COMMON AND DOMAIN-SPECIFIC COGNITIVE CHARACTERISTICS OF GIFTED STUDENTS: A HIERARCHICAL STRUCTURAL MODEL OF HUMAN ABILITIES

By

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Abstract

The present study identified common and domain-specific characteristics of gifted students through a hierarchical structural model of human abilities that was established through integrating major models of human abilities by a conceptual analysis based on interrelationships between abilities. The proposed common and domain-specific abilities in the major models were identified, compared and evaluated in terms of definitions or functions, and finally connected by interrelationships found between the abilities.

The conceptual analysis resulted in a hierarchical structural model of human abilities, which shows two levels of common and domain-specific abilities: activation level and performance level. For the common abilities, there is an ability to find relationships between stimuli on the activation level, an ability to execute cognitive processes, and an ability to reason or process information (or stimuli). The domain-specific abilities consist of three abilities on the activation level and seven abilities on the performance level. The common and domain-specific abilities and observable characteristics of gifted students were conceptually analyzed in terms of interrelationships, and finally common and domain-specific characteristics of gifted students were identified and structured into a hierarchical model of the characteristics of gifted students. The model shows that unusual curiosity (on the activation level), creativity, intensity, comprehension (or learning or understanding),
and retentiveness (on the performance level) belong to the common characteristics of gifted students; for the domain-specific characteristics, there are practical-, social-, and ideal-relevant characteristics on the activation level and language-, number-, space-, visual-, auditory-, taste and olfactory-, and tactile-relevant characteristics on the performance level.

The implications in theory in terms of the concepts of “intelligence” (i.e., general intelligence or multiple intelligences), “IQ testing” and “rationalistic or empiricist perspective” (i.e., genetic or environmental), and in practice regarding identification of gifted students are described. Research directions for further studies follow.
TABLE OF CONTENTS

Abstract...........................................................................................................ii

Table of Contents.................................................................................................iv

List of Tables and Figures..................................................................................vi

Acknowledgments...............................................................................................vii

Chapter One Introduction......................................................................................1

Study Problem and Relevant Theoretical Models.............................................1

Overview...........................................................................................................7

Chapter Two Literature Review.........................................................................9

Cognitive Characteristics of Gifted Students.....................................................9

The Primary Theories or Models of Human Abilities........................................16

General Intelligence Theory..............................................................................17

Hierarchical Models of Abilities.......................................................................19

Three-Stratum Theory......................................................................................19

The United Model of the Mind.........................................................................21

Triarchic Theory...............................................................................................23

Multiple Intelligence Theory............................................................................26

Neo-Piagetian Developmental Theory...............................................................29

Chapter Three Method.......................................................................................34

A Proposed Method for Conceptual Analysis..................................................35

Correlation and Statistical Analysis.................................................................35

Interrelationship and Mental Analysis...............................................................35

Procedure of Mental Analysis...........................................................................38

Chapter Four Results.........................................................................................42
List of Tables

Table 2.1: Cognitive Characteristics of Gifted Students

Table 2.2: The Sub-Categories of Cognitive Characteristics of Gifted Students

Table 4.1: Common Cognitive Abilities in the Four Models

Table 4.2: Common Characteristics in Three Collections

Table 4.3: Domain-Specific Cognitive Abilities in the Major Models

List of Figures

Figure 3.1: Stages of Mental Analysis

Figure 4.1: The Functions of the Activator

Figure 4.2: Executive Functioning

Figure 4.3: Processing Functioning

Figure 4.4: The Result of the Cognitive Functions: Performance

Figure 4.5: Common Cognitive Characteristics of Gifted Students

Figure 4.6: A Structure of Domain-Specific Cognitive Abilities

Figure 4.7: Domain-Specific Abilities and Characteristics of Gifted Students

Figure 4.8: A Hierarchical Structural Model of Human Abilities

Figure 4.9: Common and Domain-Specific Cognitive Characteristics of Gifted Students
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I am also grateful to Dr. Elizabeth Jordan whose comments and advice helped me clarify my thesis and achieve my task. I would also like to thank Dr. Janet Jamieson for her willingness to read my thesis and her insightful comments.
Chapter One

INTRODUCTION

Study Problem and Relevant Theoretical Models

Studies on students identified as “gifted” have suggested a variety of cognitive characteristics that seem to be common to this heterogeneous group (Amabile, 1990; Cross, 1997; Dahlberg, 1992; Davis & Rimm, 1994; Freeman, 1994; Gottfried & Gottfried, 1996; Gross, 1993; Koppel, 1991; Lovecky, 1994; Oram, Dewey, & Rutemiller, 1995; Piechowski, 1991; Roeper, 1992; Sheely & Silverman, 2000; Sternberg & Lubart, 1993). The characteristics may be categorized as follows: language-, number-, thought process-, memory and attention-, creativity-, personal sensitivity-, leadership-, and visual sensitivity-relevant characteristics (for reviews, see Clark, 2002; Silverman, Chitwood, & Waters, 1986; Tuttle, 1983). 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). Given 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), generalization may be limited. There may be common characteristics that occur in all groups of students identified as gifted, and domain-specific characteristics that would reveal as unique characteristics in
specific groups or individual students.

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 that could 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.

Studies on human intelligence have provided the bases for cognitive characteristics of gifted students, even though they have not directly focused on common and domain-specific cognitive characteristics of the students. The studies have been done by three primary groups of researchers. General Intelligence Theory (g theory) researchers have studied a common ability, g, submerged in all domains of knowledge, which could account for common characteristics of gifted students. Another group of researchers that supports
Multiple Intelligence Theory (MI theory) argues that all abilities are independent, which could explain domain-specific characteristics of gifted students. The other group of researchers is the group which has proposed Neo-Piagetian theories in which general and domain-specific characterizations of cognitive development are combined.

Researchers of $g$ have maintained that there is a general factor that underlies any domain of knowledge, and that it explains individual differences (Carroll, 1993; Jensen, 1998; Spearman, 1927). They have supported $g$ empirically through factor analysis that leads to hierarchical models of several group factors and a general factor. With the general factor not exactly revealed, recent research focuses on the functions of $g$: processing speed or capacity (Deary, 2002; Jensen, 1984; Kyllonen, 1996; Kyllonen & Christal, 1990; Vernon, 1985; Vernon & Kantor, 1986), attention (Stankow & Roberts, 1997), planning (Duncan, Emslie, & Williams, 1996; Naglieri & Das, 2002), the ability to uncover and deal with relations (Spearman, 1923), and metacomponents such as decision and selection (Sternberg, 1977). Some of the functions mentioned above could explain part of gifted cognitive characteristics. The functions of processing speed and capacity, and attention and planning could inform gifted characteristics relevant to thought processing, and attention and memory. However, considering the general disagreement on the functions of $g$, it is not certain which functions could account for common cognitive characteristics of gifted
students. It is also not easy to know whether common cognitive characteristics of gifted students originate from all of the above functions of \( g \), or from some of them, or from only one of them.

Meanwhile, hierarchical models of the mind propose structures of abilities that could inform both common and domain-specific cognitive characteristics (Carroll, 1993; Case, Demetriou, Platsidou, & Kazi, 2001; Sternberg, 1988). The functions of \( g \) and the common abilities in the hierarchical models such as reasoning- and induction-related abilities, hypercognitive factor, metacomponents, and processing efficacy and capacity, could explain the thought process-relevant characteristics. The eight second-order factors in the three-stratum theory (Carroll, 1993), the five domain-specific abilities in the unified model (Case et. al., 2001), and the three domain-specific abilities in the triarchic theory (Sternberg, 1988) could collaboratively account for most of the characteristics of gifted students (see Chapter 2).

However, the alleged functions of \( g \) in the three models are different from one another. Three-stratum theory supposes \( g \) functions as reasoning- and induction-relevant abilities, which belong to domain-specific functions in the other two models. Also, while processing efficacy and capacity belong to common abilities in the united model, they are placed in domain-specific abilities in the three-stratum theory. In addition, any of the
models alone is not enough to explain the categorized cognitive characteristics of gifted students because none of these models have enough counterparts of the characteristics of gifted students.

MI theory, which is premised on independent intelligences, presents nine multiple intelligences including future candidates of naturalist and spiritual intelligence: linguistic intelligence, musical intelligence, logical-mathematical intelligence, spatial intelligence, bodily-kinesthetic intelligence, intrapersonal and interpersonal intelligence (Gardner, 1983). However, the seven intelligences are considered in this study. These may account for domain-specific cognitive characteristics of gifted students, and may explain the language-, thought process-, number-, space-, and personal sensitivity-relevant characteristics of gifted students. However it cannot be known which characteristics could be accounted for by musical or bodily-kinesthetic intelligence. Also, it is not clear which intelligences, among the seven intelligences, could be responsible for the characteristics of leadership and creativity, as well as memory and attention.

A Neo-Piagetian theory that premises both general and domain-specific aspects of cognitive development (Case, 1992) may be useful to identify the origins of common and domain-specific cognitive characteristics of gifted students. The universal developmental stages are characterized by information processing such as schematic search, schematic
evaluation, re-tagging, schematic consolidation, and working memory (Case, 1992). In regard to the characteristics of gifted students, the information processing ability and working memory capacity could account for the thought process-, memory- and attention-relevant characteristics. On the other hand, domain-specific knowledge, which has been proposed as three domains of logico-mathematical thought, social and emotional thought (including narrative), and spatial thought could be related to the number-, language-, personal sensitivity-, and space-relevant cognitive characteristics of gifted students. However, it is not certain how clearly leadership- and creativity-relevant characteristics could be accounted for by this model.

In conclusion, despite \( g \) and hierarchical models, MI theory, and Case's neo-Piagetian theory having potential to account for common or domain-specific cognitive characteristics of gifted students, the characteristics are not sufficiently accounted for by any individual theories or models alone because of the explanatory limitations of the theories and models. Also, although the functions of common and domain-specific abilities of the theories or models could inform the common or domain-specific characteristics efficiently, disagreement on \( g \) functions and lack of knowledge about interrelationships between common and domain-specific abilities weaken the discriminatory power of the origins of common and domain-specific cognitive characteristics. Similarly, the unknown
relationships among the seven intelligences of MI theory fail to explain whether all the seven intelligences are domain-specific characteristics, or only some of them are.

The question of which characteristics are common and which ones are domain-specific may be answered by a new structural model of human abilities that can explain the interrelationships among cognitive abilities that may correspond reasonably to the common or domain-specific characteristics of gifted students. Therefore, the present study is an attempt to identify common and domain-specific cognitive characteristics of gifted students through a new hierarchical structural model of human abilities. Accordingly, the research question is, "What could be common characteristics and domain-specific characteristics of gifted students, and what could be their origins?" More specifically, (1) What could be the common abilities (or ability) and domain-specific abilities? (2) What could be the common and domain-specific cognitive characteristics that could be accounted for by the common abilities (or ability) and domain-specific abilities? Gifted abilities will be considered as a higher level of common and domain-specific abilities than that of normal abilities because all individuals may have same kinds of abilities and be different in their levels.

Overview

In the following chapter, the cognitive characteristics of gifted students are considered first. The brief review of the major theories or models of human abilities serves
as a background that suggests a need for a new integrated model of human abilities that could play a role in explaining the origins of cognitive characteristics of gifted students. The focus of the review is on the accountability of the major theories or models for common and domain-specific characteristics of gifted students. Descriptions of the method, results, and implications and research directions follow in the next chapters.
Chapter Two

LITERATURE REVIEW

Cognitive Characteristics of Gifted Students

While most studies on cognitive characteristics of gifted students have focused on specific characteristics (Bloom, 1982; Borkowski, 1985; Clark, 1988; Freeman, 1985; Gross, 1993; Kerr, 1991; Shade, 1991; Silverman & Ellsworth, 1980; Tuttle & Becker, 1980), rarely have the characteristics been studied as a whole. Thus, the review of the characteristics can only rely on the gifted characteristics that are collected as general or cognitive characteristics of gifted students (Clark, 2002; Silverman et al., 1986; Tuttle, 1983). While Clark (2002) collected the characteristics under the term “cognitive and affective function,” Silverman et al. (1986) and Tuttle (1983) categorized them into “general characteristics.” However, it is difficult to decide which ones among the general characteristics may be cognitive characteristics because the general characteristics cannot be seen as distinct characteristics that occur separately from the “cognitive” characteristics. Therefore, in this review, the term cognitive will refer to both cognitive and cognitive-relevant characteristics including the general and affective characteristics. Table 2.1 shows the collections of cognitive characteristics by Clark (2002), Silverman et al. (1986) and Tuttle (1983). Based on the cognitive characteristics of Clark, the characteristics are
divided into cognitive and cognitive-relevant characteristics.

Table 2.1 Cognitive characteristics of gifted students

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Cognitive</td>
<td>Extraordinary quantity of information and unusual retentiveness</td>
<td>Good problem solving</td>
<td>Highly developed sense of humor</td>
</tr>
<tr>
<td></td>
<td>Advanced comprehension</td>
<td>Rapid learning ability</td>
<td>Verbal orientation</td>
</tr>
<tr>
<td></td>
<td>High level of language development and high level of verbal ability</td>
<td>Extensive vocabulary</td>
<td>Understands general principles easily</td>
</tr>
<tr>
<td></td>
<td>Unusual capacity for processing information</td>
<td>Excellent memory</td>
<td>Sees relationships among seemingly diverse ideas, and generates many ideas for a specific stimulus.</td>
</tr>
<tr>
<td></td>
<td>Accelerated pace of thought process</td>
<td>Long attention span</td>
<td>Big storage capacity</td>
</tr>
<tr>
<td></td>
<td>Flexible thoughts</td>
<td>Intensity</td>
<td>Persistent in pursuit of interests and questions</td>
</tr>
<tr>
<td></td>
<td>Comprehensive synthesis</td>
<td>Perseverant when interested</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heightened capacity for seeing unusual and diverse relationships, integration of ideas and disciplines</td>
<td>Great sense of humor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ability to generate original ideas and solutions</td>
<td>Early or avid reading ability</td>
<td></td>
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<tr>
<td></td>
<td>Early differential patterns for thought processing (e.g., thinking in alternatives, abstract terms; sensing consequences; making generalizations; visual thinking, use of metaphors and analogies)</td>
<td>Ability with numbers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Early ability to use and form conceptual frameworks</td>
<td>Good at jigsaw puzzles</td>
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<tr>
<td></td>
<td></td>
<td>Vivid imagination</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>High degree of creativity</td>
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11

Unusual intensity; persistent goal-directed behavior.
. Keen sense of humor

Unusually varied interests and curiosity
. An evaluative approach toward self and others
. Unusual sensitivity to feeling of others
. Heightened self-awareness
. Idealism and sense of justice
. High expectations of self and others
. Advanced level of moral judgment
. Strong need for consistency between abstract value and personal actions
. Early ability to delay closure

Unusual curiosity
. Wide range of interests
. Personal sensitivity
. Perfectionism
. Moral sensitivity
. Concerned with justice, fairness
. Mature judgment
. Compassion for others
. Question authority
. Preference for older companions
. High degree of energy

Curious
. Critical of self and others
. Sensitive to injustices on personal and worldwide levels
. Leader in various areas
. Perceptive of environment
. Often responds to the environment through media and means other than print and writing
. Not willing to accept superficial statements, responses, or evaluation

In the categorized cognitive characteristics (Clark, 2002; Silverman et al., 1986; Tuttle, 1983), some characteristics are found in all the three categorizations (in bold) but others are unique (in italics) or common only in two categorizations (the rest). But it is not safe to say that the common characteristics are general cognitive characteristics that occur in all gifted individuals because the characteristics are collected from limited individual studies focusing on specific characteristics of different groups of gifted students. Also, the authors of the three categorizations especially remark on caution in interpreting the characteristics on the lists on the grounds that behaviors cited merely give tentative, general
characteristics, and that particular gifted individuals may not possess all the characteristics.

Limited generalizability suggests that the characteristics may be a mixture of common and domain-specific characteristics of gifted students. To test this assumption, the characteristics of the three collections were coded into sub-categories. The characteristics were grouped according to common attributes (Table 2.2).

Table 2.2 The sub-categories of the cognitive characteristics of gifted students

<table>
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<tr>
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<tr>
<td>Language (7)</td>
<td>. High level of language development, high level of verbal ability</td>
<td>. Extensive vocabulary</td>
<td>. Verbal orientation</td>
</tr>
<tr>
<td></td>
<td>. Keen sense of humor</td>
<td>. Early or avid reading ability</td>
<td>. Highly developed sense of humor</td>
</tr>
<tr>
<td>Number (1)</td>
<td></td>
<td>. High ability with numbers</td>
<td></td>
</tr>
<tr>
<td>Space (1)</td>
<td></td>
<td>. Good at jigsaw puzzles</td>
<td></td>
</tr>
<tr>
<td>Thought Process (10)</td>
<td>. Advanced comprehension</td>
<td>. Rapid learning ability</td>
<td>. Understands general principles easily</td>
</tr>
<tr>
<td></td>
<td>. Early ability to use and form conceptual frameworks</td>
<td>. Good problem solving</td>
<td>. Greater variety of techniques to process information</td>
</tr>
<tr>
<td></td>
<td>. Early differential patterns for thought processing (e.g., thinking in alternatives, abstract terms; sensing consequences; making generalizations; visual thinking; use of metaphors and analogies)</td>
<td></td>
<td>. Sees relationships among seemingly diverse ideas.</td>
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<td>. Flexible thoughts</td>
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<tr>
<td></td>
<td>. Comprehensive synthesis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memory and</td>
<td>. Extraordinary quantity of information and unusual</td>
<td>. Excellent memory</td>
<td>. Big storage capacity</td>
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<tr>
<td></td>
<td></td>
<td>. Long attention span</td>
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<td>. Persistent in pursuit of</td>
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<td>Trait</td>
<td>Description</td>
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<td>---------------</td>
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</tbody>
</table>
| **Attention (11)** | Retentiveness  
. Unusual capacity for processing information  
. Heightened capacity for seeing unusual and diverse relationships, integration of ideas and disciplines  
. Unusual intensity  
. Persistent goal-directed behavior  
. Accelerated pace of thought process  
. Perseverant when interested questions | interests and questions |
| **Creativity (8)** | Unusually varied interests and curiosity  
. Ability to generate original ideas and solutions  
. High degree of creativity  
. Vivid imagination  
. Unusual curiosity  
. Wide range of interests  
. Curious  
. Generates many ideas for a specific stimulus. |
| **Personal Sensitivity (10)** | An evaluative approach toward self and others  
. Heightened self-awareness  
. High expectations of self and others  
. Unusual sensitivity to feeling of others  
. Advanced level of moral judgment  
. Personal sensitivity  
. Compassion for others  
. Mature judgment  
. Moral sensitivity  
. Critical of self and others |
| **Leadership (7)** | Idealism and sense of justice  
. Strong need for consistency between abstract value and personal actions  
. Concerned with justice, fairness  
. Question authority  
. Preference for older companions  
. Sensitive to injustices on personal and worldwide levels  
. Leader in various areas |
| **Visual Sensitivity (3)** | Keen powers of observation  
. Perceptive of environment  
. Often responds to the |
The result of the coding shows 10 sub-categories: language, number, space, thought process, memory and attention, creativity, personal sensitivity, leadership, visual sensitivity, and others. Among the 10 sub-categories, most of the characteristics are distributed to the five categories of language, thought process, memory and attention, personal sensitivity, and leadership, whereas the categories of number and space have the smallest distributions. However, the sub-categories do not help to distinguish domain-specific characteristics from common characteristics. It is unrealistic to regard all of the sub-categorized characteristics as either common or domain-specific. If they were common characteristics, all gifted individuals would have higher levels of functioning in all of those abilities that reveal the characteristics. If they were domain-specific characteristics, what would be common gifted characteristics? Also, it is not convincing that the characteristics in the five highly concentrated sub-categories could be common gifted characteristics.

Meanwhile, the interpretation of the results suggests that definitions of giftedness
are not consistent, or that identification tools are not valid for all sorts of knowledge. In fact, considering that there are varied definitions of giftedness and general dependency on IQ test scores, the characteristics are likely to reflect the learning abilities that IQ tests predominantly measure. Then, it is questionable whether the learning abilities mainly focused on - memory, language, and logical-mathematical abilities - are common gifted abilities. Given other definitions of giftedness such as Renzulli's (1978), Gardner's (1983), the B.C. provincial (1995), the U.S. federal (1994), and Clark's (2002), it is not persuasive to limit gifted abilities to learning abilities focused on memory, language, and logico-mathematical abilities.

Some of the definitions of giftedness focus on performance in different domains. Terman (1925) referred to academic performance; Renzulli (1978) focused on creative performance; Gardner (1983) mentioned problem-solving and creating products; the B.C. definition (1995) focuses on demonstrated or potential abilities in intellect, creativity, or skills associated with specific disciplines; and the U.S. federal definition (1994) indicates performance in intellectual, creative, artistic, leadership, or specific academic fields. On the other hand, Clark (2002) noted that giftedness is no longer confined to cognitive functions and includes all brain functions such as cognitive, affective, physical, and intuitive in an integrated way. Although the varied performing skills and abilities are not irrelevant to
learning abilities, it cannot be said that the skills and abilities needed for creative, artistic, or leadership performance necessarily premise high learning abilities; the limitation of gifted abilities to learning abilities is not agreeable to Clark's view.

In short, neither the comparison of the three collections of gifted characteristics, nor the sub-categorization of the characteristics distinguishes common characteristics from domain-specific ones. Moreover, even the highly concentrated characteristics cannot be generalized to all gifted students. These facts suggest that common and domain-specific characteristics are in a mixed state. With these considerations, the review will move its focus to major theories and structural models of human abilities: general intelligence theory and hierarchical structural models of abilities, namely the three-stratum theory (Carroll, 1993), the united model of the mind (Case et al., 2001), triarchic theory (Sternberg, 1988); multiple intelligence theory (Gardner, 1983); and Case's (1992) neo-Piagetian developmental theory. The abilities suggested by the theories or models could be the origins of cognitive characteristics of gifted students, which could explain either common or domain-specific characteristics, or both.

The Primary Theories or Models of Human Abilities

Among researchers who are studying intelligence, there are few who ignore the existence of general intelligence (or \( g \)). However they are divided into two groups
according to their different foci on abilities. One is the group who believes that general abilities dominate specific ones (Detterman, 2002; Dreary, 2002; Gottfredson, 2002; Humphreys & Stark, 2002; Jensen, 2002; Kyllonen, 2002; Petrill, 2002). The other group thinks that specialized or modular processes and abilities are more important than general abilities (Berg & Klaczynski, 2002; Grigorenko, 2002; Kray & Frensch, 2002; Lautrey, 2002; Naglieri & Das, 2002; Sternberg, 2002; Wahlsten, 2002). Therefore, it is helpful to relate common characteristics to the common abilities and domain-specific characteristics to the specialized abilities in g theories and its hierarchical structural models.

*General Intelligence Theory (g theory)*

General intelligence researchers maintain that there is a general factor that underlies any domain of knowledge (Carroll, 1993; Jensen, 1998; Spearman, 1927) and that this factor has enormous predictive validity for socially significant variables, including scholastic performance and intellectual attainments, occupational status, and job performance (Gottfredson, 1998; Jensen, 1998). These researchers have supported g empirically through factor analysis, which determines the minimum number of underlying dimensions necessary to explain a pattern of correlations among measurements of intelligence (Jensen, 1998). Spearman (1927) found a specific factor peculiar to each test of mental abilities, and a general factor common to all of the variables in the analysis. In this
theory, only one factor, \( g \), accounts for all of the correlations among the variables.

Spearman invented a bifactor model with Karl Holzinger, one of his Ph.D. students, in which multiple factor analyses revealed a general factor, as well as group factors. The model derives the general factor from every variable and produces group factors that are uncorrelated with each other. Carroll (1993) suggested the general factor as a third-order factor in his three-stratum theory. He found that the general factor always emerges as either a second-order or a third-order factor, which means that no factor is revealed above the general factor in any factor analysis of cognitive ability tests.

Although \( g \) could account for the common characteristics of gifted students, it cannot be known which characteristics reflect \( g \) because there is no agreement on its definition or functions. \( G \) researchers believe that there are a number of functions of \( g \) such as processing efficiency and capacity including speed of processing (Jensen, 1998; Vernon, 1983; Vernon & Kantor, 1986), efficiency of processing (Bates & Stough, 1998), working memory (Deary, 2002; Kyllo nen, 1996; Kyllonen & Christal, 1990), and the management of both the processing resources available and the task demands and goals including attention (Stankov & Roberts, 1997) and planning (Naglieri & Das, 2002). Some researchers refer to the functions of \( g \) from different perspectives. Spearman (1923) defined \( g \) as the ability to uncover and deal with relations at different levels of complexity and
abstraction. Jensen (1984) suggested that \( g \) is associated with the neural efficiency of the cerebral cortex, which depends on the number of neurons activated by the environment and the rate of oscillation between refractory and excitatory phases of neural processes.

Sternberg (1977) argued that metacomponents such as executive functions of decision, selection, and monitoring are possible sources of \( g \). Given this dissonance, it is not easy to know whether the common cognitive characteristics of gifted students reflect all of the above definitions or functions of \( g \), or some of them, or only one of them.

Hierarchical Models of Abilities

Hierarchical models of the mind propose structures of human abilities (Carroll, 1993; Case et al., 2001; Sternberg, 1988). The models are structured by \( g \) functions, or common abilities, and domain-specific abilities. The \( g \) functions or common abilities could account for common cognitive characteristics, while the domain-specific abilities could explain domain-specific characteristics of gifted students.

Three-Stratum Theory

Carroll (1993) proposed a three-stratum theory that consists of three hierarchical factors. There are as many as 40 first-order factors. The second-order factors, which could account for domain-specific characteristics of gifted students, are fluid intelligence (reasoning, induction, etc.), crystallized intelligence (language development, verbal ability,
etc.), indeterminate combinations of factors of fluid and crystallized intelligence, broad visual perception (visualization, spatial relations, etc.), broad auditory perception, broad cognitive speediness, broad retrieval ability, and broad memory ability. Carroll found that \( g \) always emerges as either a second-order factor or a third-order factor. When a small matrix is analyzed, \( g \) appears as the second-order factor in the factor hierarchy, and when there are a large number of tests, \( g \) appears as the third-order factor. Carroll believes that \( g \) is more correlated to reasoning and induction than other factors.

Many of the cognitive characteristics of gifted students could be explained by the second-order and the third-order factors. Fluid intelligence related to reasoning and induction factors could inform the thought process-relevant characteristics; crystallized intelligence involving language and verbal factors could account for the language relevant characteristics; broad visual perception involved in visualization and spatial relation abilities could explain space-relevant or visual sensitivity-relevant characteristics; and broad cognitive speediness, broad retrieval ability, and broad memory ability could be related to the memory- and attention-relevant characteristics. However, the other characteristics cannot be explained by this model. For instance, there is not any specific characteristic of gifted students that corresponds to the broad auditory perception factor. Also, the characteristics in the sub-categories of creativity, personal sensitivity, and
leadership have no counterparts in this model. In addition, although this model argues that reasoning and induction abilities are highly correlated to \( g \) functions, it is not clear which cognitive characteristics in the thought process sub-category could be \( g \)-correspondent characteristics.

*The United Model of the Mind*

Case et al. (2001) conducted research to test what is common between the psychometric conception of the structure of the mind and the theories of cognitive development independently proposed by Case and Demetriou. They found that along with a \( g \) factor, five domain-specific factors are common to their theories. Based on their research, they presented a united model of the mind.

The united model of the mind consists of common factors and domain-specific factors. The common factors include processing efficacy and capacity as a first-order factor, and metacognition as a second-order factor. The domain-specific factors involve five factors for spatial, quantitative, causal, logical reasoning, and social-verbal thought. Processing efficacy and capacity have been considered as constraints on cognitive development by many developmental theories (Case, 1992; Demetriou & Efklides, 1998; Halford, 1988; Pascual-Leone, 1970). Metacognition has also been a focused topic in developmental psychology as a cognitive component of monitoring or regulation.
The common factors could be eligible as explanations for the origins of common cognitive characteristics of gifted students. The factor of processing efficacy and capacity could account for the memory- and attention-relevant characteristics, and the factor of metacognition could correspond to the thought process-relevant characteristics, whereas the domain-specific factors could be origins of domain-specific characteristics of gifted students. The spatial factor could account for the characteristics of the ability to solve jigsaw puzzles, visual sensitivity, or visual thinking in the thought process subcategory; the quantitative factor could explain the number-relevant characteristic; the causal and logical reasoning factors could refer to the thought process-relevant characteristics; and the social-verbal factor could explain the language- and personal sensitivity-relevant characteristics.

However, as in the three-stratum theory of Carroll (1993), the united model of the mind cannot explain leadership- and creativity-relevant characteristics. In addition, if both processing efficacy and capacity and metacognition are common factors that are supposed to explain both the memory- and attention-relevant and thought process-relevant characteristics, all gifted individuals must show a high level of thought processing and memory and attention functioning.
Triarchic Theory

Sternberg (1988) presented a triarchic theory that is constituted of three subtheories of intelligence: a componential subtheory, a contextual subtheory, and an experiential subtheory. The componential subtheory is composed of metacomponents, performance components, and knowledge-acquisition components. The contextual subtheory is made up of practical intelligence and social intelligence. The experiential subtheory has abilities to deal with novelty and to automatize information processing.

Metacomponents of the componential subtheory include the functions of (1) decision as to just what the problem is that needs to be solved, (2) selection of lower-order components, (3) selection of one or more representations or organizations of information, (4) selection of strategies for combining lower-order components, (5) decision regarding allocation of attentional resources, (6) solution monitoring, and (7) sensitivity to external feedback. Performance components involve the processes of encoding, combination, and response. Knowledge-acquisition components include selective encoding, selective combination, and selective comparison processes.

Abilities to deal with novelty and to automatize information processing are proposed as two sets of skills that may underlie intelligent behavior. The ability to deal with novelty may be one of the fluid types of abilities that has been particularly well measured.
by reasoning items such as analogies and series completions, while the ability of automatization of performance may be one of the crystallized abilities that has been measured particularly well by tests such as reading comprehension and vocabulary. Meanwhile, Sternberg (1988) regarded intelligence as mental activity directed toward purposive adaptation to, and selection and shaping of, real-world environments relevant to one’s life. He also argued that intelligence is wholly a relative construct, because the three processes of adaptation, selection, and shaping may differ across persons and groups, as well as environments. The practical and social intelligences are ones that reflect those processes of the contextual subtheory.

Metacomponents, which may be considered as general abilities responding to specific domains in the experiential and contextual subtheories, could account for the thought process-relevant characteristics. As domain-specific abilities, fluid abilities could account for the thought process-relevant characteristics; crystallized abilities and the ability to automatize the cognitive process could correspond to language-relevant characteristics; the abilities to deal with novelty could be related to the creativity-relevant characteristics; social intelligence could explain the personal sensitivity-relevant characteristics; and practical intelligence could account for one of the characteristics in the sub-category of others: “not willing to accept superficial statements, responses, or evaluation.” However,
this theory falls short in explaining the characteristics of gifted students to the full extent. The characteristics of the sub-categories of number, space, memory and attention, leadership and visual sensitivity cannot be explained by this model.

In short, $g$ theory and hierarchical structural models could explain many characteristics of gifted students. The alleged $g$-relevant abilities - reasoning and induction, metacognition, and metacomponents - could explain the thought process-relevant cognitive characteristics, and common abilities such as processing efficacy and capacity could account for the memory and attention-relevant characteristics. The domain-specific factors of the three hierarchical models are not exclusive to one model and could account for cognitive characteristics related to language, thought processes, personal sensitivity, leadership, and visual sensitivity. However, they are not sufficient to explain all the characteristics. In particular, the leadership-relevant characteristics cannot be accounted for by any of the hierarchical models. In addition, some abilities are placed contradictorily. The unified model locates the abilities of cognitive speed and memory in common functions, while the three-stratum theory places them in domain-specific functions. Furthermore, the three-stratum theory supposes $g$ functions as reasoning and induction, which belong to domain-specific functions in the unified model and in the triarchic model.
Multiple Intelligence Theory

Gardner (1983) presented Multiple Intelligence Theory (MI theory) in his book, *Frames of Mind*. He questioned intelligence as a single concept, and defined it as the ability to solve a problem or create a product that would be valued in at least one cultural setting.

Based on neurological, evolutionary, and cross-cultural evidence, he identified seven domain-specific intelligences: linguistic intelligence, musical intelligence, logical-mathematical intelligence, spatial intelligence, bodily-kinesthetic intelligence, intrapersonal intelligence and interpersonal intelligence. Gardner (1999) later suggested naturalist intelligence and spiritual intelligence as future candidates for multiple intelligences. He questioned the validity of measuring intelligence by removing a person from his or her typical context and testing his or her performance by focusing only on verbal-linguistic and logico-mathematical problem-solving skills. Gardner argued against the notion that a scientist who creates a new product is intelligent, but a musician who composes a new symphony is “talented.” He noted that such distinctions are culturally biased, value-laden, and limited to western societies by exemplifying various valued performances throughout the world such as a young master sailor in the Caroline Islands and an Iranian youth who learns by heart the entire Koran and masters the Arabic language.

Amid the controversy over the existence of a general intelligence that influences all
domains, the concept of multiple intelligences seems more compatible with the variety of
cognitive characteristics of gifted students because it can explain the quality of uniqueness
in the characteristics more reasonably. Linguistic intelligence may inform the language
related gifted characteristics; spatial intelligence may account for the characteristics of
visual thinking, visual sensitivity, or the ability to solve jigsaw puzzles; logical-
mathematical intelligence may help to explain the characteristics related to thought process
and number; and interpersonal and intrapersonal intelligences may inform the
characteristics of personal sensitivity.

However, some of the cognitive characteristics of gifted students are not explained
appropriately by the seven intelligences. It cannot be known whether there are gifted
characteristics in the sub-categories that are correspondent to musical intelligences and
bodily-kinesthetic intelligence. If so, which sub-categorized characteristics are accounted
for by such intelligences? Also, it cannot be certain which intelligences, among the seven
intelligences, could be responsible for the thought process-, leadership- and creativity-
relevant characteristics, as well as the memory- and attention-relevant characteristics.

Moreover, it is impossible for MI theory to explain common characteristics that may reflect
general abilities (or ability), because it does not account for g reasonably in the context of
the theory. It is not certain whether, given the concept of independent intelligences, the
separate intelligences share the same g, or whether there may be seven gs, one for each intelligence respectively.

The explanatory limitation of the seven intelligences for the cognitive characteristics may suggest the following. First, a reasonable account of the correlation among intelligences may be necessary. Considering Gardner’s (1983) remark that he does not know how far various intelligences actually correlate, the characteristics uninformed by any of the hypothesized seven intelligences may be explained appropriately by the relationships among the various intelligences. Second, it is necessary to explain common abilities that are involved in the seven separate intelligences. The characteristics of memory and attention are difficult to account for by the separate intelligences because there are not any specific domains for the characteristics. They may be common characteristics because the seven domains cannot be imagined without the abilities of memory and attention. The last possible suggestion is that the definitions of giftedness or identification tools for the cognitive characteristics of gifted students may not reflect well the concept of multiple intelligences. They might not have focused on individuals who are possessed of high abilities in musical and bodily-kinesthetic domains.

In brief, although MI theory looks promising in explaining the unique characteristics of gifted students, it cannot be really helpful because it is limited in its
explanatory power. The seven intelligences alone are not enough for now because all the characteristics of gifted students cannot be explained by them, even though a couple of new intelligences have been added. Also, it is not known how far the seven intelligences are independent in terms of functions; it is not certain whether some of the unexplained characteristics could be accounted for by interrelational functions among the intelligences. In addition, the concept of independent intelligence is not persuasive because there is no specific account of common qualities of human intelligence such as $g$, memory and attention.

**Neo-Piagetian Developmental Theory**

Neo-Piagetian theories that premise both general and domain-specific aspects of cognitive development may be useful to identify the origins of common and domain-specific cognitive characteristics of gifted students. In the general aspects, children's cognitive development goes through three or four levels of structure (Case, 1978, 1985; Demetriou & Efklides, 1988; Fischer, 1980; Halford, 1982), and there is an upper limit to each level of structure that children can develop at any age (Case, 1974, 1985; Fischer, 1980; Halford, 1982; Pascual-Leone, 1970). In the domain-specific aspects, the development of each structure at any level is independent from each other structure, and it is highly dependent on both context and previous experience (Case, 1978, 1985; Fischer,
The general developmental stages – the sensorimotor stage, the interrelational stage, the dimensional stage, and the vectorial stage, are characterized by a recursive executive operational process in which two existing structures are coordinated into a higher order structure (Case, 1992). Structures are assembled in each stage in the same fashion. A universal sequence of three substages may be identified: the substages of unifocal, bifocal, and elaborated coordination (Case, 1992). Higher structures are assembled by the coordination of lower-order structures (Case, 1978, 1985; Fischer & Ferrar, 1988; Halford, 1982). However, these developmental processes may be limited by the size of Short-Term Storage Space (STSS) by which children can maintain multiple goals in a particular class of operations, and the space grows with age through maturation of the relevant neurological system and experience (Case, 1992). On the other hand, according to Case (1992), the intellectual development of children is presumed to be specific because development may vary with physical or cultural environments. Children’s development may be affected by the culture in which they are raised, by formal or informal instruction, by their learning history, by particular contexts in which they receive their initial exposure to particular problems, and by affective and motivational features in their own makeup or in the world around them.
The general aspects of children's intellectual development could be related to common cognitive characteristics of gifted students, while the specific aspects could explain domain-specific characteristics. The universal developmental stages are characterized by information processing elements - schematic search, schematic evaluation, re-tagging, and schematic consolidation - and working memory (Case, 1992). With regard to the characteristics of gifted students, information processing ability and working memory capacity could account for thought process- and memory- and attention-relevant characteristics, whereas domain-specific abilities have been proposed in three domains: logico-mathematical thought, social and emotional thought (including narrative), and spatial thought. Logico-mathematical thought may inform number- and thought process-relevant characteristics; social and emotional thought may be related to the characteristics of personal sensitivity; and spatial thought may be the origin of the characteristics of visual thinking, visual sensitivity, or the ability to solve jigsaw puzzles. However, the leadership- and creativity-relevant characteristics are not clearly explained in this model. Also, it is not clear whether the level of relationship that children represent and manipulate, which differentiates each stage, changes only depending on the growth of working memory capacity, because high-level operations can also be acquired by some form of instruction.

In conclusion, the issue of uniqueness of gifted cognitive characteristics suggests
that the characteristics may involve domain-specific characteristics, which often occur in specific groups of gifted individuals, as well as common characteristics that necessarily are evident in all gifted individuals. But the problem of which characteristics are common ones and which characteristics belong to domain-specific ones has not been fully solved by any of the major theories or models of human abilities: the hierarchical models of human intelligence that are presented by g researchers, the multiple intelligence theory arguing for independent, separate intelligences, and developmental theory premising both common and domain-specific aspects of cognitive development. Even the sum of the domain-specific abilities of the three models is not sufficient to account for domain-specific cognitive characteristics of gifted students. Disagreement among the theories or models of abilities as to the functions of g (or common abilities) and domain-specific abilities is regarded as one of the big barriers in identifying common and domain-specific characteristics of gifted students. The absence of accounts of interrelationships between common and domain-specific abilities in each model does not provide any evaluative persuasiveness of the validity of specific models. In addition, the problems of varied definitions of giftedness and the validity of identification tools may have added to the confusion related to common and domain-specific characteristics, because different definitions or different identification tools may have produced different cognitive characteristics that can’t be generalized to all gifted
individuals. Therefore, a more satisfactory explanation of why the cognitive characteristics of gifted students are unique and of whether they are a mix of common characteristics and domain-specific ones may be possible when the interrelationships between the alleged functions of $g$ or common abilities and the supposed domain-specific abilities are hypothesized, and when, based on the suggested relationships, the major theories or models are integrated to a degree that will account for all the cognitive characteristics of gifted students.
Chapter Three

METHOD

The study, intended to identify common and domain-specific cognitive characteristics of gifted students, was carried out in two stages. The first was to establish a new structural model that involves common and domain-specific abilities, and the second stage was to identify common and domain-specific cognitive characteristics of gifted students through the structural model. Construction of the new structural model and identification of the characteristics was done by a conceptual analysis method. The major theories or models of human abilities were analyzed and synthesized into a hierarchical structural model of abilities through identification, comparison, evaluation, and integration. Then, according to the structural model, common and domain-specific characteristics were identified through the same procedures.

The identification of common or domain-specific cognitive abilities or characteristics may be done only through finding out interrelationships between the abilities proposed by the major models, because it is not possible to identify them only by correlations obtained through statistical or content analyses that quantitative and qualitative methodologies have employed. Jensen (2002) argued that the matter of which are common and which are domain-specific cognitive abilities could be solved by a reasonable account
of overall relationships among abilities in causal rather than merely correalational terms.

Therefore, the principle of this conceptual review method was a search for interrelationships that suggest cause.

A Proposed Method of Conceptual Analysis

*Correlation and Statistical Analysis*

Statistical analyses have been used to find correlations between research variables. However, correlations do not imply interrelationships. Even high correlations do not. They may simply tell whether variables are related to each other, or how much they are related. They do not reveal how they are related in term of interrelationships. In addition, it is not easy to find accurate correlations correctly in complex situations in which a number of variables operate in a cooperative manner because they cannot be separated from one another, especially for human cognitive abilities and characteristics that cannot be directly observed or manipulated. Therefore, it is very difficult to find out how a number of cognitive abilities or characteristics are related to each other in terms of their interrelational functions through quantitative or content analyses.

*Interrelationship and Mental Analysis*

A conceptual analysis for interrelationships between stimuli (i.e., abilities and characteristics) is termed as mental analysis in this study. It may be useful in finding
interrelationships between human abilities and characteristics, because it is conducted through analytic and synthetic cognitive processes such as identifying, comparing and evaluating, and integrating based on their definitions or functions.

Mental analysis requires two levels of abilities. One is the ability on the biological level with which one can sense stimuli through experience or learning. The result of experience or learning is memory of stimuli, which is used as information in mental analysis. The other is the ability on the mental level in which one can find relationships between stimuli in memory. This ability finds relationships in two stages. Figure 3.1 shows how the mental analysis may operate with stimuli. In the first stage, it starts to find relationships between behaviors and abilities that appear in specific environments. In the second stage, it finds the relationships between the abilities and the origins of them in the cognitive system. Finally, inside the cognitive system, it finds relationships between the origins. Once the whole relationship is found, a hierarchical structure of abilities and behaviors based on the relationships may be deduced.
Unlike statistics, this method cannot be explicit because inner analytic and synthetic procedures are not observable. Instead, the efficiency of the method can be known only through its results as the abilities can be measured by their performances. The results may reflect realities in cognitive phenomena better than those of statistical analyses, because the relationships are found among stimuli that one has really experienced or learned in real situations.
In brief, the major theories or models of intelligence and the collections of characteristics of gifted students were analyzed and synthesized through conceptual analysis by the principle of interrelationship. The conceptual analysis involved both common abilities or g functions and domain-specific abilities or group factors that are proposed by the major theories or models. The abilities, functions, and factors were reorganized into a new structure of common and domain-specific abilities. Finally, common and domain-specific abilities were related to common and domain-specific cognitive characteristics of gifted students by the same principle.

Procedure of Mental Analysis

The mental analysis was carried out in two stages. The first stage was to establish a structural model of human abilities that involves common and domain-specific abilities. The second stage was to identify common and domain-specific characteristics of gifted students through the structural model.

Stage 1: Mental analysis for a hierarchical structure of human abilities

The common and domain-specific abilities that are proposed by the major theories or models of abilities were conceptually analyzed to set up a hierarchical structure of abilities. The abilities were input as information (or stimuli), and the information was processed through the following procedures of mental processing: identification,
comparison and evaluation, and integration.

Procedure 1: Identification

The abilities were identified through their definitions or functions. The proposed common abilities such as reasoning-relevant ability, hypercognition, metacomponents, the executive operations of the conceptual structure, and processing efficacy and capacity were reviewed to identify what the abilities are, how they are defined, and how they function. Also, the suggested domain-specific abilities were identified in the same way.

Procedure 2: Comparison and evaluation

The abilities were compared in terms of their definitions or functions, and evaluated in terms of possible interrelationships. The common and domain-specific abilities were compared and evaluated based on their identifications, and relationships between the abilities were suggested: whether they are similar or different in definitions or functions and how they may be interrelated.

Procedure 3: Integration

The abilities were connected by the relationships that are found through evaluation. Common and domain-specific abilities were connected by the suggested relationships between them. The results of the integration were presented as a hierarchical structural model of abilities.
Stage 2: Conceptual analysis for common and domain-specific characteristics of gifted students

The common and domain-specific abilities and the cognitive characteristics of gifted students were analyzed to establish a hierarchical structure of the characteristics of gifted students. The abilities and characteristics were input as information (or stimuli), and the information was processed through the same procedures of conceptual analysis: identification, comparison and evaluation, and integration.

Procedure 1: Identification

The abilities identified as common and domain-specific in the first stage and the characteristics identified as 10 categories in the sub-categorization were used here. The identification showed what the common and domain-specific abilities may be, how they function, what the characteristics of gifted students may be, and how they appear.

Procedure 2: Comparison and evaluation

The abilities and characteristics were compared and evaluated in terms of interrelationships. The common and domain-specific abilities and characteristics of gifted students were compared and evaluated based on their identifications, and relationships were suggested.

Procedure 3: Integration

The characteristics were connected by the relationships that are found through the
evaluation. The common and domain-specific characteristics were integrated into a hierarchical structure of cognitive characteristics of gifted students by the relationships between them. The results of the integration were presented as a hierarchical structural model of characteristics of gifted students.
Chapter Four

RESULTS

Common Cognitive Abilities and Characteristics of Gifted Students

Common Cognitive Abilities

Possible Candidates for Common Cognitive Abilities

To identify common cognitive abilities, the 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). Multiple intelligence theory (Gardner, 1983) was exempted from consideration because it posits that there is an information-processing device in each intelligence that is unique to that particular intelligence, not common across all intelligences.

Proposed common cognitive abilities in the four major theories or models are shown in Table 4.1. Case's (1992) developmental theory suggests the executive operations of different central conceptual structures - schematic search, schematic evaluation, retagging, and schematic consolidation - that are universally identified within each major developmental stage, and processing capacity. In the following section, the proposed common abilities are identified, compared, and evaluated to find
interrelationships, and then integrated.

Table 4-1 Common Cognitive Abilities in the Four Models

<table>
<thead>
<tr>
<th>g or Common Abilities</th>
<th>Three-Stratum Theory</th>
<th>United Model of the Mind</th>
<th>Triarchic Theory</th>
<th>Developmental Theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reasoning-relevant ability</td>
<td>Hypercognition, Processing efficacy and capacity</td>
<td>Metacomponents</td>
<td>Executive Operations of Central Conceptual Structures, Processing Capacity</td>
<td></td>
</tr>
</tbody>
</table>

*Reasoning and central conceptual structures.* Reasoning and the executive operations of central conceptual structures may be the cognitive processes that find relationships between stimuli (Case, 1999; Spearman, 1923; Stankov, 2002), which are defined as information in memory, because all kinds of reasoning and the functions of the underlying mechanism of central conceptual structures are hypothesized to find relationships through information processing.

Support for the argument that reasoning is intended to find relationships comes from the cognitive processes tapped by reasoning tests. Analogical reasoning items are solved by a series of operations called encoding, inferring, mapping, and application (Sternberg, 1977). For example, take the analogical reasoning item, “Fish is to swim as bird is to [robin, fins, fly, wing, feather].” The analogy’s items are encoded; a relationship is inferred between fish and swim; mapping is performed between fish and swim; the
relation between fish and swim is applied to the third and fourth items; and then the correct answer is chosen from the answer options (Deary, 2002).

For Spearman (1923), the process of finding correct relationships between items involved three components: apprehension of experience, which means that "any lived experience tends to evoke immediately a knowing of its characters and experiencer" (p.48), education of relations, which indicates that "the mentally presenting of any two or more characters tends to evoke immediately a knowing of relation between them" (p.63), and education of correlates, which suggests that "the presenting of any character together with any relation tends to evoke immediately a knowing of the correlative characters" (p.91). Apprehension of experience may be equivalent to encoding items. It is a process of identifying items such as fish and swim from experience. Education of relations may equate to inference. It is a process of finding a relationship between fish and swim from experience. Then, the relationship is mapped and held while thinking about the items on the other side of the analogy. Education of correlates may be equal to application. It is a process of applying the previous relationship that had been mapped to a new item, bird, and relating it to fly by the same principle of relationship.

Inductive reasoning is also done by information processing to find relationships between items, for example, in an inductive reasoning item, "Which word should come
next in the following series? Penny, nickel, dime, [coin, quarter].” To solve this problem, one should identify the items from his or her experience, done through encoding or apprehension of experience. Then he or she should find a relationship between items - a process of inference, or education of relations. Once the relationship is mapped, he or she should apply it to new items, and select one that is related to the previous ones by the same principle of the relationship found between the previous items - a process of application or education of correlates.

In Case’s (1992) developmental theory, the executive operations that occur in a recursive manner in each developmental substage of a central conceptual structure may also be intended to find relationships between stimuli. According to Case, in substage 1, children find a means-end relationship between two control structures. In this stage, a subtle differentiation and interleaving of the two control structures and the creation of a higher order structure takes place. In Case’s investigation of preschoolers’ understanding of a balance beam, in substage 1, children know that if they push the nearest end of the beam, the beam will go down. In substage 2, children find some sort of causal relationship between two higher order structures (i.e., pairs of actions and reactions). In this stage, global apprehension of causal relationships takes place. Children know that if they push the beam the beam will go down at its nearest end, while the other end will go
up. In substage 3, they find reversible relationships between two higher order structures.

In this stage, there may be elaboration or consolidation. Children know that if they pull one end upward, the other end will go down.

In addition, the underlying processes of the executive operations of the conceptual structures are schematic search, schematic evaluation, re-tagging, and schematic consolidation. These are common processes, occurring in many of the activities in which children engage spontaneously in their daily lives (Case, 1992). According to Case, schematic search for a second control structure, which may equate to encoding or apprehension of experience, must be conducted, while the first one remains active. Then, the utility of the combination must be apprehended, which requires schematic evaluation, which may be the counterpart of inference or education of relations. Next the two schemes must be reorganized or interleaved, so that they can be reactivated as a pair in the future. This requires re-tagging of the two structures in question, which may correspond to mapping. Finally, the reorganized pair must be changed into a smoothly running unit in its own right, which presumably requires schematic consolidation, which may be related to application or education of correlates.

In short, it can be said that the ultimate goal of reasoning and the operational processes of central conceptual structures is to find relationships between information,
and that the processes to find relationships are encoding, inferring, mapping, and application (Sternberg, 1977), or through apprehension of experience, education of relations, and education of correlates (Spearman, 1923). The procedure finally leads to discovery of relationships between stimuli, the ultimate goal of reasoning and operations of central conceptual structures.

*Hypercognition and metacomponents.* The cognitive abilities of hypercognition and metacomponents are also fundamentally related to finding relationships between stimuli. They are instrumental cognitive functions in finding relationships.

Demetriou (2002) defines hypercognition as processes and abilities used to monitor, regulate, and coordinate the functioning of the processes and abilities represented by domain-specific factors (i.e., spatial, verbal, social, numerical, causal, and logical). Sternberg (1988) defines metacomponents as higher order processes used for planning how a problem should be solved, for making decisions regarding alternative courses of action during problem solving, and for monitoring solution processes. The two terms, hypercognition and metacomponents, refer to cognitive functions such as planning, monitoring, regulation, coordinating, or controlling that are necessary for effective information processing. Also, the two terms have generally been used to explain the same functions of monitoring and regulation of information processing, along with the
functions of planning and control (Naglieri & Das, 2002) and knowledge handling (Berg & Klaczynski, 2002).

According to the theory of metacomponents (Sternberg, 1988), one has to figure out what the problem is that needs to be solved. For example, a problem may be structured (i.e., it is obvious what needs to be done to solve it) or it may be ill-structured (i.e., the problem must be founded, or set). He or she has to select a set of lower-order components to use in the solution of a given task. He or she must select any one of a number of different possible representations or organizations for information. The choice of representation or organization can facilitate or impede the efficacy with which the component operates. He or she must sequence the components in a way that facilitates task performance, decide how exhaustively each component will be used, and decide which components to execute serially and which to execute in parallel. He or she also has to decide how much time to allocate to each task component and how much time restriction will affect the quality of performance of the particular component. Individuals must keep track of what they have already done, what they are currently doing, and what they still need to do. Finally, they have to have the ability to understand feedback, to recognize its implications, and then to act upon it.

In brief, hypercognition and metacomponents may be essential for effective
reasoning through information processing that is intended to find relationships between stimuli. To find relationships, a decision has to be made as to what the problem is that needs to be solved, and appropriate selections have to be made of lower-order components, of one or more representations or organizations of information, and of a strategy for combining lower-order components. Another decision has to be made regarding allocation of attentional resources and solution monitoring has to be done. In addition, sensitivity to external feedback is necessary. Therefore, hypercognition or metacomponents may be another cognitive function that plans, regulates, or controls to increase the efficiency of reasoning done through information processing.

*Processing efficacy and capacity.* Processing efficacy and capacity, which includes processing speed, inhibition or control of processing, attention, and working memory, may play other instrumental roles in finding relationships between stimuli by facilitating reasoning done through information processing effectively.

Processing speed contributes to information processing efficiency. The higher the speed, the more efficient the processing proves to be, and this leads to better performance on many cognitive tasks (Demetriou, 2002). The correlations between reaction time and mental test scores support this. Jensen (1988) and Vernon (1983) argue that much of the association between a battery of mental tests and reaction time tests can be contributed to
general factors in both. Neubauer et al. (2000) suggested that reaction time variables have
a strong association with fluid intelligence. Jensen (1987) also argued that simple and
choice reaction time measures are substantially correlated with intelligence as measured
by the Raven's Progressive Matrices.

Efficiency of inhibition (minimizing the effects of interference) also facilitates
information processing because this makes it possible to focus on goals. Stankov and
Roberts (1997) suggested that management of attention affects speed of processing
because speeded tasks require selective attention. Marr and Sternberg (1986) found that
intellectually nongifted students spend more time attending to irrelevant information in
reasoning tests than intellectually gifted students do.

In addition, working memory capacity increases the efficiency of information
processing because more working memory capacity makes better cognitive performance
possible. Kyllonen and Christal (1990) concluded that reasoning has a very high

correlation with a latent trait from working memory subtests (i.e., digit span, mental
arithmetic, alphabet reloading and adjacent letters) in the Cognitive Abilities
Measurement (CAM; Kyllonen & Christal) battery that tests working memory, general
knowledge, processing speed, and reasoning. Tuholski, Laughlin, and Conway (1999)
suggested that there is very strong evidence for the association between working memory
and fluid intelligence.

Case's developmental theory posits that the relative synchronism of development can be explained by processing capacity. The sequence of developmental stages is related to the increase of this processing capacity with age (Case, 1985; Pascual-Leone, 1970). Processing capacity may be a biologically determined component that may limit the operations of a central structure (Case, 1992).

In brief, processing efficacy and capacity are contributors to effective reasoning that is intended to find relationships between stimuli through information processing. Speed of processing affects performance on cognitive tests; the management of attention increases the speed of processing and task performance; and processing capacity also affects the efficiency of reasoning.

A Structure of Common Cognitive Abilities

Conceptual analysis of the major theories or models of human common abilities shows that the three common cognitive abilities of reasoning, hypercognition (or metacomponents), and processing efficiency and capacity are involved in finding relationships between stimuli in daily lives or in tests (i.e., test items). All three common cognitive abilities are in instrumental positions in finding relationships. Reasoning may be a process to find relationships through information processing; hypercognition and
metacomponents may contribute to effective reasoning by controlling, regulating, and
decision-making; and processing efficacy and capacity are used to increase the efficiency
of reasoning.

The cognitive activator. Considering the instrumental positions of the three
common cognitive abilities in finding relationships, a cognitive activator that finds
relationships through the functions of the three common cognitive abilities is
hypothesized. The cognitive activator initiates reasoning to find relationships between
stimuli with the help of executive functioning.

An interrelationship between the activator and the three common abilities may
exist such that the three common cognitive functions are activated to find relationships.
(the activation level), while the three functions operate to find relationships on the
performance level. In other words, once the activator is stimulated to find relationships
between stimuli by internal or external demands, the three cognitive abilities are activated
to perform their own functions, resulting in finding relationships. Thus, the activator may
be the origin of all the functions of the three common abilities, while the three cognitive
abilities may be performance abilities that are substantially involved in finding
relationships.

Meanwhile, with regard to the interrelationships between the cognitive abilities on
the performance level, hypercognition or metacomponents may play a role of executive functioning by planning, regulating, deciding, or controlling the performance processes.

Reasoning may function as information processing by encoding, inferring, mapping, or applying. Inhibition in processing efficacy may be a part of executive functioning by controlling attention. Processing capacity may be a processing and memory space on the performance level; it may not be one of the cognitive processes that are directly involved in finding relationships, but, rather, a place for processing and storage functions. Case (1992) posited that cognitive processes may be limited by processing capacity. He conceived of processing capacity as a limited mental space in which there is a tradeoff between the space used for processing and the space used for momentary storage of the products of processing. In other words, if the mental space is inadequate, cognitive processing and storage may be impeded, which may result in failure to find relationships.

Meanwhile, speed of processing may depend on the collaboration of all of the cognitive abilities on the performance level because if any of executive functioning, processing functioning, or processing capacity does not work properly, an individual may not process information quickly, and, in turn, may not find relationships quickly or accurately in the end. Both efficient performance of executive and processing functioning and appropriate processing capacity may promote level of performance as well as the
level of processing speed. Therefore, the efficiency of information processing and the speed of processing that result in high performance may depend on all the functions on the performance level. In conclusion, there may exist a hierarchical structure in the common cognitive abilities as shown in Figure 4.1. Note that each individual actively constructs his or her own knowledge. Terms like “the activator” are used for ease of presentation. They are not meant to imply entities separate from the individual.

Figure 4.1. The functions of the activator

At first, the activator is to find relationships between stimuli by internal or external demands (i.e., daily life or tests). Next, it activates the functions on the performance level as effectively as possible for the purpose of finding relationships. It activates the executive functions such as hypercognition or metacomponents to facilitate reasoning. On one hand, it plans, regulates, controls, and decides. On the other hand, it inhibits to keep attention from being distracted from goals (see Figure 4.2).
Internal Demands

External Demands

The Activator to Find Relationships

Activation Level

Internally Activating

Externally Activating

Executive Functioning

Hypercognition or Metacomponents

Control, Regulation, Decision

Attention, Inhibition

Performance Level

Processing Capacity

Figure 4.2. Executive functioning

Then, the activator starts to find relationships between stimuli through information processing, which may be called reasoning. It encodes, infers, maps, and applies (Figure 4.3).

Figure 4.3. Processing functioning

Finally, the result may appear as performance in forming knowledge in daily life or getting correct answers in tests.
Possible Candidates for Common Cognitive Characteristics in the Three Collections

The sub-categorization of the cognitive characteristics of the three collections reviewed earlier (Clark, 2002; Silverman et al., 1986; Tuttle, 1983) identified five common cognitive characteristics: unusual curiosity, creativity, comprehension (or understanding or learning), retentiveness (or memory capacity), intensity (or persistence), sense of humor, and sense of justice. Table 4.2 shows the characteristics common to all of the three collections of cognitive characteristics of gifted students.

The candidates for the common cognitive characteristics of gifted students are defined by observable characteristics of gifted students (Clark, 2002; Silverman et al., 1986; Tuttle, 1983). However, it is not clear what the observable characteristics are for
curiosity, comprehension (or understanding, learning), sense of humor, and sense of justice.

The seven cognitive characteristics - unusual curiosity, creativity, comprehension, retentiveness, intensity, sense of humor, and sense of justice - could be possible candidates for the common characteristics of gifted individuals. They will be accounted for by the common abilities that are proposed in the structural model. The common abilities and candidates for the common characteristics will be compared and evaluated based on their identifications and connected to each other by the same interrelationships found between the common cognitive abilities.

Table 4.2 Common Characteristics in Three Collections

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Curiosity</td>
<td>Unusual curiosity</td>
<td>Unusual curiosity</td>
<td>Curious</td>
</tr>
<tr>
<td>Creativity</td>
<td>Ability to generate original ideas and solutions</td>
<td>High degree of creativity</td>
<td>Generates many ideas for a specific stimulus</td>
</tr>
<tr>
<td>Comprehension (or learning)</td>
<td>Advanced comprehension</td>
<td>Rapid learning ability</td>
<td>Understands general principles easily</td>
</tr>
<tr>
<td>Retentiveness</td>
<td>Extraordinary quantity of information and unusual retentiveness</td>
<td>Excellent memory</td>
<td>Bigger storage capacity</td>
</tr>
<tr>
<td>Intensity</td>
<td>Unusual intensity</td>
<td>Long attention span</td>
<td>Persistent in pursuit of interests and questions</td>
</tr>
<tr>
<td>Sense of humor</td>
<td>Keen sense of humor</td>
<td>Great sense of humor</td>
<td>Highly developed sense of humor</td>
</tr>
<tr>
<td>Sense of justice</td>
<td>Sense of justice</td>
<td>Concerned with justice</td>
<td>Sensitive to injustice</td>
</tr>
</tbody>
</table>
Identification of Common Cognitive Characteristics

Figure 4.5 shows the hypothesized origins of common cognitive characteristics of gifted students. First of all, unusual curiosity may originate from high ability to find relationships between stimuli, because curiosity may appear when an individual is highly motivated to find relationships between stimuli. Gifted students may be highly curious about relationships between stimuli and start to find them through the common cognitive functions on the performance level. Creativity may appear in performance because new relationships that have never been experienced or learned may be inferred. Gifted students may "generate new ideas," or new relationships between stimuli. Secondly, unusual persistence may originate from high levels of attention and inhibition abilities because persistence may be possible when information processing continues without attentional interruptions. Gifted students may show high intensity while finding relationships. They may be "goal-directed," "perseverant when interested," and show "long attention span." Thirdly, unusual retentiveness may result from high performance in finding relationships, because if they find relationships continuously, they may have an unusual number of relationships in memory. Gifted students may show the characteristics of "excellent memory," "bigger storage," and "extraordinary quantity of information." In turn, they comprehend, understand, or learn very fast because of the unusual amount of
relationships in memory. However, the senses of humor and justice may not be informed by any of the common cognitive abilities because no interrelationships are found between them and common cognitive abilities. So, these two characteristics are turned over for candidates for domain-specific characteristics.

In brief, gifted students may be highly curious and motivated to find relationships between stimuli in daily lives or in tests because of their high abilities to find relationships; they may continue to find relationships from experience in memory or infer new relationships that have never existed before in real situations; and they may be highly persistent when they try to find relationships through reasoning. Cognitive processes may result in excellent memory of the relationships found through information processing, which is unusual retentiveness. Many relationships in memory, in turn, may enable gifted students to comprehend, understand, or learn new information much faster than those who do not have many relationships in memory (Figure 4.5).
Domain-Specific Cognitive Abilities and Characteristics of Gifted Students

*Domain-Specific Cognitive Abilities*

In this section, the domain-specific abilities suggested by the major models will be identified, compared and evaluated, and integrated with the common abilities by analyzing interrelationships. In this section, Gardner’s multiple intelligence theory is included because it presents autonomous domain-specific abilities as multiple intelligences. Possible candidates will be nominated by identifying, comparing and evaluating. Later, through their relationships with common abilities, the candidates will be supplemented and integrated.
Possible Candidates for Domain-Specific Cognitive Abilities

To identify domain-specific abilities, the five major structural models of abilities will be considered: three-stratum theory (Carroll, 1993), a united model of the mind (Case et al., 2001), triarchic theory (Sternberg, 1988), developmental theory (Case, 1992), and multiple intelligence theory (Gardner, 1983). As shown in Table 4.3, comparison of the five models reveals that some domain-specific abilities are common. Language-relevant ability (i.e., verbal or linguistic) is suggested in all five models. Number-relevant ability (i.e., mathematical or quantitative) is suggested in three models – united model of the mind, Case’s developmental theory, and multiple intelligence theory. Space-relevant abilities (i.e., spatial) are proposed in four models - three-stratum theory, united model of the mind, Case’s developmental theory, and multiple intelligence theory. Sound-relevant ability (i.e., auditory perception or musical intelligence) is included in two models - three-stratum theory and multiple intelligence theory. Social or emotional relevant ability is proposed in all the models except three-stratum theory; and reasoning ability is suggested by three models - three-stratum theory, united model of the mind, and triarchic theory. On the other hand, abilities related to practical, bodily-kinesthetic, cognitive speed, retrieval, and memory abilities appear in only one model each: practical ability in triarchic theory, bodily-kinesthetic in multiple intelligence theory, and cognitive speed,
retrieval and memory ability in three-stratum theory. However, given the fact that there is no common domain-specific ability in all the five major models except language-relevant ability, and that many of the abilities are exclusive from one another, it is not possible to determine which abilities could be prospective candidates for domain-specific cognitive abilities. It is necessary to consider this problem in the interrelationship between common and domain-specific cognitive abilities because domain-specific abilities could be identified in terms of cognitive functions within their relationship with the common cognitive abilities that may be involved with all domain-specific abilities.

Table 4.3 Domain-Specific Cognitive Abilities in the Major Models

<table>
<thead>
<tr>
<th>Specific Domains</th>
<th>Three-Stratum Theory</th>
<th>United Model of the Mind</th>
<th>Triarchic Theory</th>
<th>Developmental Theory</th>
<th>MI Theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language</td>
<td>Crystallized (i.e., verbal)</td>
<td>Social-Verbal</td>
<td>Crystallized (i.e., verbal)</td>
<td>Narrative</td>
<td>Linguistic</td>
</tr>
<tr>
<td>Number</td>
<td>Quantitative</td>
<td>Spatial</td>
<td>Logico-mathematical</td>
<td>Logical-mathematical</td>
<td></td>
</tr>
<tr>
<td>Space</td>
<td>Broad visual perception (i.e., spatial relations)</td>
<td>Spatial</td>
<td>Spatial</td>
<td>Spatial</td>
<td></td>
</tr>
<tr>
<td>Sound</td>
<td>Broad auditory perception</td>
<td>Social-verbal</td>
<td>Social and emotional</td>
<td>Intrapersonal, Interpersonal</td>
<td></td>
</tr>
<tr>
<td>Social or Emotional</td>
<td>Social-verbal</td>
<td>Social</td>
<td>Social and emotional</td>
<td>Intrapersonal, Interpersonal</td>
<td></td>
</tr>
<tr>
<td>Reasoning</td>
<td>Fluid (i.e., reasoning)</td>
<td>Causal, logical reasoning</td>
<td>Fluid (i.e., reasoning)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>Broad cognitive speediness</td>
<td>Ability to deal with novelty</td>
<td></td>
<td>Bodily-kinesthetic</td>
<td></td>
</tr>
<tr>
<td>Broad retrieval ability, Broad memory ability, Indeterminate combinations of factors of fluid and crystallized intelligence</td>
<td>Ability to automatize, Practical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Considering that the common cognitive functions mentioned in the previous section may allow an individual to find relationships between stimuli through information processing, the essential factor to the common cognitive processes is stimuli. It is reasonable to think that if there is a mechanism of information processing, there should be contents "with" which the mechanism processes (Gardner, 1999). The contents may be information, namely stimuli in daily life or in tests, that are in memory. Given the empiricist premise that knowledge of the world is acquired by a process in which the sensory organs first detect stimuli in the external world, then customary patterns or conjunctions in these stimuli are detected by the mind (Case, 1999), it may be said that human sensory organs detect stimuli in the environment. Thus, it may be that domain-specific cognitive abilities are revealed through common cognitive abilities that operate on domain-specific stimuli.

Domain-specific abilities such as verbal, mathematical, and spatial abilities,
which are partially common to the major models, may be the result of common cognitive processes operating on the stimuli of language, number, and space. Language may be one of the stimuli that come into memory through the sensory organs such as the eyes for sign language, the ears for auditory language, and the fingers for Braille points. Once language comes into memory, the common cognitive mechanism is activated to process language, which may be called verbal or linguistic reasoning. Quantitative concepts (e.g., numbers) are another kind of stimuli that come through the same sensory organs as language does. Once numbers come into memory, the mechanism is activated to process numbers, which may be called mathematical reasoning. Spatial concepts (e.g., perspective, spatial orientation) are still another kind of stimuli that come through the eyes, and are processed by a common cognitive mechanism, which may be called spatial reasoning.

In addition to those stimuli already mentioned, there may be other stimuli that come through the sensory organs. Visual stimuli of objects (light and color) come through the eyes, and the common mechanism processes with stimuli, which may be called visual reasoning. This may be the visual domain-specific ability in the three-stratum theory (Carroll, 1993). The same common mechanism is applied to auditory (i.e., sounds) and tactile stimuli (i.e., sense of touch-feelings). Each process may refer to auditory reasoning
and tactile reasoning; the former may be called auditory ability in the three-stratum theory (Carroll, 1993), or musical domain-specific ability in multiple intelligence theory (Gardner, 1983), and the latter may be termed a “tactile” domain-specific ability (Stankov, 2002), which may partially constitute social domain-specific ability because it is defined by the sensitivity to feelings of mental states (Guilford, 1967; Guilford & Hoepfner, 1971).

Tactile stimuli are defined here as feelings that are perceived through senses of touch because all feelings follow touches of internal stimuli (i.e., concepts of sadness, happiness, anxiety, etc. in memory) or external phenomena (i.e., objects, wind, temperature, etc.). This is supported by the argument that perception is preceded by sensation (Arnold, 1970; Spearman, 1923). Spearman (1923) argued that all kinds of perceptions follow sensation of stimuli. The view of the second major tradition in the psychology of emotion was that feelings arise from sensations in viscera and skeletal muscles, which comes after a state of bodily arousal and not before it (Arnold, 1970). The perception of pain may result from sensation of some sorts of physical or mental pressures. This may be why linguistic reasoning (thinking with language about internal stimuli) does not accompany feelings, while tactile reasoning (along with touches of internal stimuli) results in emotional feelings. This may mean that the sensation of
internal or external stimuli may be perceived in various forms of feelings such as soft, rough, cold or hot in case of external sensation and sadness, happiness, or loneliness in case of internal sensation. Gardner’s intrapersonal intelligence may also suggest a partial evidence for this. Intrapersonal intelligence is involved chiefly in an individual’s knowledge about his or her own feelings. Given linguistic reasoning about feelings that processes with language is different from tactile reasoning that processes with feelings, it is mostly likely that people who are better at tactile reasoning may be more knowledgeable of their own feelings than those who are good at linguistic reasoning about feelings.

With regard to taste and olfactory stimuli, the abilities to taste and smell may collaborate to constitute one ability because they may not be separated from each other in real situations (i.e., cooking); one cannot taste without smelling. When the mechanism processes tastes and smells (Stankov, 2002), which may be olfactory and taste reasoning, it may be called a “taste and olfactory” domain-specific ability.

In brief, comparison of the proposed domain-specific abilities reveals that there are some commonalities: verbal (in all five models), mathematical (in three), spatial (in four), and social abilities (in four). However, it is difficult to say these abilities define domain-specific abilities because other domain-specific abilities may not be excluded.
The interrelationship between common and domain-specific abilities suggests that stimuli coming through the sensory organs determine the specific domains and their reasoning abilities: visual, auditory, taste and olfactory, and tactile abilities. Social ability is reserved for now because it doesn’t seem to be related to a single specific organ. Also, considering that language, number, and space are stimuli that come through the sensory organs, the domain-specific abilities come up to seven: linguistic, mathematical, spatial, visual, auditory, taste and olfactory, and tactile abilities. Therefore, it is suggested that people may develop linguistic, mathematical, spatial, visual, auditory, taste and olfactory, and tactile reasoning, which result in their domain-specific performances.

Meanwhile, depending on motivation, the stimuli that reasoning focuses on may vary. Practical and social intelligences that are 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 to the abilities to decode nonverbal messages in interpersonal situations (Sternberg, 1988). Thus, when reasoning is motivated by internal or external practical demands, it would be carried out 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 triarchic theory (Sternberg, 1988). However, Sternberg discusses practical intelligence at a higher level than this. He defined it as effective and successful communication with people and effective resolution of problems (Sternberg & Grigorenko, 2004). Also, when reasoning is motivated by social demands, it 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). The general executive function plans, regulates, or controls cognitive processes through hypercognition or metacomponents, in accordance with practical or social demands.

Meanwhile, considering the similar definitions of social (Case, 1992; Sternberg, 1988) and interpersonal intelligence (Gardner, 1983), in this analysis, social and interpersonal abilities are considered to share the same definition. Triarchic theory defines social intelligence as people’s abilities to decode nonverbal messages in different kinds of interpersonal situations (Sternberg, 1988); interpersonal intelligence is defined as the ability to notice and make distinctions among other individuals and, in particular, among their moods, temperaments, motivation, and intentions (Gardner, 1983).

Meanwhile, emotion and intrapersonal intelligence are also defined similarly. They are defined as the ability to understand one’s own inner states such as feelings and desires
(Case, 1992; Gardner, 1983).

A Structure of Domain-Specific Cognitive Abilities

Conceptual analysis of domain-specific cognitive abilities shows that there are two domain-specific demands - practical and social, which may be conceived of as domain feelings of directions (Shavinina & Ferrari, 2004) that make the common activator find relationships between practical or social stimuli. The domain feelings of direction were highlighted by the citation of Albert Einstein’s remarks: “During all those years there was the feeling of direction, of going straight toward something concrete. It is, of course, very hard to express that feeling in words; but it was decidedly the case, and clearly to be distinguished from later considerations about the rational form of the solution”(Shavinina & Ferrari, 2004, p.73). The domain feelings of direction are hypothesized as mental engines by which exceptional figures in history just went for their domains. Figure 4.6 shows the structure of domain-specific cognitive abilities. At the top, there are two domain feelings of directions that urge the common activator to find relationships between specific stimuli that are discovered through the executive and processing functions on the performance level. The common activator starts to find relationships between practical or social stimuli according to the domain-specific demands. The stimuli may vary with individuals or social-cultural milieu in which the
demands are individually or socially valued. On the performance level, there are seven specific domains labeled as linguistic, mathematical, spatial, visual, auditory, taste and olfactory, and tactile domains, whose stimuli are used in reasoning driven by the domain feelings of directions. Domain-specific abilities may be the result of reasoning with domain-specific stimuli initiated by the domain feelings of directions.

![Diagram of domain-specific cognitive abilities]

**Figure 4.6.** A structure of domain-specific cognitive abilities

*Domain-Specific Cognitive Characteristics of Gifted Students*

*Possible Candidates for Domain-Specific Cognitive Characteristics*

Among the 10 sub-categories (Table 2.2) of cognitive characteristics of gifted students, the three categories of creativity, thought processes, and memory and attention were assigned to common cognitive characteristics. The creativity-relevant characteristics are related to the common activator whose ability is to find relationships between stimuli,
and the thought process- and memory- and attention-relevant characteristics are considered to originate from the common performance abilities. Therefore, possible candidates for domain-specific cognitive characteristics of gifted students are those categories left: language, number, space, visual sensitivity, personal sensitivity, leadership and “others”.

Excluding “others,” the six remaining categories are defined by the behavioral characteristics of gifted students of the three collections (Clark, 2002; Silverman et al., 1986; Tuttle, 1983) as follows.

- Language is defined by the characteristics of “high level of verbal ability,” “extensive vocabulary,” “early or avid reading,” and “keen sense of humor.”
- Number is defined by the characteristic of “ability with numbers.”
- Space is defined by the characteristics of “good at jigsaw puzzles.”
- Visual sensitivity is defined by such characteristics as “keen power of observation,” “perceptive of environment,” “often responds to the environment through media and means other than print and writing.”
- Personal sensitivity is defined by the characteristics such as “heightened self-awareness,” “an evaluative approach toward self and others,” “critical of self and others,” etc.
Leadership is defined by "idealism and sense of justice," "sensitive to injustices on personal and worldwide levels," and "concerned with justice and fairness," etc. It refers to situated leadership depending on context or situation.

The six candidates could be accounted for by some of the nine domain-specific cognitive abilities: seven on the performance level such as linguistic, mathematical, spatial, visual, auditory, taste and olfactory, and tactile abilities and two on the activation level such as practical and social abilities. The six characteristics could be possible candidates for the domain-specific cognitive characteristics of gifted students. They will be accounted for by the domain-specific cognitive abilities that are proposed in the structural model. The domain-specific abilities and candidates for the domain-specific characteristics will be compared and evaluated based on their definitions or functions.

The proposed domain-specific characteristics will be connected to each other by the same interrelationships found between the domain-specific abilities.

Identification of Domain-Specific Cognitive Characteristics

On the performance level, linguistic ability could inform language-relevant characteristics. Gifted students who have high verbal ability may show characteristics such as high level of language development, extensive vocabulary, early or avid reading, or great sense of humor. The mathematical domain-specific ability could inform number-
relevant cognitive characteristics. Gifted students who do numerical reasoning very well may show the characteristic of “ability with numbers.” The spatial domain-specific ability may account for space-relevant characteristics. Gifted students who have high spatial reasoning ability may show ability to solve jigsaw puzzles (i.e., visual sensitivity to figures). The visual domain-specific ability may explain visual-relevant characteristics. Gifted students who have high visual reasoning ability may show the characteristics of visual thinking or visual sensitivity-relevant characteristics (i.e., visual sensitivities to light and color).

Auditory domain-specific ability may explain sound-relevant characteristics. Gifted students who have high auditory reasoning ability may show broad auditory perception or auditory sensitivity. The taste and olfactory domain-specific ability may correspond to taste and smell-relevant characteristics. Gifted students who have a high ability of taste and olfactory reasoning may show high level of taste and olfactory perception, or taste and olfactory sensitivities.

The term “perception” may refer to reasoning because unlike simple sensation, it may occur through information processes such as encoding or comparing in memory. While sounds, tastes, smells, and feelings may just be “sensed” on the sensory level, on the perception level they may be encoded, or compared and connected to previous stimuli.
in memory. For instance, when a kind of sound is sensed, it is encoded if it is already in memory. If it is new, it is compared with, and connected to previous auditory stimuli. The reason for the use of the term perception may be that there has not been research on reasoning with sounds, tastes and smells, and feelings. Burt (1949) differentiated simple sensory processes from complex processes of perception. Spearman (1923, 1927) also differentiated sensory sentience as a pre-cognitive process from sensory perception as a cognitive process, and argued that sensory perceptions of sound, taste, smell, etc. involve the same cognitive processes such as apprehension of experience (or appreciation of sentience), education of relations, and education of correlates, and that sensory perception even of the simplest kind does involve g. Carroll (1993) also used the term “visual (i.e., spatial relations) or auditory perception” and Stankov (2002) used “olfactory perceptual processes” instead of reasoning.

Lastly, the tactile domain-specific ability may explain feeling-relevant characteristics. Gifted students who have high tactile reasoning may show a high level of thinking with tactile perceptual processes. However, unfortunately, in the three collections of characteristics of gifted students, no cognitive characteristics that correspond to auditory, taste and olfactory, and tactile domain-specific abilities appear. The absence of those cognitive characteristics may suggest that the identification of
gifted students may have been biased in favor of verbal, mathematical, or spatial domain-specific abilities that can be measured by IQ tests. This position is supported by Gardner's criticism of the discrimination of "intelligent" and "talented" abilities (i.e., mathematics vs. music or art) (Buescher, 1985). Given general dependency on IQ test scores for identification of giftedness, the cognitive characteristics of gifted students are more likely to reflect memory, linguistic, and logical-mathematical abilities that IQ tests predominantly measure, which could be instantiated by the highly concentrated distributions of cognitive characteristics to the sub-categories of language, thought-process, and attention and memory.

On the activation level, given the definition of practical intelligence, the common activator that is practically triggered whose ability is to deal with real-world tasks successfully may explain practical characteristics such as successful adaptation to a new culture or high sensitivity to practical stimuli (i.e., labels on bottles of household goods, street maps, chart and schedules, newspapers). However, there are no equivalent cognitive characteristics in the sub-categories. Meanwhile, with the definitions of social intelligence (Case, 1992; Gardner, 1983; Sternberg, 1988), the common activator that is socially triggered and knows self and others may explain personal sensitivity-relevant characteristics. Gifted students who are highly interpersonal and intrapersonal may show
the characteristics of heightened self-awareness, an evaluative approach toward self and
others, high expectations of self and others, personal sensitivity, and criticism of self and
others.

On the other hand, leadership-relevant cognitive characteristics, which take a
large part of gifted characteristics, are left alone among the 10 sub-categories without a
counterpart ability in the hierarchical model. The counterpart ability of the leadership-
relevant characteristics could be termed as "idealistic" ability (or others that reflect
leadership-relevant characteristics) because they may be in contrast to practical
characteristics in terms of real life. The idealistic characteristics of the three collections
include idealism, sense of justice, and sensitivity to injustice on personal and worldwide
levels. Practical stimuli may refer to real things that are practical to real life, while the
leadership-relevant characteristics may be abstract ideas that are idealistic to real life.

The cognitive abilities and characteristics fundamentally refer to the same things.
Most of the abilities have been identified by tests, while the characteristics have been
identified through observation. Thus, the characteristics may reflect abilities more
realistically than tests because tests focus on limited sets of capabilities. The idealistic
characteristics of gifted students must have originated from some counterpart in the
structure of abilities because it makes sense that idealistic characteristics must come from
idealistic ability. As in the case of practical intelligence, the absence of idealistic
intelligence may result from non-identification by tests. Therefore, it may be reasonable
to add the ideal demand to the domain-specific activating level along with the practical
and social ones. As in practical or social reasoning, once the idealistic feeling of direction
urges the common activator, gifted students become curious about relationships between
idealistic stimuli such as justice and idealism, and find the relationships through
information processing.

In summary, domain-specific abilities may consist of three domain feelings of
directions on the activation level and seven abilities on the performance level. The three
feelings of direction include practical, social, and idealistic ones, and the seven
performing abilities are linguistic, mathematical, spatial, visual, auditory, taste and
olfactory, and tactile abilities. The three feelings of direction may explain the practical-,
social-, and idealistic-relevant characteristics, while the linguistic, mathematical, spatial,
and visual abilities may account for the language-, number-, space-, and visual-relevant
characteristics of gifted students. On the other hand, the auditory, taste and olfactory, and
tactile abilities have no counterparts in the characteristics of gifted students, which may
imply excessive dependency on IQ test scores for identification of gifted students. Figure
4.7 shows the structure of domain-specific abilities and characteristics of gifted students.
Domain-specific cognitive abilities are made up of three domain feelings of direction on the activation level (practical, social, and ideal) 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.

**Figure 4.8.** A hierarchical structural model of human abilities

A Hierarchical Structural Model of Cognitive Characteristics of Gifted Students

Figure 4.9 shows how cognitive characteristics are structured hierarchically and related to each other. The figure indicates that cognitive characteristics of gifted students may consist of common and domain-specific characteristics. Unusual curiosity is suggested as a common cognitive characteristic on the activation level, and unusual intensity, comprehension (or understanding or learning), creativity, and retentiveness on the performance level. On the other hand, practical-, social-, and ideal-relevant characteristics are suggested as domain-specific characteristics on the activation level,
and language-, number-, space-, and visual-relevant characteristics as domain-specific characteristics on the performance level.

![Diagram of Feelings of Direction and Activation Level]

**Figure 4.9.** Common and domain-specific cognitive characteristics of gifted students

Given the interrelationships between the common and domain-specific cognitive characteristics, there may be a hierarchical structure (Figure 4.8). The origin or activator of all the other common cognitive characteristics may be unusual curiosity about relationships between stimuli. Once the domain feelings of direction urge the common activator to find relationships, unusual curiosities may occur in gifted students. Then, when curiosities activate the performance processes to find relationships between stimuli, the characteristic of unusual intensity may appear in gifted students. When gifted students demonstrate an unusual number of relationships through high curiosity and high intensity, they may show exceptional comprehension or learning abilities. Also, gifted students may
be creative if they infer new relationships that have never been experienced or learned.

When the characteristics are related to the three sub-categorized collections of the
cognitive characteristics of gifted students, gifted students may commonly show
creativity-relevant characteristics such as unusual curiosity, wide range of interests, high
degree of creativity, ability to generate original ideas and solutions, etc. They may also
show the thought-process relevant characteristics such as advanced comprehension,
understanding general principles easily, seeing relationships among seemingly diverse
ideas, early ability to use and form conceptual frameworks, early differential patterns for
thought processing, etc. In memory and attention, they may commonly show such
characteristics as extraordinary quantity of information and unusual retentiveness,
unusual capacity for processing information, unusual intensity, long attention span,
persistence in pursuit of interests and questions, etc.

In addition to the common characteristics that may occur in all gifted students, the
domain-specific cognitive characteristics of the three collections may appear in specific
groups or individual gifted students. On the activation level, gifted students in the
practical domain may show the practical characteristics such as high adaptation to new
cultures and high sensitivity to practical stimuli (i.e., labels on bottles of household goods,
street maps, chart and schedules, newspapers). Socially gifted students may show
personal-sensitivity relevant characteristics such as heightened self-awareness, unusual
sensitivity to feelings of others, high expectations of self and others, compassion for
others, an evaluative approach toward self and others, critical of self and others, mature
judgment, and strong need for consistency between abstract values and personal actions.

Idealistically gifted students may show leadership-relevant characteristics such as
idealism and sense of justice, concern with justice and fairness, sensitivity to injustices on
personal and worldwide levels, questioning authority, preference for older companions,
and leadership in various areas.

In the next chapter, implications of the proposed model for education of gifted
students and directions for further research will be discussed.
Chapter Five

IMPLICATONS AND DIRECTIONS FOR FURTHER RESEARCH

The hierarchical model of cognitive abilities, presented as an integrated model detailing interrelationships between cognitive abilities, shows that there may be common and domain-specific cognitive abilities that explain giftedness. The implications of this model for research and education are discussed in this chapter.

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 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 concepts of “intelligence” (i.e., general intelligence (g), or multiple intelligences), common and domain-specific abilities, and empiricism and rationalism.

The common activator’s ability to find relationships between stimuli and form knowledge could be equivalent to “intelligence,” which is believed by some theorists to be a factor (g) in all kinds of domain-specific knowledge. This is supported by Spearman’s (1923) concept of g, the ability to uncover and deal with relations. In fact, there may be no domain-specific knowledge without some sort of relationship among the...
domains. This argument is congruent with Jensen's (2002) argument for the ubiquitous presence of \( g \) in all tests. Domain-specific abilities, which may be revealed by common cognitive abilities on the performance level, may suggest that the concept of multiple intelligences is flawed. All specific domain knowledge may result from the operations of the common cognitive abilities with domain-specific stimuli. That is, there exists a single intelligence but it appears as varied intelligences according to the kinds of stimuli that the intelligence processes.

The idea of a single intelligence may suggest that valid evaluation of \( g \) and the common abilities could be made only with tests or situations in which domain knowledge is tapped. That is, theoretically, if measuring intelligence, we should measure through an individual's domain knowledge. For example, intelligence of people who are highly able with auditory stimuli should be measured by such domain knowledge, even though it is not easy to do because people may not develop knowledge only about sounds due to other socially valued domains. The current idea that the domain abilities employed by IQ tests are cognitive abilities may be because linguistic and mathematical abilities are socially valued, emphasized, and educated. Abilities that are engaged by other stimuli such as space, sound, taste, smell, and feelings are also cognitive (Spearman, 1923), even though they are not as socially valued as linguistic and mathematical abilities.
Given the fact that most definitions of giftedness are closely related to high performance (or knowledge) and curiosity in specific domains, gifted students could be defined as those who are highly curious, intrinsically find relationships between specific stimuli and perform well in specific domains. Some students who have high ability to find relationships but have problems with performance abilities could be highly curious but end up with slow performance, or failure in performance, even though they are still gifted.

In practice, the common and domain-specific cognitive characteristics of gifted students that are suggested by the hierarchical model are expected to facilitate identification of gifted students in general and domain-specific ways. Teachers could identify gifted students easily by observing their cognitive characteristics shown in specific domains. Students could be identified as gifted in all specific domains primarily by the common cognitive characteristics. For instance, are they very curious about relationships between stimuli? And do they ask “why or how” very often? Are they intense when they are engaged in their domain of interest? Do they comprehend, understand, or learn basic principles of specific domain knowledge very well? Do they retain much knowledge of specific domains? Are they creative in connecting ideas by relationships?
The hierarchical model of abilities suggests that forming knowledge (or performance) may require two elements: a processing mechanism that includes the common activator and executive and processing abilities, and domain-specific motives and stimuli in memory. The processing mechanism may be useless without stimuli in memory because there would be nothing to connect through relationships. Likewise stimuli in memory alone may be helpless if there is no connection between stimuli. Neither case results in performance. This argument may be supported by both the rationalistic and empiricist points of view on human knowledge development (Case, 1999); that is, that knowledge develops by interaction between genes and environment.

The common activator and the domain feelings of directions may be genetically provided (equipped at birth), while stimuli in memory may be environmentally provided (sensed into memory from the environment). Therefore, development of domain-specific knowledge (or performance) could be influenced by social, learning, or natural environments. For instance, children who have been exposed more often to specific language and number stimuli in social or learning environments in their early childhood may be better in linguistic and mathematical reasoning later than those who have not. They might form better knowledge with language or perform better on tests. Similarly, children who are more familiar with the natural environment than with social or learning
environments may be better in spatial or visual reasoning than those who have not. This perspective is supported by Gardner’s (1983) argument that intelligences are expressed in specific tasks, domains, and disciplines and thus, they can be assessed by watching people who already are familiar with and have some skills in these pursuits. This argument is congruent with the developmental perspective that development of children’s specific abilities varies depending on culture and instruction (Case, 1992) and may account at least in part for the paradox of having people who are high in g and have very variable performance across different domains (Demetriou, 2002). Therefore, individual differences may occur not only because of the processing mechanism that might be genetically given but also because of familiarity with stimuli in the environment.

However, the functions of the domain feelings of directions may reflect the rationalistic perspective. The domain feelings of directions that are hypothesized to urge the common activator to find relationships between domain stimuli (i.e., practical, social, and ideal stimuli), may determine the kinds of stimuli in memory. This may be why some people are interested in objects or number, while others are interested in space or time in supportive or selective environments. This may be possible because the concepts of objects, number, space, and time are already equipped in the human brain. From this rationalistic perspective, environments may affect development of domain knowledge.
only when they contain specific stimuli that the genetic domain feelings of directions require. On the other hand, with a low level of specific domain feelings of direction, such domain knowledge develops in a limited fashion even in a positive environment full of such domain stimuli, except in situations in which people have to adapt to a new environment or learn specific domain knowledge because it is socially valued.

Directions for Further Research

Three directions for further research are suggested. According to the proposed hierarchical model, domain-specific abilities are hypothesized to appear as the common activator finds relationships between specific stimuli. However, it is not described in this study which stimuli are processed when the common activator is motivated by the domain feelings of directions. That is, it needs to be specified which stimuli may be engaged in practical, social, or ideal reasoning. This research may inform sub-domains that are governed by each domain’s feelings of directions and combined abilities such as artistic or musical ability that may require two or three abilities (i.e., spatial plus visual or auditory abilities). In addition, given Gardner’s (1999) argument on additional intelligences such as natural and spiritual ones, there may be other domain feelings of directions because some people are more interested in natural environments or in religion than in other domains.
Secondly, the interrelationships between common cognitive abilities suggest that high performance would result from highly cooperative functions of the abilities because any ability with critical defects could result in poor performance (i.e., wrong answer, long time spent, or failure). Therefore, another research question would be what kinds of phenomena result when any of the common abilities is unsupportive to finding relationships. The answer to this question may be helpful in determining what kinds of cognitive disabilities may result from varied defects in the common abilities. In turn, it may make it possible for educators to help disabled students develop skills and strategies to compensate for their disabilities.

Thirdly, concerning kinds of relationships such as causal and logical ones (Case et al., 2001), questions are raised: How are they different? When does the common activator find causal or logical relationships? Are there other kinds of relationships? Is this related to levels of intelligence of individuals? Could it be the reason that some people who are very sensitive to sounds are highly perceptive of sounds, while others are very sensitive to sounds but want to know the principles or functions of the sounds and develop their knowledge about sounds (i.e., acoustics).

Lastly, given that tactile reasoning is conducted with feelings that are perceived through internal tactile sensations as well as external tactile sensations, a question is
raised if people who are very good at tactile reasoning are possessed of a higher level of
tactile sensitivity than people who are not, so that they are more sensitive to feelings of
internal tactile stimuli (i.e., sadness, happiness, nervousness, etc.) as well as feelings of
external tactile stimuli (i.e., temperature, wind, touches, etc.).
References


Personality and Individual Differences, 22, 69-84.


Vernon, P. A., & Kantor, L. (1986). Reaction time correlations with intelligence test scores obtained under either timed or untimed conditions. *Intelligence*, 10, 315-330.