause posture shifts. Much space in the Optometric Extension Program (OEP) literature as been devoted to this topic. Like lenses, yoked prisms also cause a noticeable shift in the spatial location of visual information[12]. The shift of the visual world has been hypothesized to lead to shifts in body posture[6,13,14,15]. Applications for yoked prisms in optometry have been described in detail in the OEP literature. Most applications for yoked prisms center around Kraskin's theory that many ocular defects, such as refractive condition and inappropriate tonic vergence postures, are a result of a change or alteration in body posture. He explains this theory by reminding us that approximately twenty percent of the optic nerve fibers pass through the superior colliculus and communicate with the posturing mechanisms of the body[16]. Kraskin summarizes, "Posturing and balancing mechanisms are part and parcel of the visual process"[16]. Kraskin has even outlined the body responses he predicts upon the application of yoked prism. He hypothesizes that with base-down prism visual space is moved upward, the eyes move upward, the chin moves up and out, and the center of gravity shifts forward, causing the body to move forward on the toes. He describes the opposite effect for base-up prisms. Visual space is moved downward, the eyes respond by moving down, the chin moves down and in, and the center of gravity moves backward causing the body to move back on the heels[17]. Based upon this theory yoked prisms have been prescribed to alter head posture[18], to decrease the progression into myopia[13], and reduce astigmatism[16].

Yoked prisms have also long been used in vision training. According to Horner, using yoked prisms in training creates a mismatch between the gravitational and visual worlds. The patient must learn to become aware of changes in his/her spatial world. The patient must solve the mismatch using visual and spatial feedback[19]. This therapy technique helps the patient break down established, and inefficient, patterns of vision. Typically, large amounts of yoked prism are used for this task. Two ranges tend to exist among clinicians, either between six and ten prism diopters or between fifteen and twenty prism diopters[12]. Recently, optometrists have also been using yoked prisms to induce postural shifts in neurologically impaired patients[20].

Two studies have attempted to quantify the posture shifts seen with yoked prism. Sheedy and Parson performed a study demonstrating that head posture was significantly higher at the end of two weeks of wearing four prism diopters of base-down yoked prisms as compared to head posture at the end of two weeks wearing no prism. The head posture was evaluated photographically using a rod held in the subject's teeth that extended out parallel to the floor, and a projected grid. Subjects were photographed before and after the two week trial[21].

Doug Jeske, while a student at Pacific University College of Optometry, performed a study to quantify shifts in center of balance upon the introduction of 12 prism diopters of yoked base-up and base-down prism using the Chattecx BALANCE SYSTEM™. He was able to document a significant shift rearward in center of balance during two time intervals: 0-10 seconds and 30-40 seconds from the initial application of the base-down prisms. Jeske's data showed no significant shifts in center of balance with the base-up yoked prisms, however, descriptive analysis did show forward shifts with these prisms[22]. The center of balance shifts are in the opposite direction of that predicted by Kraskin, however, the head position shifts demonstrated by Sheedy support the head response predicted by Kraskin. Jeske's data clearly indicate the wearing of 12 prism diopters of vertically yoked prisms is a task that affects posture and center of balance.

Jeske's study found individual responses to the yoked prisms to be varied in magnitude and stability[22]. Sutton has hypothesized that "individual differences in the yoked prism responses are primarily due to visual learning/thinking styles and the learned visual skills of the patient"[14]. Since peripheral visual information has been shown to affect balance, perhaps the visual learning/thinking style that relates to individual differences in the response to yoked prism is a person's tendency to prioritize either central or peripheral information. This study will attempt to replicate the results found by Jeske, as well as to seek any relationship between a person's tendency to use central or peripheral information and the magnitude and direction of his/her response to 12 prism diopters of vertically yoked prism.

METHODS

SUBJECTS:

Twenty-five subjects, twenty-one females and four males, who were non-optometry students ages twenty to thirty, participated in this study. Initial evaluations were done on each to exclude those with ocular pathology and/or a binocular dysfunction. The following criteria were used:

1) Habitual monocular and binocular Snellen visual acuity of at least 20/30 at 6 m and 40 cm
2) Stereoacuity of at least 60 sec arc as measured with the Wirt circles in the Polaroid Randot stereo test at 40 cm
3) No history of central nervous system medications
4) No history of vestibular or inner ear pathology
5) No history of, or current indications of strabismus as measured using the unilateral cover test at 6m and 40 cm
6) No symptoms of dizziness, vertigo, acrophobia, or severe motion sickness

Other data gathered included age, gender, current medications, disassociated horizontal phorias at 6m and 40 cm, refractive condition, peripheral visual response speed, and field dependency. As compensation for participation in the study, subjects were paid five dollars.

INSTRUMENTATION:

REFRACTIVE CONDITION

Subjects' refractive conditions were measured using the Canon Autorefractor (Model #R-1). The instrument was placed on an adjustable table and was located in a hallway with standard room illumination overhead.

CENTRAL VERSUS PERIPHERAL VISUAL TENDENCIES

Phoria

Measurements of subjects' horizontal disassociated phorias were obtained at two distances-- 6 m and 40 cm. Disassociation was induced with a red maddox rod oriented horizontally while the subject fixated a white spot of light. The angle was measured with a rule board calibrated in prism diopters for the appropriate distance. The rule boards had a hole in the center behind which the light was placed. For near the light source was a Keeler transilluminator and for distance the light source was a goose-neck lamp. Disassociated phoria data were taken under standard room illumination conditions (11-12 ftcd).

Peripheral visual response speed

Each subject's peripheral visual response speed was measured using the Wayne Engineering Peripheral Awareness Tester/Trainer (PATT) (Wayne Engineering, Orthoptic Division, 4120 Greenwood, Skokie, IL 60076) (Figure 1). It consists of eight lights presented randomly in eight meridians while fixation is maintained on a central fixation light. The PATT measures response time to each individual peripheral light stimulus. The subjects respond by moving the hand-held joystick in any direction indicating s/he had seen the peripheral stimulus.

PATT control settings were: Display: " Testing"
Mode: " 8 Lights/touch"
60 sec. timer: "OFF"

The instrument was located in a dim room (6-7 foot-candles) and mounted against a neutral, light color background. The PATT was positioned so the subjects' eyes were level with the central red fixation light. The subject was positioned 50 cm from the instrument.

Field dependency

Field dependency was measured using a portable rod and frame apparatus fashioned after the Stoelting Company model (620 Wheat Lane, Wood Dale, Illinois, 60191) (Figure 2a &2b). There is a high correlation between this portable rod and frame apparatus and a standard rod and frame apparatus which requires a completely darkened room[23]. The portable apparatus consisted of a rectangular enclosure which served as the frame and had sides made of translucent plastic with a matte finish on the inside and black plastic strips along the edges. The subject's field of view was restricted to the interior of the enclosure and included the frame and a rod at the opposite end 64 cm away. The rod was a stripe of black plastic 0.8 cm x 25.5 cm placed on the end panel. The frame rotated independently of the rod and deviations from vertical were measured using a photographically enlarged precision protractor fixed on the frame. The portable field dependency apparatus was positioned on a small white table so that the subject's back was straight and his/her chin was in the chin rest adjusted so eye level was at the center of the display opening. Light for this part of the experiment was provided by the diffuse overhead fluorescent lighting already present in the room.

CENTER OF BALANCE RESPONSES TO YOKED PRISM

Measurements of standing balance were taken using the BALANCE SYSTEM™ from Chattecx corporation (Chattanooga Group, Inc., 4717 Adams Road, P.O. Box 489, Hixon TN, 37343-0489). This was the same instrument used in the previous study by Jeske, 1992. It is commonly used by physical therapists in evaluations and therapy sessions. The system measured and recorded the subject's absolute center of balance position with a set of foot plates upon which the subject stood during testing. The computer used data collected from each 10 second period to calculate mean center of balance positions based on an X-Y coordinate system. The X values quantified leftward (negative values) or rightward (positive values) center of balance position (XCOB). The Y values quantified the forward (positive values) or rearward (negative values) center of balance position (YCOB). The XCOB and YCOB values signified the percentage of body weight shifted in the respective direction. Postural sway (PS) was identified as dispersion or standard deviation. A higher dispersion value indicated higher variability of the individual samples.

The BALANCE SYSTEM™ was located in the physical therapy clinic. Subjects fixated across the room at a 23 mm round amber light 3.5 m away. Constant room illumination was maintained by using overhead fluorescent ceiling lights and covering the windows with black plastic to eliminate extraneous light from outside. Any equipment visible in the room was covered with white sheeting to reduce extraneous visual stimuli.

The lenses and prisms used were 66 mm in diameter, round, clear, and made of plastic. One pair of thick plano lenses was utilized as a control condition. The plano lenses had a center thickness of 6.0 mm to match the overall weight of the prism lenses. One pair of 12 prism diopter lenses was utilized in yoked prism base orientations of base down or base up to create two vertically displaced viewing conditions. The lenses were mounted to plastic goggles available from GTVT (18807 Tenth Place NW, Lynnwood, WA 98036) using velcro strips.

PROCEDURES:

PROTOCOL:

1) Each subject read and signed the informed consent form. (Appendix 1)

2) Inclusion data were gathered for each subject (VA's, stereopsis, cover test).

3) Maddox Rod phorias were taken on each subject in the following manner:

Subjects were instructed to stand comfortably while holding a red Maddox rod oriented horizontally in front of his/her right eye while looking straight ahead at the spot of light. The subjects were asked where the red line fell on the ruler and their answers were recorded to the nearest 0.5 diopter. This was repeated three times. The procedure was then repeated three times at a distance of 40 cm. The subject was seated comfortably for the near measurements. The instruction set was as follows: "Stand with both feet behind this tape mark and hold this in front of your right eye like this," (tester orients the rod appropriately). "Try to hold it still. Look straight ahead at the light. You will see a while light and a red line. Tell me where the red line falls on the ruler." Subject responds. "Please put the cover down, relax." Wait 3 seconds. "Put the cover back over your right eye the same way it was before. Rotate it until the line is vertical. Now tell me where you see the red line." Subject responds. "Put the cover down." Wait three seconds and repeat once more. Move the subject to a chair. Adjust the calibrated card to be exactly 40 cm from the patient's spectacle plane. "Replace the cover in front of your right eye and tell me where the red line is." Subject responds. "Put the cover down, relax." Wait three seconds. Repeat three times.

4) Refractive condition for each subject was measured using the Canon autorefractor in the following manner:

All subjects were required to remove any prescriptive lenses they wore. This included contact lenses as well as spectacles. Subjects were seated comfortably at the instrument, chin in the chin rest, which was adjusted to align the subject's outer canthus with the canthus line, forehead against the forehead rest, and the table height adjusted to make the patient comfortable. The subjects were told to "place your chin in the chin rest, your forehead against the forehead rest and look at the wall at the end of the hallway." The hallway is approximately 50 feet long. Three measurements were taken for each eye and the values for sphere, cylinder, and axis were recorded.

5) Peripheral Visual Response Speed data were obtained using the PATT in the following manner:

The protocol for the PATT is identical to that used in the Pacific Sport Visual Performance Profile[3]. Subjects were directed to stand relaxed with eyes at the level of the center red fixating light. They were told that it was critical to fixate the center light at all times during the testing. One practice trial was given to each subject and then two test trials. A trial began when the start/stop button on the hand held joystick was depressed.

The instructional set follows: "This instrument evaluates your peripheral vision. I'd like you to always look at the center red light (indicate the light). When you notice a light at the end of one of the arms out of the corner of your eye, move the joystick quickly in any direction. Another light will then come on and, again, turn it off by quickly pressing the joystick. When you have responded to the last light, I will ask you to turn around while I record your scores and set up the instrument for the next trial. We will first go through one practice trial and then two actual trials. When you are ready to begin, press the red button on your joystick. Any questions?"

Response times, in seconds, were recorded for each of the eight directions for each of the two trials.

6) Field dependency data were obtained using the Portable Rod and Frame Apparatus. The subject was seated comfortably with back straight and chin in the chin rest adjusted so eye level was at the center of the display. Proper positioning of the subject was important as improper alignment may induce some degree of "body awareness." The experimenter avoided using words like left or right as this may force the subject to direct attention to either the top or bottom of the rod to use as a reference. Clockwise and counterclockwise were used instead. The instructional set was as follows: "The purpose of this test is to determine how well you can tell when something is straight up and down. That is, when it is aligned with the walls of this room. When you are positioned in the instrument you will see a square frame with a rod in the center. The rod can be rotated independently of the frame. Under your instructions, I will rotate the rod until you believe it to be perfectly vertical." Adjust the rod in 3° steps in the direction indicated by the subject. "When the rod is close to vertical say 'CLOSE' and I will move it slower." At this point move the rod smoothly at 1°/sec until the subject gives a vertical response. "This will be repeated 8 times with the frame and rod in various starting positions. I will ask you to lightly close your eyes between trials. The time it takes to complete each trial will also be recorded so make your decisions as quickly and as accurately as possible."

The subject was presented with 8 trials with the initial frame and rod tilt of 28° in a varying sequence (Table 1). The rod and frame were initially tilted either in the same direction or in the opposite direction. The presentation sequence for the rod and frame apparatus was altered for every other subject in the experiment. This allowed for half of the subjects to be exposed to clockwise (CW) tilt first, Mode A, and half to be exposed to counter-clockwise (CC) tilt first, Mode B (Table 1). The goal of this strategy was to compensate for any tendency to err in the direction that was first presented. The deviations from alignment were recorded in degrees with errors in the same direction as frame tilt recorded as positive and errors in the direction opposite to the frame tilt recorded as negative. The time it took each subject to reach perceived alignment was measured and recorded in seconds.

TABLE 1 CW=Clockwise CC=Counterclockwise

MODE A	FRAME	ROD	MODE B	FRAME	ROD
Trial 1	CC	CC	Trial 1	CW	CW
Trial 2	CC	CW	Trial 2	CW	CC
Trial 3	CW	CW	Trial 3	CC	CC
Trial 4	CW	CC	Trial 4	CC	CW
Trial 5	CC	CC	Trial 5	CW	CW
Trial 6	CC	CW	Trial 6	CW	CC
Trial 7	CW	CW	Trial 7	CC	CC
Trial 8	CW	CC	Trial 8	CC	CW

7) Center of balance characteristics were measured using the Chattecx BALANCE SYSTEM™. The subjects were positioned on the foot plates which were set up in Romberg position. In Romberg position the medial aspect of each foot is in contact with the other. This allowed for consistent foot placement with every subject versus a habitual stance individual to each subject as was used in the Jeske study[22]. The foot plates were adjusted so that each subject's toes were aligned with the front edge of the plate and heels aligned with the back edge of the plate. The subject's fixation was maintained on the fixation light throughout the data gathering intervals. Each subject's movement was kept to an absolute minimum during the testing intervals as the BALANCE SYSTEM™ was extremely sensitive to any movement.

The instructional set was as follows: " Stand comfortably with your feet together (demonstrate Romberg posture) and as still as possible with your arms at your sides. Always look at the light on the wall. Do not talk or laugh on the platform. Our first 2 trials will be for practice. When I say 'CLOSE YOUR EYES', close your eyes. At this time, the assistant will place lenses on your goggles. When I say 'OPEN', open your eyes and look at the light on the wall. We will take measurements for approximately 50 seconds. Keep standing as still as possible. After this I will say 'CLOSE' and you will close your eyes. The assistant will remove the lenses. I will then say 'OPEN' and you will open your eyes, step off the platform, walk to the chair (5 meters away), walk back to the platform and position yourself on the foot plates as before. I will say 'CLOSE' and the process will start over. There will be a total of 12 trials."

Data were gathered in two 10 second epochs for each trial, the first starting 5 seconds after the initial 'Open' command, the second beginning at 40 seconds after the command.

DESIGN

CENTER OF BALANCE RESPONSES TO YOKED PRISM

As in Jeske's study[22], three conditions were presented to each subject: plano, twelve prism diopters base-up yoked prism, and twelve prism diopters base-down yoked prism. Two plano conditions were allowed for practice. The first was run without the BALANCE SYSTEM™ computer collecting data. This allowed the subjects to experience the amount of time they were required to stand motionless. A trial period (PL1) was also run with the computer collecting data. The next two trials were also plano conditions (PL2 and PL3). These data were used to establish a normal standing baseline. The eight trials that followed were sequences that alternated plano, base-up (BU), and base-down (BD) prism conditions. A prism condition was always followed by a plano condition. Randomized assignment of subjects to one of the four sequences attempted to control prism interaction and any confounding variables. The four sequences follow:

1	PL1	PL2	PL3	BD1	PL	BU1	PL	BD2	PL	BU2	PL
2	PL1	PL2	PL3	BD1	PL	BD2	PL	BU1	PL	BU2	PL
3	PL1	PL2	PL3	BU1	PL	BD1	PL	BU2	PL	BD2	PL
4	PL1	PL2	PL3	BU1	PL	BU2	PL	BD1	PL	BD2	PL

YOKED PRISM EFFECT

The effect on center of balance induced by the yoked prism can be found by comparing the means of the PL2, PL3 conditions to the means of the BU1, BU2 and BD1, BD2.

POST-PRISM EFFECT

Any lasting effects the prisms cause after they have been removed can be found by comparing the means of the PL2, PL3 conditions to the means of the post prism conditions (PL-PTBU1, PL-PTBU2 and PL-PTBD1, PL-PTBD2).

CENTRAL VERSUS PERIPHERAL TENDENCIES

Phoria

Only the 6m phoria was used in the central versus peripheral categorization. Any 6m phoria measured to be esophoric were designated "central" for the phoria , while any 6m phoria measured to be exophoric was designated "peripheral" for the phoria.

Peripheral Visual Response Speed

The mean speed for the group tested on the Wayne PATT was found to be 0.6 seconds. Any subject whose average speed was greater than the group mean was designated as "central", while any subject whose average speed was less than the group mean was considered to be "peripheral" for the peripheral response speed category.

Field Dependency

The absolute error value of each trial was added to produce a total absolute error value. Any subject with a total absolute error of greater than 20° was designated "peripheral", while any subject with a total absolute error less than 20° was designated as "central" for the field dependency category.

Overall category

To place the subjects in either a "central or "peripheral" category the results from the three above tests were used: the 6m phoria, the PATT, and the rod and frame test. A subject was considered to have peripheral processing tendencies if s/he had peripheral tendencies on two of the three tests. Conversely, a subject was considered to have central processing tendencies if s/he had central tendencies on two of the three tests.

REFRACTIVE CONDITION

Subjects were categorized into myope (M), hyperope (H) or emmetrope (E) based upon the mean sphere value of both eyes. Subjects with a mean sphere value of between or including +/-0.37D was classified as an emmetrope. Any subject with a mean sphere value more minus than -0.37D was classified as a myope and any subject with a mean sphere value more plus than +0.37D was classified as a hyperope.

RESULTS:

CENTER OF BALANCE RESPONSES TO YOKED PRISM

The BALANCE SYSTEM™ computer calculated percentage of body weight shift values for leftward or rightward center of balance position (XCOB), forward or rearward center of balance position (YCOB), and postural sway (PS) for each epoch in each condition. Table 2 includes descriptive statistics of all trials.

The effect of yoked prism on standing balance was analyzed using one-way analysis of variance procedures between grouped PLANO, BASE-UP, and BASE-DOWN conditions. Results are presented in Table 3. No significant differences were found between conditions in the XCOB analysis during either measurement period. No differences were found in postural sway for any condition during the two intervals. Significant shifts occurred in YCOB during the BASE-DOWN condition when compared with the BASE-UP condition ($p<0.05$). This occurred for the 5-15 sec interval. No statistically significant differences were found in YCOB when either BASE-DOWN or BASE-UP were compared to the PLANO condition for either time interval.

To estimate any post-prism effect on standing balance, analysis of variance was performed on the PLANO, PL-POST-BU, and PL-POST-BD conditions. Results are presented in Table 4. No differences were found in XCOB, YCOB, or PS for any condition during either measurement period.

CENTRAL VERSUS PERIPHERAL TENDENCY EFFECTS ON CENTER OF BALANCE RESPONSES TO YOKED PRISM

To investigate the relationship of each subject's processing characteristics to the magnitude and direction of his/her responses to the yoked prism, an unpaired t-test was used to compare the subject's overall processing category (central or peripheral) and each component of the central vs. peripheral categorization to the hypothesized directional change in forward or rearward center of balance (YCOB) in each prism condition.

A difference nearing significance ($p=0.053$) was found between the overall central and peripheral groups in the BASE-UP condition during the 5-15 sec interval. No other significant or near significant relationships were found in the other balance conditions with respect to central or peripheral processing categories. Table 5 includes the mean change in YCOB for each central and peripheral category.

OTHER RELATIONSHIPS INVESTIGATED

Refractive Condition

To investigate any relationship that may exist between a subject's refractive status and his/her balance responses to yoked prism, a two way analysis of variance was used comparing each subject's refractive condition category (H,M,E) and the change in YCOB position with yoked prism.

A significant difference between groups ($p < 0.05$) was found in the BASE-DOWN condition during the 5-15 sec interval. The hyperope and emmetrope groups moved in the predicted direction (rearward with application of BASE-DOWN prism) while the myope group moved in the opposite direction.

A significant relationship ($p < 0.05$) was also found in the BASE-UP condition during the 5-15 sec interval. The myope and emmetrope groups responded in the predicted direction (forward with the application of BASE-UP prism), while the hyperopes moved in the opposite direction.

No other statistically significant relationships were found for refractive condition in any other conditions in the center of balance data (Table 6 and Figure 3).

Habitual Standing Posture

To determine the effect of each subject's habitual forward or rearward center of balance position on his/her YCOB response to the yoked prism, an unpaired t-test was used to compare baseline YCOB position (average of PL2 and PL3, 5-15 second interval) to the change in YCOB position with each yoked prism condition.

Significant differences between the group with a habitual posture rearward and that with a habitual posture forward were found in the following prism conditions: BASE-DOWN 5-15 second interval ($p = 0.007$), BASE-DOWN 40-50 second interval ($p = 0.04$), BASE-UP 5-15 second interval ($p = 0.02$), and POST BASE-UP 5-15 second interval ($p = 0.01$). The group with a habitual posture forward showed greater YCOB shifts, and in the direction predicted (rearward), to BASE-DOWN prism than the group with a habitual posture rearward. The group with the habitual posture rearward showed greater YCOB shifts, and in the predicted direction (forward), to BASE-UP prism than the forward group.

No other significant effects were found for habitual postural tendency in any conditions in the center of balance data (See Table 7 and Figure 4).

DISCUSSION

REPLICATION OF PREVIOUS STUDY

Yoked Prism and Post Prism Effects on XCOB

As seen in the previous work by Jeske[22], no significant shifts in XCOB were found between conditions during any of the comparative analyses. Lateral center of balance position seems to be unaffected by the vertical shift of visual information caused by vertically yoked prisms.

Yoked Prism and Post Prism Effects on PS

No significant increases or decreases were found in the subject's postural sway (PS) during any of the yoked prism or post yoked prism conditions when compared to the plano conditions. These data differ from those of Jeske[22], who found a significant increase in PS with base-down prism during the 0-10 sec time interval, with base-up prism during the 30-40 sec time interval, and post base-down and post-base up for both the 0-10 and 30-40 sec intervals. The shifts in PS found by Jeske[22] were unexpected. Previous research has shown postural sway to be repeatable and consistent for normal individuals[24]. Jeske[22] explained the PS shifts as likely being due to confounding factors such as the sudden opening of the eyes and breathing. In the present study, a later time interval was measured which did not include the moment of opening the eyes. The lack of significant shifts in PS would support the hypothesis that the initial opening of the eyes could have caused the inconsistent relationship between prism orientation and magnitude of sway found in Jeske's[22] data. Also, a longer time interval was allowed between trials which may account for no longer finding significant increases in PS in the post prism conditions.

Because no statistically significant differences were found in XCOB or PS in the present study, the remainder of this discussion will focus solely on the forward and rearward center of balance shifts (YCOB) induced by the vertically yoked prism.

Yoked Prism Effects on YCOB

Jeske found statistically significant shifts in YCOB when plano conditions were compared to base down during the 0-10 second and 30-40 second intervals, as well as when base up was compared to base down during those same time intervals[22]. This study does not replicate these significant differences, however, descriptive analysis of all conditions indicates that the present data show trends consistent with those seen in Jeske's[22] study. Base down prisms tend to shift center of balance rearward and base-up prisms tend to shift center of balance forward. These shifts are relative to the initial center of balance position found during the plano conditions which is slightly rear of center (Figure 5). A habitual stance with center of balance rearward of center is consistent with other research. The dynamics of standing balance require center of balance to be slightly rearward in order to overcome the effects of gravity and maintain a standing equilibrium[25].

Several possible explanations exist for the inconsistency between the two studies. A major difference between the two studies which may account for the variance in results was the time interval during which data were collected on the BALANCE SYSTEM™. This study evaluated balance data taken during the 5-15 second and 40-50 second intervals. Jeske's study[22] looked at data during the 0-10 second and 30-40 second intervals. The new time intervals were chosen per Jeske's suggestion[22] that they might provide less variation in the PS measure and thus in overall variability, potentially revealing an enhanced prism effect. Interestingly, Jeske[22] had found the most notable and reliable prism effects occurred during the initial 0-10 second time period just after the subjects had opened their eyes and "the sense of vision is abruptly added to the balance equation"[22]. By not collecting data during the initial 5 seconds, a significant portion of the initial effect of the yoked prisms may have been lost.

A second difference was the use of the Romberg stance as opposed to a habitual standing foot posture. This variation to the original protocol was also made per Jeske's recommendation[22]. It was hypothesized that standardizing the foot posture would effectively negate the proprioceptive variable from the balance equation, because all subjects would be receiving essentially the same proprioceptive input. This would allow a cleaner measurement and enhance the effect of the response to the shift in visual information caused by the yoked prisms. The results seem to indicate this hypothesis is not accurate. The new foot posture did not enhance the prism effect, but rather decreased it. Vicariance describes the fact that the various sensory systems involved in balance (vision, proprioception and vestibular) can be interchanged and are equally efficient. The tendency to use one versus the others is based upon individual differences and the present situation[9]. The Romberg foot position was less familiar to the subjects than their habitual stance and likely required more proprioceptive effort to be used to maintain balance. This would have shifted the relative importance of the sensory balance variables toward proprioception and away from vision. In this situation, a shift in visual information would have less impact upon the dynamics of standing. This could cause the response to the prisms to be decreased.

This study did replicate the significant differences in the YCOB for base-down and base-up conditions for the 5-15 second interval found by Jeske. This difference suggests the body does respond differently when visual information is shifted by yoked prisms in opposite directions. The eye movements induced by shifting the visual information lead the whole body to shift posture. Specifically, YCOB is shifted rearward with base-down yoked prism and forward with base-up yoked prism.

Post Prism Effect on YCOB

The present study indicated no significant post prism effects on YCOB. Jeske's[22] data did demonstrate a significant effect in the 30-40 second interval when comparing both base-down and base-up conditions to the plano condition. Those effects were unexpected and were not considered reliable, due to lack of instrument reliability during this interval. The present study does not support the post prism effect found in Jeske's study.

CENTRAL VS. PERIPHERAL TENDENCY EFFECTS ON CENTER OF BALANCE RESPONSE TO YOKED PRISM

Despite the lack of significantly different effects between the central and peripheral groups, descriptive analysis demonstrates that those categorized as "central" tend to respond more and in the predicted direction to the yoked prism. The response by the "peripheral" group is less and is not necessarily in the predicted direction. It seems those who tend to pay more attention to peripheral information tend to be more stable on this balance task. The "peripheral" subjects were either more likely to pay attention to the extreme visual periphery that was not affected by the prisms and thereby, were able to remain more stable, or they tended to place less importance upon visual information to maintain balance, causing the shift in visual information to have relatively little effect.

When categorizing the subjects as "central" or "peripheral" based upon each component of the central vs. peripheral testing independently, the same tendencies are found for each measure except peripheral response speed as measured by the PATT. That is, the "central" group tends to respond more in the predicted direction and the "peripheral" group responds unpredictably. The PATT results are mixed. In some cases the "peripheral" group moves more and in some cases the "central" group responds more. Perhaps the PATT is not an appropriate test to measure a person's tendency to use central or peripheral information. In future studies, the PATT should be excluded and other central vs. peripheral distinguishers should be used.

OTHER RELATIONSHIPS INVESTIGATED

Refractive Condition

Hyperopes and myopes tend to respond differently to the yoked prisms in the 5-15 second interval. The hyperopes and the emmetropes responded significantly more to the base-down prisms than the myopes. The myopes and the emmetropes responded significantly more to the base-up prisms than did the hyperopes (Figure 4). What factors related to a person's refractive condition would cause a center of balance response to be different? Kraskin advocates prescribing base-up yoked prism for myopes to increase working distance and to reduce the rate of myopic progression[13]. The data in this study would indicate the myopes may respond to the base-up prism, but in the direction opposite to that stated by Kraskin.

Myopes who wear spectacles are accustomed to looking through effective base-down prism when looking down in reading posture through their minus lenses. Hyperopes who wear spectacles are accustomed to looking through effective base-up prism when looking down in reading posture through their plus lenses. In this study, the subjects responded significantly to the prism to which they were unaccustomed. The emmetropes responded to both prism conditions. Perhaps the body/mind has learned to ignore the visual shift of information that is seen everyday, and therefore responds only to the shift in visual information that is novel. Further study in comparing ametropes who wear spectacles vs. ametropes who wear no lenses or contact lenses would help explain these results.

Habitual Standing Posture

A subject's habitual standing posture was found to be significantly related to center of balance response to yoked prism. Those with a habitual forward posture moved rearward to the base-down prisms more than did those with a habitual forward posture (Figure 4). Those with a habitual rearward posture responded more to the base-up prism than did those with a habitual forward posture. In a re-analysis of Jeske's data the same effect was found. It is significant that the effect was found in both sets of data since foot posture was different. Jeske's data being that with the habitual foot posture was probably a more accurate representation of "habitual standing posture".

These data would seem to indicate a proprioceptive "override" to the shifted visual information caused by the yoked prism. Previous analysis has shown that yoked base-down prism causes a rearward shift in center of balance. The group that starts with a habitual posture forward has "room" to respond to the base-down prism while the group that starts back cannot go back much further without disrupting the dynamics of the standing task and causing a loss of balance. Base-up prism causes center of balance to shift forward. The group with the habitual posture rearward of center has "room" to respond to the base-up prism. However, the group that starts forward does not respond much or in the predicted direction, likely because doing so would disrupt the balance equilibrium to a point where loss of balance would occur. These data support the concept of vicariance. When paying attention to and responding to visual information would cause the subject to lose his/her balance, less importance is given to that information and the other systems are allowed to take over, in this case proprioception.

SUMMARY

Replication of the previous study done by Jeske was only partially achieved. The data of this study do support the general trends seen in Jeske's data, but identical effects were not found. Changes were made to the original protocol in an attempt to reduce variability, but the reasoning in doing so appeared to be flawed. Jeske's study should be replicated following the precise protocol to verify the center of balance effects seen with yoked prism.

Central versus peripheral processing tendencies, as measured by this study, are not an accurate predictor of individual variations in center of balance response to yoked prism. The trends seen in this study indicate those who pay more attention to peripheral information tend to be more stable in their response to yoked prism. Perhaps more sensitive measures of central versus peripheral processing tendencies would show a relationship to center of balance responses to yoked prism.

Refractive condition seems to indicate to which direction of vertically yoked prism the individual will best respond. The data of this study disagree with Kraskin's philosophy of putting base-up prism on myopes to increase their working distance.

The best predictor of an individual's response to yoked prism is his/her habitual standing posture. Unfortunately, this measurement is difficult to acquire in a typical optometric practice. Some very keen observers may be able to estimate the center of balance position of their patients, but until a less expensive technique for determining habitual standing posture is obtained, individual responses to yoked prism will continue to be found by yoked prism trials.

This research has been conducted with subjects who are considered to have normally functioning nervous systems. The results of these studies cannot be generalized to the neurologically impaired population until further studies are done within this specialized population. This will be an important future step to validate the use of yoked prism to change posture in neurologically impaired patients.

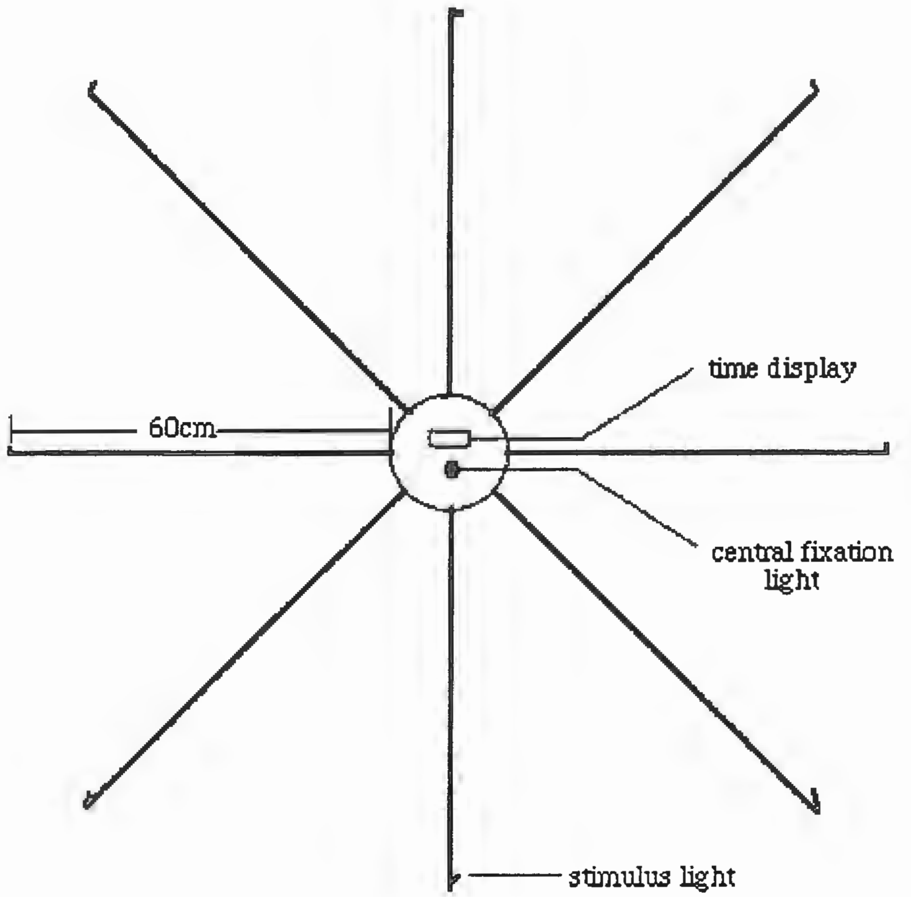

Figure 1: Representation of the Wayne Peripheral Tester and Trainer
Subject's view when PATT is mounted on a wall.

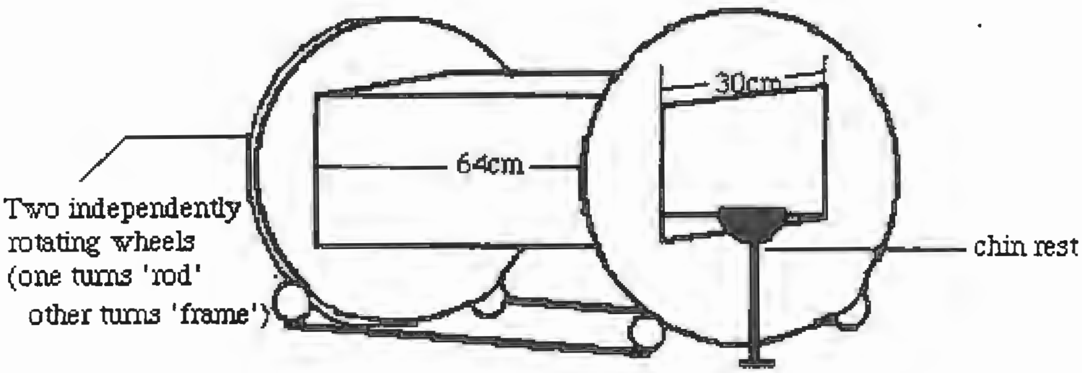

Figure 2a: Schematic representation of Rod and Frame apparatus.

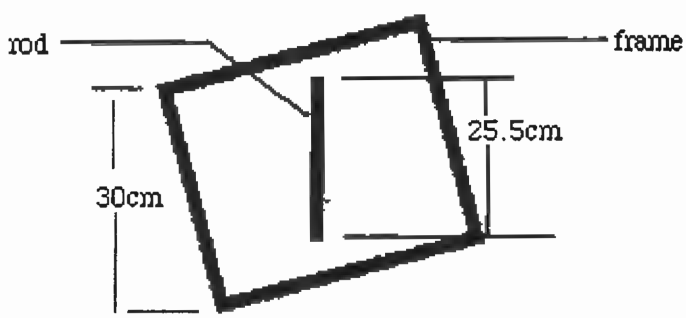

Figure 2b: Rod and Frame apparatus. Patient's view when looking into the instrument.

Figure 3
Refractive Condition Effects on YCOB Response to Yoked Prism

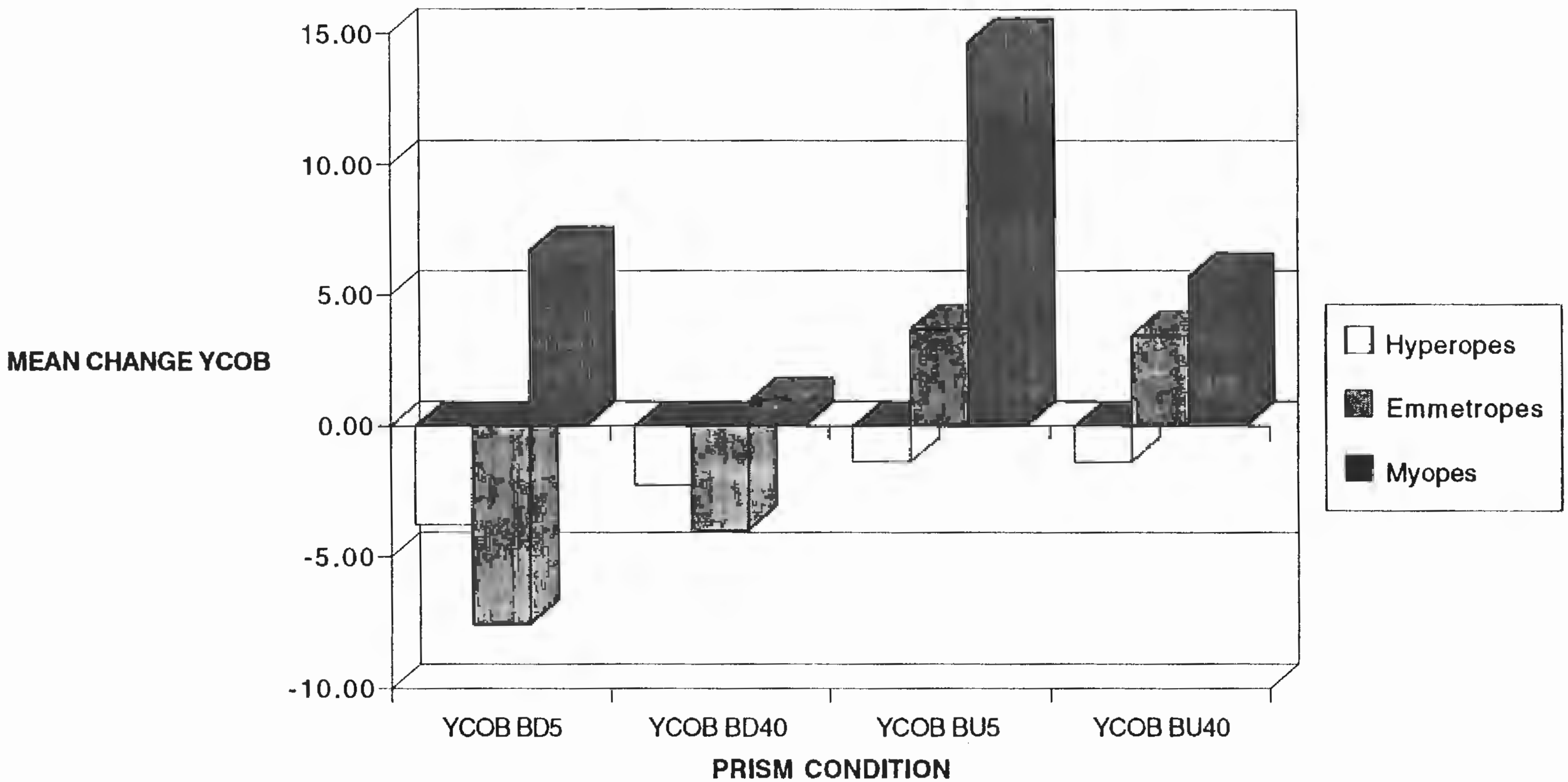

Figure 4
Habitual Posture Effects on YCOB Responses to Yoked Prism

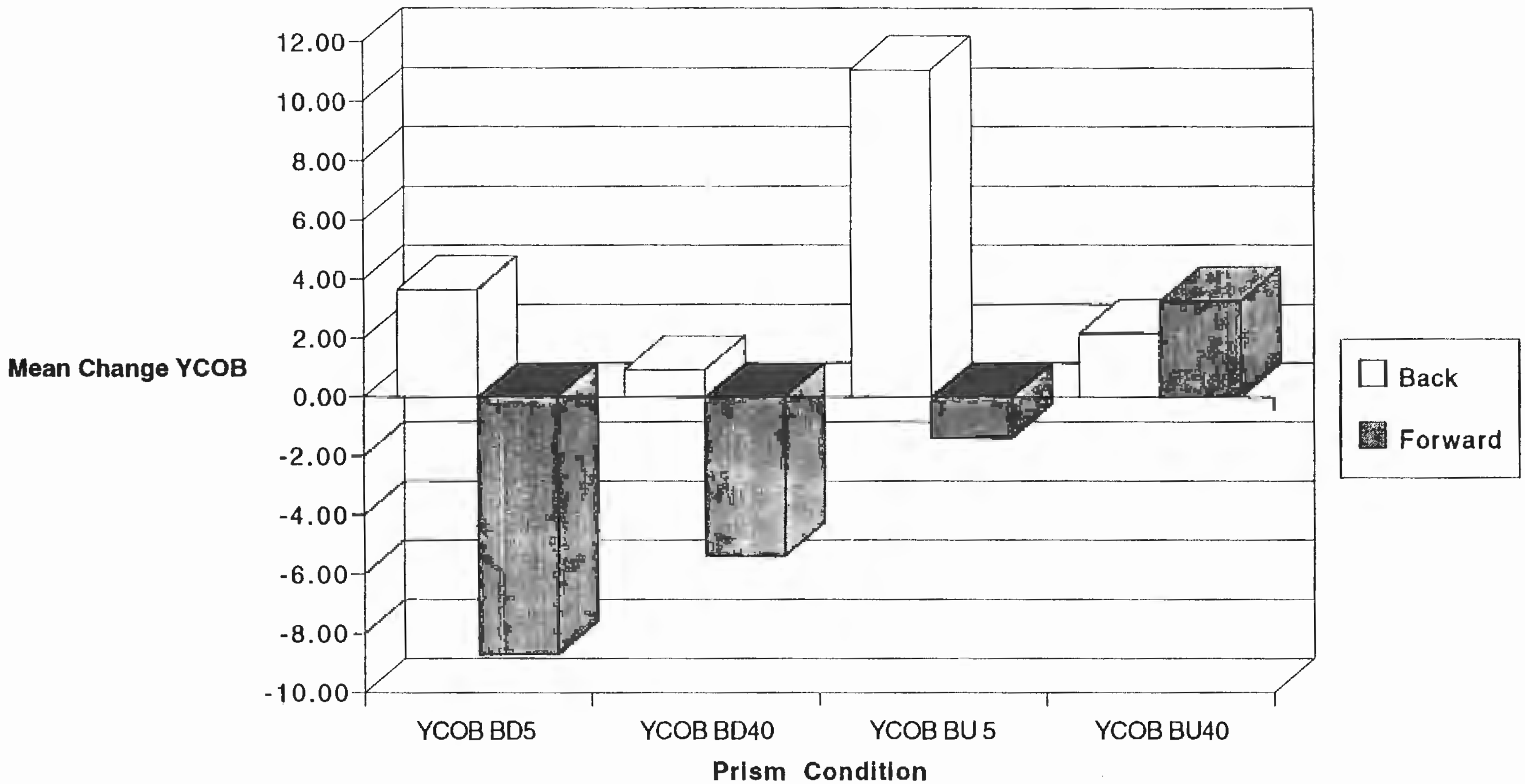

Figure 5
Mean Change YCOB in Response to Yoked Prism

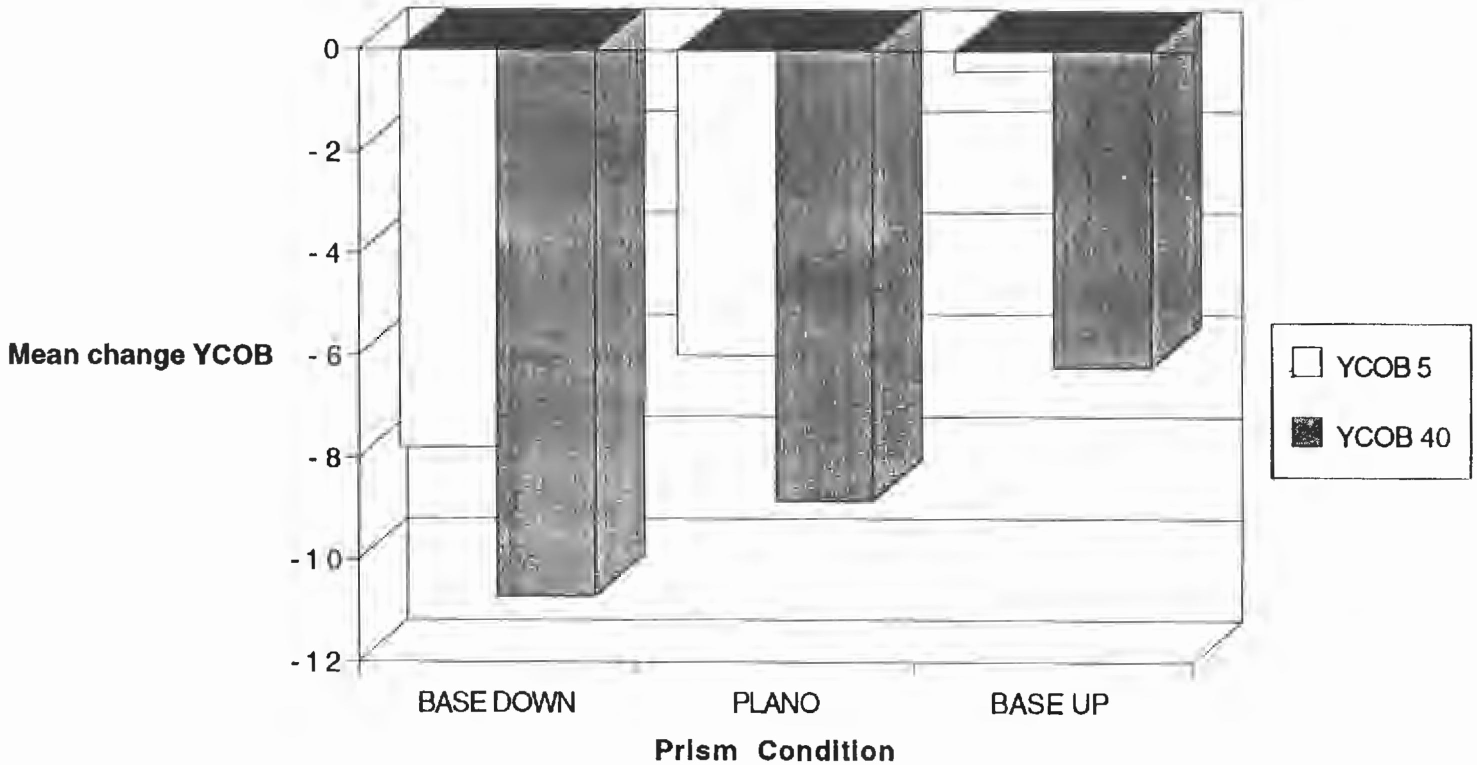

Table 2

Yoked Prism Effects on Center of Balance

			PL 1	PL 2	PL 3	PL-BU1	PL-BU2	PL-BD1	PL-BD2	BU 1	BU 2
5-15 sec.	XCOB	n	25	25	25	25	25	25	25	25	25
		mn	-4.92	-3	-5.42	-5.92	-5.52	-3.92	-4.16	-1.58	-4.52
		sd	10.76	8.43	11.65	11.68	11.23	10.13	12.33	8.36	12.07
	YCOB	n	25	25	25	25	25	25	25	25	25
		mn	-2.18	-6.69	-5.29	-10.19	-9.36	-2.85	-6.54	1.61	-2.41
		sd	19.76	20.57	20.47	18.87	17.24	18.77	18.96	19.59	17.25
	Postural Sway	n	25	25	25	25	25	25	25	25	25
		mn	7.31	8.25	6.89	6.84	8.26	7.84	6.82	7.42	6.74
		sd	3.27	4.46	2.55	2.33	5.08	3.17	2.18	2.77	1.64
40-50 sec.	XCOB	n	25	25	25	25	25	25	25	25	25
		mn	-4.07	-1.51	-4.12	-3.78	-4.33	-4.6	-2.39	-3.38	-5.24
		sd	10.32	10.8	11.62	11.61	10.56	10.05	11.72	9	11.49
	YCOB	n	25	25	25	25	25	25	25	25	25
		mn	-5.64	-9.41	-8.29	-9.98	-7.95	-9.28	-11.43	-5.64	-6.59
		sd	19.51	19.27	18.61	18.68	16.89	18.73	16.9	20.91	20.65
	Postural Sway	n	25	25	25	25	25	25	25	25	25
		mn	7.12	7.63	8.64	7.91	7.75	8.04	7.82	8.92	7.88
		sd	3.38	2.65	4.29	2.89	3.18	3.06	2.46	6.58	2.39

Legend

PL1	Plano trial 1
PL2	Plano trial 2
PL3	Plano trial 3
PL-BU1	Plano trial post first base-up trial
PL-BU2	Plano trial post second base-up trial
PL-BD1	Plano trial post first base-down trial
PL-BD2	Plano trial post second base-down trial
BU1	First base-up trial
BU2	Second base-up trial
BD1	First base-down trial
BD2	Second base-down trial

Table 3
Results of One-Way ANOVA Between Plano, Base-down, and Base-up Conditions

			PLANO	BASE DOWN	BASE UP	Statistical significance, Scheffe F-Test
5-15 sec.	XCOB	n	25	25	25	
		mn	-4.21	-4.23	-3.05	none
		sd	8.77	9.01	9.01	
	YCOB	n	25	25	25	
		mn	-5.99	-7.78	-0.40	(F=4.617, df=2, p<.05) bd vs bu=4.243
		sd	19.27	16.11	17.77	
	Postural Sway	n	25	25	25	
		mn	7.57	8.10	7.09	none
		sd	2.75	3.86	1.97	
40-50 sec.	XCOB	n	25	25	25	
		mn	-2.81	-5.42	-4.31	none
		sd	8.28	8.95	9.23	
	YCOB	n	25	25	25	
		mn	-8.85	-10.72	-6.22	none
		sd	17.53	14.61	20.23	
	Postural Sway	n	25	25	25	
		mn	8.14	8.06	8.40	none
		sd	3.09	3.51	3.70	

Legend

PLANO	Average of second and third plano trials
BASE DOWN	Average of first and second base-down trials
BASE UP	Average of first and second base-up trials

Table 4
Results of ANOVA Between Plano, Post Base-down, and Post Base-up Conditions

			PLANO	PL-POST-BU	PL-POST-BD	Statistical significance, Scheffe F-Test
5-15 sec.	XCOB	n	25	25	25	
		mn	-4.21	-5.72	-4.04	none
		sd	8.77	10.84	10.84	
	YCOB	n	25	25	25	
		mn	-5.99	-9.77	-4.70	none
		sd	19.27	16.57	17.53	
	Postural Sway	n	25	25	25	
		mn	7.57	7.55	7.33	none
		sd	2.75	3.17	2.13	
40-50 sec	XCOB	n	25	25	25	
		mn	-2.81	-4.05	-3.50	none
		sd	8.28	10.08	9.38	
	YCOB	n	25	25	25	
		mn	-8.85	-8.97	-10.36	none
		sd	17.53	15.51	16.30	
	Postural Sway	n	25	25	25	
		mn	8.14	7.84	7.93	none
		sd	3.09	2.56	2.35	

Legend

PLANO	Average of the second and third plano trials
PL-POST-BU	Average of the first and second plano post base-up trials
PL-POST-BD	Average of the first and second plano post base-down trials

Table 5

Mean Change in YCOB positions for Central vs. Peripheral Categories

		YCOB BD5	YCOB BD40	YCOB BU5	YCOB BU40	YCOB PTBD5	YCOB PTBD40	YCOB PTBU5	YCOB PTBU40
6m phoria	central	-2.53	-2.95	7.88	4.76	3.26	-4.38	-2.69	-1.02
	peripheral	-1.00	-0.69	3.12	0.34	0.85	-4.36	-4.97	-5.11
PATT	central	-5.58	-0.72	5.19	0.99	-1.27	-4.15	-4.52	-1.16
	peripheral	1.70	-2.92	5.69	4.16	3.65	-4.57	-3.10	-4.66
Rod and Frame	central	-3.50	-3.71	6.99	3.80	3.31	-5.07	-1.99	-2.95
	peripheral	0.38	0.48	3.81	1.16	-1.28	-3.48	-6.07	-3.03
Overall	central	-4.48	-1.92	8.29	3.45	1.83	-5.66	-2.89	-1.68
	peripheral	0.69	-1.81	3.10	1.89	0.79	-3.18	-4.61	-4.18

Legend: All values are mean change in YCOB for the following conditions:

BD5	Base down 5-15 second interval
BD40	Base down 40-50 secondinterval
BU5	Base up 5-15 second interval
BU40	Base up 40-50 second interval
PTBD5	Post base down 5-15 second interval
PTBD40	Post base down 40-50 second interval
PTBU5	Post base up 5-15 second interval
PTBU40	Post base up 40-5- second interval

Table 6
Mean YCOB Positions for Refractive Condition Categories

	YCOB BD5*	YCOB BD40	YCOB BU5*	YCOB BU40	YCOB PTBD5	YCOB PTBD40	YCOB PT BU5	YCOB PTBU40
Hyperopes	-3.78	-2.25	-1.37	-1.36	-3.45	--5.16	-6.78	5.69
Emmetropes	-7.58	-4.00	3.70	3.46	-1.39	-10.06	-8.55	-6.12
Myopes	6.70	0.93	14.68	5.71	9.04	2.82	4.57	3.26

Legend: All values are mean change in YCOB for the following conditions:

BD5	Base down 5-15 second interval
BD40	Base down 40-50 secondinterval
BU5	Base up 5-15 second interval
BU40	Base up 40-50 second interval
PTBD5	Post base down 5-15 second interval
PTBD40	Post base down 40-50 second interval
PTBU5	Post base up 5-15 second interval
PTBU40	Post base up 40-5- second interval

* statistically significant differences between groups

Table 7
Mean YCOB Change for Habitual Posture Categories

	YCOB BD5*	YCOB BD40*	YCOB BU 5*	YCOB BU40	YCOB PTBD5	YCOB PTBD40	YCOB PTBU5*	YCOB PTBU40
Back	3.64	0.91	11.08	2.16	-2.94	-9.07	-12.16	-8.74
Forward	-8.71	-5.40	-1.39	3.24	4.61	-12.84	2.16	1.55

Legend: All values are mean change in YCOB for the following conditions:

BD5	Base down 5-15 second interval
BD40	Base down 40-50 secondinterval
BU5	Base up 5-15 second interval
BU40	Base up 40-50 second interval
PTBD5	Post base down 5-15 second interval
PTBD40	Post base down 40-50 second interval
PTBU5	Post base up 5-15 second interval
PTBU40	Post base up 40-5- second interval

*statistically significant differences between groups

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APPENDIX 1

INFORMED CONSENT FORM

Institution

A. Title of project:	The relationship between central and peripheral visual tendencies and center of balance response to yoked prism.
B. Principle investigators:	Michael Glanzer and Suzy Scott 359-5556 and 359-3573
C. Advisor:	Dr. Bradley Coffey 359-6151 x2280
D. Location:	Pacific University College of Optometry Pacific University School of Physical Therapy
E. Date:	Spring 1993

1. Description of project

This research project is designed to determine the effects of yoked prisms (lenses that shift visual space in certain direction) on the subjects' posture, specifically, their center of balance. These effects will be measured using the Chattecx BALANCE SYSTEM™ an instrument used in the field of physical therapy capable of detecting very small shifts of balance. Because balance is affected by peripheral visual information input, these effects will also be compared to each subject's peripheral visual processing characteristics. Information related to peripheral visual processing characteristics will be obtained through various optometric tests.

2. Description of risks

This project combines the use of both standard optometric and physical therapy procedures which are used safely and routinely. The experiment involves standing motionless on a slightly raised platform while wearing a pair of prism spectacles. The spectacles worn by the participants during this part of the experiment may initially cause some disorientation, distortion of vision, nausea, mild headache and/or unsteadiness of balance in a small number of people. The subjects will be asked to step on and off the platform repeatedly. There is a possibility of tripping or falling. All precautions will be taken to avoid any injury.

3. Description of benefits

This study will serve to increase the basic understanding of how the visual system responds to changes in perceived visual space direction (caused by the yoked prisms) and may provide insight as to how these prisms should be used in the field of vision therapy to help remediate certain visual/perceptual problems. The participants will receive five dollars as reimbursement for their time.

4. Alternatives advantageous to subjects

Not applicable

5. Records of this project will be maintained in a confidential manner and no name identifiable information will be released.

6. Compensation and medical care

If you are injured during this experiment it is possible that you will not receive compensation for medical care from Pacific University, the experimenters, or any organization associated with the experiment. As stated before, all responsible care will be used to prevent injury.

7. Offer to answer any questions

The experimenters will be happy to answer any questions that you may have at any time during the course of the study. If you are not satisfied with the answers you receive, please call Dr. James Peterson at 357-0442. During your participation in the project you are not a Pacific University clinic patient or client for the purposes of the research and all questions should be directed to the researchers and/or the faculty advisor who will be solely responsible for any treatment (except for an emergency). You will not be receiving complete eye, vision or health care as a result of participation in the project; therefore, you will need to maintain your regular program of eye, vision and health care.

8. Freedom to withdraw

You are free to withdraw your consent and to discontinue participation in this study or activity at any time without prejudice to you.

I have read and understand the above. I am 18 years of age or over (or this form is signed for me by my parent of legal guardian).

Printed name ____

Signed ____________________________ Date ____________________

Address ___________________________ Phone ___________________

City ______________________________ State/Zip ________________

Name and address of a person not living with you who will always know your address:

____