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Testing the efficacy of a common visual perception test as a new method to diagnose unilateral spatial inattention with brain injury patients

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Abstract

Neglect or unilateral spatial inattention (USI) is defined as a condition where the "patient fails to report, respond or orient to novel or meaningful stimuli presented to the side opposite of the brain lesion."1 The Test of Visual Perceptual Skills non-motor Revised (TVPS-R) is a widely administered test of visual-analysis skills administered to brain injured patients to assess visual perception .. We hypothesized that USI could be diagnosed by administering the TVPS-R in the traditional horizontal format and in an experimental vertical format which would serve as a control. Our prediction being that more errors would be committed on the horizontal test items that were presented in the neglected hemi-field. We further hypothesized that by using a test we developed, the midline shift laser test, a measurable midline shift in an ipsilesional direction would be present in those subjects diagnosed with USI. We also planned to investigate the efficacy of the Star Cancellation test in paralleling the diagnoses of USI made by occupational therapists (OTs). Subjects for this investigation included those with recent brain injuries, both with neglect and without neglect. The diagnosis of neglect/US! was determined by licensed occupational therapists with experience in brain injury and neglect. The OTs then ran our series of tests, including the Star Cancellation test, two subtests of the TVPS-R in both a traditional horizontal format and an experimental vertical format, and finally the midline shift laser test. The results from all three tests were analyzed for recognizable patterns to confirm or disconfirm the study hypotheses. Results showed that subjects with neglect were not significantly more likely to miss the items in their neglected hemi-field on the TVPS-R subtests; however, they did show a greater rate of overall error compared to their non-neglect counterparts. All but one of the left neglect subjects had a significant midline shift to the right and of all three experimental methods the midline shift test appeared to be the most sensitive in diagnosing neglect. Further, the Star Cancellation test had an efficacy for diagnosing USI lower than previously reported. This study made clear that further research needs to be invested to determine the most accurate method for testing brain injured patients for USI diagnosis.

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TESTING THE EFFICACY OF A COMMON VISUAL PERCEPTION TEST AS A NEW METHOD TO DIAGNOSE UNILATERAL SPATIAL INATTENTION WITH BRAIN INJURY PATIENTS

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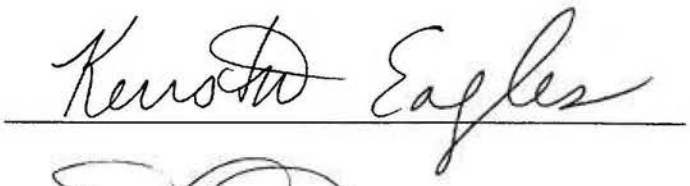
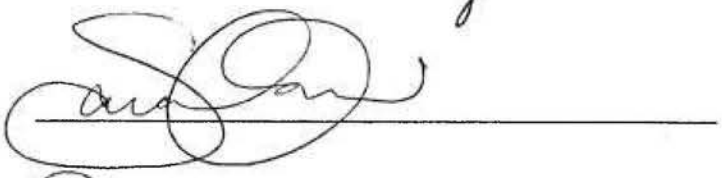
Keirsten Eagles 

Sara Olson 

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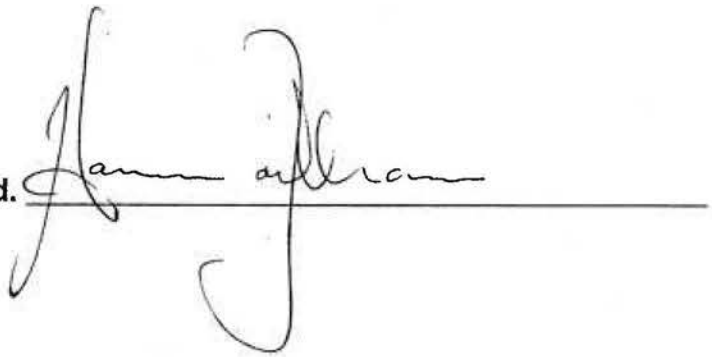
Hannu Laukkanen, O.D., M.Ed. 

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Keirsten Eagles graduated from Oregon State University with a B.S. in general science and a minor in chemistry. At Pacific University College of Optometry she is a member of American Optometric Student Association, the College of Optometrists in Vision Development, and the Beta Sigma Kappa Optometric Honor Society. Keirsten found an interest in the complexity of treatment for brain injury which inspired her involvement with this project. After graduation she plans to practice full scope optometry in Maine with an emphasis in vision therapy and rehabilitation.

Sara Olson received a bachelor's degree in biology and a minor in chemistry from Minnesota State University, Mankato in 2003. Currently she is working on her Doctor of Optometry degree at Pacific University in Forest Grove, Oregon. She is a member of the American Optometric Student Association (AOA), the AOA Low Vision Rehabilitation Section, the Beta Sigma Kappa Optometric Honor Society, and Amigos Eyecare. She hopes to return to the Midwest to practice optometry and specialize in low vision rehabilitation.

Joel Tuttle received his Bachelor of Arts degree in 2003 in biology with a minor in chemistry from Wartburg College in Waverly, IA. At Pacific University in Forest Grove, OR he is currently working on his Doctor of Optometry degree and is a member of American Optometric Student Association, Student Optometric Association, the College of Optometrists in Vision Development, Amigos, and the Fellowship of Christian Optometrists. Joel hopes to practice optometry in Iowa upon graduation.

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Abstract

Neglect or unilateral spatial inattention (USI) is defined as a condition where the "patient fails to report, respond or orient to novel or meaningful stimuli presented to the side opposite of the brain lesion."[1] The Test of Visual Perceptual Skills non-motor Revised (TVPS-R) is a widely administered test of visual-analysis skills administered to brain injured patients to assess visual perception.

We hypothesized that USI could be diagnosed by administering the TVPS-R in the traditional horizontal format and in an experimental vertical format which would serve as a control. Our prediction being that more errors would be committed on the horizontal test items that were presented in the neglected hemi-field.

We further hypothesized that by using a test we developed, the midline shift laser test, a measurable midline shift in an ipsilesional direction would be present in those subjects diagnosed with USI.

We also planned to investigate the efficacy of the Star Cancellation test in paralleling the diagnoses of USI made by occupational therapists (OTs).

Subjects for this investigation included those with recent brain injuries, both with neglect and without neglect. The diagnosis of neglect/USI was determined by licensed occupational therapists with experience in brain injury and neglect. The OTs then ran our series of tests, including the Star Cancellation test, two subtests of the TVPS-R in both a traditional horizontal format and an experimental vertical format, and finally the midline shift laser test. The results from all three tests were analyzed for recognizable patterns to confirm or disconfirm the study hypotheses.

Results showed that subjects with neglect were not significantly more likely to miss the items in their neglected hemi-field on the TVPS-R subtests; however, they did show a

greater rate of overall error compared to their non-neglect counterparts. All but one of the left neglect subjects had a significant midline shift to the right and of all three experimental methods the midline shift test appeared to be the most sensitive in diagnosing neglect. Further, the Star Cancellation test had an efficacy for diagnosing USI lower than previously reported. This study made clear that further research needs to be invested to determine the most accurate method for testing brain injured patients for USI diagnosis.

Key Words: Amsler grid, egocentric localization, midline shift, neglect, Star Cancellation test, Test of Visual Perceptual Skills non-motor Revised (TVPS-R), unilateral neglect, unilateral spatial inattention (USI), visual USI.

During the past two decades, there has been a significant increase in the number of patients who survive acquired and traumatic brain injury. A very large proportion of these brain injury patients suffer from secondary visual consequences such as Unilateral Spatial Inattention (USI), also known as neglect, visual USI, or unilateral neglect.[1] Throughout this document we will be using these terms interchangeably, but mainly referring to this condition as USI based on an earlier thesis written by Emily McCart and Gaggan Basra entitled, "Discussion of Unilateral Spatial Inattention and a Proposed New Screening Method for its Detection." USI is defined as a condition where the "patient fails to report, respond or orient to novel or meaningful stimuli presented to the side opposite of the brain lesion."[1] Visual neglect not only interferes with the quality of life, but impacts the success of potential rehabilitation as well. Thus, if sensitivity, selectivity, and the efficiency of USI detection could be improved, it could help contribute in a positive way to patient treatment and rehabilitation.

Typically, neglect is diagnosed by health care providers based upon subjective patient behaviors. One of the frustrating issues in diagnosing USI is its variable presentation. Milder forms of USI are much more difficult to uncover by observing patient behavior alone.

Less commonly, USI is objectively confirmed with the well-researched and standardized Behavioral Inattention Test (BIT). Of all of the BIT subtests, the Star Cancellation subtest (Appendix C) has the best sensitivity and selectivity[2]. The test contains 56 small stars, 52 large stars, 13 letters and 10 words. The high density of targets plus the presence of distracter items yields high sensitivity for this test. Bailey et al. found the test to have good repeatability; through intra-class correlation analysis they found a coefficient of 0.89.[3] The Star cancellation test was also found to have 80% diagnostic sensitivity and 91% diagnostic specificity in another study.[4]

This subtest, however, can be very challenging and time consuming for a patient with poor attention and fine motor skills because it requires them to sustain vigilance on a confusing visual display and to cross out 54 small stars with a pencil. We plan to evaluate the Star Cancellation test's effectiveness at diagnosing neglect as part of this study. Based on the given statistics we posit that the results of the Star Cancellation test will reflect the given statistics and closely mirror the OT diagnoses.

Another goal of this study is to determine whether an abbreviated version of a commonly administered visual perceptual screening test can also be used to identify USI. Previous research has established that neglect patients are much less likely to visually search in their neglected field than in the non-neglected field.[5] The Test of Visual Perceptual Skills non-motor Revised (TVPS-R) is commonly administered to brain injury patients by rehabilitation specialists and optometrists in order to identify visual perceptual deficits that commonly accompany brain insult.

The TVPS-R has seven sub-tests that include Visual Discrimination, Visual Memory, Visual Spatial-Relationships, Visual Form-Constancy, Visual Sequential-Memory, Visual Figure-Ground and Visual Closure. Each sub-test has sixteen test plates. The first four sub-tests present five different answer choices on each template, but the last three subtests have only four different answer choices on each page. Each TVPS-R template is rectangular, eight and a half by eleven inch paper with the answer options presented from left to right in a multiple choice arrangement. Answer choice number three is presented at the patient's midline, while answers one and two fall into the patient's left hemi-field and answers four and five fall into their right hemi-field. The frequency of position for each correct answer choice in a subtest can be seen in Figure 1.[6]

	Position of Correct Answer on TVPS-R Test Plate				
	1	2	3	4	5
Visual Discrimination	25%	12.5%	12.5%	18.75%	31.25%
Visual Memory	31.25%	18.75%	12.5%	18.75%	18.75%
Visual Spatial-Relationships	12.5%	25%	18.75%	25%	18.75%
Visual Form-Constancy	12.5%	18.75%	18.75%	31.25%	18.75%
Visual Sequential-Memory	25%	25%	25%	25%	
Visual Figure-Ground	25%	18.75%	25%	31.25%	
Visual Closure	25%	18.75%	31.25%	25%	

Figure 1. Frequency of Correct Answer Position in Each Subtest (16 pages each) of the TVPS-R[6]

We posit that USI sufferers are more likely to commit errors on those plates where the correct choice falls into the neglected hemi-field. Thus, it may be possible to uncover and diagnose USI solely by analyzing a patient's pattern of errors on the TVPS-R. Two subtests of the TVPS-R, the Visual Form-Constancy subtest and the Visual Spatial-Relationships subtest, were used to test this notion.

To help differentiate between visual-perceptual deficits and visual-neglect deficits both TVPS-R subtests will be given in the traditional horizontal format and an experimental vertical format. If the type and number of errors are consistent on the vertical and horizontal formats then the defect is most likely visual perceptual. If the errors are found mostly in the visual field opposite the brain injury on the horizontal test only, then the defect is most likely related to neglect.

In contrast to the Star Cancellation subtest, the TVPS-R subtests do not require attention to be sustained for as long a time period, plus it does not require the grasping and

manipulation of a pencil. It would be advantageous for both patients and health care providers if subtle cases of USI could be identified without having to require a taxing supplementary test to identify/diagnose visual neglect.

Another test we plan to evaluate in this study is one based on the concept of the presence of a midline shift opposite to the side of the neglect in USI patients. In other words, the midline shift is theoretically ipsilateral to the brain injured side.

According to two studies by Karnath, USI patients may experience a change in their perception of straight ahead in addition to reduced awareness in one hemi-field. With this phenomenon the patients' egocentric localization deviates from their objective midline location. This can cause patients to feel unsteady or not grounded.[5,7]

Another researcher, Padula, observed an evident change in posture following some brain injuries. He used yoked prisms with their bases located contralesionally to help correct the abnormal posture. Based on this he theorized the presence of a "visual midline shift syndrome" where an ipsilesional shift of the visual perception of midline and the body's center of mass occurs.[7]

Research has shown that red and green glasses cause reduced light transmission which can manifest a tonic-ocular motor imbalance. This imbalance may cause a more significant midline shift during the midline shift test.[8] For this reason we plan to have the subjects wear red and green glasses and hold a red laser pointer. While wearing the glasses only the eye behind the red lens of the red and green glasses will be able to see the red laser light. This essentially creates a condition referred to as monocular fixation in a binocular field. This would allow for comparisons between a midline shift present under monocular and binocular conditions.

Our intention is to explore these notions using two groups, brain injured patients with neglect, and brain injured patients without neglect. Differentiation of neglect from non-neglect will be based upon the subjective ratings given by OTs with extensive neglect diagnosis expertise. Each subject's performance on the Star Cancellation test, two subtests of the TVPS-R and the presence or absence of a midline shift will be evaluated and compared to OT diagnosis, the current "gold standard" for differentiation. In this way we hope to compare the effectiveness of each of these three methods in accurately diagnosing USI.

Methods and Materials

Our subjects were being treated for a past traumatic brain injury (TBI) or an acquired brain injury (ABI) at Good Samaritan Hospital by three occupational therapists with twenty-nine years collective experience working with brain injured patients.[9] Good Samaritan is located in Puyallup, WA, which has a population of approximately 35,600. Good Samaritan's Physical Medicine and Rehabilitation Center has provided physical and cognitive rehabilitation services for over 50 years.[10]

A total of 26 subjects with a mean age of 64.3 years and an age range of 32 to 84 participated. All of the subjects had some form of brain injury with eight suffering from a right cardiovascular accident (CVA), seven suffering from left CVA, four suffering from traumatic brain injury or motor vehicle accident, and three with tumors. The date of incident for the subjects ranged from 1998 to September 2006. Nine subjects were previously diagnosed with Unilateral Spatial Inattention (USI) and 17 were diagnosed with no signs of USI. The specific details for each subject can be found in Appendix A.

The majority of subjects were tested by licensed and registered occupational therapists who work for Good Samaritan Hospital where the subjects were being treated for their brain injuries. In efforts to save time and increase the amount of subjects, seven patients, previously diagnosed by occupational therapists as showing no signs of neglect, were tested in an optometrist's office in Puyallup, WA, by an optometry student. All test administrators were given a testing and study protocol orientation prior to initiation of any data gathering.

Exclusion criteria for participants included: Near visual acuity 20/50 or worse OU or any significant field loss in the central 20 degrees of vision in either eye.

Near Visual Acuity and Amsler Grid Test Methods

Near visual acuity was assessed using a near Snellen acuity card at 40cm. All subjects were required to wear their habitual visual correction during all procedures. The patency of each patient's central 20 degrees of vision was subjectively evaluated with monocular Amsler Grid Testing for each eye at a 30cm.

Subjective assessment for USI Methods

Each participant was subjectively assessed for USI by an occupational therapist who administered the testing protocol. Criteria used by OTs include general behavior such as the ability of the patients to function with both sides of their body and their awareness to both sides of the visual field. OTs also noted any avoidance on one side versus the other.[9] Neglect severity was rated by the OTs as: No Neglect, Mild Neglect, Moderate Neglect, or Severe Neglect.

Star Cancellation Test Methods

Next, the Star Cancellation subtest of the Behavioral Inattention Test (BIT) was given. This test is reported to have the best sensitivity and selectivity in diagnosing neglect of all the BIT subtests.[2] For the purposes of this study, the standard administration protocol was modified to incorporated a head rest. Each subject was first seated comfortably, then his/her head was placed in a head rest to assure the head was pointed straight ahead at the test material. Subjects were instructed to cross out all the small stars on the page. In accordance with standard administration protocol, the administrator first demonstrated the desired response by crossing out the two small stars on the bottom as an example. There was no time limit for this task. The test was scored in accordance with the protocol of more than or equal to three stars missed as determining neglect.

Test of Visual Perceptual Skills non-motor Revised Methods

Each patient completed two different subtests from the Test of Visual Perceptual Skills non-motor Revised (TVPS-R); however, each of these subtests was administered twice, once in the traditional horizontal format and once in an experimental vertical format. Our hypothesis was that USI patients would show increased errors with the horizontal format when the correct answer was located on the side contralateral to the site of the brain injury (in the subjects' neglected hemi-field). The midline presented vertical format version would serve as a control to help identify visual-perceptual deficits as a cause for errors.

The two TVPS-R subtests chosen were Visual Spatial-Relationships and Visual Form-Constancy. These specific subtests were chosen for several reasons. First, each template has five answer choice possibilities. Five horizontally arranged selections makes it easy to center the test booklet so that two potential answer choices fall into the subject's left hemi-field, two into the right hemi-field, and one is aligned with the subject's midline. These subtests were chosen also because the distribution of correct answer location is relatively symmetrical between right and left sides, as can be seen in Table 1.

According to the TVPS-R manual, the median reliability coefficient for the Visual Spatial Relationship subtest is 0.61, and the total group reliability coefficient is 0.85. The median reliability coefficient for the Visual Form Constancy subtest is 0.56, and the total group reliability coefficient is 0.74. Although reliability values for individual subtests are less than optimal (due to a relatively small number of dichotomous items), the median and total sample reliability numbers indicate acceptable internal consistency.[11]

Test administration order counter-balanced or alternated between horizontal and vertical. Half of the subjects completed the horizontal Visual Form-Constancy subtest first, the vertical Visual Spatial-Relationships subtest second, the horizontal Visual Spatial-

Relationships subtest third and the vertical Visual Form-Constancy subtest fourth. The other half of the subjects completed the vertical Visual Form-Constancy subtest first, the horizontal Visual Spatial-Relationships subtest second, the vertical Visual Spatial-Relationships subtest third and the horizontal Visual Form-Constancy subtest fourth. Subjects were seated comfortably and a headrest was used for all TVPS-R subtests to insure proper straight-ahead head alignment during testing.

Midline Shift Laser Test Methods

Lastly, we developed a test that to the best of our knowledge has not been used previously for the detection of neglect or quantification of midline shift. For this test, subjects were asked to stand (if able) two meters from a chart with their head in a headrest to assure straight-ahead alignment. The chart consisted of a three-meter by one-meter length of white paper with vertical black lines every eight centimeters (to help the examiners in quantifying any deviation from center). Subjects were centered in front of the middle column with the head positioned in a headrest attached to a small vertically adjustable table. This table served as the headrest anchor as well as an occluder. It was positioned so as to obscure subjects' inferior line of sight so they were unable to see their own hands. The purpose of blocking inferior visual field was to eliminate potential visual feedback about the location of straight ahead from seeing one's own arm and hand position. The investigators surmised that this procedure would cause subjects to be more reliant upon using only the laser spot on paper wall chart for judging what they perceived as straight ahead.

The laser midline test was administered to each subject in three different conditions; two with the subject wearing anaglyph red and green filter glasses, and one without. While wearing the glasses, only the eye behind the red acetate is able to see the red spot generated by the laser light. Viewing a red laser spot while wearing special red and green filter glasses

is referred to as monocular fixation in a binocular field. In this condition normal binocular fusion is maintained but each eye can be tested independently.

In the first condition the anaglyphic glasses were adjusted so that the red lens was placed over the right eye and the green lens over the left. Subjects were instructed to hold the laser pointer in their right hand, view the spot, and then bring the spot in from the right side stopping precisely at the location the perceived as being "straight ahead". The laser pointer was then transferred to the left hand and the subject was instructed to view the red spot and bring it in from the left until it was pointed directly straight ahead. In the second condition the red and green filters were reversed so that the green lens was placed over the right eye and the left eye got the red acetate filter lens. The same bracketing procedure was used where the laser was brought in from the right with the right hand then from the left with the left hand. The protocol for third condition was the same as the previous, except subjects wore no filter glasses so they could see the red laser spot with both eyes at the same time. Two data points were obtained from each of the three conditions giving a total of six data points for each patient.

Test distance was two meters and width column was eight centimeters. By recording both the column number and the location within the column, the accuracy of subjects' perceived straight-ahead judgment could be determined within three or four centimeters. The mean shift was determined for each subtest. It was arbitrarily decided that the criteria for positive USI diagnosis would be a shift of four centimeters or more for at least two of the three conditions (in the direction opposite that of the brain injury).

Results

Occupational Therapists' Diagnosis Results

For the purposes of this study the subjective diagnosis of neglect by a trained occupational therapist was considered the "gold standard" to which the Star Cancellation test, the Test of Visual Perceptual Skills non-motor Revised, and the midline shift laser test would be compared.

Of the 26 subjects who completed the testing, the occupational therapists diagnosed three subjects with mild left neglect, three with moderate left neglect, two with mild to moderate left neglect and one with moderate right neglect. This gives a total of eight subjects diagnosed with left neglect, one diagnosed with right neglect, and 17 diagnosed with no neglect. These data are summarized in Appendix A.

To simplify comparison of neglect versus non-neglect behaviors in our sample of brain-injured patients, we decided to analyze the data only from those with left neglect, the most prevalent form. This resulted in one subject (with moderate right neglect) being excluded from our data analysis. This right neglect subject showed an average midline shift of 0.66 cm left, but missed no stars on the Star Cancellation test. This subject also missed the same number of questions on the horizontal and vertical formats of the TVPS-R subtests.

Star Cancellation Test Results

Using the standard grading criteria given in the Behavioral Inattention Test (BIT) manual three or more missed stars indicates neglect. A confusion matrix demonstrating how this criterion compares to the OTs' diagnoses can be seen below in Figure 2. Analysis of this table indicates 75.0% sensitivity, 70.6% specificity, 72.0% accuracy and a false-alarm rate of 29.4%.

TP = true positives FP = false positives FN = false negatives TN = true negatives		OT Diagnosis	
		Neglect	No neglect
Star Cancellation	Neglect	TP = 6	FP = 5
	No Neglect	FN = 2	TN = 12

Figure 2 Star Cancellation test criterion of three or more stars missed indicating neglect.

Star Cancellation test results were further analyzed to determine if an alternate number of stars missed would more closely match the OTs' diagnoses.

Figure 3 shows the confusion matrix using one or more stars missed as an indication of neglect. With this criterion the Star Cancellation test would have 100% sensitivity, but only 35.3% specificity, 56.0% accuracy and a false-alarm rate of 64.7%.

TP = true positives FP = false positives FN = false negatives TN = true negatives		OT Diagnosis	
		Neglect	No neglect
Star Cancellation	Neglect	TP = 8	FP = 11
	No Neglect	FN = 0	TN = 6

Figure 3 Star Cancellation test criterion of one or more stars missed indicating neglect.

A confusion matrix using eight or more stars missed as a diagnosis of neglect can be seen in Figure 4. This criterion gives 62.5% sensitivity, 88.2% specificity, 80.0% accuracy and a false-alarm rate of 11.8%.

TP = true positives FP = false positives FN = false negatives TN = true negatives		OT Diagnosis	
		Neglect	No neglect
Star Cancellation	Neglect	TP = 5	FP = 2
	No Neglect	FN = 3	TN = 15

Figure 4 Star Cancellation test criterion of eight or more stars missed indicating neglect.

Based on our limited sample size, it would appear that the criterion of three or more stars missed indicating neglect gives the best combination of sensitivity, specificity and accuracy, as well as a relatively low false-alarm rate. A summary of this data can be seen in Figure 5. A Receiver Operating Characteristic curve (ROC curve) shown in Figure 6 also summarizes this information. A summary of the Star Cancellation test raw data can be found in Appendix C.

	Sensitivity	Specificity	Accuracy	False-Alarm Rate
One or more wrong	100.0%	35.3%	56.0%	64.7%
Three or more wrong	75.0%	70.6%	72.0%	29.4%
Eight or more wrong	62.5%	88.2%	80.0%	11.8%

Figure 5 Star Cancellation test analysis summary.

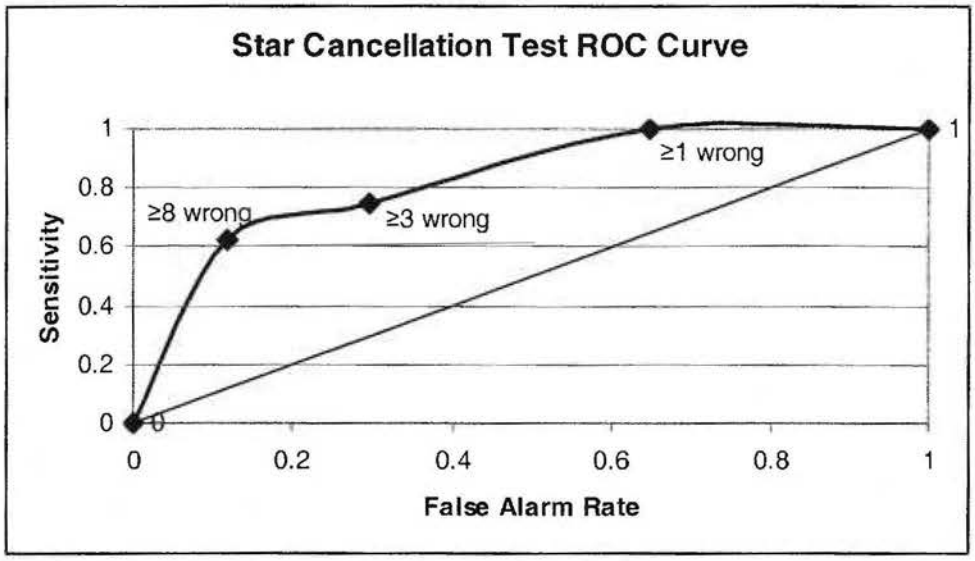

Figure 6 Star Cancellation test ROC curve.

Test of Visual Perceptual Skills non-motor Revised Results

Our original hypothesis was that patients with neglect would be more likely to commit errors on the horizontal TVPS-R test plates where the correct answer choice was located in their neglected hemi-field. By analyzing errors committed on horizontal plates where the correct answer was choice one or two versus plates where the correct answer was choice four or five we hoped to find a pattern significant enough to lend itself as a diagnosis of neglect. The experimental vertical TVPS-R would thereby serve as a control since all choices on all plates were positioned at the midline.

In order to determine the accuracy of our hypothesis the TVPS-R results from the 17 non-neglect and eight left neglect subjects were analyzed using the repeated measures analysis of variance (ANOVA).

This analysis indicated that neglect patients did perform significantly worse on the TVPS-R in general, $F(1,23) = 9.74$, $p = 0.005$. Contrary to our hypothesis, however, neglect patients did not perform significantly better on the vertical version compared to the horizontal version, $F(1,23) = 1.54$, $p = 0.227$. Also contrary to our hypothesis is that both neglect and non-neglect subjects performed significantly poorer on those test plates where the correct choice was directly in the center at choice three, $F(2,46) = 17.92$, $p = 0$, versus those plates where the correct choice was either one or two or where the correct choice was either four or five.

This information led us to perform post-hoc analysis using criteria other than location of errors as an indication of neglect. As mentioned above and illustrated in Figure 7 left neglect subjects performed significantly poorer in all three answer choice targets than their non-neglect counterparts.

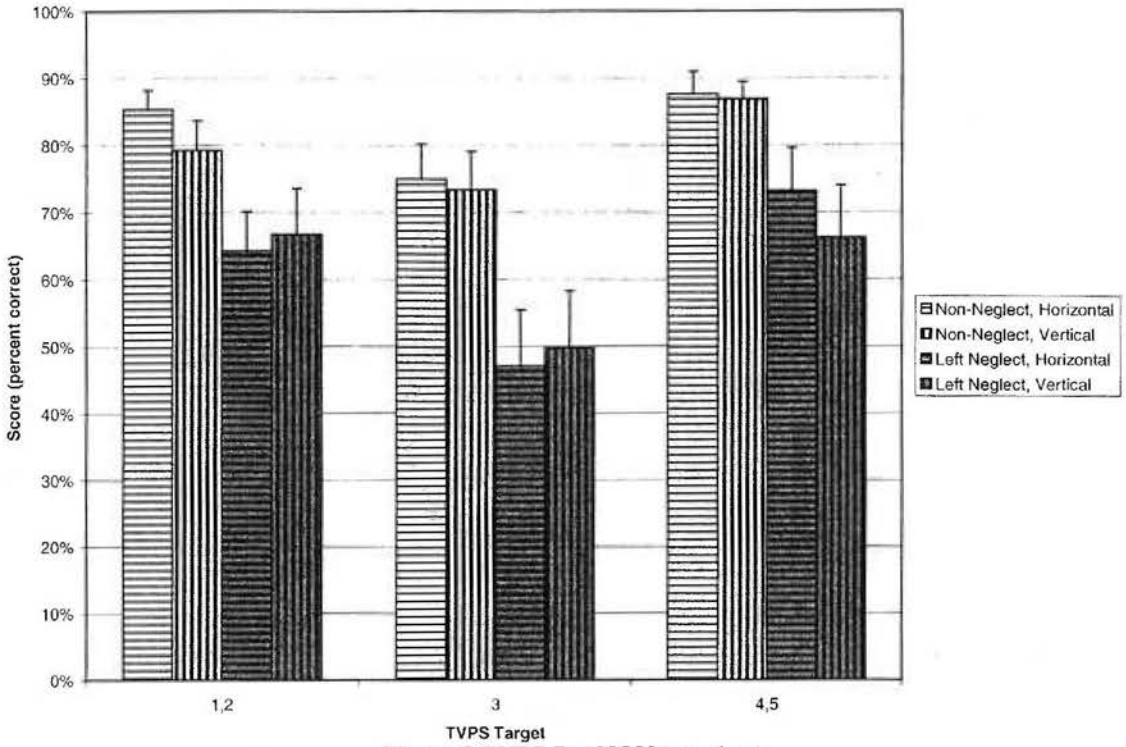

Figure 7 TVPS-R ANOVA analyses.

As can be seen in Figure 7 the average overall score for non-neglect subjects is approximately 80% and the average overall score for neglect subjects is approximately 60%. This may suggest that an overall depression in form perception ability and not a straight-forward analysis of right or left choice errors may be more indicative of neglect. Using this information we might infer that those subjects with a 40% or greater rate of error on either, choices one and two, choice three or choices four and five could be diagnosed with neglect. Variations on this criterion were analyzed using confusion matrices to determine which might best match the gold standard of OT subjective diagnosis.

The first variation uses a criterion of an error rate of 40% or more on at least one choice group in the horizontal TVPS-R as an indication of neglect. The confusion matrix in Figure 8 results in 87.5% sensitivity, 70.6% specificity, 76.0% accuracy and a false-alarm rate of 29.4%.

TP = true positives FP = false positives FN = false negatives TN = true negatives		OT Diagnosis	
		Neglect	No neglect
TVPS-R Horizontal	Neglect	TP = 7	FP = 5
	No Neglect	FN = 1	TN = 12

Figure 8 Criterion of ≥40% error rate on one or more choice groups in horizontal TVPS-R.

The second variation uses a criterion of an error rate of 40% or more on at least one choice group in the vertical TVPS-R as an indication of neglect. The confusion matrix in Figure 9 results in 75.0% sensitivity, 64.7% specificity, 68.0% accuracy and a false-alarm rate of 35.3%.

TP = true positives FP = false positives FN = false negatives TN = true negatives		OT Diagnosis	
		Neglect	No neglect
TVPS-R Vertical	Neglect	TP = 6	FP = 6
	No Neglect	FN = 2	TN = 11

Figure 9 Criterion of ≥40% error rate on one or more choice groups in vertical TVPS-R.

The third variation uses a criterion of an error rate of 40% or more on at least one choice group in both the horizontal and the vertical TVPS-R as an indication of neglect. The confusion matrix in Figure 10 results in 75.0% sensitivity, 76.5% specificity, 76.0% accuracy and a false-alarm rate of 23.5%.

TP = true positives FP = false positives FN = false negatives TN = true negatives		OT Diagnosis	
		Neglect	No neglect
TVPS-R Horizontal & Vertical	Neglect	TP = 6	FP = 4
	No Neglect	FN = 2	TN = 13

Figure 10 Criterion of ≥40% error rate on one or more choice groups in both horizontal & vertical TVPS-R.

Based on both the confusion matrix analysis and the fact that the vertical format of the TVPS-R is experimental and not widely available to practitioners the criterion of an error rate of 40% or more on at least one choice group in the horizontal TVPS-R appears to be the most useful way to diagnose neglect with the TVPS-R. Based on our limited sample size this criterion elicits relatively good sensitivity, specificity, accuracy and a relatively low false-alarm rate. A summary of this data can be seen in Figure 11. The ROC curve shown in Figure 12 also summarizes this information. The TVPS-R raw data can be found in Appendix E. The TVPS-R percent error information can be found in Appendix B.

	Sensitivity	Specificity	Accuracy	False-Alarm Rate
≥40% error on at least one group in horizontal TVPS-R	87.5%	70.6%	76.0%	29.4%
≥40% error on at least one group in vertical TVPS-R	75.0%	64.7%	68.0%	35.3%
≥40% error on at least one group in horizontal & vertical TVPS-R	75.0%	76.5%	76.0%	23.5%

Figure 11 TVPS-R analysis summary.

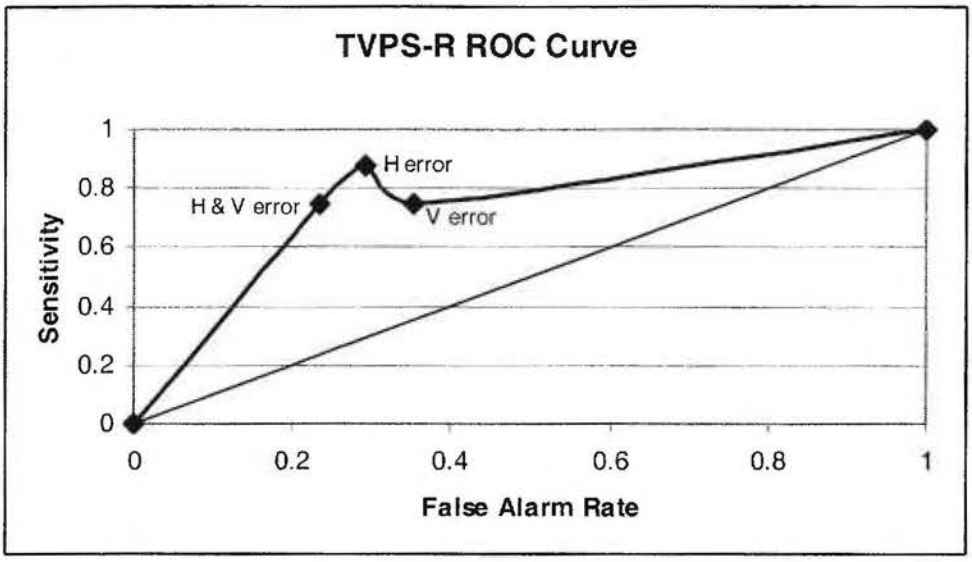

Figure 12 TVPS-R ROC curve.

Midline Shift Laser Test Results

Our original criteria for diagnosing neglect based on the midline shift laser test was that a shift of four centimeters or more in the direction opposite of the brain injury in at least two of the three subtests would be arbitrarily chosen as positive for neglect. To review, the subtests in this test were based on different lens conditions, either red lens over right eye, green lens over right eye or no lenses over either eye. Two measurements went in to each of these subtests when possible, one taken having the patient use their right hand to hold the laser and one taken having the patient use their left hand to hold the laser. This gave a total of six data points for each subject.

Using the OT diagnosis as the gold standard all but one of the eight left neglect patients showed a significant shift to the right. Further, repeated measures analysis of variance (ANOVA) indicated that there was a significant difference between neglect and non-neglect performance on the midline shift laser test, $F(1,23) = 9.87$, $p = 0.005$. However, ANOVA also indicated that there was no significant differences in the lens conditions alone, $F(2,46) = 0.22$, $p = 0.800$. Meaning, the significance of the midline shift was not altered by the state of being monocular in a binocular field which was induced by the wearing of red/green glasses and using a red laser pointer. The ANOVA analysis is illustrated in Figure 13.

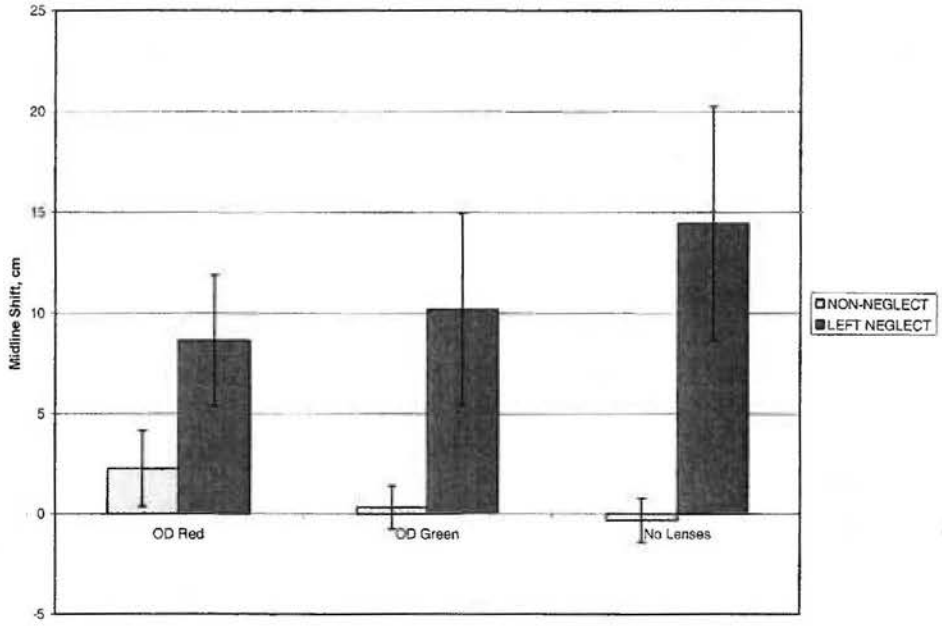

Figure 13 Midline shift laser test ANOVA analysis.

Using a confusion matrix to further analyze the clinical effectiveness of using this original criterion we found it gave 87.5% sensitivity, but only 52.9% specificity, 64.0% accuracy and a high false-alarm rate of 47.1%. This indicates that while this criterion will rarely miss any patients with neglect it will also falsely diagnose many patients without neglect. This confusion matrix is illustrated in Figure 14.

TP = true positives FP = false positives FN = false negatives TN = true negatives		OT Diagnosis	
		Neglect	No neglect
≥4cm shift in ≥2 subtests of midline shift	Neglect	TP = 7	FP = 8
	No Neglect	FN = 1	TN = 9

Figure 14 Midline shift laser test criterion of ≥4cm shift in ≥2 subtests of midline shift in the direction opposite neglect.

We then used post-hoc analysis to determine if another set of criteria might give better specificity and accuracy as well as a lower false-alarm rate while still having a relatively high sensitivity.

The first alternate criterion used was a shift of eight centimeters or more in the direction opposite of the brain injury in at least two of the three subtests being positive for neglect. Analysis of this confusion matrix gave 87.5% sensitivity, 88.2% specificity, 88.0% accuracy and a low false-alarm rate of 11.8%. This matrix is illustrated in Figure 15.

TP = true positives FP = false positives FN = false negatives TN = true negatives		OT Diagnosis	
		Neglect	No neglect
≥8cm shift in ≥2 subtests of midline shift	Neglect	TP = 7	FP = 2
	No Neglect	FN = 1	TN = 15

Figure 15 Midline shift laser test criterion of ≥8cm shift in ≥2 subtests of midline shift in the direction opposite neglect.

The second alternate criterion used was a shift of 12 centimeters or more in the direction opposite of the brain injury in at least two of the three subtests being positive for neglect. Analysis of this confusion matrix gave only 25.0% sensitivity, but a high 100% specificity, as well as 76.0% accuracy and a false-alarm rate of 0%. This matrix is illustrated in Figure 16.

TP = true positives FP = false positives FN = false negatives TN = true negatives		OT Diagnosis	
		Neglect	No neglect
≥12cm shift in ≥2 subtests of midline shift	Neglect	TP = 2	FP = 0
	No Neglect	FN = 6	TN = 17

Figure 16 Midline shift laser test criterion of ≥12cm shift in ≥2 subtests of midline shift in the direction opposite neglect.

The third and final alternate criterion looked at the data in a slightly different way. Perhaps by thinking of a midline shift more as losing localization of midline regardless of direction an even more accurate rate of diagnosis could be achieved. In this confusion matrix then the criteria was simply a midline shift of eight centimeters or more on either side of midline in at least two of the three subtests. This analysis gave 100% sensitivity, 88.2% specificity, 92.0% accuracy and a false-alarm rate of only 11.8%. This matrix is illustrated in Figure 17.

TP = true positives FP = false positives FN = false negatives TN = true negatives		OT Diagnosis	
		Neglect	No neglect
≥8cm shift in ≥2 subtests of midline shift, without specifying direction	Neglect	TP = 8	FP = 2
	No Neglect	FN = 0	TN = 15

Figure 17 Midline shift laser test criterion of ≥8cm shift in ≥2 subtests of midline shift in either direction of midline.

Based on all of the above analysis it appears the best criterion for diagnosing neglect using the midline shift laser test is a shift of eight centimeters or more on either side of midline in at least two of the three subtests. This is followed in effectiveness with using the criterion of an eight centimeter shift on the side of midline opposite that of the brain injury in at least two of the three subtests. This second method following the more traditional idea that a midline shift found in a neglect patient is always to the side opposite that of the neglect. A summary of all the confusion matrices can be seen in Figure 18. The ROC curve summarizing this information can be seen in Figure 19. Midline shift laser test raw data can be found in Appendix D.

	Sensitivity	Specificity	Accuracy	False-Alarm Rate
≥4cm shift in ≥2 subtests of midline shift	87.5%	52.9%	64.0%	47.1%
≥8cm shift in ≥2 subtests of midline shift	87.5%	88.2%	88.0%	11.8%
≥12cm shift in ≥2 subtests of midline shift	25.0%	100%	76.0%	0%
≥8cm shift in ≥2 subtests of midline shift, without specifying direction	100%	88.2%	92.0%	11.8%

Figure 18 Midline shift laser test analysis summary.

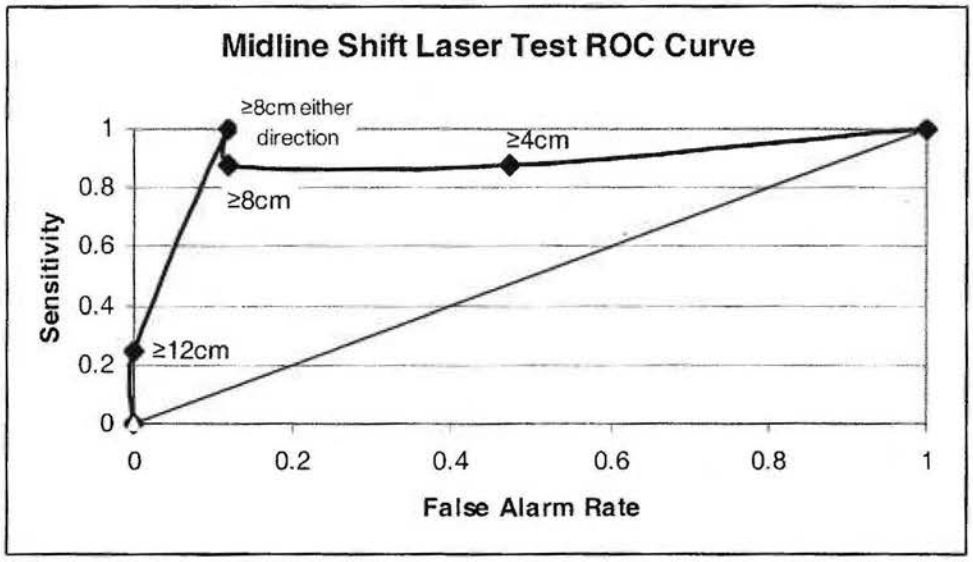

Figure 19 Midline shift laser test ROC curve.

Discussion

For the purposes of this study, the judgment of the staff occupational therapists at Good Samaritan Hospital was considered to be the definitive standard in determining whether subjects included in this study suffered from neglect or did not have neglect. This method is, however, more qualitative and largely based on the OTs' observations of patient behavior.[9] Keeping this in mind, an obvious area of further research could involve a comparison of occupational therapists' diagnoses to one another for a like set of subjects.

Prior to our study, and based upon evidence from prior studies claiming high 80% sensitivity and 91% specificity[4] for the Star Cancellation subtest of the Behavioral Inattention Test (BIT), we predicted it would most closely approximate OT diagnosis of USI. We were somewhat surprised, therefore, to find our analysis from the previously published data by some 5% in sensitivity and nearly 20% in specificity. In our post-hoc analysis we determined that even by altering the diagnostic criterion of number of stars missed from the standard three or more, to both one or more and to eight or more, we were unable to improve the sensitivity, specificity, accuracy and false-alarm rate satisfactorily. This discrepancy between published results and our results may be due to a number of factors including our relatively small sample size, the timeframe after the brain injury in which the test was administered, administrative protocol or another unknown reason. An oversight discovered only after data collection was complete involved a more thorough recording of the test results. In order to increase sensitivity of the Star Cancellation test it would have been beneficial to record the side on which the subject began the test.[12] According to the BIT scoring manual, patients with neglect typically begin the task from the right or middle part of the page and scan the sheet in an erratic manner rather than an organized left to right approach. This detail being left out may explain, in part, the discrepancies between the Star Cancellation test diagnoses

and the diagnoses made by the occupational therapists. It is also noteworthy that previous studies claiming high specificity and sensitivity for the Star Cancellation subtest were comparisons of the Star Cancellation Subtest with other subtests in the BIT battery. In this study the Star Cancellation Subtest results were compared to diagnostic results from OTs with extensive expertise in diagnosing neglect.

Arguably the greatest surprise in our data was the results obtained from the TVPS-R subtest administration. Our original hypothesis was that patients with neglect would be more likely to commit errors on the horizontal TVPS-R test plates when the correct answer choice was located in their neglected hemi-field. The vertically formatted TVPS-R subtests would serve as the control for visual perceptual deficits. Using the repeated measures analysis of variance (ANOVA) we discovered the hypothesis did not hold true. Rather, neglect subjects performed worse overall on both TVPS-R versions but not specifically on the answer choices presented on the left.

One possible explanation for the poor TVPS-R sensitivity in identifying neglect might be related to TVPS-R test ceiling. With standard TVPS-R administration protocol, after several consecutive errors, the subtest is discontinued because this is defined at the test ceiling. The logic being that since each test plate increases in difficulty as the test continues once four out of five tests plates are missed the patient is likely to continue missing each plate. Test ceiling was established by four failures out of five consecutive responses. The original intent was that all TVPS-R subtests plates would be presented and completed by every subject. In our experimental design, incorrect answers were just as significant as correct answers in determining neglect. This ceiling should not have been adhered to during our testing; however, at some point the test administrators began using the ceiling as an end point. It is conceivable, therefore, that if a patient had neglect, four plates were missed not

due to visual perceptual difficulties, but because the answers were positioned in the neglected field. In order to optimally analyze our data, any test plates not completed were not counted as misses; rather, they were excluded from analysis all together.

A possible option for future research might involve a discovery made during post-hoc analysis of the TVPS-R subtest results. Because neglect patients performed significantly worse overall on the TVPS-R subtests perhaps an overall depression of form perception ability could be used to make a diagnosis of neglect. During this study a criterion of a 40% or greater error rate on either choices one and two, choice three, or choices four and five in the horizontal version of the TVPS-R subtests gave a relatively high sensitivity of 87.5% and a specificity of 70.6%. Conceivably, then, further research and analysis along this vein may lead to a more concise and accurate method of USI diagnosis using only one or two subtests of the TVPS-R.

The results of the midline shift laser test while not completely conclusive for clinical application were, perhaps, the most promising. By changing our original arbitrarily chosen grading criterion of a four centimeter or greater shift ipsilesionally to an eight centimeter or greater shift ipsilesionally we were able to obtain 87.5% sensitivity and 88.2% specificity while maintaining a low false-alarm rate of only 11.8%. Further modification of this criterion using the theory that neglect is a loss of localization of midline in general and direction of shift may be less important than previously thought gave even better diagnostic results. The criterion of an eight centimeter or greater shift from midline in either direction gave 100% sensitivity, 88.2% specificity and a continuing low false-alarm rate of 11.8%.

Another idea disproved, at least in this study, is that rendering the patients monocular in a binocular field while performing the midline shift laser test would impact the severity, or amount, of their midline shift. According to our ANOVA analysis performed using the six

data points obtained under the three different lens conditions, there were no significant difference between the conditions. This means the amount of shift that was measured was not significantly different whether measured either monocularly or binocularly.

In general, our midline shift laser test tended to agree with the prior studies conducted by both Karnath and Padula.[5,7] Both discuss the presence of a midline shift in USI sufferers wherein the patient's subjective concept of straight ahead differs from their objective midline. They also discuss a physical posture or center of gravity change which was not evaluated during our study. Contrary to their studies, however, we were surprised that in quite a number of subjects in this study, the shift was not consistently ipsilesional. Perhaps USI causes much poorer spatial localization in general and is not always directionally predictable based only upon lesion location. Because only eight subjects in this investigation manifested neglect (according to OT diagnosis), this observation may not generalize to all neglect subjects. It is, on the other hand, a very intriguing finding that deserves further investigation. This test would benefit from further research in order to make this test more clinically useful.

It was difficult to recruit and obtain cooperation from subjects with recent brain injury and neglect. Neglect is usually associated with recent brain injury and it has been found that gross neglect can resolve within eight to twelve weeks of injury.[13] The overall cognitive ability of this population also made the testing more difficult and time consuming.

As was earlier mentioned in the results, one subject with moderate right neglect was excluded from our data analysis. According to the literature, when neglect is diagnosed in brain-injured individuals, it is almost always left neglect, and when right neglect does occur, it is not as severe. In other words, USI is more frequent and longer lasting after injury to the right inferior parietal lobe.[13] This nearly exclusive left-USI prevalence may be the result of

the right hemisphere having more bilateral control of cognitive representation of personal space and external space, whereas the left hemisphere control may be more selective for the right hemi-field. Thus potential right-USI from a left parietal injury may be compensated for by the more bilaterally spatial right parietal lobe. [6]

It is interesting that although the right neglect subject did show a midline shift to the left it occurred only during one of the six trials. Therefore, this subject did not meet our criteria for a positive neglect diagnosis. In addition, the right neglect subject missed no stars on the Star Cancellation Test suggesting no neglect, plus TVPS-R subtests also suggested no neglect was present.

Another possible confounder in this study is that we are not able rule out potential visual field cuts for all of our subjects. For unexplained reasons the Amsler Grid Test for patency of central visual field was not administered to all subjects, even though it was included in our original testing protocol. Although there are no obvious signs of visual field defects recognizable in our results, we cannot rule out this possibility.

Conclusion

This study serves as evidence for just how difficult it is to efficiently and definitively diagnose USI in brain injury patients. Although our original hypotheses were not supported by our empirical data, the midline laser shift test appears to be the most promising of the three tests included in this investigation. There remains a plethora of further research that is needed to better understand the diagnosis and management of USI.

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Appendix A

Brain Injured Subjects Tested and O.T. Neglect Diagnosis						
Patient #	**DOB**	**Sex**	**Date of Test**	**Diagnosis**	**Date of Onset**	**O.T. Subj USI analysis**
01	7/2/1935	F	3/30/2006	R CVA	3/18/2006	mild left neglect
02	3/28/1906?	M	3/31/2006	L CVA	1/10/2006	no neglect
03	12/11/1936	M	4/3/2006	CVA, direction not specified	3/2/2006	mod left neglect
04	8/5/1943	F	4/5/2006	L CVA	3/26/2006	mod right neglect
05	5/27/1935	M	4/5/2006	L CVA	3/31/2006	no neglect
06	11/25/1934	M	4/6/2006	R CVA	3/27/2006	no neglect
07	6/20/1942	M	4/13/2006	L CVA, L hemi	4/5/2006	mild left neglect
08	6/21/1943	M	4/4/2006	Hemorrhagic R CVA	3/16/2006	no neglect
09	10/11/1932	M	4/14/2006	R CVA	4/1/2006	no neglect
10	12/26/1922	F	5/3/2006	L CVA	4/17/2006	no neglect
11	86yo	F	5/3/2006	R CVA	4/18/2006	no neglect
12	5/7/1974	M	5/3/2006	R SDH	4/15/2006	no neglect
13	8/26/1958	F	9/27/2006	TBI	Dec-03	no neglect
14	4/30/1955	F	9/27/2006	TBI,vestibular hypofunction	Apr-03	no neglect
15	10/22/1964	F	9/27/2006	MVA	1998	no neglect
16	6/4/1971	F	9/27/2006	Cerebellar pontine ependymoma	Oct-02	no neglect
17	7/30/1932	M	9/27/2006	brainstem tumor	1998	no neglect
18	5/10/1942	F	9/27/2006	MVA	2004	no neglect
19	8/14/1953	M	9/27/2006	R meningioma, L CVA	Feb-04	no neglect
20	7/29/1929	F	9/27/2006	R CVA	9/12/2006	no neglect
21	2/22/1922	F	9/26/2006	R CVA	9/17/2006	mild left neglect
22	10/221936	M	9/28/2006	L CVA	9/7/2006	no neglect
23	unable to test due to decreased acuities					
24	8/31/1939	M	9/12/2006	Tumor	8/25/2006	mod-sev left neglect
25	unable to test due to decreased acuities					
26	4/17/1939	F	7/21/2006	R CVA	7/8/2006	mild-mod left neglect
27	?	M	8/7/2006	L CVA	7/17/2006	mild-mod left neglect
28	9/4/1943	F	9/14/2006	R CVA	8/26/2006	Mod left neglect

Appendix B

TVPS-R Percent Error							
		Horizontal Version			Vertical Version		
Patient #	OT Diagnosis	% Error on choices 1 & 2	% Error on choice 3	% Error on choices 4 & 5	% Error on choices 1 & 2	% Error on choice 3	% Error on choices 4 & 5
1	Mild left neglect	45.5	50.0	60.0	45.5	66.7	53.3
2	No neglect	18.2	16.7	26.7	18.2	50.0	13.3
3	Mod left neglect	54.6	50.0	13.3	72.7	66.7	26.7
4	Mod right neglect	9.1	16.7	13.3	18.2	16.7	13.3
5	No neglect	18.2	16.7	13.3	18.2	16.7	6.7
6	No neglect	22.2	60.0	18.2	30.0	16.7	20.0
7	Mild left neglect	18.2	50.0	13.3	36.4	50.0	20.0
8	No neglect	0.0	0.00	0.0	9.1	16.7	6.7
9	No neglect	18.2	0.00	0.0	9.1	0.00	0.0
10	No neglect	9.1	33.3	13.3	22.2	20.00	16.7
11	No neglect	27.3	50.0	33.3	36.4	50.0	26.7
12	No neglect	0.0	0.00	0.0	0.0	16.7	0.0
13	No neglect	18.2	16.7	0.0	18.2	16.7	6.7
14	No neglect	36.4	50.0	20.0	54.6	33.3	33.3
15	No neglect	0.0	33.3	0.0	0.0	0.00	6.7
16	No neglect	27.3	50.0	46.7	63.6	83.3	33.3
17	No neglect	18.2	50.0	13.3	27.3	50.0	13.3
18	No neglect	9.1	33.3	13.3	9.1	33.3	13.3
19	No neglect	0.0	0	0.0	0.0	0.00	6.7
20	No neglect	18.2	16.7	13.3	27.3	50.0	20.0
21	Mild left neglect	80.0	66.7	20.0	22.2	60.0	33.3
22	No neglect	0.0	0	0.0	9.1	0.00	0.0
23	unable to complete testing due to decreased acuities						
24	Mod to severe left neglect	40.0	100.0	50.0	33.3	75.0	76.9
25	unable to complete testing due to decreased acuities						
26	Mild to mod left neglect	27.3	16.7	13.3	27.3	0.00	6.7
27	Mild to mod left neglect	18.2	50.0	26.7	9.1	33.3	20.0
28	Mod left neglect	22.2	40.0	18.2	20.0	50.0	33.3

Appendix C

Star Cancellation Test Raw Data				
Patient #	Subjective USI Analysis	# Missed	Location of Missed Stars	What Test Indicates
01	mild left neglect	37	throughout	Neglect, Unspecified
02	No Neglect	1	center	No Neglect
03	moderate left neglect	25	primarily left	Left Neglect
04	Mod right neglect	0	na	No Neglect
05	No neglect	0	na	No Neglect
06	No neglect	0	na	No Neglect
07	mild left neglect	3	center and left	Left Neglect
08	No neglect	6	center and right	Right Neglect
09	No neglect	0	na	No Neglect
10	No neglect	2	1 far right and 1 far left	No Neglect
11	No neglect	1	center	No Neglect
12	No neglect	0	na	No Neglect
13	No neglect	8	greater misses on left than right	Left Neglect
14	No neglect	4	throughout	Neglect, Unspecified
15	No neglect	0	na	No Neglect
16	no neglect	2	left	No Neglect
17	No neglect	6	center and right	Right Neglect
18	no neglect	1	right	No Neglect
19	no neglect	1	left	No Neglect
20	no neglect	0	na	No Neglect
21	mild left neglect	45	throughout with more on left	Left Neglect
22	no neglect	15	throughout	Neglect, Unspecified
23	Unable to complete testing due to decreased acuities			
24	mod to severe left neglect	24	left through midline	Left Neglect
25	Unable to complete testing due to decreased acuities			
26	mild to mod left neglect	1	central	No Neglect
27	mild to mod left neglect	2	1 center and 1 left	No Neglect
28	moderate left neglect	11	majority left w/ some up to midline	Left Neglect

Appendix D

Midline Shift Raw Data							
Patient #	Subj USI analysis	Midline shift testing (distance in cm from midline and which side)					
		Red OD, right arm	Red OD, left arm	Green OD, right arm	Green OD, left arm	No lenses, right arm	No lenses, left arm
01	Mild left neglect	10, right	not done	22, right	not done	18, right	not done
02	No Neglect	6, left	8, left	2, left	4, left	6, left	2, left
03	Moderate left neglect	18, right	5, right	14, right	10, right	5, right	10, right
04	Right neglect	0	0	0	0	0	4, left
05	No neglect	0	1, right	0	4, right	0	4, right
06	No neglect	8, right	8, right	8, right	10, right	9, right	9, right
07	Mild left neglect	10, left	10, left	14, left	18, left	5, left	0
08	No neglect	10, right	5, right	0	0	0	0
09	No neglect * Used left arm for all trials	not done	10, left	not done	0	not done	5, left
10	No neglect * Used right arm for all trials	not done	0	not done	0	not done	4, left
11	No neglect * Used right arm for all trials	3, right	na	4, right	na	0	na
12	No neglect	0	0	0	0	0	0
13	No neglect	0	8, right	0	0	0	0
14	No neglect	23, right	26, left	2, right	2, left	2, right	2, left
15	No neglect	8, right	6, right	8, right	0	6,right	6, right
16	no neglect	20, right	24, left	32, right	16, left	32, right	20, left
17	No neglect	0	0	6, left	2, left	14, left	6, left
18	no neglect	2, left	2, left	2, left	2, left	2, left	2, left
19	No neglect	12, right	8, right	8, left	8, left	0	0
20	No neglect	0	8, left	2, left	10, left	2, left	4, left
21	Mild left neglect	10, right	6, right	10, right	10, right	18, right	14, right
22	No neglect *Used left arm for all trials	0	2, left	1, left	2, left	0	1, left
23	Unable to complete testing due to decreased acuities						
24	mod to severe left neglect *Used right arm for all trials	24, right	24, right	52, right	7, right	52, right	not done
25	Unable to complete testing due to decreased acuities						
26	mild to mod left neglect	8, right	8, right	14, right	10, right	4, right	10, right
27	mild to mod left neglect	10, right	10, right	10, right	10, right	10, right	5, right
28	moderate left neglect	6, right	10, right	2, right	2, right	10, right	10, right

Appendix E

TVPS-R Raw Data

Patient #	Subj USI analysis	Form Version Used	Form-constancy			Spatial-relationships		
			Horizontal	Vertical	Answer	Horizontal	Vertical	Answer
01	Mild left neglect	A	5	5	5	5	4	4
			2	1	1	1	1	1
			2	3	2	5	3	4
			4	4	4	5	5	2
			4	4	4	3	5	3
			2	2	2	1	4	4
			5	3	3	3	3	5
			5	5	4	5	5	5
			3	3	3	1	1	1
			4	4	4	1	3	4
			4	4	5	3	5	3
			3	3	4	5	2	2
			4	2	3	1	3	5
			5	2	5	5	1	2
			2	4	2	5	5	2
			1	1	1	4	4	3
		total missed	6	7		11	10	
02	No Neglect	A	5	5	5	4	4	4
			1	1	1	1	1	1
			4	2	2	4	4	4
			4	4	4	2	3	2
			3	4	4	3	3	3
			5	2	2	4	4	4
			3	3	3	2	4	5
			3	3	4	5	5	5
			2	2	3	1	1	1
			5	4	4	4	4	4
			5	5	5	3	1	3
			4	4	4	5	2	2
			3	4	3	5	5	5
			5	5	5	2	2	2
			2	2	2	2	2	2
			1	4	1	3	3	3
		total missed	6	4		2	3	

Patient #	Subj USI analysis	Form Version Used	Form-constancy			Spatial-relationships		
			Horizontal	Vertical	Answer	Horizontal	Vertical	Answer
03	Moderate left neglect	B	5	5	5	4	4	4
			1	1	1	3	1	1
			3	3	2	0	4	4
			4	4	4	2	3	2
			4	4	4	3	3	3
			2	1	2	3	4	4
			5	5	3	5	5	5
			4	1	4	5	5	5
			3	3	3	5	5	1
			4	2	4	4	2	4
			5	5	5	3	2	3
			4	4	4	5	5	2
			5	1	3	5	2	5
			5	5	5	1	5	2
			2	2	2	2	4	2
			3	2	1	5	1	3
		total missed	4	7		7	9	
04	Mod. Neglect Right	B	5	5	5	4	4	4
			1	1	1	1	1	1
			2	2	2	4	4	4
			4	4	4	2	2	2
			4	4	4	3	3	3
			4	4	2	4	4	4
			3	3	3	5	2	5
			1	4	4	5	5	5
			3	3	3	1	1	1
			4	4	4	4	4	4
			5	5	5	3	3	3
			3	3	4	2	2	2
			3	5	3	5	5	5
			5	5	5	2	2	2
			2	2	2	2	2	2
			1	1	1	4	3	3
		total missed	3	3		1	1	

Patient #	Subj USI analysis	Form Version Used	Form-constancy			Spatial-relationships		
			Horizontal	Vertical	Answer	Horizontal	Vertical	Answer
05	No neglect	A	5	5	5	4	4	4
			1	1	1	1	1	1
			2	2	2	5	4	4
			4	4	4	2	2	2
			4	4	4	3	3	3
			0	2	2	4	4	4
			3	3	3	5	5	5
			2	3	4	5	5	5
			3	3	3	1	1	1
			4	4	4	4	4	4
			5	5	5	3	2	3
			4	4	4	2	2	2
			2	3	3	5	5	5
			5	5	5	2	2	2
			2	2	2	2	1	2
			4	1	1	3	3	3
		total missed	4	1		1	2	
06	No neglect	B	5	5	5	4	4	4
			1	1	1	1	1	1
			2	2	2	4	4	4
			3	4	4	2	2	2
			4	4	4	3	3	3
			5	5	2	4	4	4
			5	3	3	5	5	5
			5	3	4	5	5	5
			4	3	3	1	1	1
			na	4	4	4	4	4
			na	4	5	3	3	3
			na	3	4	3	3	2
			na	5	3	5	5	5
			na	5	5	2	2	2
			na	3	2	2	2	2
			na	na	1	2	3	3
		total missed	5	6		2	1	

Patient #	Subj USI analysis	Form Version Used	Form-constancy			Spatial-relationships		
			Horizontal	Vertical	Answer	Horizontal	Vertical	Answer
07	Mild left neglect	B	5	5	5	4	4	4
			1	1	1	1	1	1
			2	2	2	4	0	4
			4	4	4	2	2	2
			4	4	4	3	3	3
			5	5	2	4	4	4
			2	5	3	5	5	5
			4	4	4	5	5	5
			2	2	3	1	1	1
			4	4	4	4	5	4
			5	5	5	3	3	3
			3	3	4	2	2	2
			2	1	3	5	5	5
			0	5	5	2	2	2
			2	2	2	2	4	2
			2	2	1	3	3	3
		total missed	7	6		0	3	
08	No neglect	A	5	5	5	4	4	4
			1	1	1	1	1	1
			2	2	2	4	4	4
			4	4	4	2	2	2
			4	4	4	3	3	3
			2	4	2	4	4	4
			3	3	3	5	5	5
			4	4	4	5	5	5
			3	3	3	1	1	1
			4	4	4	4	4	4
			5	2	5	3	3	3
			4	4	4	2	2	2
			3	5	3	5	5	5
			5	5	5	2	2	2
			2	2	2	2	2	2
			1	1	1	3	3	3
		total missed	0	3		0	0	

Patient #	Subj USI analysis	Form Version Used	Form-constancy			Spatial-relationships		
			Horizontal	Vertical	Answer	Horizontal	Vertical	Answer
09	No neglect	A	5	5	5	4	4	4
			5	1	1	1	1	1
			2	2	2	4	4	4
			4	4	4	2	2	2
			4	4	4	3	3	3
			2	0	2	4	4	4
			3	3	3	5	5	5
			4	4	4	5	5	5
			3	3	3	1	1	1
			4	4	4	4	4	4
			5	5	5	3	3	3
			4	4	4	2	2	2
			3	3	3	5	5	5
			5	5	5	3	2	2
			2	2	2	2	2	2
			1	1	1	3	3	3
		total missed	1	1		1	0	
10	No neglect	B	5	5	5	4	4	4
			1	1	1	1	2	1
			2	2	2	4	4	4
			4	4	4	2	2	2
			4	4	4	3	3	3
			5	5	2	5	4	4
			5	4	3	5	5	5
			2	1	4	5	5	5
			3	3	3	1	1	1
			4	5	4	4	4	4
			5	na	5	3	3	3
			4	na	4	2	2	2
			5	na	3	5	5	5
			5	na	5	2	2	2
			2	na	2	2	2	2
			1	na	1	3	3	3
		total missed	4	4		1	1	

Patient #	Subj USI analysis	Form Version Used	Form-constancy			Spatial-relationships		
			Horizontal	Vertical	Answer	Horizontal	Vertical	Answer
11	No neglect	A	5	5	5	4	4	4
			1	1	1	1	1	1
			2	2	2	4	5	4
			4	4	4	2	5	2
			4	4	4	1	1	3
			2	3	2	5	4	4
			5	3	3	5	5	5
			2	3	4	5	5	5
			3	3	3	1	1	1
			5	5	4	4	4	4
			5	5	5	3	3	3
			3	4	4	2	1	2
			1	4	3	5	5	5
			1	3	5	1	2	2
			na	2	2	2	5	2
			na	1	1	3	5	3
		total missed	6	5		3	6	
12	No neglect	A	5	5	5	4	4	4
			1	1	1	1	1	1
			2	2	2	4	4	4
			4	4	4	2	2	2
			4	4	4	3	3	3
			2	2	2	4	4	4
			3	3	3	5	5	5
			4	4	4	5	5	5
			3	3	3	1	1	1
			4	4	4	4	4	4
			5	5	5	3	3	3
			4	4	4	2	2	2
			3	3	3	5	5	5
			5	5	5	2	2	2
			2	2	2	2	2	2
			1	1	1	3	4	3
		total missed	0	0		0	1	

Patient #	Subj USI analysis	Form Version Used	Form-constancy			Spatial-relationships		
			Horizontal	Vertical	Answer	Horizontal	Vertical	Answer
13	No neglect	B	5	5	5	4	4	4
			1	1	1	1	1	1
			2	2	2	4	4	4
			4	4	4	2	2	2
			4	3	4	3	3	3
			4	3	2	4	4	4
			3	3	3	5	5	5
			4	4	4	5	5	5
			3	3	3	1	1	1
			4	4	4	4	4	4
			5	5	5	3	3	3
			4	4	4	2	1	2
			2	4	3	5	5	5
			5	5	5	2	2	2
			2	2	2	2	2	2
			3	1	1	3	3	3
		total missed	3	3		0	1	
14	No neglect	A	5	1	5	4	4	4
			4	1	1	1	0	1
			0	0	2	4	4	4
			4	4	4	2	3	2
			2	0	4	3	3	3
			3	2	2	4	4	4
			1	3	3	5	5	5
			0	2	4	5	5	5
			4	0	3	1	1	1
			4	4	4	4	4	4
			4	4	5	3	3	3
			4	4	4	2	2	2
			0	0	3	5	5	5
			5	0	5	0	0	2
			2	5	2	2	0	2
			1	1	1	3	3	3
		total missed	9	9		1	4	

Patient #	Subj USI analysis	Form Version Used	Form-constancy			Spatial-relationships		
			Horizontal	Vertical	Answer	Horizontal	Vertical	Answer
15	No neglect	B	5	5	5	4	4	4
			1	1	1	1	1	1
			2	2	2	4	4	4
			4	4	4	2	2	2
			4	4	4	4	3	3
			2	2	2	4	4	4
			3	3	3	5	5	5
			4	4	4	5	5	5
			3	3	3	1	1	1
			4	4	4	4	4	4
			5	4	5	3	3	3
			4	4	4	2	2	2
			3	3	3	5	5	5
			5	5	5	2	2	2
			2	2	2	2	2	2
			1	1	1	2	3	3
		total missed	0	1		2	0	
16	no neglect	A	5	5	5	4	4	4
			1	1	1	1	0	1
			2	2	2	4	5	4
			4	1	4	2	1	2
			4	4	4	3	0	3
			3	1	2	2	4	4
			3	3	3	5	0	5
			2	4	4	5	5	5
			1	1	3	1	1	1
			3	3	4	2	5	4
			4	5	5	3	2	3
			3	4	4	2	2	2
			1	1	3	5	5	5
			1	5	5	2	0	2
			2	5	2	1	5	2
			2	2	1	2	5	3
		total missed	9	7		4	10	

Patient #	Subj USI analysis	Form Version Used	Form-constancy			Spatial-relationships		
			Horizontal	Vertical	Answer	Horizontal	Vertical	Answer
17	No neglect	B	5	5	5	4	4	4
			1	3	1	1	1	1
			2	2	2	4	4	4
			4	4	4	2	2	2
			4	4	4	1	3	3
			5	5	2	4	4	4
			3	3	3	5	5	5
			5	1	4	5	5	5
			3	2	3	1	1	1
			4	4	4	4	4	4
			5	5	5	3	3	3
			4	3	4	2	2	2
			2	4	3	5	5	5
			2	5	5	2	2	2
			2	2	2	2	2	2
			2	4	1	2	5	3
		total missed	5	7		2	1	
18	no neglect	A	5	5	5	5	4	4
			1	1	1	1	1	1
			2	2	2	4	4	4
			4	4	4	2	2	2
			4	3	4	3	3	3
			4	4	2	4	4	4
			3	3	3	5	5	5
			3	5	4	5	5	5
			2	2	3	1	1	1
			4	4	4	4	4	4
			5	5	5	3	3	3
			4	4	4	2	2	2
			2	2	3	5	5	5
			5	5	5	2	2	2
			2	2	2	2	2	2
			1	1	1	3	3	3
		total missed	4	5		1	0	

Patient #	Subj USI analysis	Form Version Used	Form-constancy			Spatial-relationships		
			Horizontal	Vertical	Answer	Horizontal	Vertical	Answer
19	no neglect	A	5	5	5	4	4	4
			1	1	1	1	1	1
			2	2	2	4	5	4
			4	4	4	2	2	2
			4	4	4	3	3	3
			2	2	2	4	4	4
			3	3	3	5	5	5
			4	4	4	5	5	5
			3	3	3	1	1	1
			4	4	4	4	4	4
			5	5	5	3	3	3
			4	4	4	2	2	2
			3	3	3	5	5	5
			5	5	5	2	2	2
			2	2	2	2	2	2
			1	1	1	3	3	3
		total missed	0	0		0	1	
20	no neglect	B	5	5	5	4	4	4
			1	1	1	1	1	1
			2	3	2	4	4	4
			4	4	4	2	2	2
			4	4	4	3	3	3
			2	2	2	4	4	4
			3	4	3	5	5	5
			2	3	4	5	5	5
			3	2	3	1	1	1
			4	4	4	4	4	4
			5	3	5	3	3	3
			3	5	4	0	2	2
			4	5	3	5	5	5
			5	5	5	2	2	2
			2	x	2	0	2	2
			1	5	1	3	3	3
		total missed	3	9		2	0	

Patient #	Subj USI analysis	Form Version Used	Form-constancy			Spatial-relationships		
			Horizontal	Vertical	Answer	Horizontal	Vertical	Answer
21	Mild left neglect	A	5	5	5	4	3	4
			0	1	1	1	0	1
			3	2	2	4	4	4
			4	3	4	1	2	2
			4	4	4	5	3	3
			3	2	2	4	4	4
			5	5	3	5	5	5
			4	1	4	5	5	5
			2	1	3	1	0	1
			4	5	4	5	4	4
			5	nd	5	3	4	3
			3	nd	4	2	2	2
			5	nd	3	5	5	5
			3	nd	5	1	2	2
			0	nd	2	2	2	2
			nd	nd	1	3	3	3
		total missed	10	5		4	4	
22	no neglect	B	5	5	5	4	4	4
			1	1	1	1	1	1
			2	2	2	4	4	4
			4	4	4	2	2	2
			4	4	4	3	3	3
			2	2	2	4	4	4
			3	3	3	5	5	5
			4	4	4	5	5	5
			3	3	3	1	1	1
			4	4	4	4	4	4
			5	5	5	3	3	3
			4	4	4	2	2	2
			3	3	3	5	5	5
			5	5	5	2	2	2
			2	2	2	2	2	2
			1	2	1	3	3	3
		total missed	0	1		0	0	

Patient #	Subj USI analysis	Form Version Used	Form-constancy			Spatial-relationships		
			Horizontal	Vertical	Answer	Horizontal	Vertical	Answer
24	Mod to severe left neglect	A	5	2	5	4	3	4
			1	4	1	1	1	1
			2	2	2	4	4	4
			5	2	4	1	2	2
			1	5	4	2	0	3
			5	2	2	1	5	4
			5	3	3	3	5	5
			nd	4	4	nd	3	5
			nd	0	3	nd	5	1
			nd	0	4	nd	5	4
			nd	0	5	nd	5	3
			nd	5	4	nd	nd	2
			nd	nd	3	nd	nd	5
			nd	nd	5	nd	nd	2
			nd	nd	2	nd	nd	2
			nd	nd	1	nd	nd	3
		total missed	4	8		4	7	
26	Mild to mod left neglect	B	5	5	5	4	4	4
			1	1	1	2	1	1
			2	2	2	4	4	4
			4	4	4	2	2	2
			4	4	4	3	3	3
			4	4	2	4	4	4
			3	3	3	5	5	5
			3	4	4	5	5	5
			3	3	3	1	1	1
			4	4	4	4	4	4
			5	5	5	4	3	3
			4	4	4	2	2	2
			3	3	3	5	5	5
			1	1	5	2	5	2
			2	4	2	2	2	2
			4	1	1	3	3	3
		total missed	4	3		2	1	

Patient #	Subj USI analysis	Form Version Used	Form-constancy			Spatial-relationships		
			Horizontal	Vertical	Answer	Horizontal	Vertical	Answer
27	Mild to mod left neglect	A	5	5	5	5	4	4
			1	1	1	1	1	1
			2	2	2	5	4	4
			4	4	4	2	2	2
			4	4	4	4	3	3
			2	2	2	3	3	4
			3	3	3	5	5	5
			4	4	4	5	5	5
			2	1	3	2	1	1
			4	4	4	4	4	4
			5	5	5	3	3	3
			4	4	4	2	2	2
			1	1	3	5	4	5
			1	1	5	2	5	2
			2	2	2	1	2	2
			1	1	1	3	3	3
		total missed	3	3		6	3	
28	Moderate left neglect	A	5	5	5	4	4	4
			3	1	1	1	1	1
			2	4	2	4	4	4
			4	4	4	2	2	2
			4	1	4	3	3	3
			4	2	2	4	4	4
			4	3	3	5	2	5
			5	2	4	5	5	5
			2	3	3	1	1	1
			nd	4	4	4	4	4
			nd	5	5	3	5	3
			nd	2	4	2	2	2
			nd	4	3	5	5	5
			nd	0	5	2	2	2
			nd	1	2	2	2	2
			nd	nd	1	3	3	3
		total missed	5	7		0	2	

Appendix F

INFORMED CONSENT

TITLE OF PROJECT: Testing the Efficacy of a Common Visual Perception Test as a New Method to Diagnose Unilateral Spatial Inattention with Brain Injured Patients.

INVESTIGATORS: Curtis Baxstrom* OD, FCOVD, FAAO, phone: 253-661-6005 office, 253-569-9219 mobile 33919 9th Ave., Federal Way, WA 98003;

Hannu Laukkanen* OD MEd FAAO, 503-352-2751 office, 503-357-5984 home; Pacific University School of Optometry, Forest Grove, OR 97116

Sara Olson, phone: 503-357-7666, optometry student

Keirsten Eagles, phone: 503-547-9997, optometry student,

Joel Tuttle, phone: 515-230-4214, optometry student.

* Project Advisors

PROJECT DESCRIPTION: You have been invited to help study vision changes in people who have suffered brain injury. Sometimes people with brain injury do not see things like they did before the injury. One of the vision changes is when the person no longer sees the full field of vision due to how their brain was injured. Testing for this change often requires tiring testing. Your help in this study could help us to understand if simpler less tiring tests can be used to diagnosis these vision changes. To help in this test we will ask you to point towards an item or say the number that corresponds to the answer you select. We will take care to make you comfortable during this study. You will be seated comfortably in a chair with your head placed in a headrest to prevent movement. We will ask you to perform three different types of vision tests. First you will be shown a picture and asked to recognize the same picture from five different possibilities either presented horizontally or vertically. Second, you will be asked to look at a diagram with small stars, large stars, letters and numbers. You will be asked to cross out only the small stars. In the third task you will be asked to look at the center of a black and white paper grid in front of you, and then tell us whether any of the lines are missing from the grid.

LOCATIONS: Good Samaritan Hospital, Seattle, WA.

The private optometric practice of Dr. Curtis Baxstrom, 33919 9th Ave., Federal Way, WA 98003.

Progressive Rehabilitation Associates Portland, OR.

Pacific University College of Optometry Clinic, Forest Grove, OR 97116.

DATES: projected to begin September 2005 and to continue through December 2006.

RISKS: There will be very little risk to your health or welfare from any of the tasks that we ask you to do. The potential for health risk from this study, we believe, will be much less than associated with a normal eye examination in an eye doctor's office. To reduce the possibility of risk, we will carefully monitor the areas where the study is conducted and make sure they are safe and well maintained. The experimenters will assist you in proper seating, positioning of your head in the headrest.

STUDY POPULATION: You and approximately twenty other people will be adult subjects (18 years or older) who have experienced either an acquired or traumatic brain injury. Participating subjects will be recruited either from a hospital, a health care facility, or a private optometric practice.

EXCLUSION: You will not be able to help in this study if you are less than 18 years old, have near vision of 20/50 or worse in both eyes, you have limited or abnormal eye movements, or if you cannot see out of the central portion of your vision.

BENEFITS: You will not experience any benefit through your help in this study. However, your help may allow us to find new ways to diagnose vision changes after brain injury which could help others in the future. You will not be paid to help in this study. Your help in this study will not cost you anything except your time.

YOUR ALTERNATIVES: Your alternative is to not participate in this study.

CONFIDENTIALITY: Records from this study will be carefully maintained in a confidential manner. No name-identifiable information will be released. If the results of this study are published, the data will not be name-identifiable; which means that your identity will be kept confidential by the experimenters.

COMPENSATION AND MEDICAL CARE: If you are injured in this experiment and it is not the fault of Pacific University, the experimenters, or any organization associated with the experiment, you should not expect to receive compensation or medical care from Pacific University, the experimenters, or any organization associated with the experiment.

During your time as a volunteer in our study, you should not consider yourself a patient, agent, or employee of Pacific University. Participation in this study does not substitute for regular medical care. You will not be receiving complete eye, vision, or health care as a result of participation in this project; therefore, you will need to maintain your regular program of eye, vision, and health care.

QUESTIONS: The experimenters will be happy to answer any questions you may have at any time during the course of this study. During your participation in the project you are not a Pacific University clinic patient or client and all questions should be directed to Dr. Hannu Laukkanen, Dr. Curtis Baxtrom, Sara Olson, Keirsten Eagles, or Joel Tuttle (phone numbers are listed above). If you are not satisfied with the answers you receive, please call Dr. Krista Brock wood, Chairman of the Pacific University Institutional Review Board (503-352-2616).

FREEDOM TO WITHDRAW: I understand I am free to withdraw my consent at any time and stop participation in this study at any time without prejudice or consequences to myself.

_____

I have read and understand the above.

Printed name of subject: _____Subject age:_____

Subject's signature: _____ Date: _____

Address: _____

City/State: _____ Zip: _____

Telephone number: (_____) _____-_____

If the subject has a guardian, or is unable to read and understand this consent form, a guardian signature is required.

Guardian name: _____ Phone number: _____

Guardian signature _____ Date: _____

Address: _____

City/State: _____ Zip: _____

Photographic release:

I the undersigned give permission to have my picture taken. I understand my picture will be taken for research purposes only and may be used for presentations and publications. I understand that customary efforts will be made to maintain my privacy. If I have any questions about my picture I can contact Pacific University Institutional Review board or the study investigators at any time.

Printed name of subject: _____Subject age:_____
Subject's signature: _____ Date: _____

Appendix G

Unilateral Spatial Inattention Thesis Project Protocol

Check off each task as it is performed:

1. ☐ Informed Consent form must be completed for each subject.

2. ☐ Alternate which form of the testing protocol is used, A or B.

3. ☐ Fill in preliminary information including visual acuity at both near and far.

4. ☐ Perform Amsler Grid testing on each eye.

5. ☐ Give a short subjective statement based on your observations about whether or not each subject has USI.

6. ☐ Perform the Star Cancellation Test on each patient.

7. ☐ Perform the TVPS-R subtests alternating between horizontal and vertical presentations as indicated by the recording forms.

8. ☐ Perform the midline shift laser testing first with Red/Green glasses with red on the right, second with Red/Green glasses with red on the left, third without the Red/Green glasses.

9. ☐ Combine all forms for each patient and fasten together.

Amsler Grid

Seat the patient comfortably and have them wear their near prescription. Have the patient occlude one eye and hold the chart 28 to 30 cm in front of the other eye (the eye being tested). Instruct the patient to look at the center black dot and report if they see the dot the four corners and the four sides. While continuing to look only at the center dot ask the patient if they notice any spots or holes in the grid or any blurry, wavy or missing lines.

Roughly outline or otherwise note the location of any defects directly on the grid and briefly describe them on the recording form.

Star Cancellation Test

Set-up:
For each test seat the patient comfortably with their head positioned in the head rest to assure they are always looking straight ahead. Place the test on a table centered in front of the patient.

Instructions:
Tell this patient "This page contains stars of different sizes. Look at the page carefully – this is a small star. Every time you see a small star, cross it out like this." (Illustrate by crossing out the two small stars immediately above the centralizing arrow on the form.) "I would like you to go through this page and cross out all the small stars without missing any of them."

Recording:
There is nothing to record for this test, just return the actual test form with the other test material.

TVPS-R Subtests

Set-up:
For each test seat the patient comfortably with their head positioned in the head rest to assure they are always looking straight ahead. Place the test on a table centered in front of the patient.

Instructions:

Visual Spatial-Relationships test:
Using the first page as an example have the patient look at the center figure and respond on how many figures are on the page. Record this response to the side of the recording sheet. Then tell the patient that all the forms on the page are the same but one of the forms is going a different way or part of one of the forms is going a different way.

Have the patient verbally indicate to you which of the forms is going a different way using the numbers beneath each form. Do not allow the patient to touch or manipulate the page with their hands.

The procedure is the same for both the horizontal and vertical versions of this test.

Visual Form-Constancy test:
Point to the single form above the other five forms and tell the subject to find this form among the five forms below it, even though it may be smaller, bigger, darker, turned, or upside down. There is no "Example" page for this test.

Have the patient verbally indicate to you which of the forms contains the top form. Do not allow the patient to touch or manipulate the page with their hands.

The procedure is the same for both the horizontal and vertical versions of this test.

Recording:
Record the number of the form the patient chose on the blanks provided.

Midline Shift Laser Test

Set-up:
Hang the chart approximately 50cm from the ground in a location where 3 meters of wall space is available. This height may need to be adjusted based on patient height.

Position the table so the head rest is 2 meters from the chart and the center of the head rest is across from the center of the chart, column 19.

Ensure that the column numbers directly in front of the patient are obscured by the table.

Procedure:
Have the patient stand behind the adjustable table, adjusted to the appropriate height, with their head comfortably placed in the head rest.

The first set of trials will be done with Red/Green glasses with the red lens placed over the right eye. Instruct the patient to hold the laser pointer in their right hand and swing it in from their right side stopping at the location on the grid they feel is straight ahead of them. This is trial one. Next, still holding the laser pointer in their right hand have them cross this midpoint and return the laser beam from the left, again stopping where they feel straight ahead is. This is trial two.

Still wearing the Red/Green glasses with the red lens over the right eye have the patient repeat this procedure using the left hand.

Next, reverse the glasses so that the red lens is over the left eye and repeat the test with each hand.

Finally, while not wearing the Red/Green glasses have the patient again repeat the test with each hand.

Recording:
Note the column the patient stops the laser pointer at for each trial and whether the beam is in the center of the column, to the left of center, or to the right of center. Base left and right on the patient's perspective as they look at the grid.

Appendix H

Unilateral Spatial Inattention Thesis Project Recording Form
Version A

Examiner's Name: _____ **Date:** _____

Patient's Name: _____

Sex: _____ **DOB:** _____

Form of visual correction (please circle): Glasses Contact Lenses None

VA @ Far: OD ____ **VA @ Near:** OD _____
OS ____ OS _____
OU ____ OU _____

Amsler Grid Testing:

Abnormalities noted for **right** eye: Yes No

Please describe any abnormalities: _____

_____

Abnormalities noted for **left** eye: Yes No

Please describe any abnormalities: _____

_____

Subjective analysis on the presence or absence of USI by tester:

No Neglect Mild Neglect Moderate Neglect Severe Neglect

_____

_____

_____

_____

_____

Midline Shift Laser Test:

Record the column number in which the patient placed the laser pointer and circle one qualifier about the position within the column.

With Red/Green Glasses: (Red lens over right eye)

Right arm:	Trial 1:	Column #:	___	Left	Center	Right
	Trial 2:	Column #:	___	Left	Center	Right
Left arm:	Trial 1:	Column #:	___	Left	Center	Right
	Trial 2:	Column #:	___	Left	Center	Right

With Red/Green Glasses (Red lens over the left eye)

Right arm:	Trial 1:	Column #:	___	Left	Center	Right
	Trial 2:	Column #:	___	Left	Center	Right
Left arm:	Trial 1:	Column #:	___	Left	Center	Right
	Trial 2:	Column #:	___	Left	Center	Right

Without Red/Green Glasses:

Right arm:	Trial 1:	Column #:	___	Left	Center	Right
	Trial 2:	Column #:	___	Left	Center	Right
Left arm:	Trial 1:	Column #:	___	Left	Center	Right
	Trial 2:	Column #:	___	Left	Center	Right

TVPS Subtest Results:

Visual Form-Constancy Horizontal			Visual Spatial-Relationships Vertical		
Plate #	Response	Answer	Plate #	Response	Answer
			Example	_____	
1	_____		1	_____	
2	_____		2	_____	
3	_____		3	_____	
4	_____		4	_____	
5	_____		5	_____	
6	_____		6	_____	
7	_____		7	_____	
8	_____		8	_____	
9	_____		9	_____	
10	_____		10	_____	
11	_____		11	_____	
12	_____		12	_____	
13	_____		13	_____	
14	_____		14	_____	
15	_____		15	_____	
16	_____		16	_____	

Visual Spatial-Relationships Horizontal			Visual Form-Constancy Vertical	
Plate #	Response	Answer	Plate #	Response
Example	_____			
1	_____		1	_____
2	_____		2	_____
3	_____		3	_____
4	_____		4	_____
5	_____		5	_____
6	_____		6	_____
7	_____		7	_____
8	_____		8	_____
9	_____		9	_____
10	_____		10	_____
11	_____		11	_____
12	_____		12	_____
13	_____		13	_____
14	_____		14	_____
15	_____		15	_____
16	_____		16	_____

Unilateral Spatial Inattention Thesis Project Recording Form
Version B

Examiner's Name: _____ **Date:** _____

Patient's Name: _____

Sex: _____ **DOB:** _____

Form of visual correction (please circle): Glasses Contact Lenses None

VA @ Far: OD ____ **VA @ Near:** OD _____
OS ____ OS _____
OU ____ OU _____

Amsler Grid Testing:

Abnormalities noted for **right** eye: Yes No

Please describe any abnormalities: _____

_____

Abnormalities noted for **left** eye: Yes No

Please describe any abnormalities: _____

_____

Subjective analysis on the presence or absence of USI by tester:

No Neglect Mild Neglect Moderate Neglect Severe Neglect

_____

_____

_____

_____

_____

Midline Shift Laser Test:

Record the column number in which the patient placed the laser pointer and circle one qualifier about the position within the column.

With Red/Green Glasses: (Red lens over right eye)

Right arm:	Trial 1:	Column #:	___	Left	Center	Right
	Trial 2:	Column #:	___	Left	Center	Right
Left arm:	Trial 1:	Column #:	___	Left	Center	Right
	Trial 2:	Column #:	___	Left	Center	Right

With Red/Green Glasses (Red lens over the left eye)

Right arm:	Trial 1:	Column #:	___	Left	Center	Right
	Trial 2:	Column #:	___	Left	Center	Right
Left arm:	Trial 1:	Column #:	___	Left	Center	Right
	Trial 2:	Column #:	___	Left	Center	Right

Without Red/Green Glasses:

Right arm:	Trial 1:	Column #:	___	Left	Center	Right
	Trial 2:	Column #:	___	Left	Center	Right
Left arm:	Trial 1:	Column #:	___	Left	Center	Right
	Trial 2:	Column #:	___	Left	Center	Right

TVPS Subtest Results:

Visual Form-Constancy Vertical			Visual Spatial-Relationships Horizontal		
Plate #	Response	Answer	Plate #	Response	Answer
			Example		
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
10			10		
11			11		
12			12		
13			13		
14			14		
15			15		
16			16		

Visual Spatial-Relationships Vertical			Visual Form-Constancy Horizontal	
Plate #	Response	Answer	Plate #	Response
Example	_____			
1	_____		1	_____
2	_____		2	_____
3	_____		3	_____
4	_____		4	_____
5	_____		5	_____
6	_____		6	_____
7	_____		7	_____
8	_____		8	_____
9	_____		9	_____
10	_____		10	_____
11	_____		11	_____
12	_____		12	_____
13	_____		13	_____
14	_____		14	_____
15	_____		15	_____
16	_____		16	_____