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ABSTRACT

Educators, as applied scientists, must work in partnership with investigative scientists who are researching brain functions in order to reach a better understanding of gifted students and students who are intelligent but do not learn. Improper understanding of brain functions can cause gross errors in educational placement. Until recently, the popularity of IQ scores has curtailed the understanding of the measurement of demonstrated functions in human intelligence. Tests based on the Structure of Intellect (SOI), first published in 1975, evaluate 26 abilities that are highly predictable of success in school. They are based on the theories of J. P. Guilford who differentiated 96 kinds of intelligence that could be identified factorially. The Guilford model predicted the separation of sites of brain functions clearly. The Contents dimension of the model, comprised of Figural Intelligence, Symbolic Intelligence, and Semantic-Verbal Intelligence, actually maps the functions of the right, cross-over, and left hemisphere sites. IQ scores are now used as criteria for identifying giftedness in only a few states. Giftedness is recognized as a multi-dimensional human phenomenon and with more concern for the kinds of giftedness shown by an individual as can be measured by the SOI tests. (VW)

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# BRAIN RESEARCH:
# THE NECESSITY FOR SEPARATING SITES, ACTIONS AND FUNCTIONS

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Excerpts from a presentation to the
*Neurobiology Conference of Extraordinary Giftedness*
New York City, April 1985

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Brain research is experiencing a face lift. The public is excited about understanding how their brains work; psychologists have graduated from Freud's bedroom into the classroom and thanks to the influence of science, educators are now listening to "brain murmurs" in an attempt to understand gifted students and students who are intelligent but do not learn.

A handful of scientists and physicians study the *sites* of brain functions; a few study the actions of chemical and environmental variables in a search for *where* intellectual functions originate. We are beginning to understand *actions* and *sites* (*laterality, hemispheric assymmetry, duplicate representation, hormones, enzymic and causal responses*). The *functions* (and *conditions*) stemming from brain activity are also important aspects for they contribute to individual differences. The functions of actions and sites are in need of more investigation if we are to use the results of biological neurology research to its advantage. Why? Because these conditions affect the performance of gifted as well as the gifted non-performer.

Research and discovery are exhilarating, but we who are applied scientists must make additional demands on brain research—we must be partners with investigative scientists for these reasons: 1) we can offer measures of functions, such as the Structure of Intellect (SOI), and 2) psychologists, have a great need for information about characteristics of brain functions which, if not understood, cause gross errors in educational placements. There are already too many popular misconceptions about the brain which, if carried into programs for gifted children, could be detrimental to progress in their education.

Some conditions which need critical study are these:

1. The rapidity of perception by the human brain.

2. How information perceived by the eyes is sent as data precepts to both sides of the brain to be coordinated as one stimulus by the vestibular formation (visual dyslexia).

3. How sounds perceived by the ears from both sides of the head are coordinated as one stimulus by the vestibular formation (auditory dyslexia).

4. How sensory integration occurs variously between hands, feet, balance, sounds and vision, particularly across the the mid-line of the body.

5. The rapidity of encoding responses.

These five abnormalities which we find clinically allow us to separate four kinds of dyslexia from learning disabilities. Giftedness is severely affected by these aspects of brain *functions*. These variables also seriously affect the functions we measure in intelligence. They need study not only because they contribute to understanding the human brain, but also because, to the practitioner who must make decisions about human behavior, these variables do now, and will continue to play important roles in brain functions. Brain research, as it searches, is best served when there is a theoretical base from which to predict identification and treatment.

## MEASURABLE FUNCTIONS OF INTELLIGENCE

Why has the understanding of the measurement of demonstrated functions in human intelligence been so greatly curtailed? It is primarily due to the popularity of IQ scores. Whether research has been medical, educational or psychological, researchers have used IQ tests to measure intelligence. They had trust in the reliability and validity coefficients and thought they were ample reasons for using tests. And, too, IQ scores are easily manipulated statistically. But, probably, the best reason of all was that there was little else from which to choose during this century. At least, that is, until 1975 when the first SOI-LA Test was published. Why, then, the SOI?

It is critical for researchers in brain theory to know that IQ tests are not based on a theory of *intelligence*. The Binet items were selected for inclusion if any given question could be answered correctly by 68% of the respondents at a given age. The verbal tests on the Wechsler were similarly constructed, whereas the performance tests (many are also verbal) were selected with the notion that schizophrenics and brain-damaged or diseased people were unable to work with spatial ideas or manipulate concrete objects or retain specific verbal knowledge or to do reality reasoning.

It is archaic to imagine that a *number* can express the complexity of human intelligence functions. Does any serious brain researcher think a number reflects what he or she thinks is a result of brain research? A case in point: when lobotomies were popular, the researchers stated that the surgical procedure did not affect intelligence because the IQ score did not change beyond the standard error (DeMille, 1962). We all know that these people became vegetables. To match samples on global IQ scores is equally spurious. IQ scores as a measure of *intelligence* are analogous to one number of blood pressure or one count in a blood panel.

We have come a long way in measuring human intellectual functions since the advent of two *theories* of intelligence, Thurstone-Guilford approaches and the Cattell-Jastek approaches. Sternberg's notions about intelligence give Cattell's constructs new names, i.e., fluid —external intelligence and concrete—internal intelligence. Gardner's notions depart somewhat in that artificial (computer documented actions) intelligence consists of strategies for manipulating information at several levels. But the user-public has not caught up with the advancements in the measurement of intelligence because of the complexity or the infighting going on about theories of intelligence. Psychologists out in the field are suspicious generally of anything they did not learn in school anyway which is of course, *knowledge in concrete* isn't it? In fact, the less flexible any scientist is about his knowledge, the less creative he or she can be in research. No one could deny that creative intelligence is a real function—yet no achievement test, no college entry test nor the Wechsler tests sample creative thinking abilities whatsoever.

Historically, Thurstone began the search for a theory of intelligence. Cattell and Jastek also began looking at the way intelligence was measured. Cattell and Thurstone used statistical procedures which allowed them to answer the question: "How do these test items differ?" Thurstone found that certain items consistently measured the same function. He determined that intelligence consisted of at least seven different factors, and knowing the lack of sophistication of measurement, he reasoned there may be more abilities, so he called these the primary abilities.

J. P. Guilford who studied briefly with Thurstone actually grandfathered the factor analytic statistical procedures which are in use today. Guilford's study of the components of intelligence began during World War II and continued until 1966. The consistency of and predictability of abilities led to the formal Structure of Intellect by 1959 and, like the chart of elements in chemistry, intellectual abilities formed a pattern. The prediction of at least 120 kinds of intelligence within the matrix led to the discovery that 96 could be identified factorially. Since then, several confirmatory factor analyses have demonstrated the strengths of the factors.

If the IQ score is too simplistic, the SI suffers from the opposite problem—it is considered too complicated. It is important to note that the Guilford model predicted the

Figure 1

| OPERATIONS | | CONTENTS | | PRODUCTS | |
|---|---|---|---|---|---|
| C | Cognition | F | Figural | U | Units |
| M | Memory | | | C | Classes |
| E | Evaluation | S | Symbolic | R | Relations |
| N | Convergent Production | | | S | Systems |
| D | Divergent Production | M | seMantic | T | Transformations |
| | | | | I | Implications |

This chart will help you read the 14 dimensions of the SI Model.

separation of sites of brain functions clearly, and in fact that *symbolic* intelligence factored between *figural* and *semantic* actually maps the right, cross-over and left hemispheres sites.

## WHAT HAVE WE LEARNED ABOUT INTELLECTUAL FUNCTIONS?

In the years from 1974 to the present there have been some startling discoveries. The Guilford model does indeed map some of the functions predicted by site research.

**Contents.** Particularly is this true of the *contents* dimension of the model—that is, *Spatial, Figural Intelligence* (F) factored separately in the original model and again through confirmatory factor analysis (Maxwell, 1982; Roid, 1984). Thus, right hemisphere functions when intact or strong, show up as Figural strengths on the SOI-LA (Anderson, 1984; Suyenobu, 1984).

*Symbolic* (S), intelligence is composed of notation symbols, abstract numerals, notes and codes. Symbolic intelligence tends to represent connections between Figural and seMantic functions.

*SeMantic-Verbal Intelligence* (M) factored separately from Figural and Symbolic and represents left hemisphere functioning on the whole.

**Products.** The products dimension more precisely defines separations within the Figural, Symbolic and seMantic content functions which are predictive of sites and action brain research. They also define how Figural, Symbolic and seMantic content are organized, from simple *Units* to more complex and abstract *Implications*. The organization of brain functions are discretely processed as:

**Units**--one bit of information processed at a time
**Classes**--classified units
**Relations**--cause and effect or intangible relationships between Units and Classes
**Systems**--all of the above in one system
**Transformations**--changing any of the above
**Implications**--inferences from all of the above

**Operations.** We can draw comparisons of various brain models or paradigms using the Operations. This comparison is shown in Figure 2 (page 6).

*(Computer samples of various clinical patterns such as giftedness, dyslexia, aphasia, drug damage, trauma to various parts of the brain, stroke, retardation and hydrocephaly were available to the participants.)*

A given person can be gifted on any one of the 14 dimensions described in the chart in figure 1 or may be gifted on any one or more of the 26 abilities as well.

## COMMONALITIES OF THEORIES OF BRAIN FUNCTIONS

| | |
|---|---|
| **STIMULUS/RESPONSE: THEORY** | Stimulus → Response |
| **PSYCHOLINGUISTIC: THEORY** | Stimulus → Organization → Response<br>Decoding → Representation → Encoding |
| **MEDICAL THEORY:** | Receptive Intelligence → Expressive Intelligence |
| **COMPUTER MODEL:** | Input → Memory → Output |
| **SOI THOERY:** | Cognition → Memory → Convergent<br>Divergent Production |

**Figure 2**

Any research on brain functions or sites is best represented if a computer analysis of the SOI abilities is used to denote findings. A computerized analysis also makes statistical manipulation of data easier. National norms dictate levels of development on the 26 abilities and the 14 aggregated dimensions. The basic form of the test is also available in Spanish, French and German and allows for the identification of giftedness in children in countries where these languages are spoken.

### APPLYING THE GUILFORD THEORY

The first *use* of the SI theory for application occurred when this author analyized the Binet and Wechsler tests in order to identify which items could be considered as predictive of gifted or underdeveloped abilities. The Meeker Templates allowed psychologists to place the templates over a test booklet and derive a profile of intelligence for that person. The benefits from placing the IQ tests into the theory of intelligence, was the capitalizing on the validity and reliability of the instruments while we researched SI abilities as they related to learning.

But perhaps the most critical aspect of this work was the notion that *intelligence could be trained, that it was not a general global number, immutable other than in a student's cumulative folder.*

Research into *which* abilities led to successful reading or arithmetic-math achievement continued from 1962 to 1974 thus leading us to selection of the 26 (of the 96) abilities that were highly predictable of success in school. We developed the SOI-

LA Test is a *group* test, psychologist and teachers, with training, can administer the test protocols. It can be also be used individually.

## SUMMARY

The identification of giftedness has vastly changed during the last 15 years. IQ scores are used as criteria for giftedness in only a few states now. Educators, educational leaders and parents recognize that giftedness is a multi-dimensional human phenomenon and they are much more concerned about the *kinds* of giftedness any individual shows. The SOI tests allow the identification of academic giftedness as well as creative giftedness potential. But perhaps the most important use of Guilford's theory will be its partnership with brain research which itself is in need of a theory based test of brain functions.

The SOI tests reflect the application of a *theory of intelligence* to *reality programming.*

Research is available from SOI Systems in El Segundo, CA and in ERIC EC 11-0-2882 as well as in the next *Buros Mental Measurements Yearbook.*

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# UNDERSTANDING SOI DEFINITIONS

**COGNITION-Comprehension**

| | |
|---|---|
| CFU | Ability to identify objects, visually and auditorally |
| CFC | Ability to classify perceived objects |
| CFR | Ability to discover relations in perceptual material |
| CFS | Ability to perceive spatial patterns and maintain orientation (for math) |
| CFT | Ability to understand transformed objects visually (for math) |
| CFI | Ability to explore visually ways to select most effective action |
| CSU | Ability to recognize graphic symbols: codes, numbers, notes |
| CSC | Ability to identify attributes of patterns |
| CSR | Ability to discover abstract relations in symbolic patterns |
| CSS | Ability to understand systems involving symbols (arithmetic facts) |
| CST | Ability to recognize that a specific transformation of symbolic information has occurred |
| CSI | Ability to foresee or be sensitive to conquences in a symbolic problem |
| CMU | Ability to use vocabulary |
| CMC | Ability to comprehend concepts and classes of ideas and words |
| CMR | Ability to discover relations between concepts |
| CMS | Ability to comprehend systems of words and ideas (reading, instructions) |
| CMT | Ability to see several meanings in words or ideas |
| CMI | Ability to anticipate needs or consequences |

**MEMORY**

| | |
|---|---|
| MFU | Ability to recall visual and auditory stimuli |
| MFC | Ability to remember previously presented classes of figural material: visual, auditory or kinesthetic |
| MFR | Ability to memorize relations between items of figural information presented |
| MFS | Ability to recall arrangements of objects previously presented |
| MFT | Ability to remember transformations of figural material previously changed |
| MFI | Ability to remember circumstantial connections between or among items of figural information as a basis for logical or causal extrapolation |
| MSU | Ability to recall for immediate production a group of numerals or letters |
| MSC | Ability to remember symbolic class properties |
| MSR | Ability to remember definitive connections between units of symbolic information |
| MSS | Ability to remember systems of numerals, letters in exact order (spelling) |
| MST | Ability to remember changes in symbolic information |
| MSI | Ability to remember symbols and their implications |
| MMU | Ability to reproduce previously presented ideas or words |
| MMC | Ability to remember verbal or ideational class properties |
| MMR | Ability to remember meaningful connections between items of verbal information |
| MMS | Ability to remember a system of ideas presented visually or auditorially |
| MMT | Ability to remember changes in meanings or redefinitions |
| MMI | Ability to remember arbitrary connections between pairs of meaningful ideas |

**EVALUATION-Judgement, planning, reasonint and critical decision making**

| | |
|---|---|
| EFU | Ability to identify similarities and differences of shapes |
| EFC | Ability to develop the ability to judge whether figures are properly classified |
| EFR | Ability to evaluate spatial relationships |
| EFS | Ability to evaluate total systems of spatial information |
| EFT | Ability to judge or analyze how figures or objects will appear after changes |
| EFI | Ability to predict and evaluate defects and deficiencies in spatial information |
| ESU | Ability to make rapid decisions identifying letter or number sets |
| ESC | Ability to judge the applicability of class properties of symbolic information |
| ESR | Ability to determine the consistency of symbolic relations |
| ESS | Ability to estimate the appropriateness of aspects of a symbolic system |
| EST | Ability to judge adequacy of substitutive symbols |
| ESI | Ability to judge consistency of, inferences from symbolic information |
| EMU | Ability to select appropriate variations in word meanings |
| EMC | Ability to judge applicability of class properties of semantic information |
| EMR | Ability to make choices among semantic relationships based on the similarity and consistency of meanings (analogies) |
| EMS | Ability to appraise aspects of systems of words |
| EMT | Ability to apply changes in judgement about ideas |
| EMI | Ability to judge the adequacy of a meaningful deduction (deductive reasoning) |

**CONVERGENT PRODUCTION-Solving problems where answers are known**

| | |
|---|---|
| NFU | Ability to reproduce exact information in spatial forms (writing, copying) |
| NFC | Ability to sort or classify as pre-specified |
| NFR | Ability to reproduce figural relationships |
| NFS | Ability to reproduce a known system or design |
| NFT | Ability to change figural information into new forms |
| NFI | Ability to solve simple equations in terms of familiar forms from inferred data |
| NSU | Ability to reproduce patterns of single, simple symbols (coding) |
| NSC | Ability to classify items of symbolic information in pre-specified ways (filing) |
| NSR | Ability to find nonverbal responses in relationships between numerals or letters |
| NSS | Ability to solve correctly a problem using symbolic systems |
| NST | Ability to reproduce new symbolic items of information by revising given items |
| NSI | Ability to substitute or derive symbols as expected (logic and algebra) |
| NMU | Ability to correctly name semantic concepts and ideas |
| NMC | Ability to classify correctly words or ideas |
| NMR | Ability to correlate verbal representations (analogies) |
| NMS | Ability to arrange ideas into a meaningful sequence (essay writing) |
| NMT | Ability to shift functions of ideas for use in new ways |
| NMI | Ability to infer correctly from given, known information |

**DIVERGENT PRODUCTION-Solving problems creatively**

| | |
|---|---|
| DFU | Ability to produce many and unique varieties of figures within structure (art) |
| DFC | Ability to reclassify perceived objects in unique ways |
| DFR | Ability to generate new and constructive relations between figural items |
| DFS | Ability to produce composites of figural information in new systems |
| DFT | Ability to devise figural information |
| DFI | Ability to elaborate on figural information in unexpected forms |
| DSU | Ability to produce many symbolic units which conform to simple specifications |
| DSC | Ability to group items of symbolic information in different ways |
| DSR | Ability to generate a variety of relations between numbers or letters |
| DSS | Ability to produce symbolic systems in unique ways |
| DST | Ability to transform symbolic material |
| DSI | Ability to produce varied implications from given symbolic information. |
| DMU | Ability to create many ideas spontaneously (brain-storming) |
| DMC | Ability to produce new ideas appropriate in meaning to given categories |
| DMR | Ability to produce unique ideas from associated words (poetry) |
| DMS | Ability to originate unique verbal ideas (creative writing) |
| DMT | Ability to produce remotely associated, clever, or uncommon verbal responses (puns) |
| DMI | Ability to specify details that develop a scheme or variation of an idea (joke, humor) |