PREVALENCE OF PRIMITIVE REFLEXES IN A PEDIATRIC POPOULATION AND ITS RELATIONSHIP WITH DIRECTIONALITY AND VISUAL SPATIAL SKILLS

by

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ABSTRACT

Background: Primitive reflexes are unconscious reactions found in infants. The presence of primitive reflexes past the expected time limit suggests improper cortical development. This study aims to determine the prevalence of retained primitive reflexes in children tested for visual information processing problems and their correlation to directionality difficulties and/or visual-spatial difficulties. *Methods:* Exam data was retrospectively analyzed from the exam forms of patients that presented to an office that specialized in vision therapy for visual skills testing during 2011 or 2012. Data analyzed included the presence or lack of primitive reflexes, specifically the Moro Reflex, Asymmetric Tonic Neck Reflex, Symmetric Tonic Neck Reflex, Spinal Galant Reflex and Tonic Labyrinthine Reflex. In addition, exam data from the Jordan Left Right Reversals Test and the Test of Visual Perceptual Skills Visual Spatial Relationship (TVPS-VSR) subtest results was analyzed. *Results:* The study demonstrated a high prevalence of positive primitive reflexes. The majority of subjects scored below normal on the Jordan Left-Right Reversals Test, but this was not exhibited on the TVPS-VSR subtest. No significant correlation was found between retained primitive reflexes and difficulty with directionality skills or with primitive reflexes and visual spatial skills. *Conclusions:* The prevalence of retained primitive reflexes in this study population is high and will benefit the health care knowledge base. More research needs to be conducted on any correlation between retained primitive reflexes and directionality/visual-spatial skills and to see if primitive reflexes affect other visual skills.

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INTRODUCTION

Primitive reflexes are automatic patterns of body movement that are present at, or soon after, birth.[1] They are mediated by the brain stem and represent a way to assess the central nervous system.[1,2] Such reflexes are present in infants but typically disappear by 6 months of age depending on the specific reflex as voluntary motor control begins to dominate.[1,2] The persistence of these reflexes can be a sign of developmental delay, Cerebral Palsy, or dysfunction of the nervous system.[1,2,3] Specifically related to this study is the relationship between primitive reflexes and the visual system. Research studies have shown some children with reading difficulties may struggle due to developmental delays that are related to persistent primitive reflexes.[4,5] The study goal was to determine the prevalence of primitive reflexes and determine if they are correlated with difficulties with letter reversals or visual-spatial skills. Minimal research has been conducted to determine the prevalence of primitive reflexes, particularly after infanthood, and little to no research has been performed on any correlations between primitive reflexes and letter reversals or visual spatial skills.

Letter reversals are a common stumbling block for some children as they progress through academic curricula, especially letters that are mirrored on the y-axis such as "b" and "d".[6] Research regarding the Jordan Left Right Reversal Test showed significant correlation of reversals to academic accomplishment.[7] Also, research regarding children with reading disabilities shows the majority of these children have difficulty with identifying correct orientation of letters.[8] Understanding the right and left side of the body and having the concept of laterality engrained in gross motor movements is a stepping stone in understanding right and left in space outside of the body. Relationships of objects in space have no meaning without a firm foundation of understanding of laterality and directionality.[6,7] Both of those concepts seem to be the backbone of allowing children to differentiate each letter.[6,7] Persistent primitive reflexes were predicted by the author to be a hindrance to a child's understanding of laterality, leading to poor ability to correctly identify letter reversals, a more advanced directionality skill.

Visual perception is a term used to describe the task of using visual skills to analyze information from the environment.[6] This information is gathered and added to our other sensory systems (e.g., motor system) to be used in higher cognitive functions.[3,6,9] To correctly identify an object, visual information needs to be selected in order to compare similarities and differences seen in other objects.[6] The study analyzed visual-spatial skills, which is one aspect of visual perception. Visual-spatial skills are needed to determine the correct orientation of objects in space. They help differentiate right from left, front from back and up from down.[6] Visual-spatial skills are fundamental to the skills of reading and writing.[8] In order to properly write or read, one must recognize the letter. There is a direct connection between visual spatial skills in reading and writing and performance on the Jordan Left-Right Reversals Test and to academic achievement in general.[7,8] If a person

struggles with understanding left from right, they will most likely confuse letters that are flipped along the y-axis, such as "b" and "d". The child must first understand his/her position in space before he/she can understand an object's position in space and how it relates to his/her body. This is demonstrated in that first children understand left from right around 6 or 7, but do not understand objects and their positions in space until 7 to 12 years of age.[6] Letter reversals are often absent by the time a child advances beyond the second grade.[6] Correctly identifying letters and words is necessary for reading and writing skills.[6,7] Therefore, testing a person's visual spatial skills is a crucial element when determining if visual skills are negatively impacting a child's reading development.[10] The author predicted a positive correlation between positive persistent primitive reflexes and low scores on the Test of Visual Perceptual Skills-Visual Spatial Relationships (TVPS-VSR).

This retrospective study utilized data from previously completed patient charts in an office specializing in vision therapy. The majority of patients that present to the clinic are referred by professionals such as other optometrists, reading specialists, occupational therapists or by schools. Therefore, the data collected in this study may not accurately represent the general population. Although, a benefit may be present in that the study was conducted on a population that struggles with visual symptoms in school and/or daily life.

METHODS

Exam data was collected from previously completed exam forms of patients that presented to a private practice office specializing in vision therapy for visual skills testing during 2011 and 2012. Data collected included the presence of or lack of primitive reflexes, specifically the Moro Reflex (MR), Asymmetric Tonic Neck Reflex (ATNR), Symmetric Tonic Neck Reflex (STNR), Spinal Galant Reflex (SGR), and Tonic Labyrinthine Reflex (TLR). In addition, data from the Jordan Left-Right Reversals Test and the Visual Spatial Relationship (VSR) subtest from the Test of Visual Perceptual Skills (TVPS) was collected. A total of 128 subjects were included in this study.

The primitive reflexes were tested in the fashion consistent with other research studies, as is described in detail in the discussion section of this paper. The MR was tested using the duck walk by asking the patients to walk first forward and backward for five to ten steps with toes pointed outward and then the pigeon walk by asking the patients to walk forward and backward for five to ten more steps with toes pointed inward. A positive reflex was recorded if the patients' hands or arms turned outward while their toes were pointed outward or if their hands or arms were turned inward when their toes were pointed inward. Some research currently indicates that the reflex tested in this way is not a primitive MR but rather a soft sign of neurologic dysfunction and there are other methods of testing for a positive reflex.[11] For the purpose of this study we acknowledge this research but desired to preserve the standard protocol used to test the patients at this

specific clinic acknowledging this possible flaw. Secondly, the ATNR was tested by having the patients assume a crawling position on their hands and knees with a flat back while the examiners gently turned the patients' heads sideways and watched for a flexion response of the opposite limbs as a positive response. For example, if the patients' head was turned to the right the examiners watched for a bending of the patients' left elbow. The STNR was assessed by having the patients remain in the crawling position and the examiners gently lifted the patients' heads upward and watched for any bending downward (extension) of the backs, trunks, and shoulders. Then the examiners moved the patients' heads downward (chin towards their chest) and watched for any flexion of the backs (as they rose up toward the ceiling), trunks, or shoulders. Such movements of the backs up or down were recorded as positive responses. The SGR was tested by having the patients return to the position on their hands and knees and the examiners gently traced a line along the spines with a pen or stick with a small ball on the end. A positive response was the patients curving their bodies toward the side that was stroked. For example, the patients' right side of their back just next to the spine was stroked with a pen and the patients curved their body to the right into the shape of a "c" with the opening of the "c" towards the right. Finally, the TLR was tested by having the patients lay flat on their stomachs and raise their arms and legs (thighs and shin/lower legs) straight up off the ground. A positive response was the bending of the knees so that the feet were in the air but the thighs remained on the ground.

The 1990s edition of the Jordan Left-Right Reversals test was used to determine letter reversal difficulties in the patients. The test was conducted in the typical format by having children below the age of nine complete part I only while children aged nine and above completed both part I and II. Part I was comprised of identification of letters and numbers printed backwards. Part II consisted of recognizing which word from a list of words contained a letter printed backwards.

The TVPS-VSR subtest was conducted using the TVPS-R version of the test. The test consists of sixteen different pages all with five images on a single page. The five images on each page were shown to the patients who had to choose which one was rotated along the y-axis, or was backwards.

DATA

Out of 128 participants, there were 51 females (40 %) and 77 males (60%). The patients ranged in age from 6 to 28 years of age. Figure 1 shows how many participants were present in each age group. 79% of the patients were between 6 and 10 years of age.

Figure 1: Number of Participants in Each Age Group

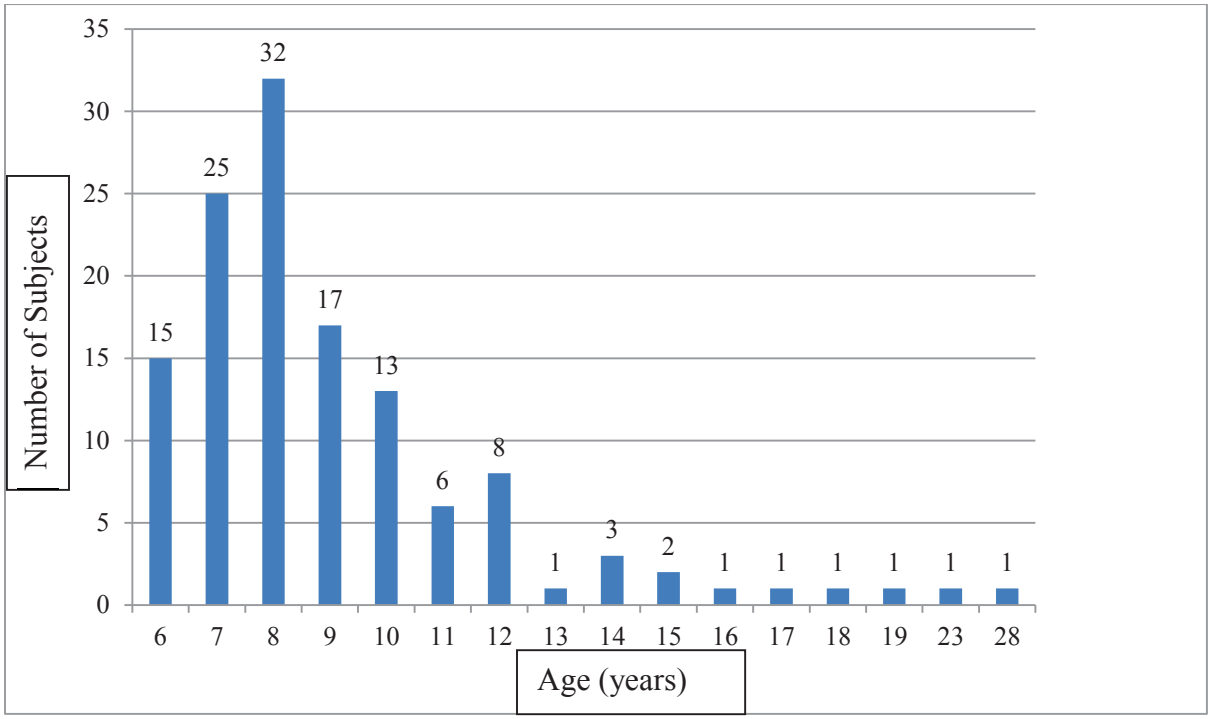


Table 1 shows how many subjects demonstrated positive reflexes. For the MR, 116 of the 128 participants (90.6%) exhibited a positive response. For the ATNR, 35 patients (27.4%) exhibited a positive response. 47 patients (36.7%) exhibited the STNR. For the SGR, 41 patients (32%) demonstrated a positive response. Lastly, for the TLR 52 patients (40.6%) tested positive. The chart also breaks down how many males and how many females had positive reflexes. Males demonstrated higher percentage of positive reflexes than females for the MR, ATNR, STNR and exhibited almost 2 times the prevalence of the TLR than females. The reflex providing the most similar result between male and female patients was the SGR, although here the females' positive reflexes outnumbered males. Figure 2 demonstrates this data in percentage form in a bar graph. As demonstrated by the information in the table, the majority of positive reflex responses for the 5 tested reflexes were male participants.

Table 1: Primitive Reflexes and Positive Responses

Primitive Reflex	Total Number of Positive Reflex Reponses	Percent of Subjects with Positive Reflex Responses	Number of Males with Positive Reflex Responses	Percent of Males with Positive Reflex Responses	Number of females with Positive Reflex Responses	Percent of Females with Positive Reflex Responses
Moro Reflex	116	90.6%	73	94.8%	43	84.3%
Asymmetric Tonic Neck Reflex	35	27.4%	24	31.2%	11	21.6%
Symmetric Tonic Neck Reflex	47	36.7%	29	37.7%	18	35.3%
Spinal Galant Reflex	41	32%	24	31.2%	17	33.3%
Tonic Labyrinthine Reflex	52	40.6%	38	33.3%	14	27.5%

Figure 2: Percentages of Positive Responses for All Subjects, Males, and Females

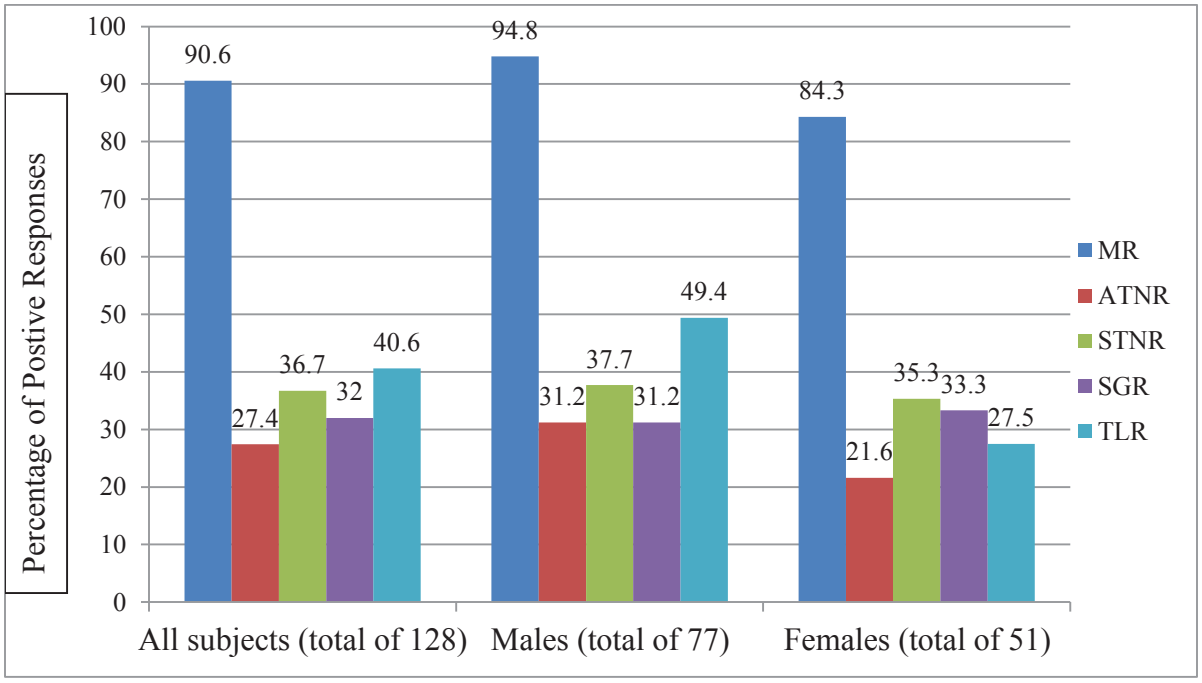
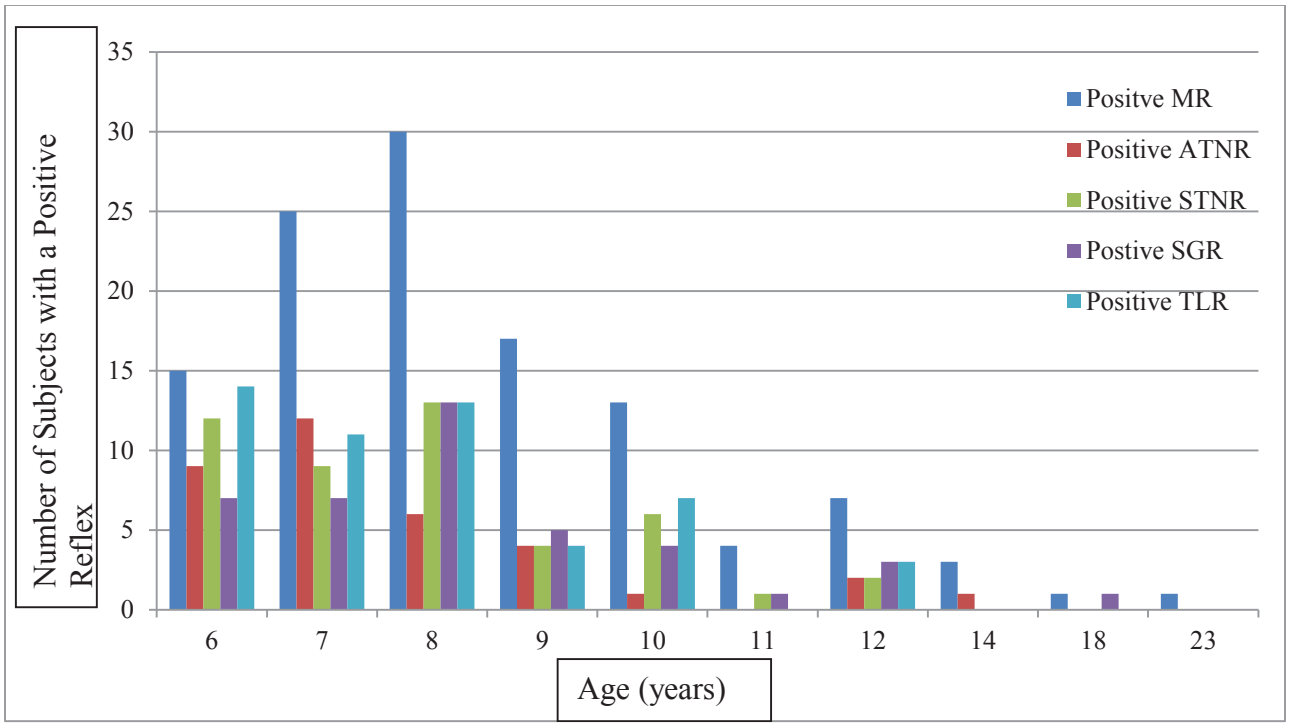


Figure 3 further breaks down this information by displaying the number of positive responses seen throughout the different age groups.

Figure 3: Number of Participants in Each Age Group with a Positive Reflex



A quick glance at figure 3 illustrates the MR as the most common positive reflex. As figure 3 shows, there were few positive reflexes measured in the 15, 16, 17, 19, and 28 year olds in this study; however, keep in mind the sample size for these age groups was 2 for the 15 year olds and 1 for the 16, 17, 19, and 28 year olds.

Table 2 combines the data from table 1 and figure 3 and depicts numerically the percentage of positive reflex responses within each age group.

Table 2: Percentage of Positive Reflexes in Each Age Group

Age	Percentage of Participants with a Positive Moro Reflex Response	Percentage of Participants with a Positive Asymmetric Tonic Neck Reflex	Percentage of Participants with a Positive Symmetric Tonic Neck Reflex	Percentage of Participants with a Positive Spinal Galant Reflex	Percentage of Participants with a Positive Tonic Labyrinthine Reflex
6	100%	60%	80%	46.7%	93.3%
7	100%	48%	36%	28%	44%
8	93.8%	18.8%	40%	40.6%	40.6%
9	100%	23.5%	23.5%	29.4%	23.5%
10	100%	7.7%	46.2%	30.7%	53.8%
11	66.7%	0%	16.7%	16.7%	0%
12	87.5%	25%	25%	37.5%	37.5%
13	0%	0%	0%	0%	0%
14	100%	33.3%	0%	0%	0%
15	0%	0%	0%	0%	0%
16	0%	0%	0%	0%	0%
17	0%	0%	0%	0%	0%
18	100%	0%	0%	100%	0%
19	0%	0%	0%	0%	0%
23	100%	0%	0%	0%	0%
28	0%	0%	0%	0%	0%

Table 3 depicts the below normal and borderline test results for the participants divided by age group. The majority of results are below normal, as is demonstrated by the bolded percentages, particularly in the younger groups with larger sample sizes. Table 4 breaks down the below normal results by gender. Females showed a slightly higher percentage of below normal scores on the Jordan Left-Right Reversals Test for the majority of the different age groups.

Table 3: Score Results for the Jordan Left-Right Reversal Test Grouped by Age Group

Age	Number of Patients Below Normal	Percentage of Below Normal	Number of Patients Borderline	Percentage of Borderline	Number of Patients Normal	Percentage of Normal
6	13	**86.7%**	1	6.65%	1	6.65%
7	14	**56%**	3	12%	8	32%
8	16	50%	8	25%	8	25%
9	14	**82.4%**	0	0%	3	17.6%
10	11	**84.6%**	1	7.7%	1	7.7%
11	5	**83.3%**	1	16.7%	0	0%
12	7	**87.5%**	1	12.5%	0	0%
13	0	0%	0	0%	1	**100%**
14	3	**100%**	0	0%	0	0%
15	2	**100%**	0	0%	0	0%
16	1	**100%**	0	0%	0	0%
17	0	0%	0	0%	1	**100%**
18	0	0%	1	**100%**	0	0%
19	1	**100%**	0	0%	0	0%
23	1	**100%**	0	0%	0	0%
28	0	0%	1	**100%**	0	0%

Table 4: Percentage of Scores of Male and Female Participants on the Jordan Left-Right Reversals Test

Age	Percentage of Males with a Below Normal Score	Percentage of Females with a Below Normal Score
6	**87.5%**	**85.7%**
7	**55.5%**	**57.1%**
8	47%	**53.3%**
9	50%	**83.3%**
10	**77.8%**	**100%**
11	**75%**	**100%**
12	**100%**	**75%**
13	**100%**	0%
14	**100%**	**100%**
15	**100%**	0%
16	0%	**100%**
17	0%	0%
18	0%	0%
19	0%	**100%**
23	**100%**	0%
28	0%	0%

Table 5 displays the totals of below normal and normal results within the different age groups. All of the results show a higher percentage of normal results with the TVPS-Visual Spatial Relationships subtest, as is shown by the bolded percentages (>50%)in the right column.

Table 5: Results for the Test of Visual Perceptual Skills Visual-Spatial Relationships

Age	Below normal	Percentage of Below normal	Normal	Percentage of Normal
6	3	20%	12	**80%**
7	1	4%	24	**96%**
8	2	6.3%	30	**93.7%**
9	1	5.9%	16	**94.1%**
10	3	23%	10	**77%**
11	0	0%	6	**100%**
12	0	0%	8	**100%**
13	0	0%	1	**100%**
14	1	33.3%	2	**66.7%**
15	0	0%	2	**100%**
16	0	0%	1	**100%**
17	0	0%	1	**100%**
18	0	0%	1	**100%**
19	0	0%	1	**100%**
23	0	0%	1	**100%**
28	0	0%	1	**100%**

Figure 4 visually demonstrates the number of subjects that had below normal or normal scores for each age group. As seen in the bar graph, all age groups demonstrated more subjects with normal scores than those with below normal scores.

Figure 4: Number of Subjects in Each Age Group with Below Normal or Normal Scores on the TVPS-VSR Subtest.

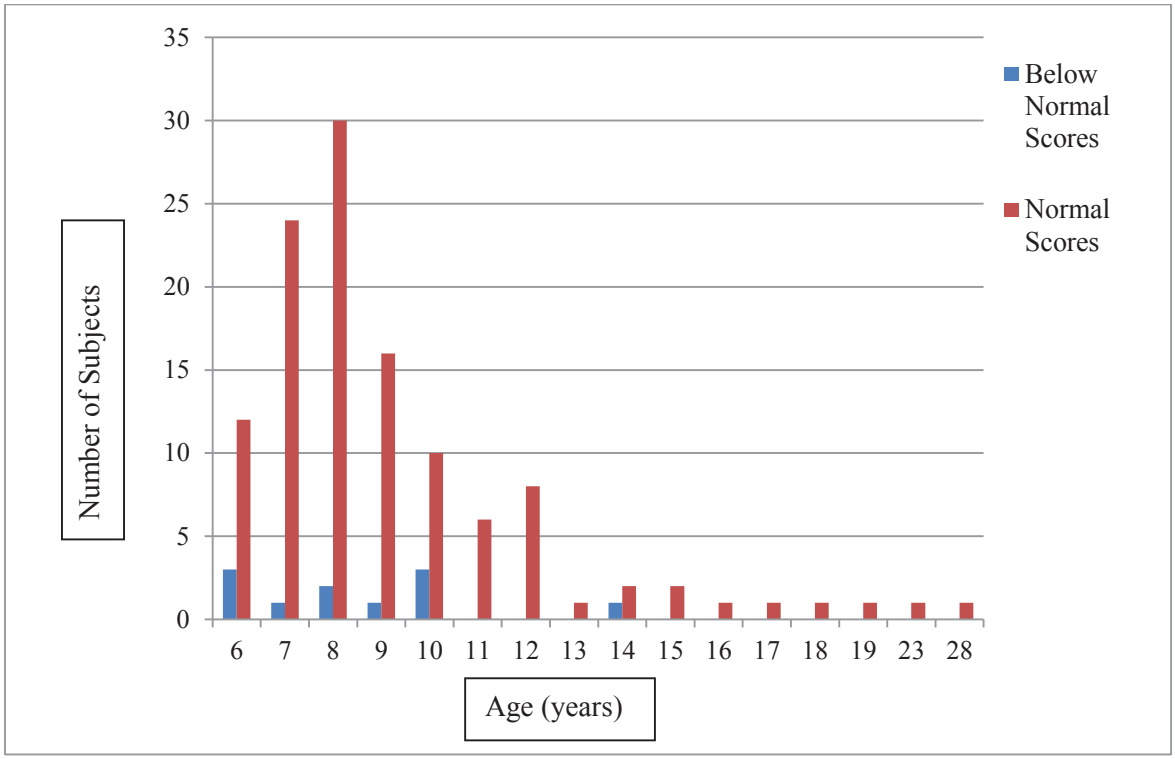


Table 6: Percent of Subjects with or without Positive Primitive Reflexes Compared to Percent of Subjects with Below Normal or with Normal Jordan Scores

	Percent of Subjects with Below Normal Jordan Scores	Percent of Subjects with Normal Jordan Scores
Percent of Subjects with Positive Primitive Reflexes	62.5%	28.9%
Percent of Subjects without Positive Primitive Reflexes	6.3%	2.3%

Table 7: Percent of Subjects with or without Positive Primitive Reflexes Compared to Percent of Subjects with Below Normal or with Normal TVPS-VSR Scores

	Percent of Subjects with Below Normal TVPS-VSR Scores	Percent of Subjects with Normal TVPS-VSR Scores
Percent of Subjects with Positive Primitive Reflexes	9.4%	82.0%
Percent of Subjects without Positive Primitive Reflexes	0%	8.6%

RESULTS

The prevalence of primitive reflexes was astounding for all of the reflexes but was most significantly elevated for the Moro and Tonic Labyrinthine Reflexes. It was more common for males to test positive for persistent primitive reflexes than females. Furthermore, the Jordan Left-Right Letter Reversals test had overall low scores for both males and females. Finally, the TVPS-VSR subtest revealed mostly normal or above normal test scores.

Tables 6 and 7 pull together all of the data to determine if those who had positive primitive reflexes were more likely to have below normal scores on the Jordan Left-Right Reversals Test or the TVPS-VSR subtest. The percentages for the Jordan Left-Right Reversals Test show that subjects with persistent primitive reflexes do appear to be more likely to struggle with letter reversals. Due to the high number of patients with a positive MR, the data was also calculated for positive primitive reflexes minus the patients with only a positive MR. The data showed similar results of 47.7% of patients with positive persistent primitive reflexes excluding the MR and a below normal letter reversals score and 21.9% with a normal letter reversals score. This is greater than the 21% of patients without positive primitive reflexes and a below normal letter reversals score and the 9.4% without positive primitive reflexes and a normal letter reversals score. For visual-spatial skills, persistent primitive reflexes do not seem to hinder a child's ability to correctly develop visual-spatial skills.

Although the percentage was high for the number of subjects that had persistent primitive reflexes and struggled with letter reversals, chi square statistics showed there was no significant correlation between positive primitive reflexes and low scores on either the Jordan Left-Right Reversals Test or the TVPS-VSR subtest. The p-value for correlation between positive primitive reflexes and low scores on Jordan was 0.766 and the p-value for positive reflexes and the TVPS-VSR was 0.265. These results show we fail to reject the null hypothesis that positive primitive reflexes are independent of letter reversals and primitive reflexes are independent from visual-spatial skills.

The high majority of below normal test results for the Jordan Left-Right Reversal Test is noteworthy and stands out to the author as an area where children referred to this clinic struggle. A possible explanation for the high percentage of below normal results is that the data was collected from a clinic serving as a referral center for other professionals and schools for children that were struggling visually and/or with academic performance. Additional research gathered from the general population will help to further determine if there is a correlation between primitive reflexes and letter reversals, as well as the overall prevalence of persistent primitive reflexes in the general population.

The better scores on the TVPS-VSR subtest demonstrate that the participants did not show difficulty with visual spatial relations to the extent of directionality. Rather, participants generally excelled at this visual perceptual task. These test results point to a lack of correlation between primitive reflexes and visual spatial skills. This contradicts the hypothesis of the author. The physical aspects of primitive reflexes do not seem to impair the visual perception of space and objects.

DISCUSSION

Being aware of the prevalence of primitive reflexes in a population that struggles with visual or school related tasks is a significant asset to medical professionals, teachers, schools, and parents. The high prevalence demonstrated by this research clearly illustrates the large number of children and young adults affected by persistent primitive reflexes. Research should be expanded in this area to determine other visual tasks affected by persistent primitive reflexes. Introducing screening tests in various professional offices would allow for persons with positive reflexes to be discovered so they can be corrected before educational scores and development is hindered. Pediatricians and pediatric neurologists are commonly the professionals that assess primitive reflexes in infants and young children; however, these reflexes need to be tested in older children that are struggling in school in order to rule out retained primitive reflexes as the cause of academic struggles.[1] Similarly, the relationship demonstrated by this research between persistent primitive reflexes and identification of letter reversals offers one specific area affected by the presence of retained primitive reflexes that can be improved upon using recognized interventions.

This study tested the primitive reflexes in a way that was consistent with similar research studies. The MR is tested differently in children than in infants. For infants, the head is extended quickly to create a startle reflex by a light drop of the head and the response watched for is abduction (arms jerk outward) followed with adduction and flexion of the arms.[1,11] This is regarded as a positive primitive reflex response. Our study instead used the duck walk and pigeon walk to determine if the MR was positive or not. Recent studies show this may indeed be a soft sign of neurological dysfunction; however, it is not the typical means of determining if the MR is present.[11] In an effort to maintain the standard protocol at the clinic site, the duck walk and pigeon walk were used to grade the MR response. This may be a misleading representation of a true positive MR, but it is a practical, swift way of testing for a positive MR in clinic. The ATNR is stimulated by a rotation of the head to the right or the left (keeping the head parallel to the spine), this is consistent with testing of an infant or a child. [1,2,4,11] The ATNR reflex response seen is when the head is turned to the right, the right arm and leg bend while the left arm and leg extend. This is consistent in the way the examiners that collected the data for the patients referred to in this paper conducted the ATNR reflex test. The child was on their hands and knees (in a crawling position) while the examiner turned the child's head (e.g., to the right) and watched for a bend in the arm on the opposite side (e.g., the left arm). The STNR is elicited by having the child in a crawling position (on hands and knees with a flat back) and moving their head upward or downward (chin down towards the chest) and watching for flexion or extension of the arms, legs, and trunk.[1,5] When the head is lifted upward, the arms will straighten (extend) and the legs will flex, this also causes a extension in the back, trunk and hips.[1,5] The extension of the back, shoulders, and truck when the head is extended upward, or the flexion of the back, shoulder, trunk, and hips when the head is flexed downward, was what was measured by the examiners when testing reflexes on the patients represented in this paper. The SGR is triggered by stroking one side of the back and the response is a twitch toward the same side (body curves like a "c" toward the side that was stroked). [1] This is how our examiners tested for the SGR. The TLR is also stimulated by extending the child's backwards and watching for an extension of the arms and legs.[2] It is also tested in the supine position by flexing the head forward and watching for flexion of the arms and legs towards the child's body.[2] The way in which the reflex was tested in regards to this paper was the extensor approach, honing in on mainly the bend of the knee (the foot lifting off the ground while the thigh remained on the ground). If the knee was bent the reflex was marked as positive, if the knee was straight and the whole leg (foot, knee and thigh) was lifted off the ground the reflex was negative.

Typically the MR, ATNR, STNR, and TLR have disappeared by the age of 6 months. [1,2,5] The STNR has also been reported to linger until 9 months to 12 months. [2,5] Additionally,

the SGR has mixed findings with the reflex being inhibited by 6 months or taking until one year to 18 months to disapear.[1,2,5] With all of the patients in this study being age six or older, the normal time frame for the primitive reflexes to remain had past.

Primitive reflexes are automatic motor movements organized at the brain stem that allow an infant to respond to stimuli and interact with the environment.[1,3] These early movements are controlled by the brain stem and are not voluntary.[1, 2,12] The basic movements provided by primitive reflexes build into righting movements seen in postural reflexes and then continue over time to become cognitively controlled movements.[1,3,12] The reflexes are inhibited by higher cortical control in the central nervous system as it matures to allow for voluntary movement.[3,5,12] The more mature movements are organized and controlled at the cortical level, which is a higher level of the brain that overrides the reflexive movements seen in young infants.[1,12] If primitive reflexes are retained, also referred to as aberrant reflexes, other motor developmental skills can still be learned and developed; however, the retained reflexes often affect this motor development making it more of a challenge and often uncoordinated.[2,3,5] This is because the reflexes are a foundation for later motor function and if they are retained upper and lower and right and left extremities cannot move independently.[3] Cortical control of motor movements allows voluntarily guided motion as well as isolated movement of one area of the body.[3] Retained primitive reflexes not only affect motor skills but also sensory perception, cognitive abilities, reading skills and academic achievement.[4,5,12]

Movement involves many senses, such as proprioception, visual, auditory and kinesthetic information.[9, 13] Vision in particular seems to be a driving force that affects movement, especially locomotion in a forward, purposeful direction.[3,13] Visual interest of a child to the environment guides purposeful movement; movement that is coordinated in a higher level, subcortical and cortical, than the brain stem.[3,5,13] At one month old, infants begin to develop oculomotor coordination and can look at near objects and follow them as they move.[3,14] At 3 months infants start to recognize objects and faces which is followed by purposeful reaching.[3,5,14] At 4.5 months, infants begin to reach across their midline, which is important as it helps them develop trunk stabilization as well as basic laterality integration and skills.[3] Around 5 months old a child looks out at objects of interest at arm's length which triggers reaching and rolling; this is also when hand-eye coordination begins to develop.[3,14] Infants are able to roll from back to front, supine to prone, at 6 months and able to grasp objects at 7 months.[3,15] 6 and 7 months is also when stereopsis, or depth perception, develops.[16] Crawling is seen around 7 months, pulling on objects to a standing position at 8 months, and walking with help and sitting without support at 9 to11 months.[14,15] This timeline helps demonstrate how intricately vision, motor, and other senses are integrated as a child develops. Vision is a large motivating factor that drives forward movement as a child is interested in his/her environment, and vision and visual

perception also allow for ability to control movements in a directed, voluntary, and coordinated manner.[3,13]

Primitive reflexes are crucial in early development as they allow the infant to adjust the body's posture to allow for forward movement and visual inspection of surrounding objects.[3,5] Long term effects of a retained MR are seen in oculomotor and visual perceptual problems as well as poor fixation because the person cannot disregard irrelevant visual information.[5] The ATNR triggers both the right and left side of the body and, therefore, retained ATNR cause difficulty with crossing the midline, poor tracking ability particularly at the midline, and visual-perceptual difficulties especially with symmetrical figures.[5] Retained ATNR also affects hand-eye coordination skills.[4] The STNR helps the child lift the head and flex the legs (or drop the head and extend the legs) which moves the baby up off the floor onto hands and knees.[1,5] This also encourages creeping and crawling as well as focusing visually from near to far as the head position changes.[5] Retained STNR can affect accommodative skills (focusing near and far), binocular vision skills (converging to look up close and diverging to look far), and hand-eye coordination.[5] TLR assists in learning to creep, crawl, kick and jump.[3] When the infant is able to lift his/her body off of the ground numerous senses are involved, such as proprioception, vestibular, and tactile, and this allows for sensory integration and cortical development.[3,5] It also allows for learning depth perception.[3] Retained TLR affects visual-perception, visual-spatial skills, and convergence (which is triggered by the child looking down and at his/her hands).[5] The SGR stimulates movement of the spine and when retained causes difficulty in sitting still which affects concentration.[5]

As all of the reflexes relate to visual perceptual abilities, it is easy to see how retained reflexes could affect visual skills needed for letter identification and visual-spatial tasks. Although the data represented in this paper did not show a significant correlation between retained primitive reflexes, further research is needed in this area as there is minimal data currently represented. Early treatment, such as physical therapy and motor skills training, can reduce or eliminate persistent primitive reflexes.[3] Primitive reflexes are a factor in learning difficulties , academic success, attention difficulty, writing problems, and reading skills.[4,5,12] Therefore, they are an important foundation to academic success and visual skills.

As stated previously, patients with primitive reflexes are more likely to have low scores on the Jordan Right Left Reversals Test.[7] Laterality is typically taught to children as a physical body task, related on one's right or left side of the body. The letter "b" faces right while the letter "d" faces left. Also, written symbols are recognized based on their position in space.[7] Primitive reflexes affect gross motor movements and one's ability to differentiate between the right and left side of the body. This is demonstrated by the ATNR in particular, when the child's head is turned to the right, the left arm bends. This demonstrates that the two sides of the body cannot move independently of one another.

Therefore, when the child attempts to learn the right and left side of the body confusion sets in as the persistent primitive reflexes contraindicate the separation of the right and left sides of the body. This is significant as letter reversals are related to academic achievement.[6,7] Also, children with learning challenges or disabilities are often found to struggle with laterality.[6]

On the other hand, visual spatial skills are not related to physical body movements but rather represent visualization and spatial manipulation in the brain. The TVPS-VSR subtest asks the subject to visually compare five different pictures and look for the image that is different or is backwards. Therefore, the subject must use comparative skills and may also use the skill of mentally rotating the object to find the match. This is independent of physical movements and of the body and, therefore, should not be restricted by the presence of persistent primitive reflexes.

The lack of correlation between primitive reflexes and visual spatial skills is encouraging, demonstrating that persons troubled with persistent primitive reflexes are still able to visually analyze and orientate objects and space, a higher level cortical task.[6] Visual perception is a large part of the foundation needed for reading and a properly operating visual system's success. Visual spatial skills are needed in order to understand directions given by an instructor or how to travel to an unknown location, to understand language and the symbols that represent it, and to modify or rotate visual information, such as tested in the TVPS-VSR subset.[6]

More research to further delve into primitive reflexes persistent past infancy and young childhood is needed in order to understand all of the visual functions that are affected by the reflexes. One particular disadvantage of this research paper is the limited age group represented. Research extending into older age groups would be helpful to the community of professionals, teachers, and parents. Such research would greatly assist parents and teachers in helping children reach their full potential physically and visually. Correcting for these reflexes by means of physical therapy and motor skills training when able may offer the individual greater academic and reading success, positive self-esteem, and increased learning potential and prevent the person from being hindered by these basic and involuntary reflexes.

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