Article ▸ # Statistical Relationships Between Visual Skill Deficits and Retained Primitive Reflexes in Children

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ABSTRACT

Background: Objective: The purpose of this study was to examine the relationship between Visual Skill Deficits (VSD) and retained primitive reflexes in children ages 6-14.

Method: The data was collected through retroactive chart reviews of one hundred and thirty-five (N=135) participants ages 6-14, who were evaluated at a private behavioral optometric practice near Cleveland, Ohio. Chi Square and Logistic Regression analyses were applied to the participants' recorded scores from the New York State Optometric Association King-Devick (NYSOA K-D) test, the Gardner Reversals Frequency test, the Motor Speed and Precision test, The Test of Visual Perceptual Skills-Revised (TVPS-R), the Rapid Automatized Naming (RAN) test, and the Draw-a-Person test, as well as the Institute of Neuro-Physiological Psychology (INPP) screening form for the Moro Reflex (MR), Tonic Labyrinthine Reflex (TLR), Asymmetrical Tonic Neck Reflex (ATNR), Spinal Galant Reflex (SGR), and Symmetrical Tonic Neck Reflex (STNR).

Results: The Chi Square analyses indicated that there are statistically significant relationships between VSD and three of the five primitive reflexes observed: TLR ($p=0.007$), ATNR ($p=0.020$), STNR ($p=0.012$). Furthermore, scores taken from the Draw-a-Person Test and the Motor Speed and Precision Test also suggest relationships with primitive reflex retention and VSD. Logistic Regression analysis suggested that the Tonic Labyrinthine Reflex is a potential predictor of VSD; the Motor Speed and Precision Test and Gardner Reversals Frequency Test can potentially be used to predict Neuro-Sensory Motor immaturity.

Conclusion: There is a significant correlation between retained primitive reflexes and vision skill deficits in the children, ages 6-14, who participated in this study.

Keywords: academic performance, motor development, retained primitive reflexes, visual skill deficits (VSD)

Background

Optometrists providing vision therapy services use a wide array of whole brain techniques with vision paramount to nurture neurological sensory-motor connections. Optometrists and therapists become skillful in both the art and science of providing the optimal intervention, exercise, or activity so that the patient can discover the capacities of their own unique visual system. Lenses, prisms, filters, and sensory motor experiences are the tools the optometrists use to change the brain and to improve lives.

Throughout the history of behavioral optometry, doctors have been interested in the brain and body connection. Dr. A.M. Skeffington's model of vision spoke to the importance of the antigravity sub-process as a key factor in affecting the full emergence of vision. Dr. William Padula wrote, "At birth, an infant enters a gravity-based environment. In order to cope with this new existence, the baby must develop an ability to right his body in space. Righting responses occur at an automatic level of the nervous system and start with the lifting of the head off the surface. …. [P]ostural response is also creating an opportunity for the visual system to begin to organize." Dr. Albert Sutton stated that "[t]he child must learn good control of movement (mobility) before he can learn to control non-movement (attention)." Furthermore, Dr. Donald Getz reminded us that "[t]he subject matter of body bilaterality cannot be ignored in most patients if efficient binocularity is going to be achieved. From a developmental standpoint, a child first learns to team the two halves of his body before he learns to team his two eyes together… The problem of strabismus is not strictly an ocular or eye muscle problem. Most strabismics are strabismics from head to toe."

We now understand that Dr. Skeffington's model of vision spoke to the processes of primitive reflex integration leading to postural control that enable us to maintain posture and balance against gravity so that we can attend, explore, experience, and manipulate the environment. Combining the developmental process of antigravity with the other sub-processes that Dr. Skeffington proposed—centering, identification, and auditory/

speech—vision emerges! Reflex integration is the early developmental stage in the process of Neuro-Sensory Motor Maturity (NSMM). NSMM is the maturation of the nervous system that occurs when motor neurons link with sensory neurons repetitively to create detailed brain maps that result in higher levels of motor control and greater understanding of our world.

Infant reflexive movement patterns are part of the neurological foundation to the development of vision. Optometrists who gain knowledge of the role and the effect that primitive reflexes have on vision development can use reflex movement patterns as a catalyst to improving vision skills. An association between retained primitive reflexes and delays in reaching developmental milestones is supported in the literature.[1] Considering that Visual Skill Deficit (VSD) contributes to difficulties with academic achievement, social skill performance, and depression, it is helpful for doctors to identify appropriate evaluation and intervention modalities that target those neurologically persistent reflex abnormalities that are most likely to impede optimal acquisition of visual skills. For the purposes of this paper, VSD is defined as decreased visual perceptual and oculomotor skills. Visual skills are fundamental for successful learning and participation in social, recreational, and sport experiences. The research presented here is focused on determining what relationships, if any, exist between VSD and retained primitive reflexes.

The acquisition of functional visual skills, as derived through sensorimotor experiences, is contingent upon a range of client factors including but not limited to energy, drive, attention, and temperament, each of which affects an individual's ability to learn. According to Goldstand, Koslowe, & Parush,[2] visual skills are used to gather and to process visual input from the environment in an accurate and efficient manner. Adaptive visual skills are achieved as the infant transitions from primitive reflexes to postural reflexes.[3] These visual skill functions continue to be refined along a developmental continuum. In this light, it follows that under-developed postural reflexes impede the development of eye movements such as fixation, convergence, and tracking, which are required skills for both reading and writing in the school setting.[4] These reflexes provide infants with the neuro-sensory motor foundation to establish mature brain and body maps that allow attention to develop and lead to higher level perceptual and cognitive skills. These maps include connections between the ocular musculature and the senses, which are needed to develop functional visual skills.

McPhillips[5] reports on the repetition of primary reflex movements inhibited by aberrant primitive reflexes and how movement may impact reading skill outcomes. Results indicate a significant reduction in observed aberrant reflexes in participants who consistently engaged in movement therapy interventions that target reflex integration; furthermore, the aforementioned interventions contribute to significant improvements in reading scores.[5] Blythe[6] suggests that adaptive neuro-motor skills indicate a mature central nervous system (CNS), which in turn promotes "functioning of the vestibular, proprioceptive, and postural systems, which collectively provide a stable platform for centers involved in oculomotor functioning and subsequently visual perception."[6] Retention of primitive reflexes may contribute to associated deficits acquired during the learning of visual perceptual skills.

It is reported that Convergence Insufficiency (CI) is the leading cause of eyestrain, blurred vision, double vision (diplopia), and/or headaches. In recent randomized clinical trials comparing vision therapy/orthoptics, pencil push-ups, and placebo vision therapy for the treatment of symptomatic CI, vision therapy/orthoptics resulted in statistical and clinical significant improvements in the signs and symptoms associated with CI.[7] As previously stated, aberrant visual tracking and visual perceptual skills are adversely affected by the retention of persistent primitive reflexes; therefore, behavioral optometry could play a key role in the advancement of evidence-based practice regarding intervention strategies that introduce participation in meaningful developmental movements to help remediate VSD.

Methods

Research Design

Data for this research was retrieved from a private optometric therapy practice in the Northeast Ohio metropolitan region. All metrics were compiled from the following six standardized visual skill test sets: the New York State Optometric Association King-Devick (NYSOA K-D) test, the Gardner Reversals Frequency test, the Motor Speed and Precision test, the Test of Visual Perceptual Skills-Revised (TVPS-R), the Rapid Automatized Naming (RAN) test, and the Draw-a-Person test. These tests provide metrics regarding the visual skills that facilitate achievement in academics, daily living, leisure, and social participation. Results of these tests were analyzed for possible relationships (as indicated by Chi Square analysis), predictors (as indicated by Logistic Regression), and measures of descriptive statistics when applied to the following primitive reflexes: Moro Reflex (MR), Tonic Labyrinthine Reflex (TLR), Asymmetrical Tonic Neck Reflex (ATNR), Spinal Galant Reflex (SGR), and Symmetrical Tonic Neck Reflex (STNR).

Measures

The NYSOA K-D test was used to measure performance of saccadic eye movements. In this test, the child is timed when reading a series of numbers across a page.[8] A deficit in saccadic eye movements is noted if a child's score falls below age level expectations. The Gardner Reversals Frequency Test is used to examine a child's ability to write, to recognize, and to match letters and numbers, in their correct orientation, in order to evaluate the child's skill in directionality.[9] The Gardner Reversals Frequency Test contains three subtests: the Reversals Execution subtest, the Reversals Recognition subtest, and the Reversals

Matching subtest. In the Reversals Execution subtest, the child is asked to write a specific list of numbers and letters. For the Reversals Recognition subtest, the child is presented with an array of numbers and letters, some of which are correctly oriented and some of which are presented as mirror images; the child is instructed to cross out all incorrectly oriented items. In the Reversals Matching subtest, a model number or letter is followed by four samples of the same number or letter; one of the four samples is correctly oriented like the model, while the other three are inverted and/or rotated in various ways, and the child is asked to circle the one that matches the model. Overall deficit in directionality skill is noted if the child's scores reveal below-age-level expectation in any of the three subtests.

The Motor Speed and Precision Test was administered to assess the child's ability to guide fine motor movement visually. This test evaluates eye-hand coordination as well as peripheral vision processing.[10] The test requires subjects to mark an "x" in a series of circles that are of decreasing size. There is a specified time limit to make the "x" marks. The number of accurate marks is recorded and compared to age norms. A deficit in motor speed and precision skill is noted if the child's score is equivalent to more than six months below age level.

TVPS-R examines the participant's functional abilities in visual form perception.[11] This test includes subtests that specifically measure to what extent a subject can identify forms (discrimination), remember single forms individually (memory), determine the correct direction of forms (spatial relations), recognize the same form when it varies in size or orientation (form constancy), remember a number of forms in a series (sequential memory), find a form when it is hidden among other forms (figure-ground), and determine the whole form from given parts (visual closure). A deficit in visual perceptual skill is noted if the child scores below the 50th percentile in any one of the subtests.

The RAN test evaluates the child's ability to coordinate visual information with speech. According to Wolf & Denckla,[12] this test assesses the ability to map visual symbols with verbal labels. A series of outlined pictures are shown on the test form. The examinee is asked to name each stimulus item as quickly and as accurately as possible. Test results are based on the recorded time used to name all stimuli on the test. A deficit in coordinating vision with speech is noted if the child scores below the 50th percentile. The final test, Draw-A-Person, provides a common set of scoring criteria to estimate intellectual ability according to the child's drawing of a human figure.[13] A deficit in visualization skills is noted if the child scores more than one year below age level.

The Institute for Neuro-Physiological Psychology (INPP) method was used to test for primitive reflexes. A primitive reflex is noted if the child's chart indicates that the individual reflex is retained rather than integrated. A retained vestibular MR is observed when the body moves into extension with arms stretched out, back arched, head back, and then draws back into a flexed position following a vestibular stimulus. This reflex should be integrated by 2-4 months post-natally.[14] When stimulated, TLR is noted when the participant demonstrates flexion of upper extremities and lower extremities with head flexion. With the head in flexion, the child curls up into a flexed position; with the head in extension, the child extends the arms and legs. This reflex should be integrated by approximately 4 months of age.[14] The ATNR, also known as the fencing reflex, is observed when a child flexes one arm and extends the opposite arm, with the head turned toward the extended arm. This reflex eventually becomes integrated with time and practice, and children use it as a point of transition for other complex movements.[15] This reflex should be integrated by approximately 6 months.[14] The SGR is observed when a child in a four-point stance reacts to the slight touch of a finger stimulating one side of the back near the spine, which causes a rotation of the hip toward the side of stimulation. This reflex should be integrated by approximately 9 months.[14] The STNR is observed in four-point viewing when a child is in kneeling and flexion of the head causes the arms to flex while the legs extend; head extension causes the arms to extend and the legs to flex when in four-point stance. As STNR emerges, visual reaching may motivate a child to transition to a crawling position by enabling extensions of the arms and flexion of the legs at the same time in order to facilitate increasingly complex movements. This reflex should be integrated by 9-11 months.[14]

Participants

The records of 180 children ages 6-14 and reported to be neurotypical from the Cleveland metropolitan area were reviewed to determine whether their metrics met the qualifications for this study. Of these 180 children, 135 met the aforementioned requirements. Inclusion criteria were met if the participants completed six standardized visual skill assessments in addition to assessment for five reflexes. Participants were excluded from the study if results for any of the visual assessments or reflexes were unavailable. All participants had a comprehensive eye exam conducted by a behavioral optometrist prior to their participation. Children found to have refractive conditions were prescribed appropriate compensatory lenses, by a behavioral optometrist, prior to completing the six standardized visual skill assessments and the assessment of five primitive reflexes.

Data Analysis

The criterion for reflex deficit for this study was defined as demonstrating the presence of three or more retained primitive reflexes. VSD was defined as demonstrating five or more individual visual skill test scores that indicated deficit. The Statistical Package for the Social Sciences (SPSS) was used to complete Conditional Stepwise Logistic Regression, descriptive frequencies, and Chi Square Test. VSD on the above-mentioned test scores are discussed in context with any of the following primitive reflexes: MR, TLR, ATNR, SGR, and STNR.

Table 1. Frequencies for Proportion of VSD to Retained Primitive Reflexes *Statistically significant

	MR	*TLR	*ATNR	SGR	*STNR
% yes/yes	61.7%	54.1%	57.1%	39.2%	59.8%
% no/no	5.3%	13.5%	10.5%	10.0%	9.1%

Table 2. Frequencies for Proportion of Reflex Deficits to Visual Skill Test Deficit *Statistically significant

	NYSOA K-D	*Motor Speed and Precision	TVPS-R	RAN	Gardner Reversals Frequency	*Draw-A-Person
% yes/yes	65.9%	57.1%	68.1%	60.6%	56.3%	53.0%
% no/no	3.7%	15.8%	1.5%	5.3%	10.4%	14.9%

Results

Chi Square analysis was used to determine the relationship between VSD and each primitive reflex (Table 1), as well as the relationship between reflex deficit and individual visual skill test deficit (Table 2). Results indicated that for the population of participants demonstrating retained primitive reflexes, there were, in each category, a significant proportion of children who were affected by VSD. The proportions of 'yes' to VSD and 'yes' to retained primitive reflex results showed that, in all cases excluding SGR, over 50% of the total population for each category of reflex had test score results suggesting significant VSD. Most notable was the high proportion of the population exhibiting the retention of MR (61.7%). Even at 39.2% in the 'yes' to VSD and 'yes' to retained primitive reflex category, persons with retained SGR represented a noteworthy segment of the population. For proportions in the 'no' to VSD and 'no' to retained primitive reflex category, significant findings indicated that overall there was no category where more than 15.8% of the population was without both visual skill deficit and retained primitive reflexes. Simply, the overall population expressed a considerable degree of deficit across all variables.

Chi Square results indicated that TLR (p=0.007), ATNR (p=0.020), and STNR (p=0.012) had statistically significant relationships with VSD (Table 3). The visual skill test scores that indicated significant relationships with reflex deficits were the Motor Speed and Precision test (p<0.001) and the Draw-A-Person test (p=0.004) (Table 3). Although the Gardner Reversals Frequency test was close to suggesting a relationship with reflex deficits, it was not statistically significant (p=0.064).

Conditional Stepwise Logistic Regression was run in two ways: in the first instance, the dependent variable (grouping variable) was whether or not the clients had significant VSD; in the next instance, the dependent variable was whether or not the clients had significant reflex deficit. Starting with VSD as the dependent variable, the potential predictor of VSD was TLR (p=0.011) (Table 4). Next, Logistic Regression was run with the dependent variable (grouping variable) being whether or not the clients had significant reflex deficits. Here, two visual tests turned out to be potential predictors of primitive reflex deficits: the Gardner Reversals Frequency Test (p=0.016) and the Motor Speed and Precision Test (p<0.001) (Table 4). The coefficient of determination R2 (0.106) for predictor of VSD and R2 (0.199) for predictor of reflex deficit in the Logistic Regression represented the unexplained variation resulting from a participant population wherein almost all persons showed many retained primitive reflexes and many expressed VSD.

Table 3. Relationships Observed for Retained Primitive Reflexes to VSD / Relationships Observed for Visual Skill Tests to Reflex Deficits *Statistically significant

Primitive Reflex	P-value
MR	0.155
TLR*	0.007
ATNR*	0.020
SGR	0.224
STNR*	0.012
Visual Skill Tests	
NYSOA K-D	0.232
Motor Speed and Precision*	0.000
TVPS-R	0.605
RAN	0.562
Draw-A-Person*	0.004
Gardner Reversals Frequency	0.064

Table 4. Statistically Significant Predictors of Reflex Deficit / Statistically Significant Predictor of VSD

Visual Tests	P-value	Odds Ratio
Motor Speed and Precision test	<0.001	0.221
Gardner Reversals Frequency test	0.016	0.321
Primitive Reflexes		
TLR	0.011	0.008

Discussion

Blythe[6] expresses a concern that children whose primitive reflexes are retained in the absence of an identifiable pathology may not receive the clinical services they need to succeed in school-based settings. The results of the present research indicate that students who retain ATNR, STNR, and/or TLR may benefit from therapy services that focus on integrating these reflexes in order to promote the development of visual skills needed for success at school. For the Logistic Regression model, retention of TLR was shown to be a potential predictor of VSD; furthermore, scores on both the Motor Speed and Precision test and the Gardner Reversals Frequency test were potential predictors of primitive reflex deficit. For Chi Square, there was a suggested relationship between VSD and TLR, ATNR, and STNR; in addition, Motor Speed and Precision and the Draw-A-Person tests were found to have a relationship with primitive reflex deficits. Frequencies revealed that 89 of 133 participants (67%) had VSD in five or more of the visual skill tests, and 95 of 133 participants (71%) had retained three or more of the primitive reflexes. Notably, the frequencies revealed that the participants overall demonstrated a high proportion of VSD and retained primitive reflexes.

Retention of TLR may limit a child's ability to adjust head position in response to movement of the body to environmental stimuli. Those children who retain TLR past the age of three and a half exhibit deficits in balance, muscle tone, spatial skills, and control of eye movements necessary for reading, writing, copying, and mathematics.[6] Maladaptive integration of TLR affects spatial awareness and the ability to move skillfully in space. A child might experience difficulties securing a visual reference point in order to perform school-based occupation involving both near and far copy (for example, a child with difficulty replicating the alphabet as is written on a whiteboard). Gonzalez, et al.[16] posited an association between primitive reflexes and the development of ocular movements in fifth grade students with reported reading problems. They indicated that the MR, TLR, STNR, and ATNR were associated with decreased precise saccadic eye movements, in addition to poor reading performance, with TLR showing the strongest association with deficit.[16] Incidences of primitive reflex retention and Visual Skill Deficit in children with reading problems demonstrates the need for comprehensive screening strategies where primitive reflexes, specifically TLR, impact atypical visual skill development.

Logistic Regression modeling revealed that scores on the Motor Speed and Precision ($p<0.001$) and the Gardner Reversals Frequency ($p=0.016$) tests were found to be potential predictors of reflex deficit. Deficit on the Motor Speed and Precision test indicated that a child had difficulty when rapidly and accurately copying material from one position to another; for example, from looking at a chalkboard to copying text to paper. Some children are accurate but slow, whereas others are quick but inaccurate. Difficulties in motor skills such as eye-hand coordination make handwriting more stressful and/or fatiguing and impede the expression of both ideas and concepts in graphic form. Additional research indicates that the retention of primitive reflexes negatively impacts motor development.[5] This was supported in a study of primitive reflexes in infants, where it was reported that the lack of integration of primitive reflexes led to poor eye movements and poor fixation from far to near.[14] The study also argued that the lack of integration caused difficulty in visual coordination, hand-eye coordination, and visual memory. This further indicates the importance of applying interventions for integrating retained reflexes to remediate eye-hand coordination in order to decrease stress on the child's body and to promote a context for attaining targeted outcomes.

The Gardner Reversals Frequency test is another potential predictor of reflex deficit; it evaluates directionality. Laterality, a related skill, is defined as the self-awareness and understanding of two sides of the body, which requires the proprioceptive sense of an internal midline.[17] Laterality impacts a person's sense of spatial directionality and the subsequent refined development of left and right orientation in space.[17] Children who have not developed laterality may experience difficulty with bilateral coordination and crossing midline, which may cause them to switch hands while engaged in handwriting tasks. Berne discussed how learning occurs when basic physical skills, such as balance and awareness of both sides of the sagittal plane, become automatic. These automatic skills can develop once reflexes become integrated, which results in increased body awareness. When children retain reflexes, behaviors such as reversals in writing and reading, poor attention, and lack of coordination become apparent. Although the child may "demonstrate good potential intelligence, further development may not occur until the delay is addressed. Part of addressing the developmental delays is learning to integrate the reflexes".[14] Furthermore, Melillo[18] noted that a large percentage of children with learning disabilities have mixed dominance not only in hand dominance, but throughout the whole body. This may affect a child's ability to keep pace with age-related peers in school contexts. As such, the integration of primitive reflexes is essential for developing body awareness: they influence motor function and they play a role in the cognitive development needed for both academic success and competence in daily living skills. Given that many therapeutic interventions use a proximal-to-distal approach to addressing deficit, it may benefit therapists to consider ocular musculature as distal, in a fashion similar to body core musculature or shoulder musculature transmission to skilled hand use.

With respect to the Chi Square frequencies, it is important to note that more than half of the participants with reported deficits in visual skill tests also had significant reflex deficits (Table 2). Although the majority of the sample population included children with significant VSD, only a small proportion (<13.5%) of children without significant VSD were also without the retention of any of the five primitive reflexes (Table 1). Chi Square p-values suggested a significant relationship between VSD and TLR, ATNR, and STNR (Table 3). This was supported by prior research, which found that the primitive reflexes most involved with visual development include MR, TLR, SGR, ATNR, and STNR.[19] In this light, children retaining TLR, ATNR, and/or STNR appear to be at risk for developing VSD and would benefit from skilled therapeutic interventions to address these retained reflexes.

Chi Square results also indicated that there was a relationship between a deficit on the Motor Speed and Precision test and a reflex deficit, which is compelling considering that this study found it to be a potential predictor of reflex deficit. In addition, Chi Square results indicated a relationship between a deficit on the Draw-A-Person test and a reflex deficit. The Draw-A-Person test evaluates body awareness and visualization skills. The integration of primitive reflexes contributes to the development of body schema as well as to eye-hand coordination; these skills augment the child's ability to complete movements, such as crossing the midline.[20]

Callcott found that children with retained primitive reflexes had below-average scores on a human figure-drawing test, which was consistent with the present findings. The author also noted that the retention of primitive reflexes, specifically ATNR, was "related to issues involving the crossing of the visual midline and poor eye tracking, and can interfere with hand-eye coordination and control of the hand when writing".[20] This signifies that children who have retained primitive reflexes may have poor proprioceptive body awareness, which further contributes to VSD.

In a global sense, children with VSD may be at risk for developing issues with attention, depression, and anxiety, all of which decrease occupational performance. The child might experience a continuum of health care and psychosocial issues stemming from the retention of primitive reflexes, leading to visual skill deficit, physiological and psychological stress, and subsequent academic delay.[4] Academic difficulties can cause the child to experience a sense of anxiety when engaged in other school-based occupations, such as play, which may manifest in depressive symptoms if performance does not meet expectation. Children who appear to have difficulties with attention in the context of underlying neuromotor immaturity are likely to experience challenges in many cognitive areas.[1] In addition, research indicates that a relationship exists between attention, energy, learning, and visual skill function.[4] As such, focus on the integration of primitive reflexes in children with VSD may improve performance skills in all areas, further promoting academic success and greater engagement in opportunities of life. Further research into the long-term impact of improved integration on academic and other areas of life is worthwhile.

Implications for Behavioral Optometry

The findings of this study imply that patients with retained primitive reflexes are more likely to have visual skill deficits as measured by the NYSOA K-D, The Gardner Reversals Frequency test, The Motor Speed and Precision test, the TVPS, the RAN test, and the Draw-A-Person test.

Limitations and Future Research

Future research into the possible relationships between VSD and retained primitive reflexes should include in the population of participants those children who have neither reported deficits in visual skills nor primitive reflex deficits. Inclusion of a population without recorded deficits in the aforementioned variables, conducted in accordance with the protocol in the current study and added as an addendum to the data collected, might provide a more accurate description of the greater populace. Overall, an evenly distributed data set might result in a model with less unexplainable variation around the line of regression. The data from this study contained a high proportion of participants who retained primitive reflexes and VSD.

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