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ABSTRACT

This paper describes five major conceptualizations of intelligence as: (1) a general ability; (2) a pair of abilities; (3) a limited set of multiple intelligences; (4) a complete set of multiple intelligences, and (5) a set of interacting cognitive and noncognitive factors that determine cognitive performance. Theories of multiple intelligence developed by J. B. Carroll (1993) and R. B. Cattell and J. L. Horn (1988, 1991, 1994) are emphasized and compared. The theory of fluid and crystallized intellectual abilities (Gf-Gc) developed by Cattell and Horn is identified as the major empirical theory of multiple intelligences available today. The combination of Gf-Gc theory with information processing theory has produced the Gf-Gc Information Processing Model. Several implications derived from a multiple intelligences viewpoint are presented for teaching and learning, clinical assessment, educational research, and test development. It is concluded that intelligence batteries of the future will be more informative and probably more complex. (Contains one table, four figures, and nine references.) (SLD)

CONCEPTUALIZATIONS OF INTELLIGENCE AND THEIR IMPLICATIONS FOR EDUCATION

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Intelligence, as a singular noun, is the root of much evil. Teachers with narrow views of intelligence may fail to appreciate the rich differences in cognitive ability within and among their students. Instructional planning at the classroom level and curricular decisions at the district or state level may be influenced by a restricted view of cognitive ability. Clinicians in the same school system, who operate with different conceptualizations of intelligence, may interpret the same set of test results differently.

As cognitive science has advanced our understanding of cognitive processing, views about the nature of human intelligence have become more informative and more complex. Unfortunately, the understanding of cognitive ability, along with much of current test technology, lags far behind cognitive science. As educators, psychologists, and test developers update their conceptualizations, this lag will be reduced and application improved.

Conceptualizations of Intelligence

How do educators and others view intelligence? The answer is, of course, in a multitude of ways. I suggest, further, that these various views are shaped, in part, by the particular tests to which a professional has been exposed.

For our purpose, the many conceptualizations of intelligence can be grouped into five broad categories (see Figure 1):

1) as general ability,

2) as a pair of abilities,

3) as a limited set of multiple intelligences,

4) as a "complete" set of multiple intelligences,

5) as a set of interacting cognitive and noncognitive factors that determine cognitive performance.

Figure 1 about here.

Intelligence, conceptualized as general ability or "g," is manifested in tests designed primarily to provide a single score (e.g., the Stanford-Binet L-M or the Raven's). It is also exhibited by the use of a single score to summarize performance from a multi-test battery (e.g., Full-Scale IQ from a Wechsler or Broad Cognitive Ability from the WJ-R). Further, regardless of the source, this conceptualization is implicit in statements such as "Sally's IQ is 87."

The view that intelligence is defined by two, perhaps contrasting, abilities is the second conceptualization. Familiar dichotomies include verbal-nonverbal, verbal-performance (Wechslers), and sequential-simultaneous (K-ABC). Two recent test publications (K-BIT and KAIT) are based on a fluid-crystallized dichotomy. This view should not be confused with modern Gf-Gc theory discussed later.

The third and fourth conceptualizations envisage intelligence as a set of multiple abilities, from 3 or 4 to as many as 10. Limited theories of multiple intelligences are specific to given intelligence batteries. The views are limited due to the restricted variety of cognitive tasks included in a particular battery (e.g., the 3 or 4 factors of the Stanford-Binet IV, the 4 factors of the WISC-III, and the 4 factors of the 1977 Woodcock-Johnson).

"Complete" theories of multiple intelligences are based on attempts to capture the breadth of important cognitive abilities. Gardner's (1983) theory of multiple intelligences is one such conceptualization. Gardner's theory has captured the attention of many educators and has been used, for example, as a model for designing programs for the gifted. The works of Carroll (1993) and of Cattell and Horn (Horn, 1988, 1991, 1994) are the two most prominent empirically derived theories of multiple intelligences. Stratum 2 of Carroll's three-stratum theory and the set of second-order factors described by the Cattell-Horn Gf-Gc theory are quite similar.

Since 1941, Gf-Gc theory has emerged as a major empirical conceptualization of multiple intelligences. "Gf-Gc" is the acronym for "fluid and crystallized intellectual abilities." The 1989 WJ-R is based on this theory and measures abilities associated with eight of the factors. An important feature of Gf-Gc theory is that it is not based on any particular battery of tests; it is a description of what will likely result from any appropriately designed and analyzed factor analysis study. These are studies that include enough breadth and depth of variables to address a research question such as the factorial structure of a particular intelligence battery. The criterion of "breadth" requires that the variety of tests included in such a study span all the factors implicitly measured by the battery. By "depth" is meant that there are at least two, and preferably three, good measures of each factor in the study. For most, if not all, intelligence batteries it is necessary to include tests in addition to those in the battery itself to ensure meeting these requirements (Woodcock, 1990).

Modern Gf-Gc theory (Horn, 1988, 1991, 1994) has implications for educators, educational researchers, and clinicians regardless of the tests, if any, that they use. The theory relates to our perception of how people think and learn, as well as to the theoretical structure of any instrument purporting to measure intelligence.

To date, at least 9 and perhaps 10 broad abilities have been consistently identified and replicated through factor analysis studies (Carroll, 1993; Horn, 1991, 1994; Woodcock, 1993, 1994). Ten Gf-Gc factors are listed and defined in Table 1.

Table 1 about here.

Gardner's theory of multiple intelligences and Gf-Gc theory are often perceived incorrectly as competing conceptualizations of intelligence. The two theories conceptualize intelligence from perspectives that literally differ by 90 degrees (the columns or rows of Figure 2). Both views are equally informative (for different purposes), could conceivably utilize the same battery of tests, but require different investigative methods. Gf-Gc theory describes intelligence with a set of common factors represented by the columns in Figure 2. The factors are identified and validated primarily through the procedures of factor analysis. Each factor represents a broad cognitive ability, and the evaluation of these abilities by clinicians often provides useful information regarding the nature of a learning disability. Gardner's theory, on the other hand, describes areas of human expertise as represented by the rows in Figure 2. Each area of expertise requires a different mix and weighting of abilities for its performance. Areas of expertise, as a way to view human abilities, is not new. We are well aware that a different mix of abilities is required to be a medical student than to be a law student. Selection psychologists in industry and the military have worked assiduously at improving their techniques for identifying individuals who will perform better in certain training programs or jobs. The relevant analysis procedure for investigating Gardner's point of view is multiple regression, not factor analysis.

Figure 2 about here.

The fifth conceptualization in Figure 1 comprises dynamic models that view intelligence as an interactive process producing cognitive performance through the effect of several cognitive and noncognitive factors. The Gf-Gc Information Processing Model (Woodcock, 1993, in press) shown in Figure 3 is an example. This model was derived from combining Gf-Gc theory with information processing theory. It portrays cognitive performance as resulting from the interacting effects from Gf-Gc abilities and "facilitator-inhibitors" (e.g., processing speed, health, motivation, and cognitive style). No intelligence battery, presently available, is based on an interactive model of abilities.

Figure 3 about here.

Implications

Are there implications for education from broader conceptualizations of intelligence? Certainly. In contrast to the "one type fits all" consequence of a single ability view of intelligence, the concept of multiple intelligences unveils a host of implications related to teaching and learning, clinical assessment, educational research, and test development. A sampler of implications is described next.

Teaching and learning. The Gf-Gc Information Processing Model suggests at least four implications for teaching and learning:

1) Automatic cognitive performance is constrained by a student's short-term memory (Gsm) and processing speed (Gs).

2) New learning is constrained by the student's thinking abilities (Gv, Ga, Glr, and Gf).

3) All performance, automatic or new learning, is constrained by the student's stores of knowledge (Gc, Gq, and Grw).

4) All performance, especially new learning, is constrained by the student's facilitator-inhibitors.

It is generally believed that the capabilities underlying implications 1 and 2 above are not readily amenable to improvement and, if limited in a student, usually require compensatory modifications in the environment (e.g., modifying an instructional presentation to accommodate a student's short-term memory deficit). Some writers and researchers are more optimistic, and a number of cognitive training programs are becoming available. On the other hand, the capabilities underlying implications 3 and 4 are amenable to change that can result in a significant improvement in cognitive performance. Stimulating class interest in a topic that is to be studied, for example, is a well-known teaching strategy for improving the cognitive performance of learners.

Clinical assessment. I believe that the most justifiable reason for assessing intelligence in educational settings is to ascertain cognitive strengths and weakness in pupils who present learning problems. The Gf-Gc Diagnostic Worksheet (Woodcock, in press) in Figure 4 is designed to aid clinicians by drawing attention to and facilitating the evaluation of cognitive and noncognitive information about a referral. (Mike is a 17-year-old high school junior who is experiencing marked difficulty in his Spanish language class.) The Gf-Gc Diagnostic Worksheet is a modification of the Gf-Gc Information Processing Model of Figure 3. The cognitive performance rectangle has been modified to facilitate recording information about the referral question. The facilitator-inhibitors portion of the worksheet draws attention to, and provides space for recording, relevant information about several noncognitive variables that may be impacting cognitive performance. Within the circles representing immediate awareness, the thinking abilities, and the stores of acquired knowledge are spaces for recording scores obtained from the assessment.

Figure 4 about here.

Educational research. An important implication for educational research is that control or experimental variables representing ability cannot be interpreted meaningfully or compared if they are cast in broad fuzzy terms such as intelligence, ability, or IQ. The complex cognitive ability of research subjects cannot be defined by single scores, unless the composition of that score is clearly stated and understood by investigator and reader alike. A common misunderstanding is to assume that scores from respected tests of intelligence are valid measures of "general ability." The score from any intelligence battery is simply the arithmetic average of the subtest scores, and every battery has its unique mix of subtests to average (Woodcock, 1990).

Test development. There are also implications for test development--both good news and bad news. Newer conceptualizations of intelligence suggest that while tests of the future will be more informative they may also be more complex, not simpler, as conscientious test developers strive to reduce the lag behind cognitive science.

Summary

This paper describes five major conceptualizations of intelligence. Two theories of multiple intelligences are emphasized and compared. Gf-Gc theory is identified as the major empirical theory of multiple intelligences available today. The combination of Gf-Gc theory with information processing theory has produced the Gf-Gc Information Processing Model. Several implications derived from a multiple intelligences viewpoint are presented for teaching and learning, clinical assessment, educational research, and test development. It is concluded that intelligence batteries of the future will be more informative, and probably more complex.

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CONCEPTUALIZATIONS OF INTELLIGENCE

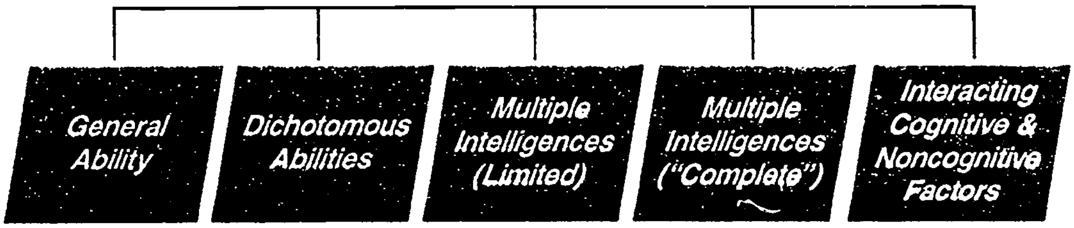


Figure 1. A continuum of conceptualizations of intelligence.

Gf-Gc Broad Abilities

Gardner's Multiple Intelligences	Gsm	Gc	Gq	Grw	Gv	Ga	Glr	Gf	Gs	CDS
Linguistic										
Logical-Mathematical										
Spatial										
Musical										
Bodily-Kinesthetic										
Interpersonal										
Intrapersonal										

Figure 2. Comparison of Gf-Gc and Gardner theories of multiple intelligences.

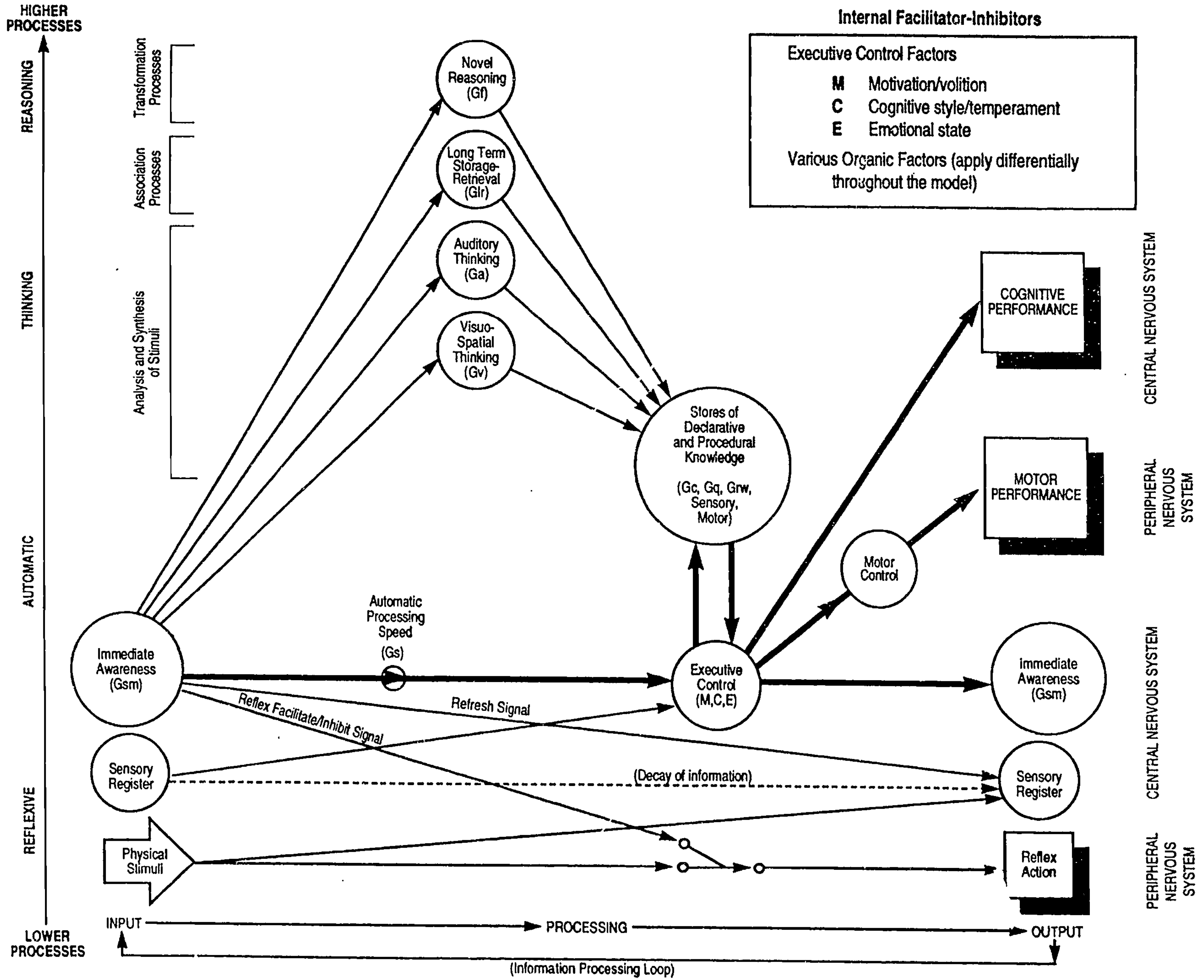
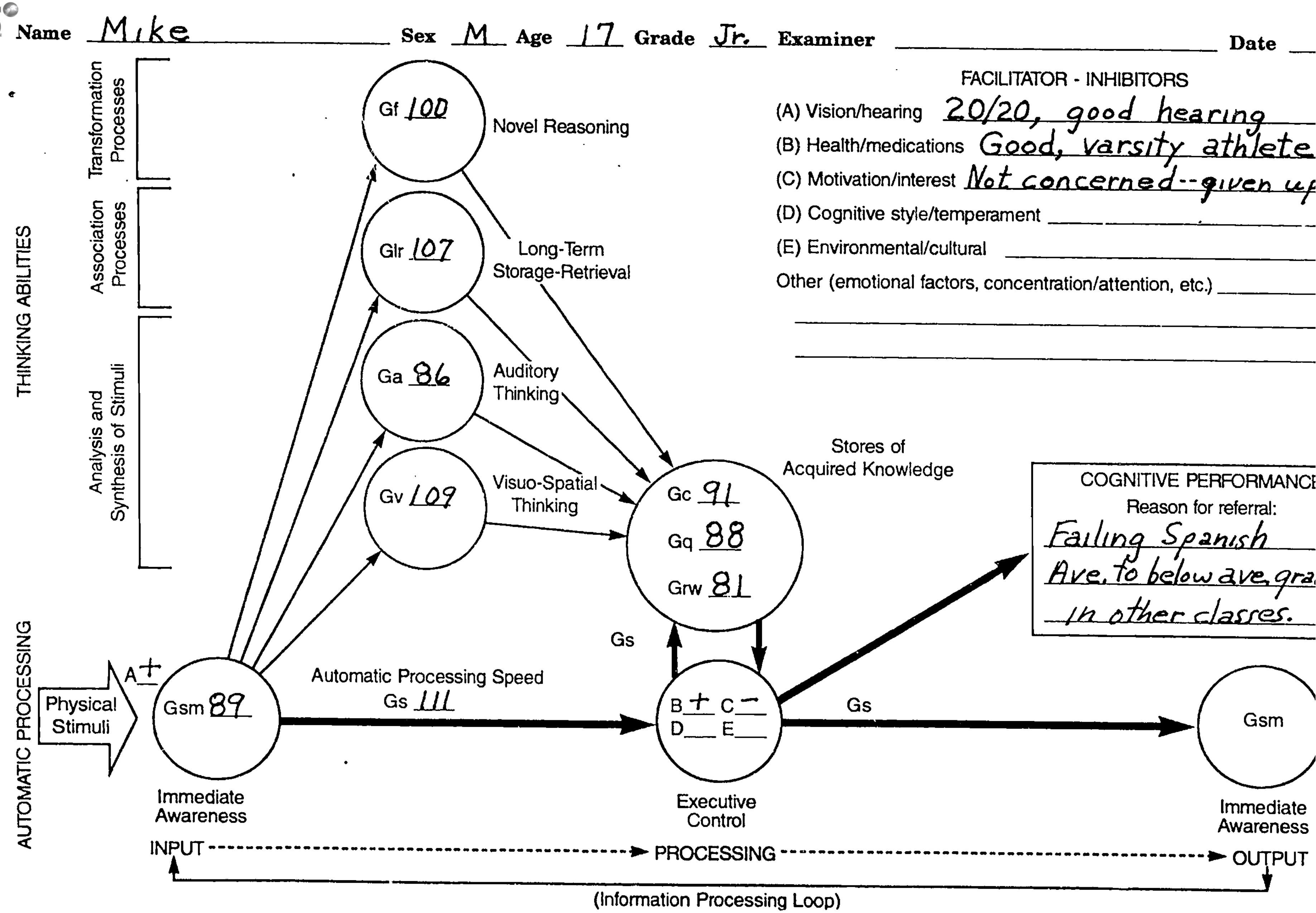


Figure 3. The Gf-Gc Information Processing Model.



<u>Figure 4</u>. The <u>Gf-Gc</u> Diagnostic Worksheet completed for Mike, a 17-year-old high school junior who is failing Spanish.

Table 1. Ten Gf-Gc Broad Abilities

Name	Symbol	Description
Immediate Awareness:		
Short-Term Memory	Gsm	Ability to hold information in immediate awareness and then use it within a few seconds.
Stores of Acquired Knowledge:		
Verbal-Conceptual Knowledge	Gc	Breadth and depth of knowledge including verbal communication, information, and reasoning when using previously learned procedures.
Quantitative Knowledge	Gq	Ability to comprehend quantitative concepts and relationships and to manipulate numerical symbols.
Reading-Writing	Grw	An ability associated with reading and writing, probably including basic reading and writing skills and the skills required for comprehension/expression. (Not yet well defined in the literature.)
Thinking Abilities:		
Visuo-Spatial Thinking	Gv	Spatial orientation and the ability to analyze and synthesize visual stimuli.
Auditory Thinking	Ga	Ability to analyze and synthesize auditory stimuli.
Long-Term Storage-Retrieval	Glr	Ability to store information and retrieve it later through association.
Novel Reasoning	Gf	Ability to reason, form concepts, and solve problems that often include unfamiliar information or procedures. Manifested in the reorganization, transformation, and extrapolation of information.
Facilitator-Inhibitors:		
Automatic Processing Speed	Gs	Ability to rapidly perform automatic or very simple cognitive tasks.
Correct Decision Speed	CDS	Speediness in finding correct solutions to problems of moderate difficulty.