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A Comparison of Vestibula-Motor Abilities with Language, Intelligence, and Perceptual-Motor Skill in Kindergarteners

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A COMPARISON OF VESTIBULO-MOTOR ABILITIES WITH LANGUAGE, INTELLIGENCE, AND PERCEPTUAL-MOTOR SKILL IN KINDERGARTENERS

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THESIS ACCEPTANCE

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THE PROBLEM

Introduction

The three semi-circular canals, saccule, and utricle of the inner ear, the acoustic cranial nerve, the four vestibular nuclei in the brain stem, and ascending and descending tracts of the central nervous system comprise the vestibular system. Responsible for body spatial information, reception and integration and reflexive motor control, this system is the neurological basis for human postural stability, modification of muscle tone, equilibrium and postural reactions of the trunk and extremities.

The role of the vestibular system in human development is being explored with growing interest by researchers with medical, psychological, and educational perspectives. The importance of this system in the regulation of muscle tone, posture, and equilibrium, and in the coordination of ocular movement with movement of the head is clearly understood. The vestibular apparatus of the inner ear detects linear and angular acceleration and deceleration of the body, and the position of the head with respect to gravitational pull. This sensory information is carried via the 8th (acoustic) cranial nerve to the brain stem vestibular nuclei, where impulses are integrated with other sensory information from proprioceptive, tactile, and visual systems. Impulses are then transmitted through ascending and descending tracts of the brain to produce the appropriate motor responses in the muscles of the eyes, trunk, and extremities.[1,2]

As the function of the vestibular system in motor development is more clearly defined, there is an increasing interest in and awareness of its importance in cognitive development also, particularly in the realm of communication. Ayres, deQuiros, Ottenbacher and others have studied the relationship between vestibular function and various communication and academic skills. They found it to be significant, although speculation regarding cause and effect has yet to be fully substantiated.[3,4,5] It is generally proposed that receiving, processing, and integrating sensory input from one's environment is the basic mechanism for all learning, and that this reactive process must occur in an orderly progression from integration of most primary sensory information through increasing complexity of responses to higher symbolic learning. Hence, a dysfunction of the vestibular system, which is responsible for automatic perception and integration of basic body spatial information, may interfere with more advanced sensory integrative processes such as oral and written communication.[6,7,8,9] Although the precise mechanism by which this disruption occurs has not been identified, Ayres and deQuiros both espouse the concept of delayed or disrupted cerebral hemispheric specialization caused by vestibular dysfunction. In normal central nervous system development, one hemisphere (usually the left) establishes dominance, controlling expressive and receptive communication and certain behavioral and emotional traits. Motor behavior and physical responses are primarily controlled by the opposite hemisphere. If, due to vestibular processing dysfunction, motor behavior fails to become largely subcortically controlled, then conscious maintenance of posture and equilibrium competes and interferes with the crucial specialization and development of language skills in the other hemisphere.[4,7] This hypothesis is supported by studies recognizing suppression of speech in children during particularly challenging episodes of motor development, and by research identifying a high frequency of abnormal vestibular function in language delayed, autistic, schizophrenic, and emotionally disturbed children and adults.[10]

Studies by Ottenbacher and Ayres suggest that vestibular procession dysfunction and subsequent abnormal visual and gross motor performance may comprise a syndrome specific to certain types of learning disorders, and that assessment of vestibular integrity may be useful in definitive diagnosis of learning disorders.[3,11,12]

Thus far vestibular function has been evaluated most frequently through measurement of the vestibulo-ocular reflex, or nystagmus response. The nystagmus response is usually elicited through stimulation of the semi-circular canals by rotation of the subject in three planes, or by hot/cold water irrigation of the ear canal. Literature has indicated a number of factors which compromise the accuracy and validity of this method. Furthermore, it should be noted that the nystagmus response demonstrates the status of only one aspect of vestibular function, and assessment of other aspects by association is subject to error. Finally, the practicality of nystagmus testing on a large scale is limited by the need for special training and equipment and/or assistance from medical personnel.

Attempting to develop other methods of evaluation, Ayres, Ottenbacher, and others have evaluated and compared the gross motor manifestations of vestibular function with nystagmus test results. Initial studies have indicated a signficant correlation between nystagmus response and vestibulo-motor performance in a variety of subject types, and a tentative relationship between learning disorders and vestibularly dependent motor performance has been presented as well.

Significance

In light of the present paucity of information and research on vestibulo-motor performance in normal children, this study quantifies several aspects of performance and explores the relationship of that performance with language, intelligence, and visual-motor skills in normal five and six year olds. Conclusions from this study may contribute to the present understanding of the vestibular system as it relates to cognitive development, and serve as a baseline from which additional research in this area may be developed.

Statement of the Problem

What is the normal range of vestibulo-motor performance in four and five year old children? In what way do the various aspects of vestibulo-motor performance relate to language, intelligence, or visual-motor skills?

The Hypotheses

1. There exists a significant correlation between the subjects' scores on vestibulo-motor tests and language abilities as measured by the Preschool Language Assessment.

2. There exists a significant correlation of subjects' scores on the vestibulo-motor tests with intelligence as measured by the Peabody Picture-Vocabulary Test.

3. There exists a significant correlation of subjects' scores on the vestibulo-motor tests with visual-motor development as measured by the Bender-Gestalt Test.

4. There is a significant commonality among the seven vestibulo-motor tests.

Assumption

In normal human development, there is measurable neurophysiological interaction of motor, cognitive, and emotional functions.

Delimitations

Participants in this study were children age four to six years. Testing was accomplished over a three week period. All ten tests were administered to each subject within a two hour period. All subjects were tested on weekdays between 8:30 am and 4:30 pm during the months of March and April, 1981.

Limitations

Confounding variables such as previous general and specific motor experience may have affected performance on vestibulo-motor tests.

The time and effort required of participants during testing may have introduced the effect of fatique as a variable in the performance of later tests.

Behavioral traits of motivation, stress tolerance, and attentiveness may have significantly affected performance on all test items.

Definitions

Vestibulo-Motor Abilities. Those motor abilities which require and are significantly affected by the sensory organs, and brain stem components of the vestibular system. These include postural stability, righting and equilibrium reactions, facilitation or inhibition of muscle tone in trunk and extremities, and integration of primitive reflexes in motor behavior.

Postural Stability. The utilization of visual, kinesthetic, and vestibular stimuli, and initiation of appropriate motor responses in maintaining an upright posture with respect to gravitational pull.

Nystagmus. The reflex response of the ocular muscles caused by angular acceleration due to spinning or hot/cold irrigation of the ear canal. The response as observed is a rhythmic, horizontal movement of the eyes with a slow "drift" and compensatory quick snap components.

Tonic Labyrinthine Reflex. A primitive medullary response to vestibular stimulation resulting in the facilitation of extensor tone in the supine position and flexor tone in the prone position.

Symmetrical Tonic Neck Reflex. The primitive response of reflexive extension of upper extremities and flexion of lower extremities to neck extension; and flexion of the upper extremities, extension of the lower extremities to neck flexion.

Asymmetrical Tonic Neck Reflex. The primitive response of extension of one arm and leg and flexion of the other arm and leg to rotation of the neck. (Extension occurring on the side to which the head is turned.)

Chapter 2

REVIEW OF RELATED LITERATURE

General Implications of Vestibular Dysfunction

A syndrome of hypoactive nystagmus, delayed motor development, and speech disorders was first observed by Precechtel in 1925 in persons with congenital defects of the vestibular otoliths.[4] A summary of research presented by Rapin in 1974 based on case studies and vestibular function screening of 353 infants and children, associated abnormal nystagmus responses with delayed sitting and walking, low muscle tone, and poor head control.[13] Clark, Kantner, and others have contributed to the statistical evidence supporting this relationship by demonstrating significant improvement in motor performance of normal and developmentally delayed infants following vestibular stimulation. Similar results have been reported following vestibular stimulation of subjects with neurological disorders.[14,15]

Vestibular Function in Language and Cognitive Development

Statistical evidence upholding the importance of the vestibular system in sensory integration, psychological development, and communication skills has accumulated from a number of sources. Kraus and Herschland in 1954, during development of a physical fitness test for school children, observed a positive relationship between the ability to hold the head and legs extended in a prone position and general academic achievement. They speculated that both may relate to a positive self-concept.[16] The Prone extension posture test appears in some form in many tests of motor abilities and assesses the integration of the tonic labyrinthine response and the symmetrical tonic neck response.[7]

Kephart and others recognized the significance of balance and responses to gravitational force in academic learning.[29] A significant frequency of reading and arithmetic disorders was found by Cheek among children with irregular electronystagmus.[28]

deQuiros, in four studies between 1957 and 1967, evaluated vestibular function, motor development, communication skills and academic performance in nearly 2,000 children. Following 77 vestibularly disabled infants and 83 infants with normal vestibular function from birth to three years, he observed a syndrome of abnormal nystagmus response, delayed motor development, unstable walking, and language delays in the former group.[4] These symptoms were nearly identical to those described by Precechtel over thirty years earlier. In a study of school aged children with learning disabilities of unknown origin, he found 52 of 63 subjects demonstrated abnormal nystagmus responses (delayed, diminished or asymmetrical) to hot/cold irrigation of the ear. This group characteristically displayed, along with the nystagmus hyporeflexia, restlessness, motor problems such as poor eye-hand coordination in reading and writing, and loss of interest in school studies. He concluded from his investigations that the sensory integrative function of the vestibular system is a fundamental element in learning, specifically in the realm of communication.

Ayres has contributed extensively to the present level of understanding of sensory-motor integration and learning disabilities of all types. In fifteen years of applied research, she has explored methods of evaluation and remediation of learning disorders. The therapeutic approach of sensory integration developed by Ayres incorporates many activities which require vestibular procession function.

In a 1969 study of sensory integrative deficits in learning disabled children, areas of neuromuscular, perceptual, and academic achievement were evaluated by Ayres. The 64 separate test items were subjected to factor analysis, distinguishing several patterns of dysfunction in association with low academic performance. One pattern consisted of postural dysfunction, poor bilateral integration, and residual primitive reflexes, all of which are symptomatic of vestibular dysfunction.[3] In a study of sensory integrative therapy on learning disordered children, she reported the existence of hypoactive nystagmus response in 55% of children with auditory-language deficits, and concluded that vestibular dysfunction is a factor in idiopathic learning disorders, particularly in the realm of bilateral integration, vocalization, and speech fluency. The use of vestibular function assessment in distinguishing subgroups of learning disorders was strengthened in an additional study. Responses to sensory integrative therapy were signficantly greater in learning disabled children with hyperactive nystagmus responses.[17,28]

Ottenbacher in a comparative study of nystagmus response and other vestibular functions in learning disabled children found abnormal nystagmus response in 46% of the 92 subjects and a signficant relationship of selected motor tests including prone-posture, standing-balance, and muscle co-contraction, with nystagmus response.[5] In a second study, Ottenbacher and colleagues associated nystagmus hyporeflexia with behavioral problems in learning disabled children.[11] Other authors have extended this association to include schizophrenia and other psychiatric problems.[10] The concept of vestibular dysfunction occurring in specific varieties of learning disorders was reiterated by Ottenbacher, Short, and Watson in their 1979 report of nystagmus duration changes during sensory integrative therapy for learning disordered children. They found that changes in duration secondary to therapy were dependent upon the baseline nystagmus response prior to therapy, and were effective in those cases with short initial duration only.[11]

Evaluation of Vestibular Function

Barany, in 1918, in conclusively linking the nystagmus response with the vestibular system, provided the basis for quantitative vestibular assessment.[18] Measurement of nystagmus response remains the predominant method of vestibular assessment. Jean Ayres' Southern California Postrotatory Nystagmus Test is a frequently employed protocol for this method.[19] Several authors have cited factors which suggest that nystagmus testing is less than fully satisfactory. Rapin found conflicting results of initial and repeat nystagmus testing in 24% of her subjects. She states that due to variable cooperation and other uncontrollable factors, nystagmus testing of children is prone to inaccuracy, and she voices a definite need for standardization of test procedures. Ottenbacher cites level of arousal and oculomotor status as possible confounding variables in nystagmus tests.[13] Levy and colleagues found that visual fixation during testing may also interfere with the nystagmus response.[20]

Heriza reminds those interpreting results from past studies that a hyporeflexia nystagmus indicates a dysfunction in perceiving angular velocity by the semicircular canals, and transmission of impulses primarily through the superior and medial vestibular nuclei and vestibular mesencephalic tract to the oculomotor nuclei. Mechanisms of postural and equilibrium responses involve to a greater extent the utricle and saccule, lateral and spinal nuclei, and descending vestibulospinal tracts. Dysfunction may be specific to one action of the system, and conclusions from nystagmus response alone may be incomplete.[21]

As understanding of the neurophysiology of the vestibular system expands, the possibility of vestibular assessment by motor performance becomes evident. Research in this direction has yielded test batteries which include some or all of the functions of the vestibular system in motor performance. Ayres' Southern California Sensory Integration Test includes items which evaluate standing balance with and without visual input.[19] In evaluation of vestibular function specifically, she has added test items which investigate integration of primitive reflexes, muscle tone, static and dynamic posture, and normal equilibrium responses.[3]

Ottenbacher investigated potential motor tests of vestibular function, and found that prone extension posture, standing balance with eyes open and closed, and muscle tone contributed significantly to the multiple correlation with postrotatory nystagmus. Respective Beta weights were .3513, .3200, .3185, and .2444.[5] Cornish included some measures of balance and tone/strength in the development of a motor planning abilities test but made no comment applying test results to assessment of vestibular function.[22]

For measurement of the more abstract role of the vestibular function in sensory integration, the Southern California Sensory Integration Tests,[19] Purdue Perceptual Motor Survey,[23] and Frostig

Perceptual Motor Development Program[24] are currently available. These tests cover a broader range of perceptual skills with visual emphasis, and conclusions from them regarding vestibular function are speculative.

Summary

The importance of the vestibular system in human development is evident in the literature. The effects of vestibular dysfunction and vestibular stimulation on motor behavior have been demonstrated conclusively by a number of studies. The role of the vestibular system in sensory integration, learning, and languages has been investigated as well. Ayres, deQuiros, and Ottenbacher have found a significantly high incidence of vestibular dysfunction in various groups of learning disabled subjects and have concluded from these findings that integration of muscle tone and primitive reflexes, and development of automatic postural reflexes (all functions of the vestibular system), are necessary for learning to advance to more complex levels. The current conclusions are based heavily on correlative statistics due to the nature of human subjects' studies, thus cause-effect relationships cited by various authors must be interpreted with caution. Assessments of vestibular function presently rely heavily on the measurement of nystagmus response. This method of evaluation is subject to error due to lack of standardized protocol, test specificity, visual input, and difficulty in administering tests to infants and children.

In attempting to augment current methods of evaluation, appraisal of other motor manifestations of vestibular function has been proposed. Little information is available regarding the degree to which vestibulo-motor abilities and cognitive skills interrelate in the normal range of performance. Preliminary results have supported the relationship between gross motor manifestations of dysfunction and learning disorders. It appears, however, that the establishment of a clinically practical assessment of these aspects of vestibular dysfunction, particularly in association with learning disorders, will require further investigation.

Chapter 3

METHOD

Subjects

Participants in this study were boys and girls ages 4.33 to 6.0 years entering Kindergarten in the Westside Community School District of Omaha, Nebraska in the fall of 1981. Table 1 shows age, birth order and sex of the subjects.

TABLE 1 - Subjects

		Range	Mean
Chronological age (years)		4.33 - 6.00	5.09
Birth order		1.00 - 8.00	2.14
	Female	Male	Total
Number	167	156	323
Percent	52	48	100

Subjects had parental consent to participate in the school district's annual pre-enrollment screening program, of which this study was a part. Subjects with pre-existing orthopedic or neurological conditions (cerebral palsy, myelodysplasia, birth defects, or mental retardation) which would limit performance on any tests were excluded. Subjects who were incompliant with any part of the testing due to behavioral disturbance or refusal were excluded. One Spanish speaking subject who was unable to follow verbal instructions during testing was excluded also.

A total of 372 subjects were randomly selected for the study in accordance with the above criteria. Forty-nine subjects were tested as a pilot group during which test procedures were practiced, methods of scoring and recording were finalized and orientation of a second scorer for evaluation of inter-rater agreement on vestibulo-motor tests was accomplished. The remaining 323 students were included in testing and statistical analysis for this study; 47 of which were included in the inter-rater agreement study.

Procedure

Testing of subjects was accomplished during Kindergarten Round-up programs of 14 elementary schools in the Westside Community Schools, between 8:30 am - 4:00 pm, March 30 and 31, April 1-3, 6-10, and 21-23. Testing stations were located in each school's gymnasium or multipurpose room, with motor tests administered in an area of the gym or room separated from the other test stations by room dividers. This separation was necessary to avoid the effects of prior observation of test procedures on performance, and distraction of subjects at other testing stations with the noise and activity occurring with the motor testing. The language, visual-motor, and vocabulary tests were administered at tables with chairs or benches on which the tester and subject were seated opposite one another. The subjects were issued name tags which chronological age, and color-coded gummed stars were added by the testers to indicate which tests had been completed.

Items four through ten (vestibulo-motor tests) were randomly ordered on the scoring sheet by preselection from a table of random numbers. Items one through three and the group of motor tests were administered in random order as well. Subject order was randomly assigned by the Kindergarten Round-up coordinator.

Following each morning or afternoon's testing, the testing team, school principal, and Kindergarten teacher met to compile test results for each subject. At this time scores for the Preschool Language Assessment, Peabody Picture-Vocabulary Test and the Bender-Gestalt Test were added to the vestibulo-motor scoring sheet. Following verification of scores by subject name, the name was removed from the scoring sheet and thereafter reference to a subject was by subject identification number.

Equipment

The testing of subjects was accomplished with a minimum of equipment for measurement and timing, all of which was maintained and transported to each screening site by the researcher. Items not transported by the researcher but obtained from the participating school were four folding gym mats, three of which were placed on end to form a room divider. The fourth mat was folded to form a rectangular platform. Prone extension posture was tested on this surface which was comfortable to the prone-positioned subject, yet firm enough to prevent the subject from sinking in, and allowed the tester a clear view of head and extremity clearance of the mat. Balance tests, arm extension tests, and prone extension posture were timed with an Advance 930 Chronograph. Stepping patterns and one foot hopping tests were performed on a 10 foot length of one inch width masking tape on the floor, highlighted with a black felt tipped pen. A tape measure was used to measure the 10 foot distance. A 12 inch ruler was used to measure the subject's arm movement during the arm extension tests.

The scoring sheet for the motor tests was developed by the researcher and included space for the subjects' name, identification number, age, birth order, and sex.

All test materials for the three standardized tests were in compliance with the protocol provided in the respective manuals, and were maintained and transported to each screening site by the psychologist or speech pathologist administering the particular test. Description of these test materials is included in the description of each test.

Tests

1. Preschool Language Assessment. This language screening tool was developed by the Peotone, Illinois Title III ESEA project "Early Prevention of School Failure" in 1974.[26] It consists of five sections, each relating to a specific area of language abilities. Part I - Information (10 pt, mean 7, sd 2) measures verbal responses to questions regarding objects and actions. Part II - Comprehension (8 pts, mean 5, sd 2) measures the ability to understand, and answer verbally presented questions with appropriate response. "What is paper made of?" (trees, wood, old paper). Part III - Auditory Memory (9 pts, mean 5, sd 2) uses a tray of colored blocks and balls and small toys to test the child's ability to follow increasing complicated verbal directions. ("Put two flowers and doll in the small box") Part IV - Grammatic closure (9 pts, mean 6, sd2) measures the subject's ability to complete a sentence initiated by the tester. "The ground is dry, but a river is (WET)." Part V - Visual Sequential Memory (14 pts, mean 9, sd 3)

uses geometric felt silhouettes to test the subject's ability to view a pattern of symbols and reproduce the pattern from memory. The 50 point total (mean 32, sd 8 for 5 year olds) provides a useful scale of language abilities. The scoring sheet for this test was developed by the Westside Community School in accordance with the Peotone Manual for test administration. Preliminary studies of scorer reliability of this test show correlations of .95 and .91 for five year old children, and test-retest reliability of .86 for five year olds.

2. Bender Visual-Motor Gestalt Test. This pencil and paper test is widely used by clinical psychologists to assess perceptual-motor development in children ages five to ten. Performance on this test has been used to estimate intelligence and predict school achievement in children prior to visual-motor maturation. A .79 correlation of Bender scores and Stanford-Binet Intelligence Quotients for five year olds was found by Koppitz.[27] The developmental scoring method originated by Koppitz was used by the psychologist testing subjects for this study. The test consists of nine figure plates which are presented individually to the subject. He is asked to copy the figure he is viewing with a pencil on a blank piece of paper. His score is derived from the number of deviations and distortions from the twenty-five categories designated by Koppitz, identified in the figures drawn by the subject. The number of errors (maximum 25, mean 12, sd 4) is converted to an age equivalent for the test score. Scorer reliability of this method has ranged from .88 to .96 in several studies of five year olds. Test scoring method (test-retest) for five year olds correlated significantly at the .001 level. The Bender-Gestalt Test (Koppitz Scoring) form was used by the psychologist administering this test.

3. The Peabody Picture-Vocabulary Test. This verbal intelligence test is used for a quick assessment of intelligence which eliminates the effects of reading, motor, and speech limitations in performance. The subject is required to point to which picture on a card of four illustrates the vocabulary word presented verbally by the tester. The test progresses through increasing difficulty of vocabulary until six errors occur in eight consecutive answers. The raw score for the test is determined by the ceiling item minus total number of errors on the test. The raw score is then converted to a mental age estimate. Standard protocol as outlined by the Manual for the Peabody Picture-Vocabular Test [25] was followed and the test was administered by a speech pathologist. For chronological age 5.1, mean raw score was 54, sd 10; mean mental age was 71 months, sd 17 months. Validity research has demonstrated correlation with the Stanford-Binet mental age and WISC Intelligence Quotient ranging from .78 to .84. Test-retest reliability for five to six year old normal children is .88. The individual test record (form B) cc. Lloyd M. Dunn was used for all subjects.

The seven tests of vestibulo-motor abilities were derived from Jean Ayres' Southern California Sensory Integration Test and have been used in studies by Ottenbacher and others.[19,5] All are commonly employed by pediatric physical and occupational therapists in the assessment of a child's motor development and level of postural stability.

4. Prone Extension Posture. This test indicates the degree of integration of the Tonic Labyrinthine Reflex in the prone position and the presence of adequate extensor tone of the trunk and extremities. The subject was positioned on the folded mat in prone position with elbows

flexed and shoulders abducted to 90 degrees. Hips were in midline with no rotation or abduction, and knees were extended. The subject was instructed to raise head, arms, and legs off the mat for as long as he could, with the instruction repeated continually while the lift was being timed. If the subject could not initiate the posture, the tester would passively raise arms or legs off the mat to demonstrate the position. The subject would then resume the initial position and attempt to assume the posture actively. When all extremities and head were clear of the mat, the lift was timed for five seconds, and scored in the following manner.

One point: the subject cannot lift all extremities and head simultaneously.

Two points: the subject lifts all extremities and head, and maintains position for 1-4 seconds.

Three points: the subject lifts all extremities and head, maintains positions for 5 seconds, with anterior surface of thighs in partial contact with the mat.

Four points: the subject lifts all extremities and head, maintains position for 5 seconds, with anterior surface of thighs fully clear of the mat.

5. Standing Balance; eyes open. This test demonstrates the integration of visual proprioceptive and vestibular stimuli in the maintenance of postural stability. Positioned on a non-carpeted surface away from walls and furniture, facing the tester, the subject was instructed to stand on one (either) foot for as long as possible. Verbal reinforcement, "Keep your foot up, don't fall over...." was provided throughout the timing. Subject's score was the length of time between

lifting up and returning the foot to the floor, rounded off to the nearest second. A limit of 20 seconds was placed on this test.

6. Standing Balance, eyes closed. This test also evaluates postural stability in the upright position. Visual input was removed with subsequent reliance on vestibular and proprioceptive information to maintain balance. Test procedure and scoring was the same as with eyes open, except that subjects were allowed one additional trial with the longest balance time used for scoring.

7. One Foot Hopping. This test reflects dynamic balance, motor coordination, and lower extremity strength. Subjects were instructed to hop on one (either) foot along a 10 foot tape line to the tester at the end of the tape. Score consisted of the number of sequential hops on the same foot with a maximum of 10 hops

8. Stepping Pattern. This test reflects more complex motor planning and visual-gross motor coordination, as well as challenging postural stability in a weight shifting activity. The tester demonstrated a pattern of line walking, crossing over the tape line on the floor with a scissors gait. Subjects were instructed to observe and repeat the pattern. Score for this item was the number of errors (incorrect foot placement or balance loss with lateral toe touch) occurring in 10 steps, subtracted from 10.

9. Arm Extension Test, arm position. This test indicates the presence or absence of residual Asymmetrical and Symmetrical Tonic Neck Reflexes in a stability challenging position. The subject was positioned in standing with feet together, eyes closed, and arms outstretched parallel to the floor with palms down. The subject was instructed not to open his eyes or move until told to do so. Deviations in arm

position over 30 seconds was measured by the tester. Scoring was as follows: 1 = asymmetrical movement of either arm greater than 6 inches vertically or horizontally; 2 = asymmetrical movement of either arm less than six inches horizontally or vertically; 3 = maintains original position without movement (minimal symmetrical downward movement was allowed due to fatigue).

10. Arm Extension Test, active head turning. This test specifically elicits remnants of the Asymmetrical Tonic Neck Response by rotating the head to facilitate the response while placing the subject in a position challenging postural stability. Test procedure and scoring were the same as in test 9, except the subject was instructed to turn his head slowly to one side then to the other side, repeating several times.

Consistent continual positive verbal reinforcement was provided for all subjects in all test performances. This continuous reinforcement was used to improve attentiveness, cooperation, and motivation during testing. "Doing a good job.... eyes on me..... Keep it up" and other phrases geared to four and five year olds were used.

Inter-Rater Agreement

Due to the unavailability of reliability data on test items four through ten, an inter-rater agreement study was conducted with forty-seven subjects. A second tester, a physical therapist previously instructed and knowledgable in the test procedures, observed and simultaneously scored the performances of 47 randomly selected subjects during the three weeks of testing. Administration of test items was performed by the researcher. The agreement of scores on the subjects was evaluated with Pearson Correlation coefficients and ranged from .99 to .84. The lowest agreement occurred with Arm Extension Test, active head turning, which was difficult for a second observer to score from a distance. The highest agreement occurred with the One Foot Hopping. All values were acceptable for rater reliability of tests.

TABLE 2 - Inter-Rater Agreement Correlations for Vestibulo-Motor Tests

Test Item	Number	r
Prone Extension Posture	47	.91
Standing Balance, eyes open	47	.90
Standing Balance, eyes closed	43	.99
One Foot Hopping	47	.99
Stepping Pattern Errors	48	.96
Arm Extension Test	46	.95
Arm Extension Test with head turned	46	.84

Statistical Analysis of Data

To investigate the normal range of performance, mean scores, ranges and standard deviations were computed for all tests as well as subject age, sex, and birth order. To test the hypothesis of a significant correlation of vestibulo-motor tests with language abilities, a step-wise multiple regression equation was computed. The multiple regression equation was used to test the significance of correlation of vestibulo-motor test items with verbal intelligence, and with visual-motor development. To investigate the intercorrelation of tests, a simple correlation matrix was developed including all 10 tests. The hypothesis of significant communality among test items was tested with a varimax rotated factor matrix. Matrices of eight factors through three factors were computed with adequate loading of variables noted with the inclusion of three factors only.

Chapter 4

RESULTS

Descriptive Statistics and Simple Correlations

Descriptive statistics were computed for the scores of all ten test items and are presented in Table 3.

A correlation matrix of test items was computed, indicating significant relationships among many of the individual test items (Table 4). The highest single correlation noted was of the Peabody Picture-Vocabulary Test with the Preschool Language Assessment ($r = .533$, $r^2 = 29\%$). Other moderate correlations of the two standing balance tests ($r = .408$, $r^2 = 17\%$) and of the two arm extension tests ($r = .396$, $r^2 = 16\%$) were also found. Percent shared variance of scores (r^2) for significance at the .05 level ($r = .113$) is 1.3%. At the .01 level of significance ($r = .148$), percent shared variance of scores is 2.2%. The remaining significant correlations reflected a shared variance of scores from 1.3 to 10.0%. Standing balance time with eyes open correlated significantly with all other test items. Preschool Language Assessment correlated significantly with all other tests. except standing balance with eyes closed. Prone extension posture and both arm extension tests were significantly correlated with all other tests except age and the Peabody Picture-Vocabulary. Despite its strong correlation with the Preschool Language Assessment, the Peabody Test showed the fewest and lowest correlations with other tests.

Multiple Correlations

The results of the multiple correlations and step wise multiple regression equations for the Preschool Language Assessment and Bender-

TABLE 3 - Ranges, Means, and Standard Deviations of Tests

Test	Range	Mean	Standard Deviation
Preschool Language Assessment			
(I)	2-10	7.57	1.47
(II)	2-8	4.53	1.31
(III)	0-9	4.86	2.03
(IV)	1-9	6.16	1.55
(V)	0-14	9.69	3.03
TOTAL	11-48	32.81	6.66
Peabody Picture Vocabulary Test			
Raw Score	39.00-77.00	57.3	7.54
Mental Age (years)	3.75-10.17	6.44	1.27
Bender-Gestalt Test			
Raw Score	2.00-23.00	12.40	3.80
Age Approximation (years)	4.00- 9.50	5.32	0.90
Prone Extension Posture	1-4	3.04	0.97
Standing Balance, Eyes Open (sec)	2-20	11.92	6.37
Standing Balance, Eyes Closed (sec)	0-20	3.67	3.11
One Foot Hopping	0-10	6.29	2.66
Stepping Pattern Errors	0-10	8.11	2.62
Arm Extension Test	1-3	2.73	0.51
Arm Extension Test with Head Turned	1-3	2.46	0.61

TABLE 4 - Correlation Matrix of Tests

	PLA	PEP	SBO	SBC	OFH	SP	AET	AET-Head	PPVT	BGT	Age
Preschool Language Assessment (PLA)	1.0	.172[a]	.171[a]	.076	.145[b]	.181[a]	.176[a]	.178[a]	.534[a]	.307[a]	.282[a]
Prone Extension Posture (PEP)	.172[a]	1.0	.317[a]	.151[a]	.211[a]	.150[a]	.165[a]	.222[a]	.042	.221[a]	.101
Standing Balance, Eyes Open (SBO)	.171[a]	.317[a]	1.0	.408[a]	.201[a]	.198[a]	.194[a]	.201[a]	.151[a]	.286[a]	.180[a]
Standing Balance, Eyes Closed (SBC)	.076	.151[a]	.408[a]	1.0	.158[a]	.146[b]	.174[a]	.210[a]	.054	.199[a]	.217[a]
One Foot Hopping (OFH)	.145[b]	.211[a]	.201[a]	.158[a]	1.0	.240[a]	.255[a]	.240[a]	.097	.132[b]	.128[b]
Stepping Pattern (SP)	.181[a]	.150[a]	.198[a]	.146[b]	.240[a]	1.0	.231[a]	.261[a]	.114[b]	.103	.055
Arm Extension Test (AET)	.176[a]	.165[a]	.194[a]	.174[a]	.255[a]	.231[a]	1.0	.396[a]	.116[b]	.166[a]	.054
Arm Extension Test with Head Turned (AET-Head)	.178[a]	.222[a]	.201[a]	.210[a]	.240[a]	.261[a]	.396[a]	1.0	.083	.239[a]	.057
Peabody Picture Vocabulary Test (PPVT)	.534[a]	.042	.151[a]	.054	.097	.114[b]	.116[b]	.083	1.0	.232[a]	.240[a]
Bender-Gestalt Test (BGT)	.307[a]	.221[a]	.286[a]	.199[a]	.132[a]	.103	.166[a]	.239[a]	.232[a]	1.0	.263[a]
Age	.282[a]	.101	.180[a]	.217[a]	.128[b]	.055	.054	.057	.240[a]	.263[a]	1.0

NOTE - a = significance at the .01 level; b = significance at the .05 level

Gestalt visual motor tests support the hypotheses of significant correlations of those tests with the vestibulo-motor tests. For both, the inclusion of all seven motor tests was significant at the .01 level, but only those tests contributing one percent or more to the common variance were included in the final regression equation.

The Bender-Gestalt Test showed a multiple correlation of .263 with the following variables listed in order of significance: standing balance with eyes open, arm extension test with head turned, prone extension posture, and standing balance with eyes closed. (Table 5).

TABLE 5 - Multiple Regression Coefficients for the Bender-Gestalt Test with Vestibulo-Motor Tests

Variable	Multiple R	R^2	Beta	B
Standing Balance, Eyes Open	.286	.081	.185	.27
Arm Extension Test Head Turned	.341	.116	.146	.24
Prone Extension Posture	.358	.128	.112	.11
Standing Balance, Eyes Closed	.363	.132	.068	.20
Constant				4.01

A multiple correlation of vestibulo-motor tests with the Preschool Language Assessment yielded an R of .373 accounting for 14% of the variance. The variables of chronological age, stepping pattern errors, arm extension test, prone extension posture, and arm extension test with head turned, in order of importance, added one percent or more to the variance of scores with the Preschool Language Assessment. (Table 6).

TABLE 6 - Multiple Regression Coefficients for the Preschool Language Assessment with Vestibulo-Motor Tests

Variable	Multiple R	R^2	Beta	B
Age	.282	.080	.256	4.87
Stepping Pattern Errors	.327	.107	.111	.28
Arm Extension Test	.351	.123	.091	1.20
Prone Extension Posture	.367	.135	.097	.67
Arm Extension Test with Head Turned	.373	.141	.077	.85
Constant				-1.69

The multiple correlation of vestibulo-motor variables with the Peabody Picture-Vocabulary Test was .195 for all seven variables. The correlation of standing balance with eyes open and the arm extension test; .175, was significant at the .01 level. Standing balance with eyes open accounted for 2.3% of variance of the Peabody Test and the arm extension tested accounted for an additional .8% of variance. (Table 7).

TABLE 7 - Multiple Regression Coefficients for the Peabody Picture-Vocabulary Test with Vestibulo-Motor Tests

Variable	Multiple R	R^2	Beta	B
Standing Balance, Eyes Open	.150	.023	.133	.26
Arm Extension Test	.175	.031	.090	.23
Constant				5.50

Factor Analysis of Test Items

Factor analysis of all variables using the varimax rotated factor matrix indicated three common factors; language abilities, motor coordination/reflex inhibition, and balance/perceptual-motor integration. These factors were identified by the tests loading most heavily under each of the three factors. (Table 8).

TABLE 8 - Three Factor Matrix for Communality of Tests

	Language and Verbal Intelligence	Motor Coordination/ Reflex Inhibition	Balance/Perceptual Motor Integration	Communality
Preschool Language Assessment 1	.615	.255	.002	.443
Preschool Language Assessment 2	.557	.032	.010	.312
Preschool Language Assessment 3	.663	.196	.212	.523
Preschool Language Assessment 4	.586	.076	.105	.360
Preschool Language Assessment 5	.482	.064	.065	.240
Peabody Mental Age	.653	.037	.097	.437
Bender Mental Age	.298	.198	.341	.245
Prone Extension Posture	.098	.258	.329	.187
Standing Balance, Eyes Open	.086	.144	.754	.597
Standing Balance, Eyes Closed	.017	.190	.482	.269
One Foot Hopping	.080	.375	.212	.192
Stepping Pattern Errors	.133	.387	.152	.190
Arm Extension Test	.108	.540	.129	.320
Arm Extension Test (head turned)	.059	.648	.141	.443
	2.277	1.281	1.192	

Chapter 5

DISCUSSION

Implications of the Results

As was hypothesized, significant relationships were demonstrated among the vestibulo-motor abilities and the measures of language, intelligence, and visual-motor skills. It should be noted that due to the large N-size, significance was reached at relatively low correlations, and consequently are of limited practical value. The most significant correlations occurred with the Bender-Gestalt Test. Individually, every vestibulo-motor test item except stepping pattern errors correlated significantly with this test. In the multiple regression equation, balance and integration of tonic reflexes were the most effective predictors of performance on this test. These results support the existence of an interrelation of basic sensorimotor integrative processes of postural stability and control of primitive reflexes, and the more complex perceptual-fine motor abilities measured by the Bender-Gestalt Test.

Of similar significance was the correlation of the Preschool Language Assessment with the vestibulo-motor test items. All but standing balance with eyes closed were significant individually. In the multiple regression equation tests, age accounted for the greatest percentage of variance in scores. Following age, stepping pattern errors, the two arm extension tests, and prone extension posture were all of approximately equal importance as predictors of language ability.

The correlation of the Peabody Picture-Vocabulary Test with the vestibulo-motor tests was weaker, with a multiple correlations of .195, in contrast to correlation of .366 and .382 with the Bender-Gestalt Test and Preschool Language Assessment respectively. Standing balance with eyes open and the arm extension test were the most significant variables, with a multiple correlation of .175, accounting for 3.1% of variance of scores on the Peabody Test.

These results are supportive of the conclusions of Ayres, deQuiros, and others, that vestibular functions relate with speech and language and sensori-motor integration primarily, and intelligence secondarily, as a function of its relationship with language abilities and sensori-motor integration. Thus, a measure of intelligence not reflecting these abilities (such as the Peabody Test) would correlate less significantly with vestibulo-motor function.

The three factors identified via the factor matrix are named by the tests loading most heavily in each of the factors. Factor one, "language and verbal intelligence", includes all sub tests of the Preschool Vocabulary Test. The existence of this factor is predictable and reflects the interrelation of various aspects of language skills and vocabulary knowledge.

A second factor was labeled "motor coordination/reflex inhibition" because of the relatively high loading of hopping and the stepping pattern. Both are reflective of complex dynamic skills which require motor coordination. The reflex inhibition portion of the label was so named for the loading of the two arm extension tests under this factor. The maintenance of arm extended posture with eyes closed and head stationary or turned tests the integration of primitive tonic reflexes of the neck. It can be speculated that maintaining such a posture without visual input may reflect also accuracy of body-in-space awareness, and motor coordination in voluntarily controlling the tendency to raise or lower arms and/or flex the elbows in this challenging posture. Although the involvement of vestibular function in these skills is known, it is felt that the integrity of vestibular function is less apparent in these tests. This may be due to the confounding effects of motor coordination, strength, and kinesthetic acuity which also contribute significantly to performance on these comparatively complex motor skills.

The third factor identified among the variables was labeled "balance/perceptual motor integration" due to the loading of both balance tests in this factor, as well as the Bender-Gestalt mental age, and prone extension posture. In considering the similarity of sensory integrative processes required for balance and eye-hand coordination, and the integration of Labyrinthine reflexes necessary to maintain prone extension posture, it is believed that this common factor is the most valid indicator of vestibular function in the subject. The accuracy of these two tests of balance in comparison to the hopping and stepping may be attributed to their relative simplicity of performance. The maintenance of an upright posture over a small base of support requires the processing of vestibular input, integration of this information and appropriate motor responses of the trunk and extremities. This loop of sensory input, integration, and motor out takes place on a subcortical level. Likewise, the task of copying designs on paper requires the processing of visual input, integration of the information, and appropriate motor responses of the hand. In both tasks, the sensory-motor integration takes place nearly instantaneously and at a subcortical level. The prone-extension posture is linked to these sensory integrative processes by the requirement of facilitated trunk extensor tone, which is a specific motor function of the vestibular nuclei and descending vestibulo-spinal tracts.

In summary it appears that standing balance and prone extension posture, both basic abilities relating to postural stability through sensori-integrative processes are most significantly related to the perceptual fine motor skills measured by the Bender-Gestalt Test. However, the dynamic hopping and weight shifting balance activities and the maintenance of body position without visual input are less useful as measures of vestibular function. This may be attributed to the obscuring effects of other abilities in the realm of motor behavior on these more complex motor activities.

Despite the existence of two exclusive factors among the vestibulo-motor tests, all seven tests were significantly correlated. Several points may be discussed with regard to relative strength of correlation of test items. Uncontrolled variables which may have detracted from the potentially higher correlation of scores include previous motor learning and motor abilities not related to vestibular function. Although the subject age range for this study (4.33 - 6.0 years) was believed to be young enough to diminish the importance of previous motor experience, it would be wrong to negate its effects completely.

Subjects' variance of participation in sports and games generally or specifically related to test items most probably did confound the results of this study. It should be noted that even if previous motor experience significantly affected performance, this may have been accomplished in part by a change in vestibular processing function as a result of the naturally occurring vestibular stimulation of those activities. Compensatory enhancement of other sensory and motor systems, kinesthetic acuity, increased strength and dexterity, and specific motor learning would also result from the previous motor experience. Psycho-social variables which may be speculated encompass the number and age of siblings, physical status of parents, living quarters, (all related to the motor experience factor), motivation and aspiration to achieve, tolerance of stress, and many others. These factors indeed influence the performance on all ten tests. The performance factors specific to the place and time for each subject; his physical health and emotional status on that day, his clothing, and interaction with testers and other subjects, may in some way vary subjects' performances for reasons other than vestibular function.

As summarized by Fitts, perceptual motor behavior is the result of the composite effect of physiological and psychological status, motor abilities and tendencies, and unique performance factors. Likewise, language, intelligence, and visual-motor development are the product of an equally complex combination of abilities, traits, and experiences.

It follows that, in a population which demonstrates vestibulo-motor function, language abilities, and intelligence in the normal range of performance, the relationship between them may be obscurred by these confounding effects. The existence of a more obvious relationship may be identified in subpopulations for which any of the performance variables of this study are not within normal limits. The vestibularlydysfunctioning children studied by deQuiros and Rapin and the learning disabled students studied by Ottenbacher, Ayres, Cheek and others have shown this to be true.

Discussion of Tests and Procedures

The test items and procedures included in this study were chosen with the purpose of developing a clinically practical screening tool which could be used for large groups efficiently and economically. The inclusion of more elaborate measures for language and intelligence and the post rotatory nystagmus test for vestibular function would have been valuable in supporting the validity of test items, but would have defeated the purpose of investigating quick and practical screening tools. Despite highly significant intercorrelation of the language, intelligence and visual-motor test items, vestibulo-motor correlation with them was sufficiently varied to allow speculation on the relationships demonstrated by the variance.

In retrospect, several items and procedures are worthy of discussion. The subject's score of one foot hopping (the number of hops on a ten foot line) was highly indicative of their height and length of hop, with long "hoppers" reaching the tester in six hops while short "hoppers" may have taken ten or more to travel the same distance. Yet dynamic balance as demonstrated by the ability to hop was equal. Those subjects hopping only one to four times were more obviously less proficient in the skill and therefore, a more valid score for this item would have been one point for one through three hops, two points for four and five hops, and three points for six or more hops.

The task of timing one foot standing balance was difficult due to the subjects' tendency to touch the raised foot down and then raise it again before the tester could reset the timer. Then, when the subject was instructed to stop and begin again, he was actually allowed three trials rather than the two specified in the test procedure. Also, the allowance of two trials would have yielded a more valid score on the standing balance with eyes open. The effect of a 20 second limit for these tests on the results is unclear, but it is felt that if allowed to do so, several subjects would have stood for one or more minutes. This not only would have skewed the distribution of scores dramatically, but would have been impractical for the time limits in which the tests were given.

For the most part these tests chosen for this group were age appropriate. Standing balance with eyes closed was felt to be the most difficult although particular caution was used to avoid communicating this to the subjects. It was noted in the pilot group of forty-nine that there is a general reluctance for the four to five year olds to keep eyes closed in the presence of strangers so the continual instruction to "keep your eyes closed" was provided during the timing of the two arm extension tests and the standing balance with eyes closed. In order to gain some consistency in motivation during the prone extension posture test, which was the most challenging test to maintain, continual encouraging instruction was provided by the tester while timing all subjects. The need to be passively placed in the position prior to performing it actively may have been a significant variable for some subjects.

Conclusions

The results of this study have provided additional information on normal vestibulo-motor performance in four and five year olds, to assist in the identification of vestibular dysfunction in this group. Significant correlations of tests of vestibulo-motor abilities with the Bender-Gestalt Visual Motor performance and the Preschool Language Assessment were demonstrated. These results support the proposed connection of vestibular function with sensory-motor integration and language development in children. A significant correlation of the Peabody Picture-Vocabulary Test of intelligence was found with only two vestibulo-motor tests which indicates a less direct relationship between vestibular function and this measure of intelligence.

The identification of two exclusive factors among the vestibulo-motor tests, indicates that performance on some of these tests may reflect the effect of other performance variables to a greater degree, thus making them less valid as measures of vestibular function.

In summary this study supports the association of motor and cognitive development, and the interrelation of vestibulo-motor performance, visual-motor performance and language in particular.

Recommendations for Additional Research

The complexity with which the vestibular system affects human development is not fully understood. The role of the vestibular system in affecting and augmenting motor, language and cognitive abilities cannot be fully realized without extensive continued research in this area.

Further substantiation of the correlation of vestibulo-motor abilities and standardized neurological tests of vestibular function is needed. Standardization of these abilities for all ages is necessary prior to broader investigation of vestibulo-motor dysfunction. An analysis of variance of students' scores on academic achievement tests, a general physical fitness test, and specific vestibularly affected motor skills tests would indicate if the relationship of general physical abilities is more or less significant than that of vestibulo-motor skills with academic achievement. In research pertaining to the relationship of these specific test items, the identification of a significant correlation in a known language or perceptual-motor disordered population would be valuable. The subjects' sex and age are variables that would warrant analysis as potentially significant affecters of vestibulo-motor skills and academic achievement. Finally, a longitudinal study of normal and learning disabled students, in which development of vestibulo-motor and academic abilities are studied, would investigate concurrent changes in these skills, and further substantiate their positiverelationship in human development.

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APPENDICES

APPENDIX A

INFORMED CONSENT FORM

SCHOOL OF HEALTH, PHYSICAL EDUCATION, AND RECREATION
UNIVERSITY OF NEBRASKA AT OMAHA

PARTICIPANT CONSENT FORM

The Westside Community Schools are invited to participate in a study examining specific motor abilities of 4 and 5 year olds in correlation with language and academic abilities. Its purpose is to determine if motor abilities associated with vestibular function have a significant relationship with areas of cognitive development in kindergarteners. It is hoped that conclusions from this study will assist in the development of a clinical screening tool for vestibular function based on motor abilities.

This investigation will be based on test scores collected during the Westside Community Schools Pre-Kindergarten screening on March 30 and 31, April 1-3, April 6-10, and April 22-24, 1981. Only those test proce-edures normally included in pre-kindergarten screening will be analyzed. Individual subject's anonymity will be preserved and only statistical information takenfrom the original test scores will be used in this study. The results of this study will be included in a thesis in partial fulfillment of the requirements for the Master of Arts degree in Physical Education, and may be submitted for publication or presented at professional meetings if deemed appropriate.

Your decision whether or not to participate will not prejudice your future relations with the University of Nebraska at Omaha. You should feel free to withdraw from participation in the study at any time without prejudice.

If you have questions regarding any facet of the study, please ask. Mrs. Kristin Dye (phone: home, 558-8183 or work, 453-7400 x 121) will be happy to answer any questions that you may have at a later date.

You will be given a copy of this form to keep for your records.

YOU ARE MAKING A DECISION WHETHER OR NOT TO PARTICIPATE. YOUR SIGNATURE INDICATES THAT YOU HAVE DECIDED TO PARTICIPATE HAVING READ THE ABOVE INFORMATION.

____________________________ ____________________
Signature Date

____________________________ ____________________
Witness Investigator

APPENDIX B

SUBJECT SCORING SHEET

LANGUAGE AND MOTOR ABILITIES TESTS

SCORING SHEET

Subject #______ Test date:____________________________

Male Female (circle) Birth order:_________________________

Age ________ Examiner:____________________________

1. Peabody Picture-Vocabulary Test _______

2. Preschool Language Assessment

   I____ II____ III____ IV____ V____ Total _______

3. Bender-Gestalt Test _______

4. Prone Extension Posture
   1 = no lift
   2 = lift 5 sec.
   3 = lift 5 sec.
   4 = thighs clear of mat _______

5. Standing Balance, eyes open - Time _____sec.
   (max of 20 sec.) _______

6. Standing Balance, eyes closed - Time _____sec.
   (max of 20 sec.) _______

7. One Foot Hopping - # of Hops_____
   (max of 10 hops) _______

8. Stepping Pattern - # of Errors in 10 Steps _______

9. Arm Extension, arm Position
   1 = asymmetrical movement 6"
   2 = asymmetrical movement 6"
   3 = no movement _______

10. Arm Extension, arm position with head turned
    1 = asymmetrical movement 6"
    2 = asymmetrical movement 6"
    3 = no movement _______

APPENDIX C

TEST FORMS

WESTSIDE COMMUNITY SCHOOLS

EARLY AND CONTINUED INTERVENTION FOR THE EARLY LEARNER

PRE SCHOOL LANGUAGE SCALE

NAME ______________________ DATE ______________________

D.O.B. ____________ C.A. ________

SCHOOL ______________________

EXAMINER ______________________

COMMENTS: ______________________

____

____

____

____

I.	INFORMATION	____
II.	COMPREHENSION	____
III.	AUDITORY MEMORY	____
IV.	GRAMMATIC CLOSURE	____
V.	VISUAL SEQUENTIAL MEMORY	____
	TOTAL SCORE (50 points)	____

I. INFORMATION

Procedure:

Begin with button.
Use button as demonstration if missed.
Continue testing until three consecutive answers are missed.

Scoring: One point for each correct response.

____ (Button) What is this? What color is it? (Score second answer on fourth response.)

____ (Slicing, cutting) What is mother doing to the bread?

____ (Drawing, writing) Tell me what this boy (or girl) is doing.

____ (White, silver, gray)

____ (Laughing, smiling) Tell me what the clown is doing.

____ (Sink, basin) You wash in a ....

____ (Jar) Peanut butter and jelly come in a ....

____ (Nine) Count these apples. How many are there?

____ (Music, note, staff) What is this?

____ (Rising, setting) What is the sun doing?

Score ______________________

10 points

II. COMPREHENSION

Procedure:

Read questions clearly.
Use responses for television as demonstration if missed.
Present all eight questions.

Scoring: One point for each correct answer.

_____ What do you do with television? (see, look, watch, hear)

_____ How does ice feel? (cold, wet)

_____ What is a dish made of? (glass, china, plastic, paper)

_____ Why do we have windows? (let light in, ventilation, to see out)

_____ What makes a clock run? (electricity, wind, battery, motor, weights)

_____ When you dance you need ....(music, record, record player, radio, stero)

_____ What is ketchup made of? (tomatoes)

_____ What is paper made of? (trees, wood, old paper)

8 points Score ______________

III. AUDITORY MEMORY

Materials:

Blue and red balls, six blocks, (red, blue, green, yellow, orange, white), three flowers, sock, doll, red and blue cars, box, and bat.

Procedure:

Place the tray with the toys toward the child, unless the child has poor self-control. Say in a loud, clear and normal voice with proper inflection:

" I AM GOING TO TELL YOU TO DO SOMETHING ONLY ONCE. LISTEN, THEN DO IT."

Start with first.
Use first as sample if missed.
Continue testing until three consecutive answers are missed.

Scoring: One point for each correct response.

_____ Point to the red block.

_____ See all these toys. Put all blue toys here. Point to the large green area. (ball, block and car without error)

_____ Find a block, car and sock. Put them here. Point to the large green area.

_____ Put two flowers and doll in the small box.

_____ Put the bat beside the doll and make all balls roll.

_____ Clap your hands three times, then blink your eyes twice, then touch your nose. (In sequence)

_____ Put a block in each corner of this box. (no gesture)

_____ Place the green block on the yellow block and the yellow block on the white block here. Point to the large green area.

_____ Find two different living things. Put a blue block between them here. Point to the large green area. (doll and flowers - felt silhouette flowers are also acceptable.)

9 points Score _____________

IV. GRAMMATIC CLOSURE

Materials:

Two cars, box, doll, sock and sandpaper

Procedure:

Begin with first.
Use car as demonstration if missed.
Continue testing until three consecutive answers are missed.

Scoring: One point for each correct response.

_____ Here is a car, here are two: CARS

_____ This car is in the box, Now the car is: OUT

_____ The doll is walking (demonstrate). Now the doll is (demonstrate): RUNNING

_____ Ground is dry, but a river is: WET

_____ This car is fast (demonstrate). This car is even (demonstrate): FASTER

_____ This sock goes over the car (demonstrate). This box goes (demonstrate): UNDER THE CAR

_____ (Spoken metrically) Mickey the mouse lives in a : HOUSE

_____ The car goes. Yesterday the car: WENT

_____ Feel this sandpaper. It is: ROUGH

9 points Score _____________________

V. VISUAL SEQUENTIAL MEMORY

Materials:

Felt silhouettes: Two circles, two triangles, two flowers, one sun and one donut.

Procedure:

Place and mix on large green area: Two triangles, two circles, one sun.

Say: " LOOK, SEE WHAT I HAVE."

Screen the green placement dots.

Place pattern on dot location, from examiner's right to left, beginning with first dot.

Expose placement. Say: " SEE WHERE THESE ARE. REMEMBER WHERE THEY ARE - RIGHT HERE."

Expose for five seconds.
Screen pattern on round placement dots.
Return silhouettes to green area. Mix silhouettes.
Expose the large green area.

Say: "PUT THEM BACK LIKE I HAD THEM."

Begin with first.
Demonstrate first error.
Continue testing until three consectuive patterns are missed.

Scoring: Two points for each correct response.

T _____	T _____	
T _____	C _____	
C _____	T _____	
S _____	C _____	
T _____	T _____	C _____
T _____	S _____	T _____

Add to large green area: two flowers and one donut.

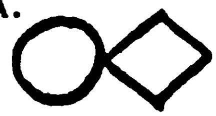
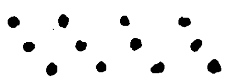
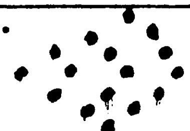
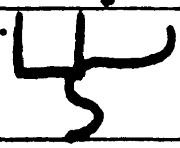
C _____	F _____	C _____	F _____

14 points Score _______________

BENDER GESTALT TEST

KOPPITZ SCORING

Student ____________________
Date ______________ School ____________
B.D. ______________ CA _____ Grade ________
Time ____ ' ____ " Mean ____ ' ____ "
Hand ___ R ___ L Foot ___ R ___ L Eye ___ R ___ L

FIGURES	BEHAVIOR OBSERVATIONS
A. 	
1. 	
2. 	
3. 	
4. 	
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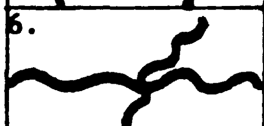
6. 	
7. 	
8. 	

FIGURE

A.		1. Distortion	
	*	a. Shape	____
	6) *	b. Proportion	____
	*	2. Rotation	____
	*	3. Integration	____
I.	*	4. Distortion	____
	**	5. Rotation	____
	7)**	6. Perseveration	____
II.	8) *	7. Rotation	____
	6)**	8. Integration	____
	7)**	9. Perseveration	____
III.	6) *	10. Distortion	____
	7) *	11. Rotation	____
		12. Integration	
	5) *	a. Space	____
	**	b. Line	____
IV.	**	13. Rotation	____
	**	14. Integration	____
V.	8) *	15. Distortion	____
	*	16. Rotation	____
		17. Integration	
		a. Shape	____
	**	b. Line	____
VI.		18. Distortion	
	*	a. Angles	____
	**	b. Line	____
	*	19. Integration	____
	7)**	20. Perseveration	____
VII.		21. Distortion	
	7) *	a. Proportion	____
		b. Shape	____
	6) *	22. Rotation	____
	6) *	23. Integration	____
VIII.	6) *	24. Distortion	____
	**	25. Rotation	____

Emotional Indicators

1. Confused order ________
2. Wavy Line (1 & 2) ________
3. Dashes (2) ________
4. Increasing size (1,2,3) ________
5. Large size ________
6. Small size ________
7. Fine lines ________
8. Overworked lines ________
9. 2nd attempt ________
10. Expansion ________
11. Constriction ________

Developmental Errors ____
Mean ____

Extra or missing angles (A,7,8)
Angles for curves (6)
Straight line for curves (6)
Disproportion of parts (A,7)
Substitution of 5 circles for dots (1,3,5)
Rotation of design by 45° (1,4,8,A,5,7,3,2)
Failure to integrate parts (A,4,6,7)
Omission or addition of row of circles (2)
Shape of design lost (3,5)
Line for series of dots (3,5)
Perseveration (1,2,6)