Assessing the visual/cognitive interface: SOI in optometry

Kristine J. Gyving

Pacific University
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Abstract
Success in achieving specific optometric goals, with learning disabled individuals, depends upon the method and the quality of diagnostic tools. To be able to accurately identify specific disabilities, and for direct remediation, the optometrist must have a differentiated definition of visual/perceptual processing and visual physiological functioning that includes testing and remediation. The SOI (Structure of Intellect) developmental vision test is based on a differentiated definition of intelligence and examines the visually dependent components of intelligence thought to be important for school success. Parallels between SOI and optometry are developed by reviewing and contrasting the SOI developmental vision test sequence to current optometric definitions, perceptual testing, and SOI remediation modules to optometric perceptual training techniques. The SOI developmental vision test is distinguished as being a clinically useful tool to the behavioral optometrist in assessing the visual perceptual/cognitive abilities that are important to successful school learning.

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ASSESSING THE VISUAL/COGNITIVE INTERFACE:

SOL IN OPTOMETRY

by

Kristine J. Gyving

Advisor

Bradley Coffey, O.D.

Submitted to the Faculty of Pacific University College of Optometry For
Partial Fulfillment of the Requirements for the Doctor of Optometry

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ABSTRACT

Success in achieving specific optometric goals, with learning disabled individuals, depends upon the method and the quality of diagnostic tools. To be able to accurately identify specific disabilities, and for direct remediation, the optometrist must have a differentiated definition of visual/perceptual processing and visual physiological functioning that includes testing and remediation.

The SOI (Structure of Intellect) developmental vision test is based on a differentiated definition of intelligence and examines the visually dependent components of intelligence thought to be important for school success.

Parallels between SOI and optometry are developed by reviewing and contrasting the SOI developmental vision test sequence to current optometric definitions, perceptual testing, and SOI remediation modules to optometric perceptual training techniques.

The SOI developmental vision test is distinguished as being a clinically useful tool to the behavioral optometrist in assessing the visual perceptual/cognitive abilities that are important to successful school learning.
Optometrists providing vision therapy for individuals with learning disabilities may find that vision therapy oriented toward physiological visual factors alone (refractive status, accommodation, convergence, accommodative/convergence interactions, fusional abilities) may be incomplete and/or ineffective. Physiological factors can often interfere with efficient reading and may impair an individual's ability to respond to incoming information, but with the learning disabled individual these are often not the only factors involved (Flax 1968, 1970). Even when clear single efficient binocular vision is established, the individual may still exhibit fundamental visual perceptual/cognitive difficulties in learning. Visual perceptual/cognitive factors must therefore be accurately identified and any specific visual cognitive deficit assessed in order to maximize the effects of a vision therapy program. In light of this, it has become more important that the optometrist have not only an understanding of the physiological aspects, but also the perceptual/cognitive aspects of visual function and the ability to learn. Much classroom education is structured such that learning is a visual experience, and any impairment in visual function can have a great influence on a child's success.

Vision is the process of taking in information (input), interpreting and integrating the information, and generating a response (output). The input of information involves the physiological factors (refractive status, oculomotor control, binocularity, fusional abilities, accommodation, convergence and accommodative/convergence interactions) that enables clear
single, binocular vision. The interpretation and integration of information is accomplished via perceptual and cognitive processes and, when complete, results in the generation of a response to the original input information. Processing also involves the integration of visual information with other sensory information (auditory, kinetic, etc.) in producing the most appropriate response, the output.

In order to adequately evaluate an individual for the prevention and remediation of a learning disability, a meaningful differential diagnosis of visual physiological abilities and visual perceptual/cognitive abilities is required.

The behavioral optometrist working with learning disabled individuals routinely evaluates those visual abilities known to be important for efficient school learning. The optometrist systematically investigates the following areas: refractive status, a potential source of decreased visual acuity, visual discomfort, or reduced performance; oculomotor control, necessary for the individual to accurately converge, aim, and perform pursuit and saccadic eye movements; accommodation, necessary to focus the eyes or to produce a clear image at near, and to control focus for all distances; accommodation/convergence interactions, their matching, facility, amplitude and relative independence; fusional abilities, which can contribute to blurring or doubling of vision; visual health, in order to assess any potential disease-related factors affecting visual function. Additionally, the optometrist must maintain an awareness of nutritional aspects, allergy considerations and emotional factors in light of their effects on learning ability (National Institute of Health 1983, Crook 1980, Lane 1978).
After a thorough analytical examination, the behavioral optometrist seeks data regarding the visual perceptual skills of the individual. Investigations have indicated that learning disabled children have a higher incidence of both auditory and visual perceptual problems (Flax 1968, Solan 1979, Gardner 1979). Visual-motor skills, visualization ability, visual memory, laterality, directionality, visual-closure, and figure-ground differentiation abilities are a few of the visual perceptual areas typically assessed.

To further improve care and facilitate success when working with a learning disabled child, the optometrist seeks information from the schools regarding the student's potential learning ability and intellectual function. Possible organic problems must be ruled out since likelihood of success of visual remediation is decreased if general intellectual functions are low. Relative academic potential can be interpreted from such intelligence tests as the WISC-R or the Binet. The optometrist may review the subtest scores of the WISC-R, for example, knowing that a low performance score versus a high verbal score is a "red flag" indicative of a possible visual problem or visual inefficiency. Being able to understand the visual information processing demands of each subtest would give much more information in defining a visual difficulty than just a single verbal, performance or total IQ score. Knowledge of the specific visual and cognitive abilities required to perform any particular IQ subtest could provide a functional tie between measurable abilities and remediation. For what differentiates the learning disabled child from a normally developing child is not a limitation of potential or intelligence, but an inability to utilize specific cognitive and perceptual skills in an academic situation (Solan 1982). The optometrist may enhance his/her delivery of care by
being able to differentiate and measure those visual perceptual/cognitive skills necessary for learning success. The differentiated abilities can than be dealt with directly and remediation aimed towards specific sources of difficulty.

A standardized diagnostic test battery that will systematically probe the visual perceptual/cognitive abilities that are important to successful school learning, is essential for a differentiated diagnostic procedure. J.P. Guilford's (1967) Structure-of-Intellect model (SI) of cognitive abilities is an approach to understanding intelligence which has been useful for the purpose of differentiating specific abilities. Based upon the SI model, Dr. Mary Meeker (1969) developed a testing battery, the Structure-of-Intellect Learning Abilities Test (SOI-LA), which may be used in evaluating 21 specific cognitive abilities important for efficient classroom learning. Dr. Meeker has also recognized the importance of vision in learning, and has developed a developmental vision test derived from the 21 cognitive abilities of the SOI-LA test. Dr. Meeker feels the SOI-LA developmental vision test gives a "cognitive representation of the physiological function of vision as it relates to the learning situation" (Meeker 1979). The structure of intellect test (SOI) may serve to provide a link between optometry, education, and the cognitive abilities that are important for efficient learning.

The SOI developmental vision test will be reviewed in light of its usefulness as a diagnostic tool in differentiating visual perceptual/cognitive abilities for the direct remediation of specific learning abilities. The individual subtests of the SOI developmental vision test will be described and defined both in Dr. Meekers terms and in optometric
terms. Comparable, widely-used optometric test procedures will be listed along with optometric training techniques and SOI remediation modules. For each SOI ability a table will be provided for comparison of the SOI subtests, optometric tests, SOI modules, and optometric training.

**Structure of Intellect**

The following section will cover the theoretical basis underlying the SOI-LA test. The intellectual abilities that are tested by the SOI-LA test will be delineated and operationally defined in terms of the kinds of mental tasks for which they are utilized.

The SOI concept is based on a differentiated theory of intelligence developed by J.P. Guilford (1967). Guilford's structure of intellect model (SI) is the result of factor analytic research following the work of Thurstone. Thurstone developed, by means of factor analysis, a battery of tests which measured six factors of intelligence; he termed these the primary mental abilities. Guilford began working with Thurston's primary mental abilities and, following the factor analysis of many tests of intellectual abilities, developed a unified theory of intelligence. Factor analysis is a statistical procedure that has been used to distinguish and classify what intellectual functions exist and what their mental properties are (Guilford 1967, 1968).

Through the factor analytic approach, 120 different intellectual abilities have been designated by Guilford which influence not only learning ability but also behavioral and social aspects of intellectual functioning. Each intellectual component or factor represents a unique
ability that is needed to accomplish a specific class of tasks or tests.

The intellectual abilities may be graphically portrayed as a three dimensional model where each intellectual ability is characterized in terms of content, operation and product. An operation is used to process given information, content, to bring about new information, product.

The three dimensional cube pictured in Figure 1 is an aid to conceptualize the three-way classification system. Letters are employed as codes to specify the operations, contents, and products, that represent an intellectual factor. As seen in the figure there are four content categories, five operation categories, and six product categories taken together, these categories describe the 120 definable factors of human intellect.

Complete characterization of each intellectual ability is achieved by the differentiation of the three major dimensions into subclasses. Content which defines kind or type of information, is broken into figural, symbolic, semantic and behavioral content. Figural (F) is defined as perceived forms, shapes or concrete objects. For example, figural content may be depicted as a geometric shape, an animal, or an object such as a house. Symbolic (S) representations of content are in the form of numerals, single letters, or musical notes, or any other sign that has a "token" or culturally-defined value or meaning. Semantic (M) content, the third category, refers to words or ideas which have automatic and instantaneous, yet abstract, meaning to the individual. Guilford defined it as "imageless" thought. It is knowledge that has been internalized by the individual such that meaning is not dependent on external representation of the object or idea. Honesty, truth, friend, are ideas
that are examples of semantic content. Word representation of an object, for example house, where a house does not have to be present for the word to have meaning, is also semantic content. The final content category, behavior (B) represents our "social intelligence" as opposed to the abstract or concrete. It represents attitudes, needs, perceptions, etc., involved in human
interactions with social stimuli. Only a few behavioral factors have been identified leaving this dimension open to further investigations and discoveries.

Content is always associated with the second letter in the trigraph labeling of the sub-cells of the cube. This is by convention and not by any priority.

Along a second major axis of the cube lie the intellectual factors called products. The product refers to the organization of information for processing. There are six product categories, units, classes, relations, systems, transformations, and implications. A Unit (U) has its own unique set of attributes. The unit may be single figure, symbol, word or idea as from the content categories. A class (C) is the collection of similar units, ideas, or concepts. To produce a class the individual must be able to understand the underlying idea or concept that is the nature of the class. For example, car, truck and airplane make up a class pertaining to the concept of transportation. The relations (R) category is the ability to make connections or relations between the units. The ability to discriminate between likeness or differences in relationships is based on information from content: figures, symbols, words, ideas, or behavior. The "if, then" equation is an example of a relation; if it rains then you'll get wet. Systems (S) is an organization of information in an orderly, logical, and convenient sequence. A system can range from a mathematical expression to understanding a social situation. Transformation (T) involves more abstract abilities. It is the making of changes in, or re-arranging of, information for the redefinition of new information. The simplification of a mathematical equation or the ability to visualize a change in an object, such as the
rotation of a geometric form, would be examples of transformations. The ability to easily manipulate transformations is often characterized in what we call "creative" people. Implication (I) has been noted as the most abstract of the abilities. It involves the extrapolation of information, the ability to interweave ideas across old and new information from one event, act, task or problem to another. It is the ability to generalize from one situation to a different situation. Implications are more difficult to define than are the relational connections.

On the third dimension of the SI model lies the operations category. Operation is defined as the method by which information is processed. There are five mental operations: cognition, memory, divergent production, convergent production, and evaluation.

Cognition (C) is considered the most basic and essential intellectual operation. It is defined as comprehension, discovery, knowing, or understanding. New information must be comprehended before it can be manipulated, thus cognition is basic to any other mental operations involved in learning. Memory (M) is the process of putting information into storage. It, like cognition, underlies all the operations, and all of the defined intellectual abilities are dependent upon it. Convergent production and divergent production are both scanning or searching processes that involve information retrieval from memory in generating a solution. Convergent production (N) is the processing of information to systematically determine a unique set of answers to a particular question. It is considered to be "rigorous" thinking. Convergent production is a measure of performance by output, for example, the output of a solution to a presented problem. Since there is only one answer, a close relationship between this answer and the processes that converge on it
is assumed. Convergent production of information is what is most often expected in school work, and is evaluated in almost all intelligence and achievement tests. **Divergent production** (D) is a much broader process, it emphasizes expanded thought rather than narrowed thought. Divergent production capability is suggestive of creativity, individual flexibility, and ability to break away from the normal. **Evaluation** (E) is utilized in carefully appraising information to determine its adequacy, or its desirability with respect to making a logical judgement which will satisfy a particular criterion. It is the basis of decision-making skills.

**Application of the SI Model**

Dr. Guilford's SI Model is not a dynamic model, but a static classification theory on how information may interact and be interrelated. The model suggests the processes which may guide human information processing. After comprehension (cognition) of a bit of information several processing options are available. For example, one may store information, evaluate it, reproduce it, or associate it. Guilford's model serves to specifically identify and classify these various operations.

Dr. Meeker in 1962 began applying Dr. Guilford's work to operationally define a relationship between mental abilities and academic performance. Dr. Meeker analyzed widely used IQ tests (Stanford-Binet (LM), WISC, and WPPSI) in terms of the SI classification system and found those intellectual abilities which where common to all of the IQ tests. Dr. Meeker's application of the SI model is called the SOI and is based on the assumption that specific intellectual abilities underlie the learning of subject matter, and that these
intellectual abilities can be developed. Dr. Meeker's studies have indicated a wide range of intellectual abilities, as defined by the SI model, that are necessary for a child to learn academic subject matter (Meeker, 1963, 1965, 1969). A test of specific learning abilities, those which Dr. Meeker found to be fundamental to successful learning, has been developed based on these SI factors. This test is the SOI-Learning Abilities Test (SOI-LA). Twenty six abilities are evaluated in the SOI-LA Basic test. Of these, twenty one are considered necessary to school achievement. These abilities are thought to be the "basic" skills that are prerequisites to developing reading skills and which are necessary for learning mathematics. Most of the abilities tested by the SOI are represented by tests with a visual input, a few are auditory, and one kinesthetic. Within the twenty one abilities of the learning abilities test, nine have been distinguished as being visually dependent and are felt to be foundational for reading and arithmetic learning. The nine cognitive abilities that are vision dependent and correlated to school achievement are summarized in Figure 2.

The SOI-LA test is a near-centered paper-pencil test. Any basic visual dysfunction involving accommodation, convergence, binocularity, or oculomotor ability will be a confounding factor that should be taken into consideration when giving the test and when interpreting the results. A substantially lowered score could therefore be due to either a visual input problem or a visual processing (cognitive) problem. Thus, the diagnostician must know before administration of the test the visual input status of the child. The SOI-LA developmental vision test is an additional diagnostic tool to be used in conjunction with optometric analytical findings to probe more thoroughly those cognitive functions that relate to vision and school learnings.
THE NINE SOI VISUAL ABILITIES

<table>
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<th>SOI</th>
<th>DEFINITION</th>
<th>RELATION TO SCHOOL ACHIEVEMENT</th>
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<tr>
<td>Cognition of Figural Units (CFU)</td>
<td>Ability to pull unattached partial figures together into a whole.</td>
<td>Visual preparation for reading and closing letters into words that are meaningful. Right hemisphere.</td>
</tr>
<tr>
<td>Cognition of Semantic Units (CMU)</td>
<td>Ability to read and comprehend verbal ideas.</td>
<td>Comprehension of information when reading. Left hemisphere unless nouns are spoken one at a time.</td>
</tr>
<tr>
<td>Cognition of Figural Transformations (CFT)</td>
<td>Ability to comprehend a visual whole or form from any perspective.</td>
<td>Important of mathematics, but gives a measure of lines accommodation.</td>
</tr>
<tr>
<td>Memory of Symbolic Units (MSU-vis)</td>
<td>Ability to attend, to concentrate on, and remember visual stimuli.</td>
<td>Critical for attending, concentrating and recalling information presented visually for spelling and for reading new words.</td>
</tr>
<tr>
<td>Memory of Symbolic Systems (MSS-vis)</td>
<td>Ability to attend to, remember, and process sequences of visual stimuli</td>
<td>Critical for reading where the student is required to hold ideas in mind and manipulate sequential information. Left and right hemispheres.</td>
</tr>
<tr>
<td>Evaluation of Figural Units (EFU)</td>
<td>Ability to distinguish small detail differences in figural</td>
<td>Reading which depends upon recognizing and working with small details. Especially critical for staying with reading over an extended period. Left and right hemispheres.</td>
</tr>
<tr>
<td>Convergent Production Figural Units (NFU)</td>
<td>Ability to reproduce the integrity of visual details where eye and hand motor responses are required.</td>
<td>Fine motor tasks such as writing letters and numbers and words. Motor, visual and premotor.</td>
</tr>
<tr>
<td>Convergent Production Symbolic Transformations (NST)</td>
<td>Ability to differentiate and track words (timed).</td>
<td>Recognizing words and keeping up with reading assignments. Right hemisphere (nouns only).</td>
</tr>
<tr>
<td>Divergent Production Semantic Units in written form (DMU)</td>
<td>Ability to communicate ideas either in verbal or in or</td>
<td>Creative writing, integration ideas. Samples spelling characteristics as visual or auditory.</td>
</tr>
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Figure 2
SOI-LA Developmental Vision Test

The following section will discuss each of the nine intellectual abilities on the SOI-LA developmental (SOI-LADV) vision test. The abilities will be presented both in terms of how Dr. Meeker defines, tests, and remediates these designated abilities, and in terms of how the optometrist would approach these same abilities.

Two subtests of cognition ability, CFU and CMU are found on the SOI-LADV test. CFU is felt to be a preparatory skill for learning to read, and CMU a test of vocabulary ability or word concepts. CFU, Cognition of Figural Units, is defined by Meeker to be the ability to recognize or understand a figural entity based on partial or incomplete visual information (see figure 3). The intellectual ability of CFU is felt to be important in the discrimination of units, and in completing the outline of the letter or word. Optometrically this is defined as a test for visual closure. The test consists of partially complete pictures which are to be indentified.

Feldman (1960), in a study of SOI abilities and learning to read, found CFU the only SOI ability tested out of six abilities that was not significantly related to reading achievement in the first grade. CFU was explained to be a "threshold" variable that, by six years of age, no longer has a differential effect on reading. CFU, visual closure, was found in Feldman's study to play a more important role in cases of severe reading disabilities.

Visual closure is also one of the many visual perceptual (or processing) skills that optometrists evaluate when dealing with learning disabled
Figure 3

CFU Subtest

individual. Perceptual tests which optometrists may use to assess the CFU ability are items 22-32 of the MVPT (Motor-Free Visual Perception Test), ITPA (Illinois Test for Psycholinguistic Abilities)-Visual closure, or the split form board. Additionally, the picture-completion section of the WISC-R relates to CFU. While visual closure difficulties may play a part in early reading difficulties, most optometrists do not consider them to be a major factor in reading inefficiency for higher grades (Flax, 1970). As with many visual perceptual abilities (form perception, directional
awareness, visual motor control, eye-hand coordination, etc.) visual closure ability should be developed by six years of age to successfully learn to read. A fundamental visual problem encountered in learning to read is the ability to appreciate the shape (form perception, visual closure) and directional orientation of symbolic figures (letters) and semantic figures (words) (Flax, 1968, 1970).

Remediation of visual closure or CFU difficulties consists primarily of workbook exercises. The SOI Institute has an excellent source book of exercises and materials that can be integrated into a therapy program. Other materials which may be utilized are incomplete or degraded images, connect-the-dot books, visual closure cards (Modern Education Co. MEC), and templates are helpful in developing visual closure ability.

CMU, the second of the two cognitive subtests, tests the cognition of semantic units; the ability to comprehend meanings of words. It is tested in either oral or written form through the recognition and/or comprehension of words. (See Figure 4). CMU has been found to be a high predictor of reading skill, particularly in paragraph comprehension (Feldman, 1960). Vocabulary-type tests have long been used in intelligence, achievement and reading tests. Optometrists, in their assessment of reading problems, often use standard reading tests and sight word tests to acquire a knowledge of a patient's reading level, oral and silent reading skill, and comprehension. Widely-used reading tests employed by optometrists for testing this ability are the Peabody Reading Recognition and Comprehension test, Peabody Picture Vocabulary Test, Gray Oral Reading test, Slosson Oral Reading test, Gates-McGinnity Reading test, and the Standard Reading Inventory. From the WISC-R, the verbal subtests of information and vocabulary
Figure 4

CMU Subtest

will give an indication of this SOI ability. Meeker suggests that CMU be administered twice. First given visually, the child is to do the test alone, read and mark the answers. The second time the test (both stimulus items and choices) is given orally. A difference in scores yields an indication of possible visual or auditory difficulties relative to the lower score. If, however, the scores are nearly the same and are still low, then vocabulary concepts are suspect.

Training in this area consists primarily of incorporating sight word
lists, reading paragraphs and flashcards into the therapy program. SOI has workbooks in this area that are good for developing word recognition and meaning.

MSU-Visual and MSS-Visual are the two memory subtests of the SOI Vision test. MSU, Memory for Symbolic Units, is thought to assess visual retention span. The test (see figure 5) consists of visual presentation of a sequence of numbers for a specific length of time, after which the numbers are covered and the examinee is asked to write the numbers, but with one specific number left out (if the child cannot write, the examiner can write the response). MSS, memory for Symbolic Systems, is a sequencing skill that requires the ability to hold information and re-sequence it. The test is the same as MSU except that the examinee is asked to write the numbers backward, again leaving out a designated number. Dr. Meeker (1971) interprets MSU as a measure of visual attending which is dependent on memory retention, and MSS as a sequencing and processing ability. MSU and MSS test factors which are considered "readiness" abilities for reading and spelling.

The ability to take in visual information, store it, retain it, and retrieve it must be sufficiently developed to insure success in reading and related learning tasks (Gardner, 1979). Reading is a process of decoding symbols, and memory is the process by which we retain that code. In reading one must be able to associate symbols with the information each represents, retrieve that stored information about the symbol, and interpret it in light of the context of the reading material. Without memory, reading becomes a confusing and frustrating exercise.

Tests optometrists use to probe memory skills consist of tachisto-

SOI has modules with memory-matching exercises that can be used along with other optometric training techniques such as: Tachistoscope with objects, numbers, or words; concentration game; flash cards; parquetry blocks; coding games; or DLM-Visual Memory Booklet. Memory training is
very easily combined with other training activities across other cognitive abilities such as CMU, word comprehension.

EFU, Evaluation of Figural Units, is the only evaluation subtest on the vision test. Evaluation, as previously defined, is the critical comparison of information with known information to produce a logical judgement in satisfying a particular criterion. The EFU test is a visual discrimination task which consists of the ability to accurately judge visual units of information as being similar or different. (See Figure 6)
The evaluation is a checking and correcting procedure wherein information is matched against past experience or directed to short term memory storage in a process to meet the specific criteria. Visual discrimination or EFU has been shown to be a strong predictor of reading success, (Leedman, 1960; Shea, 1968). The ability to quickly and accurately assimilate printed symbols is not only important in learning to read but also to be efficient at reading for meaning. In reading, the child must be able to recognize individual letters as well as configurations of letters as words. Symbols must be cognizied (CFU), evaluated (EFU), and stored (MFU) to continue processing information. The individual's visual functioning ability is imperative in performing the visual discrimination task required in the EFU subtest. If the visual input is compromised by an accommodative, convergence, divergence, refractive, fusional or oculomotor problem the individual will not be able to clearly or accurately evaluate the incoming information. As stated earlier visual functioning abilities should be thoroughly assessed before administration of the test so as to be taken into consideration in interpreting the results.

Optometric tests which probe abilities similar to EFU include the following: items 1-3, 9-13, 33-36 of the MVPT, Raven Colored Progressive Matrices, form boards, Frostig Developmental Visual Perceptual Test (form constancy subtest III), and the coding subtest of the WISC-R.

SOI training in this area consists of workbook exercises. EFU-like abilities are developed optometrically via activities using parquetry blocks, Geoboard, Rosner program, Michigan tracking (symbol discrimination and sequencing, word tracking), sorting and matching of forms or
Convergent production is defined by Meeker (1969) as the "generation of information from given information when there is only one best answer". There are two tests on convergent production of information on the SOI-LA vision test. They are NFU, which evaluates visual-motor interactions, and NST which assesses speed of word recognition. NFU, convergent production of figural units (see Figure 7) is tested by having the individual reproduce several geometric figures within a specified time. Test performance is recorded in terms of both speed and quality of the reproduced
figures. If only a few figures are reproduced and are poorly done, then visual-motor integration is suspect. If, however, the figures are carefully and accurately reproduced but only a few are done, this is considered adequate visual-motor function and may even be evaluated in terms of possible artistic ability.

Optometrists routinely investigate visual-motor integration when working with children and learning problems. Some of the tests administered to probe this area are the Beery Test of Visual-Motor Integration (VMI), Bender-Gestalt, Wold Sentence Copy, Wold Visuo-Motor, Rosner Test of Visual Analysis Skills (TVAS), Winterhaven Copyforms, and Frostig Developmental Visual Perception Test. Like the SOI subtest, NFU, the child is asked to reproduce figures, letters or designs, but without the time restraint in most cases.

In evaluating these tests, much more than quantity and quality of reproductions is interpreted. Not only the finished product is important but in addition how it was achieved. Body posture, hand and body tension, pencil grip, organization, spacing, and speed of reproduction are analyzed along with fine motor ability. The visual purpose of these copying tasks is to see how well the child can duplicate what she/he sees: Can her eyes steer and direct her hands (does vision lead motor action) to form lines in proper sequence, correct orientation, and proper size. The child is asked to visually perceive a spatial pattern as a whole and reproduce it. She/he is to translate a spatial input to a temporal sequence of related lines. If the child cannot reproduce basic forms she/he will unlikely be able to reproduce symbols such as letters or numbers which are necessary for school learning. The eye-hand abilities necessary to write become the foundational
discriminating the difference in symbols for reading ability (McQuarrie, 1974).

Training in this area may begin with basic form board and puzzle manipulations, tracing activities with numbers and letters, templates, chalkboard routines, dot-to-dot activities, perceptual motor pen, peg rotator, Michigan color by numbers, mazes, string beads, and pattern boards. This is by no means a conclusive discussion of training techniques in this area; there are many more that develop this cognitive skill. SOI modules in this area involve exercises in copying and tracing, and maybe integrated into a therapy routine.

NST, convergent production of symbolic transformation, is felt by the SOI researchers to be a test of word recognition speed. In the first part of the test (see Figure 8) the child is asked to recognize symbols (letters that make up a word). The second level of the test consists of sentences printed with no spaces between words. The child is instructed to separate out as many words as possible in a limited period of time. The third section is more difficult in that there are hidden words and animal names within the sentences that are to be found. The last section consists of sentences written upside down and oriented right-to-left rather than left-to-right (backward spelling). The child's task is to demarcate words within these sentences without turning or reorienting the test booklet. Performance on this test is felt to be representative of reading speed or speed of word recognition. Optometrically it can be considered analogous to a figure-ground test. The ability to discriminate the target information, which, if it is developed, should allow for quicker recognition of the word and thus increased speed. Once again the optometrist should be
aware that any visual dysfunction would be detrimental to performance on the NST subtest. As discussed earlier, the importance of a complete visual analysis of the physiological functions (binocularity, accommodation, convergence, fusional ability etc.) should be addressed and taken into consideration before the test is given.

Other visual perceptual/cognitive abilities that may affect NST performance are visual closure, in pulling the animal names together, and visual discrimination, in accurately and quickly recognizing letters and/or words. SOI subtests which probe these areas should be considered when

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**Figure 8**

**NST Subtest**

<table>
<thead>
<tr>
<th>M</th>
<th>Dog</th>
<th>The dog and the go to the store</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>Go</td>
<td>The dog and the go to the store</td>
</tr>
<tr>
<td>D</td>
<td>Dog</td>
<td>The man and the dog go to the store</td>
</tr>
<tr>
<td>S</td>
<td>Saw</td>
<td>The girl saw it where it was</td>
</tr>
<tr>
<td>A</td>
<td>Many</td>
<td>The man has many dogs and cats</td>
</tr>
<tr>
<td>N</td>
<td>Came</td>
<td>She and he came to the game</td>
</tr>
<tr>
<td>Y</td>
<td>Line</td>
<td>Theninedogstooldinaline</td>
</tr>
<tr>
<td>E</td>
<td>Good</td>
<td>The boy will go onto a good place</td>
</tr>
<tr>
<td>V</td>
<td>View</td>
<td>We've taken a view and see it</td>
</tr>
<tr>
<td>T</td>
<td>There</td>
<td>Here and there and everywhere</td>
</tr>
<tr>
<td>M</td>
<td>Day</td>
<td>My dog ran all day</td>
</tr>
<tr>
<td>R</td>
<td>Pretty</td>
<td>She's very pretty</td>
</tr>
<tr>
<td>H</td>
<td>Around</td>
<td>He found a house by the school</td>
</tr>
<tr>
<td>E</td>
<td>White</td>
<td>Black, white, and brown are good colors</td>
</tr>
<tr>
<td>A</td>
<td>Happy</td>
<td>I feel glad and happy is a fun trip for people</td>
</tr>
<tr>
<td>D</td>
<td>Times</td>
<td>Right now is a hard time said the woman after she thought for a minute you are right aman replied since you thought you have a true and you have considered every possibility</td>
</tr>
</tbody>
</table>

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**The lawyer will summon key witnesses**

1. He would ogle her all day
2. He always traveled by public owned transportation
3. She will be around for a little while longer
4. We looked over the bridge at the blue water
5. I wish Arkansas came later in the tour
6. Call a mason to build a brick wall
7. The ink will spot terribly on light material
8. The car I bought was a lemon
9. You will see her at the beach or seashore
10. You owe a selfish man nothing
evaluating NST scores.

Optometric tests which probe NST-like abilities consist of tests such as the Southern California figure-ground test, Frostig Developmental Visual Perceptual Test (figure ground subtest), MVPT items 4-8, Rosner Perceptual Survey, and ITPA-figure ground. Optometric remediation techniques for NST involve use of geoboards, parquetry blocks, Michigan symbol discrimination and sequencing, embedded figures and letters. There are no SOI remediation modules in this area at present.

The last section of the SOI-LA vision test examines the area of divergent production of information. Divergent production is one of the intellectual abilities generally associated with creativity (Meeker, 1969). The subtests in this section are administered to assess "spelling responses", learning style, and quality of ideas. First, the examinee is instructed to draw spontaneous pictures in each of sixteen squares—DFU, divergent production of figural units (see Figure 9). In the SOI-Learning Abilities Test the DFU subsection tests the child's ability to use "ambiguous stimuli in creative ways." After completion of the drawings, the examinee is asked to write a story about anyone of the pictures she/he has drawn. This story-writing task comprises the DMU subtest, divergent production of semantic units; i.e., creative usage of words. In the normal frame work of the test, the examinee evaluates the results based on verbal creativity, not on punctuation or spelling skills. On the SOI-LA vision test, however, the DMU section is evaluated relative to spelling ability: Is the child spelling phonetically or visually.

The DMU result should be compared with the scores on the visual memory subtest and also auditory memory subtests (auditory memory will be discussed
Children with good visual memory usually spell accurately while children with good auditory memory usually spell phonetically. Dr. Meeker also suggests that visual placement, spacing and reproduction of letters and words be evaluated in terms of visual-motor function. Visual-motor functions such as these are also probed in the NFU subtest (copy task). Results on NFU and DMU can therefore be compared and if both are found low it is indicative of low motor skills.

Divergent production is a unique testing aspect in that rarely does
one test for creativity or try to enhance or develop this intellectual ability. In this light DMU is an important aspect to the SOI-LA test. However, DMU on the SOI-LADV test is no longer a test for creativity but a spelling indicator and visual-motor test. The applicability of DMU in gaining new essential information about visual processing problems and learning disabilities is questionable in that the two areas it tests, spelling and visual-motor, are better assessed in other subsections.

In order to gain maximum insight regarding an individual's learning abilities, it may be beneficial for the optometrist to substitute other subsections from the SOI-LA test in lieu of the DFU and DMU subtests. There are five subtests from the SOI-LA test which are not included in the SOI-LADV test that may be of particular value to the optometrist seeking maximum diagnostic value from the SOI testing sequence. These subtests, MSU-Auditory, MSS-Auditory, MFU, CFS, and CFT, probe, respectively, auditory memory ability, basic visual memory, and visualization ability. Information regarding these subtests is included here due to their potential value in developing optometric remediation programs based upon SOI analysis. The following five subtests will be discussed, as the previous test sections have been, in terms of how Dr. Meeker defines, tests, and remediates these designated abilities, and in terms of how the optometrist would approach these same abilities.

The perceptual modality through which a person processes information most efficiently, either visual or auditory, can be determined by analyzing performance on comparable tests of visual and auditory ability. SOI subtest MSS-Auditory and Visual and MSU-Visual and Auditory evaluate similar memorial ability within these two systems (see Figure 10).
Administration of the subtests MSS-Auditory and MSU-Auditory involves the same format as the visual counterpart of these tests. Sequences of numbers are presented auditorially and the child writes them either forward or backward with a specific number deleted. Auditory memory is important in language, spelling and arithmetic skills (Gardner 1979). It has been indicated (Gardner 1979, Solan 1982, Flax 1970) that children with learning
disabilities show more visual and/or auditory perceptual deficits. In this respect it is likely in the optometrist's best interest to evaluate the auditory processing skills of a suspect child if such testing has not already been performed, such that specific therapy can be pursued, etiology better determined, or the necessary referrals made if indicated. Tests the optometrist generally employs are the ITPA auditory sequential memory, Wepman's auditory discrimination test (which tests primarily auditory discrimination but also auditory short-term memory), Birch-Belmont test of auditory-visual integration, and the digit span subtest of the WISC-R. No SOI modules or source books are available for remediation in this area. Visual training activities may consist of using auditory input while utilizing visual tasks, using letter sounds or metronome activities if a combination auditory-visual problem exists.

MFU, Memory for Figural Units, is a test of visual memory for details (see Figure 11). The test calls for the child to recognize figures previously seen throughout the previously administered SOI subtests. Individuals who are precise and highly detailed usually score high in MFU and in most of the unit subtests. Several studies have dealt with the MFU ability and have found it to have an effect on reading achievement and in predicting academic success (Feldman 1960; Meeker 1971; Hays and Periua 1972). The process of decoding symbols and retaining this information for reading is dependent on visual memory. By improving memory skills one can affect reading achievement. Dr. Meeker's study (1971) found that individuals who were clinically identified as learning disabled showed a decrease in memory abilities; indicating a possible short-term memory deficit which may constitute a characteristic of this group.
Visual memory can be sub-divided into two different underlying memorial processes. Visual recognition and visual recall memory. Visual recognition memory requires an input to be present and recall memory is dependent on prior information. For example, reading requires recognition memory while spelling is dependent upon recall memory. If an individual is poor in visual recognition memory skills they are often also poor in recall memory.
Optometric testing for visual memory ability as well as training in this area has been presented in the discussions of MSS-V and MSU-V earlier in this paper, and will not be repeated here. SOI Institute has specific MFU workbooks that assist in development of this recognition memory skill. The booklet contains exercises much like the test itself, starting from very basic recognition tasks and progressing to very difficult.

The last two cognitive abilities to be discussed are those of CFS, Cognition of Figural Systems, and CFT, Cognition of Figural Transformations. Systems (in SOI terminology) deal with the temporal or spatial order of information and transformations, the redefinition or modification of the existing information or function. The test for CFS calls for the individual to recognize a figure that is to be rotated to a designated viewpoint (see Figure 12). CFT requires the individual to recognize the stimulus item in any rotated position (see Figure 13). Both of these two abilities require visual flexibility in dealing with visual space and relations. Dr. Meeker (1969) feels that CFS and CFT are critical abilities for understanding geometry, trigonometry and calculus. Dr. Meeker describes them as "Piaget-type tasks which locate the body in space for internalizing conservation, and that are important for the spatial understanding behind mathematics". From a visual cognitive perspective these subtests demand a good grasp of laterality, directionality (body/self relationship in space), visual memory, and visualization ability. The tests require that the examinee perceive the test stimulus, create the visual image of how it is transformed or reordered, hold that image in memory, and be able to compare it in a visual discrimination task against the test choices.
Visualization skill, defined optometrically, is a process of visual comparison, visual memory and visual imagery that allows one to "see" and know something, place, idea, or concept; to manipulate and view it from any angle or perspective (Hendrickson, 1967). The development of this skill not only allows one to understand mathematics, as Dr. Meeker describes, but is also important in producing a good writer, reader, and especially speller (Hendrickson, 1967; Meeker 1969). Visualization is an ability that

Figure 12
CFT Subtest
can be enhanced or developed through visual training activities. Optometric tests of visualization include: Getman visualization test, reversals of pegboard patterns, Gordon test of visual imagery control, Minnesota spatial relations test, Piaget tests of conservation of mass and reversibility, and the WISC-R Block design test. Training activities are based on the level the child is at for visual memory skill, beginning with visual recognition memory, recall memory, and the ability to perform imagery tasks. Remediation techniques include tachistoscope activities, (using numbers, letters, pictures, or figures) flashcards, visualizing objects, rooms, or pictures that are either briefly exposed or well known to the individual, then to ask to describe in detail, parquetry activities, and pegboard designs.

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Figure 13

CFS Subtest
Summary and Conclusions

The primary objective of visual perceptual/cognitive therapy is to have the learning disabled individual attain their learning potential. To accomplish this goal the optometrist must be able to identify and remediate specific disabilities. To be able to identify specific disabilities and remediate them the optometrist must have a differentiated definition of visual processing, visual perception, and visual functioning/physiology that includes testing and remediation.

Dr. Guilford's structure of intellect model of intelligence can give the optometrist a definition of differential visual/cognitive processing, and Dr. Meeker's SOI-LADV test a means of testing the visually dependent components of intelligence.

Behavioral optometrists working with learning disabilities test for specific visual abilities which may affect learning potential. The optometrist uses a differential approach in testing these specific areas, i.e. she/he test for accommodation, convergence, accommodative/convergence interactions, oculomotor ability, fusional ability, and binocularity. Remediation is directed at specific weak areas.

To enhance delivery of care the behavioral Optometrist will also evaluate visual perceptual/cognitive aspects (i.e. visual closure, visual discrimination, figure-ground discrimination, visual-memory, etc.) as they relate to learning success.

With visual physiological/functioning testing there is a reasonable degree of standarization and reliability. Optometrists can easily
communicate their findings to other professionals both inside and outside the profession with a fair amount of understanding and reliability. However, in the visual perceptual testing area this is often not the case. There are many different visual perceptual tests that test the same visual skill. Most of these tests are poorly normed, normed differently for the same skill, or not normed at all. Inadequate, or no, validity studies or research studies have been performed on many of these tests (Spache 1976, 1981). Often the perceptual test will be one of learned subjective observation, which is the most difficult to interpret with consistent interprofessional results. An optometrist who has used such an objective test for a number of years will be able to glean much more useful information than an optometrist just beginning to use such a test. Often visual perceptual tests will examine more than one visual perceptual/cognitive ability at the same time. This can result in dubious findings unless the optometrist knows exactly how each specific visual perceptual skill contributes to the overall visual performance of the individual.

Important to the optometrist is a well researched and validated testing battery that will give him/her reliable and understandable results, and will also provide a means to easily and accurately communicate these results with some assured degree of interprofessional understanding.

The SOI-testing sequence was developed from a psycho-educational background. It has years of research and continued validity studies in support of it. It is based on a differentiated model of intelligence and through factor analytic research has been shown to differentiate specific visually dependent intellectual abilities. The SOI-LA Developmental Vision test examines these visual cognitive abilities felt by Dr. Meeker (1969) to
be primarily related to vision and learning success. These abilities have been statistically derived, researched, and validated to be unique intellectual abilities important to school success. They are the same abilities that optometrists have felt are important to vision and learning.

The SOI Developmental Vision Test examines the individual abilities of visual closure, visual discrimination, visual-motor interaction, visual memory, vocabulary, and figure ground discrimination. With the added subtests from the SOI-LA, visualization ability and auditory memory are also examined. Each subtest examines one specific ability; the results from all sections taken together will provide a profile reflecting an individual's specific learning abilities and disabilities. Specific and direct remediation can be accurately applied tying those weak abilities to the strong using traditional optometric techniques along with SOI modules where indicated.

The optometrist will find the SOI-LA Developmental Vision test a reliable and understandable testing sequence that is easily interpreted and yields results that can be accurately communicated to other professionals, especially in education and psychology. The SOI-LA Developmental Vision test presents a concise testing and diagnostic tool for obtaining the necessary profile of intellectual abilities that are important for learning success.
<table>
<thead>
<tr>
<th>SOI Subtest</th>
<th>OPTOMETRIC Definition</th>
<th>OPTOMETRIC Perceptual Tests</th>
<th>SOI Module</th>
<th>OPTOMETRIC Training Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFU Vision Closure</td>
<td>MVPT Items 22-23, ITPA-Visual Closure, WISC-R Picture Completion Subtest</td>
<td>Work Book Available</td>
<td>Work books of incomplete pictures, incomplete or degraded images, visual closure cards (MEC) Fitzhugh Plus Program (MEC) connect-the-dot books</td>
<td></td>
</tr>
<tr>
<td>Cognition of Figural Units</td>
<td>Peabody Reading Recognition and Comprehension test, Peabody Plc. vocab. test, Gray Oral Reading test, Slosson Oral Reading test, Gates-McGinitie Reading test, Standard Reading Inventory, WISC-R Information and Vocabulary Subtests</td>
<td>Work books available to develop word recognition and meaning</td>
<td>Sight word lists reading paragraphs, free reading, flashcards</td>
<td></td>
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<tr>
<td>CMU Vocabulary</td>
<td>MVPT Items 14-21, ITPA Sequential Memory, WISC-R Subtests, Monroe Memory Retention Test, Visual Retention Test, WISC-R subtests Picture Completion and Object Assembly</td>
<td>SOI Work Books Tachistoscope, Concentration Games, Flash Cards, Parquetry Blocks, Coding Games, Dot-to-Dot Exercises</td>
<td>Visual memory book</td>
<td></td>
</tr>
<tr>
<td>MSS-Visual Memory Recall</td>
<td>MVPT Items 1-3, 9-16, Raven Colored Progressive Matrices, form boards, Frostig Developmental Visual Perception Test (Form Constancy Subtest III), WISC-R Coding Subtest</td>
<td>Workbook exercises available</td>
<td>Parquetry blocks, Geoboards, Rosner Program, Michigan tracking (symbol discrimination and sequencing), sorting and matching of forms and puzzle parts</td>
<td></td>
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<tr>
<td>EFU Evaluation of Imagination</td>
<td>Beery (VM), Bender-Gestalt, Wold Sentence Copy, Wold Visuo-Motor, Rosner TVAS, Winter-Haven Copy Forms, Frostig Developmental Visual Perceptual Test, WISC-R Coding Test</td>
<td>SOI Copying and Tracing Workbooks Available</td>
<td>Form board, puzzle manipulations, tracing activities, templates, chalkboard routines, dot-to-dot activities, perceptual motor pens, peg rotator, Michigan color by numbers, mazes, string beads, patternboards</td>
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</tr>
<tr>
<td>MSE-Visual Memory</td>
<td>Southern California Figure-Ground Test, Frostig Developmental Visual Perceptual Test (Figure-Ground Subtest), MVPT Items 4-8, Rosner Perceptual Survey, ITPA-Figure Ground</td>
<td>No SOI remediation modules</td>
<td>Geoboards, parquetry blocks, Michigan tracking (symbol discrimination and sequencing), embedded figures and letters</td>
<td></td>
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<td>SOI SUBTEST</td>
<td>OPTOMETRIC DEFINITION</td>
<td>OPTOMETRIC PERCEPTUAL TESTS</td>
<td>SOI MODULE</td>
<td>OPTOMETRIC TRAINING TECHNIQUES</td>
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</tr>
<tr>
<td>MSU-A</td>
<td>Auditory Memory</td>
<td>ITPA auditory sequential memory, Wepman's auditory discrim. test, Birch- Belmont test of auditory-visual integ., WISC-R Digit span</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSS-A</td>
<td>Memory of Symbolic Units</td>
<td>-</td>
<td>No SOI remediation modules</td>
<td>Use of auditory input letter sounds, metronome activities</td>
</tr>
<tr>
<td>Memory of Symbolic Units</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Memory of Symbolic Units</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>MFU Memory of Figural (Visual recognition memory)</td>
<td>Visual Memory</td>
<td>Same as in other memory sections</td>
<td>workbooks available</td>
<td>Tachistoscope, concentration games flash cards, parquetry blocks, coding games, DLM- Visual memory book, memory matching and sequencing games</td>
</tr>
<tr>
<td>CFS Cognition Figural System; CFT</td>
<td>Visualization</td>
<td>Getman Visualization test, reversal of pegboard patterns, Gordon test of visual imagery control, Minnesota spatial relations test, Piaget test of conservation of mass and reversability, WISC-R block design and object assembly</td>
<td>CFS &amp; CFT Puzzle, CFT workbook</td>
<td>Tachistoscope activities, flashcards, visualizing objects, rooms, pictures that are briefly exposed or well known and describe, parquetry activities, pegboard designs.</td>
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</table>
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