Common and Domain-Specific Cognitive Characteristics of Gifted Students: A Hierarchical Structural Model of Human Abilities

Faculty of Education The University of British Columbia Kwang-Han Song

Address for correspondence: Kwang-Han Song, Department of Educational and Counselling Psychology, and Special Education, The University of British Columbia, 2125 Main Mall, Vancouver, BC, Canada V6T 1Z4, Songshat@lycos.co.kr

< Abstract >

The purpose of this study was to identify common and domain-specific cognitive characteristics of gifted students based on a hierarchical structural model of human abilities. This study is based on the premise that abilities identified by tests can appear as observable characteristics in test or school situations. Abilities proposed by major models of intelligence were reviewed in terms of their power to explain cognitive characteristics of gifted students. However, due to the lack of their explanatory power and disagreement on common and domain-specific cognitive abilities, a new hierarchical structural model was conceptualized in a unique way based on interrelationships between abilities proposed by the models. The newly established model hypothesizes a cognitive mechanism that accounts for how domain-specific knowledge is formed, as well as which abilities are common and domain-specific, how they are related functionally, and how they account for common and domain-specific cognitive characteristics of gifted students. The cognitive mechanism has important implications for our understanding of the chronically controversial concepts, "intelligence" and "knowledge." Clearer definitions of what intelligence is (g or multiple), what knowledge is, and how knowledge develops ("genetic or environmental," "rationalistic or empiricist") may result from this model.

< Introduction >

Studies on students identified as "gifted" suggest a variety of cognitive characteristics that seem to be common to this heterogeneous group However, the characteristics cannot be generalized to all students identified as gifted because students have their own unique patterns of development (Clark, 2002; Tuttle, 1983).

Why cannot cognitive characteristics of "gifted" students, which seem common to this heterogeneous group, be generalized to all individual gifted students? To address the question above, it was hypothesized that there must be cognitive characteristics common to all gifted individuals and domain-specific cognitive characteristics common only to specific groups of gifted individuals because of the considerable agreement that the mind has conceptual capabilities that are general, as well as those that are specific (Carroll, 1993; Case, 1992; Demetriou, 2002; Jensen, 1998; Spearman, 1923; Stankov, 2002).

The general capabilities may appear as common characteristics that occur in all groups of students identified as gifted, and specific capabilities may be shown as domain-specific characteristics that would reveal as unique characteristics in specific groups or individual students. Therefore, this study was to identify common and domain-specific cognitive characteristics of gifted students through the general and specific capabilities proposed by major theories or models of intelligence.

The discrimination of common and domain-specific characteristics of students has the potential to contribute to early identification and education of gifted children by parents and teachers. Parents and teachers could then provide an appropriate educational environment to facilitate the development of children's giftedness or their domain-specific knowledge and skills. Given the developmental perspective that children's specific abilities vary as a function of the culture in which they are raised and the historical epoch within that culture's life (Case, 1992), and that children depend increasingly on some form of instruction in order to acquire the high-level operations that the culture values (Case, 1975), early identification of giftedness by common and domain-specific behavioral characteristics would help to provide an effective cultural or instructional environment, especially for children's development of domain-specific abilities.

< Cognitive Characteristics of Gifted Students >

The review of characteristics ispremised on collections of general or cognitive characteristics of gifted students (Clark, 2002; Silverman, Chitwood, & Waters, 1986; Tuttle, 1983). The characteristics of the three collections were coded into sub-categories according to common attributes(Table 1). The results of the coding shows 10 sub-categories: language, number, space, thought process, memory and attention, creativity, personal sensitivity, leadership, visual sensitivity, and others. In addition, the cognitive characteristics that arecommonly attributed to all three collections (in bold) and may be candidates for common cognitive characteristics of gifted students, were grouped as curiosity, creativity, comprehension (or learning), retentiveness, intensity, sense of humor, and sense of justice.

< Review on Theories of Intelligence >

Major theories or models of intelligence - three-stratum theory (Carroll, 1993), united model of the mind (Case et al., 2001), triarchic theory (Sternberg, 1988), Case's developmental theory (Case, 1985, 1992), and Multiple intelligence theory (Gardner, 1983)- were reviewed in terms of their accountability for the cognitive characteristics of gifted students identified by Clark (2002) Silverman et al. (1986) and Tuttle (1983). Specifically, the focus was the degree to which common and domain-specific cognitive abilities proposed by major models accounted for the cognitive characteristics of gifted students.

However, the major theories or models of human abilities that suggested common and domain-specific cognitive abilities did not show enough power to explain common and domain-specific cognitive characteristics of gifted students. No single model could account for all cognitive characteristics of gifted students. Most of the characteristics were explained individually or collectively by the major theories or models, but creativity- and leadership-relevant characteristics were not accounted for by any theory or model.

The major theories or models are also problematic in identifying common and domain-specific characteristics of gifted students because of the disagreement on common (including *g*) and domain-specific cognitive abilities among major theories or models and lack of knowledge about interrelationships between common and domain-specific abilities. Lack of explanatory power and knowledge about interrelationships between abilities and disagreement among theories suggests that a new structural model of abilities is necessary. A model that consists of common and domain-specific cognitive abilities that are hierarchically structured by reasonable interrelationships between them, and that accounts for observable common and domain-specific cognitive characteristics of gifted students is required.

< Method >

Interrelationships between abilities or abilities and characteristics, that is, relationships in terms of interfunctionality, were sought via conceptual analysis that searched for hypothesized interrelationships between stimuli (or information in memory) based on their definitions or functions. The conceptual premise is that interrelationships between stimuli can be found from knowledge of what the stimuli are and how they function in relation to each other. The characteristics, obtained from Clark's, Silverman et al. (1986), and Tuttle's collections, were categorized according to common attributes as follows: language-, number-, thought process-, memory and attention-, creativity-, personal sensitivity-, leadership-, and visual sensitivity-relevant characteristics.

Conceptual analysis followed three steps. (1) Identification: abilities or characteristics were identified through their definitions or functions; (2) comparison and evaluation: abilities or characteristics were compared in terms of their definitions or functions, and evaluated in terms of possible interrelationships; and (3) integration: abilities or characteristics were connected by the relationships that were found through evaluation. The results were mapped in the form of a hierarchical structural model of human abilities.

< Results >

Common Cognitive Abilities and Characteristics of Gifted Students

To identify common cognitive abilities, the common cognitive abilities of four major theories or models were examined: three-stratum theory (Carroll, 1993), united model of the mind (Case et al., 2001), triarchic theory (Sternberg, 1988), and Case's developmental theory (Case, 1985, 1992). The common cognitive abilities proposed by the four models were reasoning-relevant ability (i.e., inductive and deductive reasoning) in three-stratum theory; hypercognition defined as processes and abilities used to monitor, regulate, and coordinate cognitive functioning and processing efficacy and capacity in the united model of the mind; metacomponents in triarchic theory; and executive operations of central conceptual structures and processing capacity in Case's developmental model.

All the proposed common cognitive abilities are in instrumental positions to find relationships between stimuli (or information in memory). Reasoning and executive operations of central conceptual structures are information processing conducted through conceptual components (Case, 1992; Spearman, 1923; Sternberg, 1988) in order to find relationships between stimuli; metacognition and metacomponents are the executive functions of planning,regulating, controlling for reasoning or executive operations of central conceptual structures; processing efficacy and capacity are necessary for reasoning. Processing speed is necessary for better reasoning (Jensen, 1988; Neubauer et al., 2000; Vernon, 1983); inhibition is a kind of executive function because it is a controlling function of attention. Processing capacity is the mental space where processing and short-term memory occur for reasoning (Case, 1992). Therefore, it was hypothesized that there must be a cognitive "**activator**"that finds relationships between stimuli through its executive and processing functions in mental space (Figure 1). When the activator is stimulated by internal or external demands ("activation level"), it may activate the instrumental cognitive functions - executive and processing functions ("performance level") - to find relationships. The activator may start to reason while it executes its cognitive processes (i.e., planning, regulating, or coordinating) on the one hand and controls attention (i.e., inhibition) on the other hand. Once the activator finds relationships, it may connect stimuli by the relationships, which may be defined as "knowledge."

The analysis for common cognitive characteristics revealed that there are five common cognitive characteristics of gifted students (Figure 1): unusual curiosity, unusual creativity, unusual intensity, unusual retentiveness, and unusual comprehension. The five common cognitive abilities may appear as the five common observable cognitive characteristics. High ability to find relationships may appear as unusual curiosity on the activation level; on the performance level, highly efficient executive functions (planning, decision-making, regulating, and inhibition) may appear as unusual intensity; ability to find new or inferred relationships may appear as unusual creativity; and ability to find a lot of relationships may appear as unusual retentiveness. In short, unusual cognitive characteristics on the performance level may be the result of an unusual curiosity at the activation level which prompts a search for relationships between stimuli.

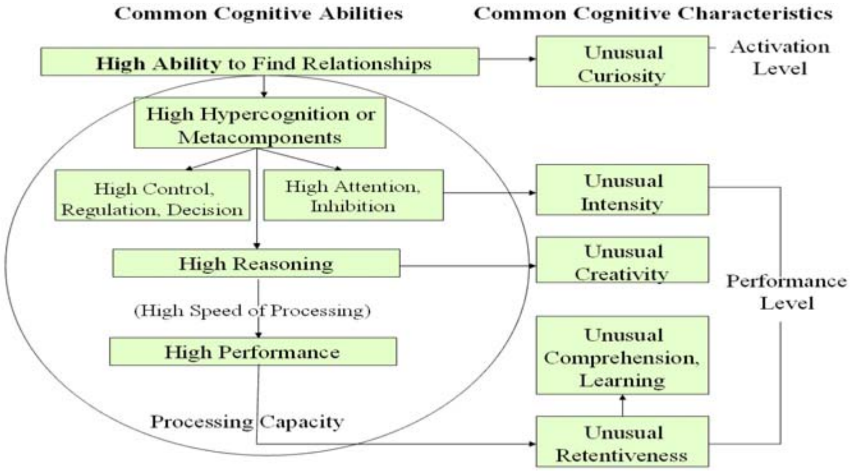


Figure 1 Common abilities and characteristics

Domain-Specific Cognitive Abilities and Characteristics of Gifted Students

Analysis showed that the cognitive activator, who finds relationships between mental stimuli, appears as domain-specific abilities when it processes domain-specific stimuli. The kind of stimuli determines domains because the activator 'must' have stimuli to process. Domains could be language, number, space, and sound proposed as domains by the major models. In addition, they may include color and light (visual stimuli), taste and smell (taste and olfactory stimuli), and feelings (tactile stimuli), although these are not included in the major models.

Functionally, the activator reasons with different kinds of stimuli and connects them according to relationships between them, which appear as different domains of knowledge accordingly. The activator's ability to find relationships may appear as domain-specific abilities on the performance level. When the activator reasons with language, it appears as linguistic reasoning and results in linguistic domain-specific knowledge and ability; when the activator reasons with number, it appears as mathematical reasoning and results in mathematical domain-specific knowledge and ability; when the activator reasons with other stimuli such as space, color, taste or smell, and feelings, it appears as spatial, visual, taste and olfactory, or tactile reasoning and results in the respective domain-specific knowledge and abilities. The ignorance of visual, taste and olfactory, and tactile reasoning in present research may be attributed to the belief that they are not cognitive abilities that can be measured by IQ tests. However, given the interrelationships in the cognitive mechanism proposed by this study, all domains of reasoning and knowledge may be cognitive because no form of domain knowledge, even "perception," can be formed without some sort of relationships found through the activator's reasoning.

Meanwhile, depending on motivation (i.e., internal or external demands), the stimuli that reasoning focuses on may vary. Practical and social intelligences proposed by the triarchic theory (Sternberg, 1988) may be examples of this. Practical intelligence is defined as "the ability to perform real-world tasks successfully"(e.g., adapting to a new culture), while social intelligence refers tothe abilities to decode nonverbal messages in interpersonal situations (Sternberg, 1988). Thus, when reasoning is motivated by internal or external practical demands, the activator reasons according to the demands. Reasoning may proceed with practical stimuli in real-life situations such as labels on bottles of household goods, street maps, chart and schedules, newspapers, etc. (Willis, Schaie, & Lueers, as cited in Sternberg, 2002), which may refer to the practical domain-specific ability in the triarchictheory (Sternberg, 1988). Also, when reasoning is motivated by social demands, the activator would necessarily follow the demands. Reasoning with social stimuli may involve social situations such as human behavior and the mental states that faces portray (Guilford, 1967; Guilford & Hoepfner, 1971).

Meanwhile, the hypothesized counterpart ability of leadership-relevant characteristics was labeled as "idealistic"because the characteristics were idealistic as opposed to practical. The absence of a counterpart ability of leadership-relevant characteristics suggests that the ability has not been detected and defined through tests of ideal ability.

In the structure of domain-specific cognitive abilities (Figure 2), there were three domain-specific abilities on the activation level that stimulate the activator to reason with their domain-specific stimuli: practical, social, and idealistic, which may be conceived of as "domain feelings of direction" (Shavinina & Ferrari, 2004). The domain feelings of direction are hypothesized as "mental engines" by which exceptional figures in history just "went for" their domains.

The analysis for domain-specific cognitive characteristics showed that there are three domain-specific cognitive characteristics on the activationlevel: practical-, social-, and idealistic-relevant characteristics, and seven domain-specific characteristics on the performance level: language-, number-, space-, visual-, auditory, taste-and olfactory-, and tactile-relevant characteristics (Figure 2).

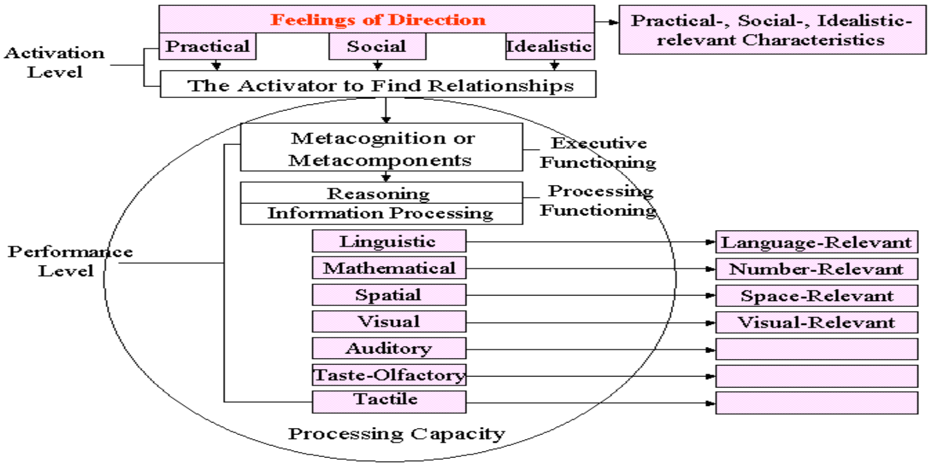
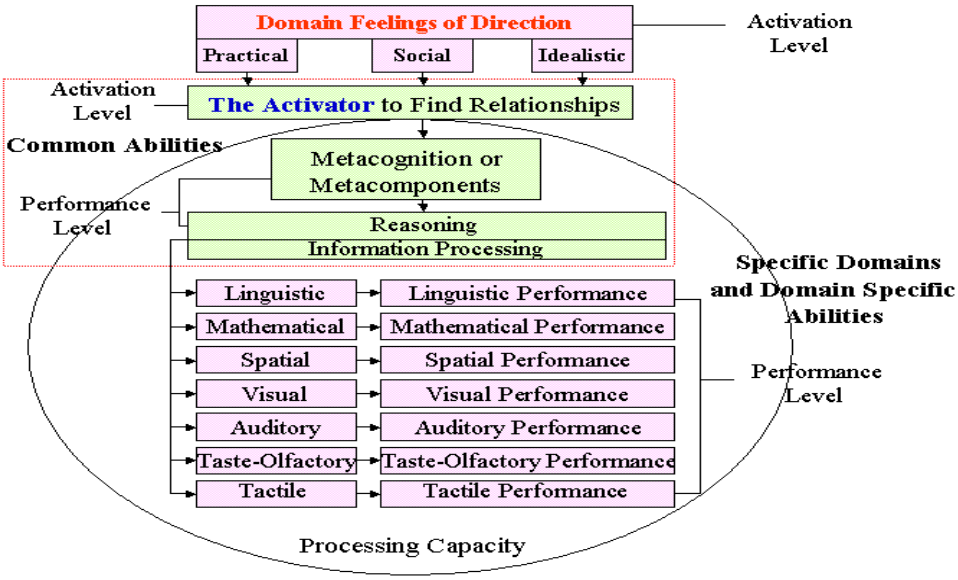


Figure 2 Domain-specific abilities and characteristics

< A Hierarchical Structural Model of Human Abilities >

The common and domain-specific cognitive abilities form the hierarchical structure of human abilities (Figure 3). Domain-specific cognitive abilities are made up of three domain feelings of direction on the activation level (practical, social, and idealistic) and seven domain-specific abilities on the performance level (linguistic,mathematical, spatial, visual, auditory, taste and olfactory, and tactile). Domain-specific abilities may be revealed through the common cognitive abilities. Once the domain feelings of directions urge the common activator to find relationships between specific stimuli, the common activator starts reasoning with the stimuli required by the domain feelings of direction. The results of reasoning may be linguistic, mathematical, spatial, visual (i.e., knowledge about lights or colors), auditory (i.e., knowledge about sounds), taste and olfactory (i.e., knowledge about tastes and smells), and tactile (i.e., knowledge about feelings) performances. The common and domain-specific cognitive abilities may be observed as cognitive characteristics in test, school, daily-life situations.

The origin of all the other common cognitivecharacteristics may be unusual curiosity about relationships between domain-specific stimuli. Once the domain feelings of direction urge the common activator to find relationships, unusual curiosities may occur domain-specifically in gifted students. Then, when curiosities activate the performance functions in order to find relationships, the characteristic of unusual intensity may appear in domains. When gifted students find new or inferred relationships that have never been experienced or learned, their unusual creativity may appear. When gifted students demonstrate knowledge of an unusual number of relationships through high curiosity and high intensity, they may show exceptional comprehension or learning abilities in their domains.



< Implications >

The hierarchical model of cognitive abilities and characteristics suggested in this study may contribute to studies on human intelligence and giftedness in theory and in practice in that abilities and characteristics may be better understood in terms of interrelationships between them. Theoretically, the hierarchical model of abilities may inform the controversial concepts of "intelligence"(i.e., a general intelligence, *g*, or multiple intelligences) and "knowledge," common and domain-specific abilities. It may also integrate, at least to some extent, the philosophies of empiricism, premising that knowledge of the world develops by the mind's detecting customary patterns in stimuli detected by the sensory organs, and rationalism, arguing that knowledge develops not by the mind's simply detecting patterns but by the mind's imposing order on the data that the senses provide (Case, 1999).

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