Vertical yoked prisms affect standing center of balance

Douglas N. Jeske
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Abstract
This experiment was designed to determine the effect of vertically yoked prisms on standing balance. The BALANCE SYSTEM from Chattecx Corporation was utilized to quantify center of balance position in the leftward or rightward direction, forward or rearward direction, and the amount of variability in position, postural sway. Test lenses for the conditions of plano, 12 prism diopters yoked bases-up, and 12 prism diopters yoked bases-down were fitted over the habitual lens prescriptions of 36 young adult subjects with normal vision. Pressure sensitive transducers under the ball and heel of each foot provided data at a rate of 100 samples per second during two 10-second test periods; 0-10 sec and 30-40 sec immediately after opening the eyes and fixating a muscle light at 5 meters. No differences in right/left center of balance were found in any comparative analysis. Instrument test-retest reliability was established during the 0 to 10 sec time period for right/left center of balance, forward/rearward center of balance and postural sway. Differences in forward/rearward center of balance occurred during the 30 to 40 sec time period. Significant rearward shifts occurred with base-down yoked prisms when compared to base-up and plano during both the 0-10 sec and 30-40 sec periods. Significant increases in postural sway occurred with base-down compared with plano during the 0-10 sec epoch and base-up compared to plano during the 30-40 sec epoch. During post-prism plano conditions, significant rearward shifts occurred with post-base-up plano and post-base-down plano compared to plano during the 30 to 40 sec period. Additionally, post-prism plano conditions showed a significant increase in postural sway during 0 to ~ 0 sec and the 30 to 40 sec periods. During the 0 to 10 sec period immediately after opening eyes, objective measurement indicates base-down vertically yoked prisms produce a significant rearward shift in and increased postural sway when compared to plano lenses. These results further support vision's strong role in standing balance.

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VERTICAL YOKED PRISMS

AFFECT STANDING CENTER

OF BALANCE

By

DOUGLAS N. JESKE

A thesis submitted to the faculty of the
College of Optometry
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Forest Grove, Oregon
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ABOUT THE AUTHOR

Douglas N. Jeske calls Ellensburg, Washington his hometown. He graduated from Ellensburg High School in 1980. Douglas then went to Pullman, Washington for four years, graduating from Washington State University in 1984 with a Bachelors degree in mechanical engineering. The next five years were spent in Wenatchee, Washington were he was a senior mechanical engineer for the Aluminum Company of America, better known as ALCOA. A change in careers was chosen to allow development of other interests. He was accepted for admission into optometry school at Pacific University in Forest Grove, Oregon during the fall of 1989.

While attending Pacific, Douglas enjoyed learning and considers vision therapy; pathology detection, diagnosis and treatment; contact lenses; and functional lens prescriptions all a part of providing full scope optometry services. Douglas will receive his doctorate of optometry degree on May 23, 1993. His future plans include attending a post-graduate residency to refine skills before entering private practice.
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VERTICAL YOKED PRISMS AFFECT STANDING CENTER OF BALANCE

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ABSTRACT

This experiment was designed to determine the effect of vertically yoked prisms on standing balance. The BALANCE SYSTEM™ from Chattecx Corporation was utilized to quantify center of balance position in the leftward or rightward direction, forward or rearward direction, and the amount of variability in position, postural sway. Test lenses for the conditions of plano, 12 prism diopters yoked bases-up, and 12 prism diopters yoked bases-down were fitted over the habitual lens prescriptions of 36 young adult subjects with normal vision. Pressure sensitive transducers under the ball and heel of each foot provided data at a rate of 100 samples per second during two 10-second test periods; 0-10 sec and 30-40 sec immediately after opening the eyes and fixating a muscle light at 5 meters. No differences in right/left center of balance were found in any comparative analysis. Instrument test-retest reliability was established during the 0 to 10 sec time period for right/left center of balance, forward/rearward center of balance and postural sway. Differences in forward/rearward center of balance occurred during the 30 to 40 sec time period. Significant rearward shifts occurred with base-down yoked prisms when compared to base-up and plano during both the 0-10 sec and 30-40 sec periods. Significant increases in postural sway occurred with base-down compared with plano during the 0-10 sec epoch and base-up compared to plano during the 30-40 sec epoch. During post-prism plano conditions, significant rearward shifts occurred with post-base-up plano and post-base-down plano compared to plano during the 30 to 40 sec period. Additionally, post-prism plano conditions showed a significant increase in postural sway during 0 to 10 sec and the 30 to 40 sec periods. During the 0 to 10 sec period immediately after opening eyes, objective measurement indicates base-down vertically yoked prisms produce a significant rearward shift in and increased postural sway when compared to plano lenses. These results further support vision’s strong role in standing balance.
# TABLE OF CONTENTS

INTRODUCTION ........................................................................................................... 1  
METHODS ..................................................................................................................... 6  
SUBJECTS ..................................................................................................................... 6  
INSTRUMENTATION .................................................................................................... 7  
PROCEDURES ............................................................................................................. 11  
DESIGN OF THE EXPERIMENT .............................................................................. 14  
DATA ANALYSIS ........................................................................................................ 15  
  INSTRUMENT RELIABILITY .................................................................................. 15  
  YOKED PRISM EFFECT .................................................................................... 15  
  POST-PRISM EFFECT ....................................................................................... 15  
RESULTS ..................................................................................................................... 16  
  INSTRUMENT RELIABILITY ............................................................................. 16  
  YOKED PRISM EFFECT ................................................................................ 16  
  POST-PRISM EFFECT ...................................................................................... 17  
DISCUSSION ................................................................................................................ 18  
REFERENCES .............................................................................................................. 23  

Tables and Figures pertaining to data analysis  
Appendix 1: The optometric use of yoked prisms-a review.  
Appendix 2: Vision screening recording form.  
Appendix 3: Informed consent form.
INTRODUCTION

Yoked prisms are utilized to facilitate the rehabilitation of the traumatic brain injured and the neurologically impaired. During the utilization of yoked prisms, the most significant clinical observations reported include shifts of standing balance, improved or normalized posture, and improved mobility. These changes may help non-optometric health care providers obtain valuable patient information regarding rehabilitation potential, thereby enhancing the rehabilitation services provided. The purpose of this research was to determine, by objective measure, the effect of yoked prisms on standing balance.

Yoked prisms are defined as a pair of prismatic lenses of equal power with bases oriented in the same direction. Horizontally yoked prisms may be base-left or base-right, and vertically yoked prisms, base-up or base-down. A prism optically displaces light from the environment toward the prism base, consequently, the associated eye movement required to view the image is toward the prism apex. Therefore, base-down prisms shift the perceived visual environment upward, and base-up prisms shift the environment downward. Displacement of the visually perceived environment is the most obvious and noticeable prism affect. Additional effects created by prisms include sphere and cylinder power effects, chromatic aberration, and spatial distortion. A detailed review of yoked prisms prepared by the author is included in Appendix 1.

Yoked prisms have been utilized for many years as an optometric treatment for various conditions including myopia, oculomotor imbalances, anisometropia, convergence insufficiency and excess, visual perceptual dysfunction and psychiatric disorders. Yoked prism utilization has also been recommended to enhance optometric vision therapy. Additionally, yoked prisms can be incorporated into a patient's full-time eye glass prescription. Full-time vertically yoked prism prescriptions of 2 prism diopters or less are accepted by most patients without creating any subjective symptoms or changes in head posture. Full-time vertically yoked prism prescriptions of 4 prism diopters are subjectively rejected and create a shift in head posture to decrease the necessary shift in eye position. Yoked prisms of larger than 4 prism diopters are used in vision
therapy to assess an individual's ability to react and adapt to a changed visual world.\textsuperscript{2,6,7}

Additionally, yoked prisms of 15 prism diopters and greater have been called disruptive in nature, potentially stimulating somatosensory and visual motor reorganization.\textsuperscript{4} Greenwald believes "yoked prisms aid in the functional expansion and enhancement of peripheral vision by creating an induced spatial shift which possibly acts as a cortical arousal mechanism and literally forces the person to attend more to the peripheral world." Furthermore, Greenwald states, "It is this initial and abrupt change in awareness of self movement and of optical velocity field movements which leads to an eventual return to stability, but now at a more biologically efficient level of performance."\textsuperscript{9} Yoked prisms apparently disrupt our awareness of location in space. This disruption possibly allows or demands our brain's adaptive mechanisms to be engaged, causing a reorientation of ourselves in space, and a reorganization of movement patterns in order to perform efficiently. Subjective clinical observations provide most of the evidence that yoked prisms affect balance. No scientific documentation or quantification of the effect of prisms on standing balance exist in optometric literature.

Extensive scientific documentation does exist which conclusively supports the adaptation effect associated with a yoked prism-induced, visually displaced environment. The technique of displacing the environment with prisms is generally attributed to Helmholtz.\textsuperscript{10} Most of the perception and psychological literature on this topic addresses misguided eye-hand coordination movements or misguided finger pointing tasks caused by displaced visual environments. Researchers have theorized about the physiological mechanism responsible for the correction of spatial miscues associated with yoked prism wear called "yoked prism adaptation." Theories explaining yoked prism adaptation have been grouped into three categories: proprioceptive (position sense) change, efferent muscle command change, and central processing change.\textsuperscript{11} Kornheiser makes the conclusion that "yoked prism adaptation is a learning process which acts to minimize disparities between different sensory modalities." While the definitive yoked prism adaptation theory is disputed, the phenomenon of yoked prism adaptation has been repeatedly
However, very little information was found to support an adaptation or disruption in standing balance while using yoked prisms.

Reviewing rehabilitation and balance literature helps provide clues to how standing balance is maintained and controlled. Postural control of standing balance is a complex dynamic process. Sensory processes in balance control involve interaction among orientation inputs from somatosensory (proprioceptive, cutaneous, and joint), visual, and vestibular systems. Under normal sensory conditions, vision and somatosensory inputs dominate the control of orientation and balance. The somatosensory system senses rapid changes while vision provides sensitivity to slower changes in orientation and balance. The vestibular system is an essential internal orientation reference for identifying and quickly adapting to inaccuracies in the other two senses. To some degree, all three systems act as safeguards for each other. Neurological insult can create a situation where one or more of the three systems are damaged, thus affecting balance. In an unusual case report, deficits in the somatosensory system (due to polyneuropathy) and the vestibular system (due to gentamicin treatment) created a condition where the primary stabilization system was vision. It was reported that when this individual closed his eyes, he lost balance within one second. With eyes open, he was able to stand and walk slowly. Similar situations exist more frequently and to a lesser degree when central nervous system damage occurs to the somatosensory, vestibular, and/or visual systems.

Within physical rehabilitation networks, it is well known that there is a growing body of knowledge in the diagnosis, management, and treatment of balance disorders. To clinically assess the influence of sensory interaction on postural stability, a clinical series of tests called the Sensory Organization Test (SOT) was designed by Shumway-Cook and Horak. The SOT attempts to identify which sensory system(s) is/are dysfunctional. Rehabilitating sensory system deficits requires techniques to encourage use of the remaining systems, as well as facilitation of the damaged systems. Techniques for rehabilitation of the visual sense include standing on rocker boards, or walking stairs or rough terrain. These techniques reportedly help to promote visual and vestibular system functions. Rehabilitation techniques often include changing the
environmental inputs to allow each system to react and adapt to a variety of stimuli. In optometry, this type of rehabilitation is called optometric vision therapy. The main tools utilized by optometrists to change the visual input are lenses and prisms. It appears that little interaction exists between balance experts and vision experts; therefore, emphasis in rehabilitation of balance disorders is centered around treating vestibular and somatosensory dysfunctions. Most of the research providing important clues in understanding vision’s role in balance is found in a separate body of literature: perception and psychology.

Typically, measurement of standing balance is accomplished with the use of a platform on which subjects stand. The platform contains electrical strain gauges which are calibrated to accurately determine shifts in body weight. Using microcomputer control and analysis, the standing center of balance leftward or rightward and forward or rearward can be quantified and studied. Additionally, the amount of variability in standing center of balance position can be quantified. Standing balance is inherently unstable due to the constant effect of gravity which the body must resist. Electromyographic studies on muscle tone in the standing human body show continuous but variable activity in the calf muscles and the muscles in the lower thoracic region. Measurements of standing humans indicate the standing center of balance is slightly rearward of geometric center with a greater percentage of body weight on the heels than on the toes. The calf muscle activity keeps the center of balance just rearward to counteract the constant pull of gravity. As the calf muscles relax, center of balance shifts forward over the toes which facilitates walking. Thus, while standing, the body is efficiently resisting gravity and the natural tendency to fall forward, and begin walking. This inherent amount of variability in standing balance is called postural sway.

Visual stabilization of posture is critically dependent on stimulus characteristics as well as on the performance of the visual system. Postural sway increases approximately 100% when eyes are closed and increases proportionately with decreasing visual acuity. An intriguing experiment by Charles Fox showed that postural sway under binocular conditions was consistently and significantly less than postural sway under monocular conditions, even in total
darkness. Closing the eyes, in addition to increasing sway, also yields a slow shifting of the standing center of balance forward. Saccadic eye movements have also been shown to affect postural sway. Horizontal eye movements are followed, after a 400-600 ms latency, by a change in standing center of balance in the same direction as the eye movement. These studies provide evidence for a significant interaction between vision and balance. No experiments were found to support a shift in standing center of balance with vertical eye movements.

The purpose of this experiment was to determine if vertically yoked prisms cause an objective, clinically measurable change in standing balance. Based on the literature review, vertically yoked prism should not cause a significant shift in left or right center of balance position (XCOB). Theoretically, vertically yoked prisms should cause a shift in forward or rearward center of balance position (YCOB). The direction of the shift should reduce the necessary eye movement to fixate the target, similar to what has been reported in horizontal eye movement experiments. Thus, base-down prisms would be expected to create an eye movement upward, a rearward shift of head position, and a corresponding rearward shift in YCOB. Similarly, base-up prisms would yield a forward shift in YCOB. It was also hypothesized that postural sway (PS) would not be significantly affected by vertically yoked prisms since yoked prisms do not significantly degrade the retinal image. This study was an attempt to identify an effect with normal subjects using a body position and clinical setting that closely corresponds to current clinical treatment scenarios.
METHODS

SUBJECTS

Thirty-six Pacific University graduate students participated in this study. Each subject was given a vision screening to insure normal binocular vision function and the absence of ocular or systemic disease. A copy of the vision screening recording form can be found in Appendix 2. Subjects were accepted into the study by satisfying the following criteria:

1) Compensated monocular and binocular Snellen visual acuity of at least 20/30 at 6 m and 40 cm.
2) Stereo acuity of at least 60 sec arc as measured with vectographic Wirt circles at 40 cm.
3) No history of central nervous system medications.
4) No history of vestibular or inner ear pathology.
5) No history or current indications of strabismus as measured using the unilateral cover test at 6 m and 40 cm.
6) No symptoms of dizziness, fear of heights, or severe motion sickness such as would be experienced while walking across bridges, riding in cars, or while riding carnival rides.

Additional data gathered included refractive status, 6 m and 40 cm horizontal and vertical dissociated heterophorias, age, gender, and current medications. As compensation for participating in the study, all subjects were offered a credit toward college course requirements in optometry. No other compensation was offered.
INSTRUMENTATION

Commercially available equipment and instrumentation was chosen to maintain the clinical orientation of this research. The lenses and prisms utilized were 66 mm diameter round, clear, plastic lenses with front base curves of 6.75 diopters. Each had four small pieces of velcro glued to the back surface. The corresponding velcro match was glued to goggles available from GTVT shown in Figure 1. The design of this goggle lens system is attributed to Dr. Frank E. Puckett.

The goggles were worn over the subjects' existing prescription eyeglasses or contact lenses. One pair of plano lenses was utilized as a control condition. One pair of 12 prism diopter lenses was utilized in yoked prism base orientations of bases down or bases up to create two vertically displaced viewing conditions.

Measurements of standing balance were taken using the BALANCE SYSTEM™, from Chattecx Corporation. This clinical device is utilized to diagnose and treat balance disorders. The system is controlled by an IBM™ AT-compatible computer utilizing MS-DOS™ and Chattecx Corporation operating software. The system measured and recorded the subject's absolute center of balance position with a set of patented footplates (Figure 2) upon which the subject stood during testing. Each of the footplates consisted of two sections, one centered under the ball and one centered under the heel of each foot. Each footplate section contained four pressure sensitive transducers electrically connected to the computer. During two, 10-second periods, data were collected at a rate of 100 samples per second. The computer used data collected during each ten second period to calculate a mean center of balance position, based on an X-Y coordinate system.

The X-axis values quantified leftward or rightward center of balance position (XCOB) and Y-axis values quantified the forward or rearward center of balance position (YCOB). Both XCOB and YCOB were calculated corresponding to the mathematical means of all the data collected during the specified time period. The XCOB value was negative if the subject's center of balance position was displaced toward the left side, or positive if the center of balance position was displaced toward the right side. Similarly, the calculated YCOB value was negative if the subject's
center of balance position was rearward, or positive if the center of balance position was forward. The XCOB and YCOB values signified the extra percentage of body weight shifted in the respective direction. For example, an XCOB value of +5 signified that 5% more body weight was shifted toward the right side than to the left side. A value greater than or equal to 60, in any direction, clinically indicates the individual is about to fall over or take a step.

Postural sway (PS) was identified by the BALANCE SYSTEM™ as dispersion. The dispersion is analogous to a standard deviation of all the instantaneous X-Y coordinates collected during a specified period. A higher dispersion value indicated higher variability of the individual samples and thus, increased PS.

The testing apparatus was located in a physical therapy clinic in which other clinical equipment was visible. In order to reduce visual stimuli, the extraneous equipment was covered with white sheeting. When standing on the force plates, the subjects looked across the room at a wall 4 m away. The wall had rose colored Levelor™ blinds covering windows which stretched across the entire horizontal expanse of the wall from a height of 2 meters to the ceiling at 3 meters. The windows were covered with black plastic beneath the Levelor™ blinds to eliminate illumination fluctuations. The bottom of the window sill was 1.8 m above the floor. On the window sill, directly in front of the subject, was placed a 23 mm round amber fixation light. Fluorescent ceiling lighting provided a constant room illumination throughout all testing. Figure 3 shows a subject in the testing position as she is standing on the BALANCE SYSTEM™.
Figure 1: Visitor spec goggles and prisms.

Figure 2: Chattecx Corporation BALANCE SYSTEM™ footplates.
Figure 3: Subject positioned for testing using the BALANCE SYSTEM™.
PROCEDURES

At the time of data acquisition, each subject was treated in a similar manner as described in the following protocol:

1) Each subject read and signed an informed consent form (Appendix 3).

2) Each subject's natural foot positioning was measured by having him/her walk naturally toward, and then stand upon, an open manila file folder. A marking pen was used to trace around the feet to provide an outline of the natural foot position. The folder was placed on the BALANCE SYSTEM™ platform. The BALANCE SYSTEM™ footplates were set directly on the foot tracing in order to create the proper footplate separation and angular placement to mimic normal standing foot position.

3) A pair of goggles was placed on the subject over the habitual prescription eyewear or contact lens used for far distances.

4) The subject was positioned on the footplates by the assistant and was told by the assistant that s/he would move on and off the footplates several times. Additionally, the subject was instructed that it was critical to position the toes at the front of the footplates every time s/he returned to the footplates.

5) From this point, the experimenter gave all the instructions. The instructional set follows; actions taken are in parentheses.

All you need to do is to stand comfortably, with arms at your sides, looking at the light on the wall, standing as still as possible. Our first trial will be for practice. When I say "CLOSE YOUR EYES," you close your eyes (prompt the subject nonverbally to close the eyes) and continue to stand as still as possible. At this time, as you keep your eyes closed, the assistant will place lenses on the goggles (the assistant attaches the plano lenses onto the goggles). When I say the word OPEN, open your eyes, look at the light on the wall, standing as still as possible. OPEN. We will take measurements for approximately forty seconds during which time you only need to continue looking at the light and stand as still
as possible. After this time I will say CLOSE, at which time you close your eyes (again nonverbally prompt the subject to close the eyes). The assistant will remove the lenses (the assistant removes the lenses and hides the lenses from view). I will then say OPEN, at which time you open your eyes, (the subject is prompted to do everything the experimenter is saying), look down at the floor, step off the platform, walk over to the chair [located 2 meters away], sit down, take a deep breath, stand up, walk back to the platform, position yourself on the footplates, arms at your sides, looking at the light, standing still, and CLOSE, at which time the process starts all over. It is extremely important to continue looking at the light during the full 40 seconds. You will have a chance later to look around with the lenses on. Additionally, if you have a tendency to laugh, you are to do so in the chair and not on the platform since it will affect the results. Do you have any questions? (answer questions). Are you ready to begin?

6) Data were gathered during eleven trials as outlined below. Instructions are quoted.

"Standing still, arms at sides, looking at the light, CLOSE your eyes." The assistant attached the lenses to the goggles, returned to a position away from the subject, and gave a signal for the experimenter to start testing.

"OPEN."

Data gathering by the computer was initiated coincident with the "OPEN" command and continued for 10 sec. These data were saved prior to the next 10-sec data collection period which began 30 sec after the "OPEN" command.

"CLOSE."

After the subject closed his/her eyes, the assistant removed the lenses and hid them from view. The second set of data were saved and the computer was prepared for the next data gathering period.
"Open your eyes, look down, step off the platform to the chair, sit down, take a deep
breath, stand up, move back onto the platform, stand still, arms at your sides, look at the
light, and CLOSE."

This process was repeated using the next pair of lenses in a series of 11 for each subject.

The subject was not told how many trials s/he needed to complete, nor was s/he told or
shown which lenses or prisms were being attached to the goggles. Also, the experimenter had
no knowledge of which lens or prism condition was being tested during each trial. The initiation of
data gathering was prompted by the assistant after she had attached the lenses and positioned
herself away from the subject.

Each subject completed 11 trials. Each trial consisted of two, 10 sec data collection
periods. Measurements were taken during the first 10 sec, and during the period between 30
and 40 sec after the eyes were opened. This allowed for measurement of the initial response to
the lenses as the subject opened their eyes, and any short term (30 sec) adaptation response to
the lenses.
DESIGN OF THE EXPERIMENT

Each subject was tested with three conditions: plano, 12 prism diopters yoked bases-up, and 12 prism diopters yoked bases-down. The initial three trials for each subject were always the plano condition (PL1, PL2, and PL3) in order to establish a standing balance baseline. The subsequent eight trials included the following: two 12 prism diopter base-up conditions (BU1 and BU2), two plano conditions which followed the base-up conditions (PL-BU1 and PL-BU2), two 12 prism diopter base-down conditions (BD1 and BD2), and two plano conditions which followed the base-down conditions (PL-BD1 and PL-BD2). These eight trials alternated between a prism condition and a plano condition. The three conditions were tested in a counter-balanced design in an attempt to control possible confounding variables and interactions. The four alternation sequences were as follows:

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

This experimental design allowed determination of three experimental affects: Instrument reliability, yoked prism affect, and post-prism affect.
DATA ANALYSIS

INSTRUMENT RELIABILITY

Instrument reliability was a concern since the BALANCE SYSTEM™ has not been extensively utilized for statistical analysis of the XCOB and YCOB values. Historically, the PS value has been studied since this value is a measure of stability, critically important for patients in rehabilitation. To verify the instrument reliability to replicate repeated measures, the PL2 data set was compared to the PL3 data set. The PL1 data set was considered a practice trial and was not utilized for comparative analysis.

YOKED PRISM EFFECT

To measure any prism effect, data sets were paired as follows:

PL2 with PL3 (PLANO)
BU1 with BU2 (BASE-UP)
BD1 with BD2 (BASE-DOWN).

Assuming instrument reliability is achieved, comparative analysis of these three paired data sets allow determination of how vertically yoked prisms affect standing balance when compared with the control (PLANO) condition.

POST-PRISM EFFECT

Similarly, to analyze the post-prism effect, data sets were paired as follows:

PL2 with PL3 (PLANO)
PL-BU1 with PL-BU2 (PL-POST-BU)
PL-BD1 with PL-BD2 (PL-POST-BD).

Comparative analysis of these three paired data sets allows determination of how vertically yoked prisms affect standing balance after the prisms have been removed and the subject has stepped off the platform, taken a few steps, sat down, and returned to the platform.
RESULTS

For each data gathering period (0 to 10 sec and 30 to 40 sec), values for leftward or rightward center of balance position (XCOB), forward or rearward center of balance position (YCOB), and postural sway (PS) were calculated by the BALANCE SYSTEM™ computer and recorded. Descriptive statistics of all trials were calculated by condition and are included in Table 1.

INSTRUMENT RELIABILITY

To determine the reliability of the instrument a T-test was performed on the initial plano conditions, PL2 vs PL3. Results are presented in Table 2. No differences were found between plano conditions in XCOB during either measurement period.

No differences were found between plano conditions in the YCOB during the 0 to 10 sec measurement period. Significant rearward shifts occurred in YCOB during the PL3 condition when compared to the PL2 condition during the 30 to 40 sec measurement period ($T=2.2$, $df=35$, $p<0.05$) shown in Figure 4.

No differences were found between conditions in PS during either measurement period.

YOKED PRISM EFFECT

Analysis of variance between grouped PLANO, BASE-UP, and BASE-DOWN conditions was performed to determine the effect of yoked prisms on standing balance. Results are presented in Table 3. No differences were found between conditions in the XCOB analysis during either measurement period.

Significant rearward shifts occurred in YCOB during the BASE-DOWN condition when compared with either the BASE-UP or PLANO conditions. The rearward shift occurred during both the 0 to 10 sec epoch ($F=20$, $df=2$, $p<0.05$) shown in Figure 5, and the 30 to 40 sec epoch ($F=6.2$, $df=2$, $p<0.05$) shown in Figure 6. No differences were found in YCOB when the BASE-UP condition was compared to the PLANO condition during either measurement period.
Significant increases in PS were found during both measurement periods; BASE-DOWN greater than PLANO during the 0 to 10 sec epoch (F=8.6, df=2, p<0.05) shown in Figure 7, and BASE-UP greater than PLANO during the 30 to 40 sec epoch (F=4.1, df=2, p<0.05) shown in Figure 8.

POST-PRISM EFFECT

Analysis of variance between the grouped PLANO, PL-POST-BU and PL-POST-BD conditions was performed to assess any post-prism condition effect on standing balance. Results are presented in Table 4. No differences were found between conditions in the XCOB analysis during either measurement period.

No differences were found between conditions in the YCOB during the 0 to 10 sec epoch. YCOB shifts were found during the 30 to 40 sec epoch (F=6.4, df=2, p<0.05) with rearward shifts occurring during both the PL-POST-BU and PL-POST-BD conditions when compared with the PLANO condition shown in Figure 9.

During the 0 to 10 sec epoch, PS increased (F=78, df=2, p<0.05) during both the PL-POST-BU and PL-POST-BD conditions when compared with the PLANO condition shown in Figure 10. Similar increases in PS were found during the 30 to 40 sec measurement period (F=63, df=2, p<0.05) shown in Figure 11.
DISCUSSION

As expected, no significant shifts in XCOB were found between conditions during any of the comparative analyses. Vertically yoked prisms seem to have little effect upon leftward or rightward center of balance position. The lack of change in XCOB may also provide additional support for the test-retest reliability of the BALANCE SYSTEM™, or could suggest XCOB stability is maintained more easily than YCOB stability. Future research to determine the effect of horizontally yoked prisms on XCOB could provide a better understanding of these results.

It was expected that no differences in YCOB between PL2 and PL3 conditions would be found, thus insuring test-retest instrument reliability. No differences were found during the 0 to 10 sec time period, however significant differences were found during the 30 to 40 sec time period. This result emphasizes the extreme sensitivity of the BALANCE SYSTEM™, and why historically the quantification of standing center of balance position has not been emphasized.

The ability to achieve reliability during the initial 0 to 10 sec measurement period may be related to the time period chosen for measurement. During the relatively short and early time period of 0 to 10 sec, subjects may have held their breath. The simple action of breathing has been shown to affect standing balance. As muscles expand and contract to change the air volume in the lungs, the ribs and internal organs move, thus creating a continuous change in center of gravity. After the initial 10 sec, each subject’s breathing may have added a variable which was not adequately controlled. Future research should attempt to control this potential variable by having the subjects hold their breath during the testing sequence.

Another variable which was not controlled during this experiment, and could help explain the lack of reliability achieved in the YCOB, was the practice effect. Although the Plano 1 data set was considered a practice trial, no attempt was made to measure changes in COB due to practice. The 0 to 10 sec time period is actually capturing the initial subject response to adding the sense of vision to the balance equation. The test lenses were attached to the goggles while the subject’s eyes were closed. Additionally, as discussed previously, an individual shifts forward when their...
eyes are closed.\textsuperscript{21} It was confirmed by this study that the 0 to 10 sec YCOB was consistently further forward than the 30 to 40 sec YCOB. The protocol during the 0 to 10 sec time period may have provided the consistency to allow test-retest reliability to be achieved. During the 30 to 40 sec time period, the initial reaction to adding the visual component to balance may not have been a factor. Thus the YCOB variability during the 30 to 40 sec period which did not allow test-retest confirmation, may have been confounded by each subject’s ability to learn how to stand without moving while on the footplates. Practice effects should be determined for this instrument prior to future research.

Throughout the rest of this discussion the 30 to 40 sec results will be discussed, however, the reader should keep in mind the lack of instrument reliability obtained during this period of measurement. The 0 to 10 sec measurements and corresponding results should be considered fully since very good test-retest reliability was achieved during this time period.

A shift in YCOB was objectively measured while using vertically yoked prisms. Base-down yoked prisms caused a significant rearward shift in YCOB, toward the heels. When comparing the PLANO to the BASE-DOWN yoked prism condition, a 6.0 percent shift occurred during the 0 to 10 sec epoch and a 5.5 percent shift occurred during the 30 to 40 sec epoch. Although the percentage of shift appears relatively consistent it should be noted again that all [PLANO, BASE-UP, and BASE-DOWN] 30 to 40 sec measurements were rearward as compared to the 0 to 10 sec measurements.

No significant shift in YCOB was measured with Base-up yoked prisms. Apparent forward shifts with Base-up prisms are indicated by the descriptive analysis, but comparative analysis did not reveal significance. The time period of measurement may not have allowed the measurement of a base-up-induced YCOB shift prior to the body’s recalibration of YCOB to a position slightly rearward of center. The apparent difference in Base-down versus Base-up findings suggests a difference in how the body responds to vertical eye position changes related to YCOB measurements in this study. These results may indicate a rearward shift is tolerated more easily
than a forward shift. This could be due to the innate dynamics of standing balance which require the YCOB to be slightly rearward of center in order for standing equilibrium to be maintained.\textsuperscript{17}

Yoked prisms were found to increase PS. Postural sway was influenced by the prisms as shown in the comparison of the initial PLANO condition to the prism conditions. This comparison indicates an increase in postural sway due to the BASE-DOWN yoked prism wear during the 0 to 10 sec epoch and due to BASE-UP yoked prism wear during the 30 to 40 sec epoch. The inconsistent relationship between prism orientation and magnitude of sway could be due to the confounding factors of eye opening and breathing as described earlier.

During the post-prism plano conditions, unexpected shifts in YCOB and PS were found. No differences in YCOB were found during the 0 to 10 sec period, and the rearward shifts occurring during the 30 to 40 sec post-prism plano conditions were unexpected. Although the 30 to 40 sec time period may not be reliable, the quantity of the difference in the means may suggest a post-prism effect. Further research investigating this phenomenon should be performed to establish the effect more concretely.

Additionally, a consistent and strong increase in PS was found when comparing the PLANO condition to either the PL-POST-BU or the PL-POST-BD conditions during both time periods. During the 30 to 40 sec period PL-POST-BU was significantly larger than the PL-POST-BD condition. The magnitude and significance of the post-prism PS increases seemed to suggest an effect in PS after vertically yoked prisms were removed. This PS effect was not expected after only 40 sec of wear, nor after the subject moved from the footplates between trials. Postural sway has been shown to be repeatable and consistent for normal individuals.\textsuperscript{13} Discussions with researchers familiar with the BALANCE SYSTEM\textsuperscript{TM} revealed surprise that differences in postural sway were measured in any condition of this study.\textsuperscript{24} Additional research is needed to replicate and further define the postural sway increases due to yoked prism wear and subsequent after effect. The time and movement between trials could be extended to attempt to reduce the potential post-prism effect.
This research determined that vertically yoked prisms do not affect XCOB, but cause a rearward shift in YCOB and increase PS. The design of this experiment was to create a simulated clinical environment in order to measure the effect of vertically yoked prisms on standing balance. To enhance application of the data to the typical optometric clinical environment, subjects were tested while standing in the normal standing position. Subjects wore comfortable athletic shoes in a further attempt to replicate a clinical situation. Additionally, there was no attempt to modify or eliminate peripheral or central visual field input which has been found to affect postural sway. Young adults with intact balance systems were chosen as subjects due to their availability in order to provide baseline measurements. Therefore, by replicating a clinical environment, the objectively measured shifts in XCOB, YCOB and PS found in this experiment have clinical significance and relevance.

Future research to confirm these results could be performed by attempting to enhance the potential effect. Use of the tandem Romberg position where feet are positioned heel to toe, and/or control of peripheral visual cues should enhance measurable effects. Research with samples of elderly or neurologically impaired patients may also provide enhanced effects since their balance systems are reportedly more unstable than young normal adults.

If future research confirms the results found in this study, clinical tests using yoked prisms may be designed to determine the expected response of a standing individual to a visually displaced environment. For example, a normal person standing with a 60 degree central visual field may maintain stability when looking through vertically yoked prisms. However, a person with a balance system deficit, looking through the same prisms, may need to take a step in order to keep from falling over when vertically yoked prisms are in place. This test could help determine the influence of visual sensory input on balance much like the Romberg test measures somatosensory system influence.

Additionally, the effect of yoked prisms on standing balance could be used to measure the efficacy of visual rehabilitation, as in optometric vision therapy or balance training provided in rehabilitation settings. Pre-therapy standing balance measurements and changes in standing
balance induced by yoked prisms could be compared with post-therapy measurements. Differences between pre-therapy and post-therapy balance measurements may be indicative of the effectiveness of the therapy which was provided.

Shifts in XCOB and YCOB, and the amount of PS induced by yoked prisms may be a measure of an intact, healthy balance system. An abnormally large response to yoked prisms could indicate an unusually high dependence on vision for maintaining standing balance and a reduced ability to utilize/incorporate the vestibular and/or somatosensory systems in maintaining standing balance. This type of patient would have difficulty adjusting to abrupt changes in the visual environment due to a hypersensitive visual component of balance. Conversely, if yoked prisms cause minimal shifts in XCOB, YCOB and PS, adjustment to abrupt changes in the visual environment would be easier. This patient would perhaps be able to more efficiently integrate the other sensory components of balance to achieve better standing balance stability and adaptability.

This research provides evidence that vertically yoked prisms affect standing balance. The most notable and reliable effects occur during the initial 0 to 10 sec time period just after the subject has opened the eyes. During this period the sense of vision is abruptly added to the standing balance equation. It was shown that vertically yoked prisms oriented base-down can increase postural sway and cause a rearward shift in standing center of balance position. Considering the suggestions provided in this discussion, additional research should be performed to confirm and elaborate these effects. However, the evidence presented in this research suggests that a vertically yoked prism effect on standing balance can be objectively measured, further supporting the strong role of vision in standing balance.
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a. GTVT, 18807 10th PL. W., Lynnwood, WA 98306. 1-800-848-8897 or (206) 486-0159.

b. Chattex Corporation, Chattanooga Group, Inc., 4717 Adams Road, P.O. Box 489, Hixson TN, 37343-0489. 1-800-322-7343.
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Table 2: T-test between Plano 2 and Plano 3.
Figure 4: Initial Plano means ± one st. dev.
Table 3: Analysis of variance between grouped Plano, Base-up prisms, and Base-down prism conditions.

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Figure 5: YCOB means ± one st. dev. for the 0 to 10 sec time period.
Figure 6: YCOB means with ± one st. dev. for the 30 to 40 sec time period.
Figure 7: Postural sway means ± one st. dev. for the 0 to 10 sec time period.
Figure 8: Postural sway means ± one st. dev. for the 30 to 40 sec time period.
Table 4: Analysis of variance between grouped Plano, Plano post base-up prism, and Plano post-Base-down prism conditions.
Figure 9: YCOB means ± one st. dev. for the 30 to 40 sec time period.
Figure 10: Postural sway means ± one st. dev. for the 0 to 10 sec time period.
Figure 11: Postural sway means ± one st. dev. for the 30 to 40 sec time period.
THE OPTOMETRIC USE OF YOKED PRISMS-A REVIEW.

DOUGLAS N. JESKE

ABSTRACT

Yoked prisms are a misunderstood, yet extremely valuable optical device. They are used in powers of 5 to 10 prism diopters to probe for overall task performance changes, from which powers of 2 to 3 prisms diopters are prescribed for full time wear until task performance changes no longer occur. Prism powers greater than 10 have been utilized in neurologically impaired patients where a large shift of spatial orientation is required. Yoked prisms should be applied cautiously and with knowledge of expected outcomes. The major purpose of yoked prisms is to disrupt the self-perceived orientation in the environment, causing adaptations to occur. Yoked prisms have been effective in changing optometric findings, creating postural shifts, and enhancing specific task performance. Their proposed action is theoretically caused by reorganization of visual-motor behavior.
INTRODUCTION

The use and prescription of optical lenses is the primary domain of the vision care professional. The use of prism lenses are prescribed carefully and with caution due to the known powerful impact they have on the visual system. Prisms are used with symptomatic patients to alleviate vertical or horizontal fixation disparities, high phorias, and strabismus deviations.

However, in most typical applications the prism bases are directed in opposing directions; base out, base in, base up O.D. and base down O.S.. Yoked prisms, where the prism bases are oriented in the same direction, are less commonly utilized in optometric practices and much less prescribed. However, professionals that use yoked prisms often observe and achieve significant reduction in the patients subjective symptoms and objective signs of visual dysfunction. This paper will hopefully serve to review the use of yoked prisms, what they are, theories on why they are used, and current prescribing methods.

All optometrist receive specialized training allowing the use of lenses to improve overall human performance by enhancing visual function and efficiency. Behavioral optometrists attend particularly to the visual aspect of human performance and the impact of environmental factors on the visual system. When yoked prisms are utilized, they impact on both visual and motor performance. For these reasons, most of the literature describing the use of yoked prisms is found in behavioral optometric journals.

OPTICAL PROPERTIES OF YOKED PRISMS

Knowledge of optical properties of lenses is required in order to effectively alleviate patient problems. It is relatively easy to compensate for a patients refractive condition at any given point in time and for any given distance, however, most lenses prescribed are used at all distances, at various times, and with a human visual system which is not static but extremely dynamic. Effective utilization of yoked prisms require a complete understanding of their optical properties which include the following: refractive power, variable prism displacement, and chromatic dispersion. Each of these will be discussed in detail.
Appendix 1

Refractive Power

Yoked prisms used are typically a plano prism of standard base curve, for example a -6.75 diopters, ground on ophthalmic lenses. The back surface power through the center of this prism is plano, however, back surface power when looking toward the base or apex is not plano (Streff-1973). Induced back surface power through a center-beveled plano prism is $+0.64 + 0.89 \times 180$ when viewed 40 degrees toward the base and $-0.62 - 0.92 \times 180$ when viewed 40 degrees toward the apex. Back surface power through a front surface bevelled plano prism is $+0.54 + 0.66 \times 180$ at 40 degrees toward the base and $-0.77 - 1.36 \times 180$ at 40 degrees toward the apex. Center-bevelling is much preferred since the cosmetically pleasing front bevelling produces an increased discrepancy between the apex and base powers. In either case, viewing toward the base yields plus power and cylinder and viewing toward the apex yields minus power and cylinder. The relative amounts of induced plus or minus sphere and cylinder is attributed to the following three factors (Streff-1973):

1. the power of the prism.
2. the angle of incidence of incoming light.
3. the amount of curvature of the ocular surface of the prism. Increasing any one of these factors causes a corresponding increase in the refractive power. Application of plano prisms may subconsciously cause a held tilt in order to compensate for the patients current refractive condition. In some cases this property can be used to identify a patients awareness of noticeable differences in clarity.

Variable Displacement Effect

Any corrected curve plano prism placed in front of the eye will bend incoming light toward the base which is then perceived in the direction of the apex. The amount of deviation is directly proportional to the distance away from the point of reference (Prentice law). The increased actual deviation is visually perceived as a decrease in deviation. This has been called a bowing of straight
Appendix 1

lines effect (Margach-1979). For example, the center of a straight line viewed through a plano prism will appear deviated further from the apex than the ends of the line. The actual deviation of the center of the line is less than the ends, but perceptually this is interpreted backwards due to the retinal image placement. In summary, lines are perceived to deviate or bow towards the base of any corrected curve plano prism.

Another effect due to off axis viewing is peripheral magnification. When considering the power associated with plano prisms as described above, it becomes apparent that the plus powered base will produce greater magnification than the minus power at the apex. Combining the two displacement effects yield the perception of a square window to appear as expanding and bowing toward the base.

Chromatic Dispersion

One of the more subtle properties of a plano prism is the chromatic separation of full spectrum light. Shorter wavelength light (blue) is refracted a greater amount than longer wavelength light (red). This characteristic is noticeable when looking at a white sheet of paper through plano prisms, the paper edge toward the base appears reddish and the paper edge toward the apex appears bluish. This phenomenon may allow a practitioner to evaluate one aspect of the patients environmental awareness.

Perceptual Effect

Similar to the effect observed while using vectographic or tranaglyphic targets on transparent medium, yoked prisms also produce a SILO effect (Kaplan-1978). A base up prism perceptually creates closer and smaller targets while the base down prism creates farther and larger targets. This is yet another method for the practitioner to evaluate the awareness of the patient. Learned behavior must be ignored in order for the patient to give correct responses to basic questions about his environment. The patient is forced to attend to their visual sense in order to gain insight and understanding from the environment.
Appendix 1

As described above, the corrected curve plano prism is a complex optical device which effects visually sensed spatial location, geometry, and color. Knowledge of these variables allow critical assessment of a patient's ability to extract and interpret visual information from their environment. Additionally, the displacement effect disrupts previously learned visually guided movement, thereby, creating a situation in which efficient movement is achieved by allowing visual input to guide. Patient responses may include postural repositioning (Horner-1973) and changes in performance of specific tasks (Kaplan-1978). Yoked prisms are utilized, just as other optical lenses, in order to reduce or eliminate the patient's chief complaints. The various methods for application will be discussed in the next section.
Appendix 1

METHODS OF APPLICATION

Yoked prisms have been used for patients with convergence insufficiency and convergence excess (Kaplan-1978), motion sickness (Getman-1976), psychological problems (Kaplan-1985), neurological impairments (JCTBO-1991), cerebral palsy, learning disabilities (Getman-1976), and general binocular dysfunctions. There are four basic methods for applying yoked prisms: Probing, disruptive, compensatory, and therapeutic.

Probing

Probing with yoked prisms is a technique to establish the effect of the lens on a specific task performance. Typically powers of 5 to 10 prism diopters are utilized in all four primary base directions; base up, base down, base right, and base left. Subjective and objective changes in task performance are observed and noted. Many times, one prism base direction will improve performance, and the opposite prism base direction will decrease performance on the task. The specific task can be related to the individual’s needs, or can be a generic tasks such as catching and throwing a ball and peripheral awareness (Kaplan-1973), or Polaroid stereo acuity and stereo localization (Kraskin-1982). The powers used for the probe prisms are not typically prescribed for full time wear, but are used to establish the existence of performance changes.

Disruptive

Disruptive yoked prisms are usually of powers of 10 to 20 prism diopters and are utilized in controlled vision therapy sessions to radically disrupt the patients self-perceived orientation in the environment. In other words, this application causes a new or renewed awareness of the environment and forces postural shifts and visual-motor recalibration in order to efficiently interact with the environment. This used of prisms is used in severe cases of spatial disorientation and is commonly found within the neurologically impaired patient. Additionally, disrupting yoked prisms may be used in vision therapy patients when a large spatial shift is required to establish attentional
Appendix 1
direction. Additionally, due to the optical effects, visual awareness and perceptual abilities can be determined.

Compensatory lenses are prescribed for use outside the office or vision therapy room. In the case of severe neurological dysfunctions, the prisms may be the minimum amount required to create conditions which produce a shift in the patients center of balance and/or awareness in order to improve performance of standing, walking, talking, and/or attentional abilities. The improved patient orientation in their environment allows physical, occupational, and speech therapists to more effectively administer patient care. The yoked prism treatment is rapidly gaining acceptance in progressive rehabilitation centers, throughout the United States. Compensatory lenses are also prescribed for the more common patient seen in the optometric practice. These prescriptions are typically of powers 2 to 3 prism diopters, which is below conscious awareness of the patient (Sheedy-1987,Kaplan-1973). The main component of a compensatory lens is that the base direction prescribed is the one which enhances task performance. This philosophy has been elaborated by Melvin Kaplan in various OEP continuing education articles.

Kaplan's view is one of improving performance with yoked prisms. A probe prism of 5 prism diopters is used in all prism base directions to evaluate performance changes while throwing and catching a ball, and while performing peripheral awareness tasks which measure peripheral acuity. Kaplan describes a syndrome which may aid practitioners in determining when to prescribe yoked prisms. For more information on the Kaplan Syndrome, refer to Kaplan's 1978 OEP booklet entitled Vertical Yoked Prisms. Unfortunately, It is not apparent why yoked prisms are prescribed in the prism base direction which enhances performance vs in a prism base direction which deteriorates performance. The compensatory lens compensates for a visual spatial mismatch and therefore improves performance. I believe the concept of improving performance intuitively made sense and therefore was not explained in great detail by Kaplan. The compensatory prism prescription is for full time wear and is worn until the probe yoked prisms,
utilized during an office visit, show no increase or decrease in performance. This suggest the patient is able to adapt quickly to a variety of visual spatial orientations. The learning to adapt usually is completed within one year.

Therapeutic

Therapeutic yoked prisms are prescribed much like compensatory yoked prisms with one big difference, the prism base direction is 180 degrees apart. Robert Kraskin, in his OEP Lens Power in Action series of 1982-83, wrote about the use of therapeutic yoked prisms. The Kraskin view suggests prescribing the prism base in the direction which reduces performance, or in the direction opposite to that which improves performance, in order to stress the system such that it reacts in the opposite direction. He mentioned that the compensatory use of yoked prisms to enhance performance are rarely prescribed, but that therapeutic utilization is the more common and preferred prescription. They serve to induce physiological stress in the direction of the performance asymmetry, leading to a homeostasis response in the opposite direction in order to reduce the prism induced stress. Kraskin backed up his therapeutic usage by comparing it with other stress induced biological changes such as growth of bones due to compression. Kraskin's performance test is third degree fusion (stereo acuity and localization) performance. Kraskin also mentioned use of therapeutic yoked prisms on patients with early non-embedded myopic refractive conditions. The generalized myopic development of centering closer in space, or becoming more centrally oriented is counteracted with base-up prisms which cause the same effect, thus creating conditions which allow the patient to adapt in the opposite direction.

Summary of Yoked prism applications

1. Probing yoked prisms of powers 5 to 10 prism diopters are used in all prism base directions to determine if they effect task performance.
2. If the probe prisms do not affect task performance, yoked prisms are typically not prescribed for full time wear.

3. Alternatively, if the probe prisms do affect task performance, a full time prescription may be beneficial to the patient.

4. The yoked prism power for full time wear is typically less than 4 diopters such that the patient is not consciously aware of any lens induced distortions. A feeling of uneasiness may be experienced initially but distortions should not be observed.

5. The yoked prism base direction for compensatory prisms is that which enhances performance. This is advocated by Kaplan.

6. The yoked prism base direction for therapeutic prisms is that which deteriorates task performance, or the opposite direction to that which improves task performance. This is advocated by Kraskin.

7. Compensatory and therapeutic lens prescriptions are worn full time until the ability to adapt to yoked prisms is enhanced. At this time, the probe yoked prisms will not produce performance changes. Timing for this ability is learned is typically less than one year.

8. Disruptive yoked prisms of powers in excess of 10 prism diopters are utilized when a large spatial shift is required to bring the patient's self-perceived orientation in the environment into conscious awareness.

Both the Kraskin and Kaplan philosophies are reportedly successful in creating changes in the visual system and in visual-motor performance. This reality of functional success
Appendix 1

Independent of prism base orientation suggest the yoked prism treatment is more important than the yoked prism base direction. Literature describing or theorizing what effect yoked prisms have on an individual add credibility to this suggestion and will be discussed briefly.
THEORIES OF YOKED PRISM APPLICATION

The premise for any application of yoked prisms in the vertical direction is generally agreed upon by most behavioral optometrist. This premise is one of eso versus exo postured individuals. The eso person is discussed as being centrally oriented, showing convergence excess tendencies, and sees the "figure" better than the "ground". The exo person is peripherally oriented, shows convergence insufficiency tendencies, and sees the "ground" better than the "figure". These are broad generalizations but, for the purposes of this paper will suffice.

The behavioral optometric goal of treatment of an exo person is to create conditions which allow the patient to become more centrally aware of their environment, or contract the field. Similarly, the goal of treatment for a eso person is to create conditions to allow increased awareness of the peripheral environment, or expand the field.

Base up yoked prisms, due to their optical characteristics, redirect attention downward and inward and thereby contract the field. Base down yoked prisms redirect attention outward, thus, expanding the field. The treatment goal for both eso and exo types is to create conditions which allow growth toward increased peripheral/central visual system equalization and freedom. Depending on your philosophy, that of compensating vs therapeutic yoked prism application, you can choose the proper prism orientation. In either case, enhancement of both peripheral and central visual systems allow the individual to call upon which ever system is required to efficiently perform a specific task. This improves task performance and eliminates yoked prism induced performance changes.

Theories of how or why yoked prisms create a reduction of patients symptoms and improved optometric findings have been eluded to throughout this paper. Many authors have written their views on the subject, most of which are located in OEP articles. Many of the statements have common threads. In an attempt to tie the thought together I will report on one authors comments that seem to sum up the yoked prism effect.
Israel Greenwald in the OEP series entitled *The Brain's Response to Visual Training* wrote:

"When we use yoked prisms, binasal or bitemporal occluders, low power equal spheres or deliberate combinations of plus/minus spheres while the patient is engaged in movement tasks, we are basically asking that person to "rethink" where he is spatially." These lenses "all act to expand or contract physical space and in so doing greatly affect our self-movement and visual appreciation of objects moving in our field of gaze. These same lenses exert their influence on the movement specific visual neurons." Greenwald continued to tie in the neuronal influence by discussing the role of X and Y cells in the visual system. The concept here is one of two different processing systems which are activated by different stimuli. Making a broad generalization, the Y cells react to fast moving, low contrast demands, and the X cells react to slow moving, high contrast demands. The cortical hardware and specificity of function appears to exist. It is Greenwald's feeling that "yoked prisms aid in the "functional" expansion and enhancement of peripheral vision by creating an induced spatial shift which possibly acts as a cortical "arousal" mechanism and literally forces the person to attend more to the peripheral world." He also states, "It is this initial and abrupt change in awareness of self movement and of optical velocity field movements which leads to an eventual return to stability, but now at a more biologically efficient level of performance."
CONCLUSIONS

Vision Therapy is the art and science of arranging conditions to allow an individual to become more fully aware of his environment. Additionally, by arranging conditions in which an individual must learn new behavior in order to function efficiently, the individual accesses one of the most powerful healing devices known to man--his own brain. Yoked prisms, used with caution and knowledge, can be utilized as a powerful, therapeutic device. They create an unknown self-perceived orientation in the environment which, in order to function efficiently, causes an increase in awareness of the visual sense. Following the visual guidance, new visual-motor relationships are created, leading to increased adaptability in any given environment. The goal of most vision therapy regimes is to provide flexibility and adaptability to the visual system. Few procedures can create the overall effect that yoked prisms appear to have on behavior and on the visual system. I sincerely hope this article has helped to clarify the use of yoked prisms; an under-utilized, misunderstood, and valuable optometric tool.
BIBLIOGRAPHY


Horner SH, The Use of Lenses & Prisms to Enhance Visual Training, Optometric Extension Program: Continuing Education Course, 1972-73;45:1(1-12)


Appendix 2

Name ___________________________ Graduation date: 92 93 94 95
Patient Number ________________
Researcher Initials _______________
Age: ______________
Gender: M F

Current Rx description: Spects CL's BOTH
OD ______________________
OS ______________________

Exclusion questionnaire: (ASK ALL QUESTIONS, circle N=no or Y=yes)

<table>
<thead>
<tr>
<th>POHX</th>
<th>PMHX</th>
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<tbody>
<tr>
<td>strabismus</td>
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</tr>
<tr>
<td>amblyopia</td>
<td>inner ear infections</td>
</tr>
<tr>
<td></td>
<td>dizziness</td>
</tr>
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<td>vertigo</td>
</tr>
<tr>
<td></td>
<td>fear of heights</td>
</tr>
<tr>
<td></td>
<td>motion sickness</td>
</tr>
</tbody>
</table>

MEDICATIONS: _______________________________________________________

Aided VA's
VA @ 20 FT.    OD 20/    OS 20/    OU 20/
VA @ 40 cm.    OD 20/    OS 20/    OU 20/

Stereopsis: Polaroid Ran Dot at 40 inches (circle correct responses)

1 2 3 4 5 6 7 8 9 10

Cover Test far and near: Strabismus observed NO YES

Horizontal phoria _______ 6 M exo eso _______ os hyper hypo

Verticle phoria _______ 40 cm exo eso _______ os hyper hypo

2.1
Appendix 3

INFORMED CONSENT FORM

Pacific University

A. Title of project: The Effect of Yoked Prims on Center of Balance.
B. Principal investigator: Douglas Jeske 359-5501
C. Advisor: Bradley Coffey, O.D. 245-2607
D. Location: Pacific University Optometry Clinic and Physical Therapy Clinic, Forest Grove, OR
E. Date: 1992

1. Description of project

This research project is designed to determine the effect of an optical lens on one function of performance. To participate in this research you will be asked to provide vision and health information and undergo a visual screening process to identify the qualifications required. Upon approval, you will be scheduled for an appointment to measure the effect of wearing a special lens. In order to take measurements you will be asked to stand in place for periods of 30 seconds, looking at a small spot on a wall approximately 20 feet away, and standing as still as possible. Multiple measurements will be taken during a period of approximately 15 minutes.

2. Description of risks

Participants may experience a mild headache or eye fatigue during or shortly after the visual screening process; no more than experienced during a complete visual examination. Participants will wear a sport type goggle which may cause blunt trauma while applying or removing the goggles; the same risk as any pair of spectacles. During the measurement period when you will be wearing lenses attached to the goggles, you may experience dizziness, nausea, or a distorted view of the environment. The lenses may produce the same effect after they have been removed and you are asked to walk a short distance and sit in the chair. These effects are rare.

3. Description of benefits

This research will serve to increase the understanding of how lenses effect the human body. It may provide evidence to support the use of this particular type of lens in neurological rehabilitation facilities. Additionally, it may provide insight as to how lenses could be prescribed in order to alleviate headaches and to improve performance.

4. Records of this project will be maintained in a confidential manner and no name-identifiable information will be released.
5. **Compensation and medical care**

All responsible care will be taken to prevent injury during this research. If you are injured in this experiment it is possible that you will not receive compensation or medical care from Pacific University, the experimenters, or any organization associated with the experiment.

6. **Offer to answer any inquiries**

The persons involved in this research will be happy to answer any questions that you may have at any time during the course of the study. 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). If you are not satisfied with the answers you receive, please call Dr. James Peterson, 357-0442. As a result of your participation in this project, you are not a Pacific University clinic patient. 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.

7. **Freedom to withdraw**

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

I have read and understand the above. I am 18 years of age or over.

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

______________________________