

# Reductionism Versus Emergentism: A Framework for Understanding Conceptions of Giftedness

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## The Nature of Giftedness: From Myth to Science

*In this article, I propose that various conceptions and theoretical models of giftedness can be understood along a continuum from the most reductionist to the most emergentist. Along with this continuum, I specify four levels of analysis based on the human functional hierarchy: the biological, operational (computational), intentional, and activity levels. I illustrate how reductionist and emergentist approaches provide contrasting views of intelligence and giftedness, with the former seeking basic elements and lower level explanations and the latter stressing complexity and higher level organization. I suggest that clearly articulating levels of analysis and principles for efforts of the reductionist or emergentist nature will enhance conceptual clarity and methodological rigor. Whether giftedness is understood in the reductionist or emergentist frameworks has many practical and policy implications for gifted education.*

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*Jennifer is a third-grade student. She has a keen interest in sciences, particularly biology. She has already shown deep insights into the workings of biology, far beyond the knowledge levels of her age peers. She also reads at a more advanced level and has access to many books in the family library. She was recently accepted to a GT program in her school district.*

How do we explain Jennifer's impressive showing of intellectual potential? Any conception of giftedness is an attempt to provide an explanatory framework, if not an explicit theory (Sternberg & Davidson, 1986), for understanding children like Jennifer. In this article, I propose a metatheoretical framework that can serve as a common basis for comparing various kinds of conceptions of giftedness. The purpose of proposing such a framework is to facilitate dialogue among researchers and practitioners of different ideological convictions regarding the nature of "giftedness." To be sure, this framework by no means claims to cover all conceptions of giftedness, such as looking at giftedness (or more accurately, the gifted education movement) as a sociological or political phenomenon (e.g., Sapon-Shevin, 1994, 1996), or as a socially constructed category that serves specific moral and practical ends (Borland, 1997, 2003). Admittedly, the framework has a scientific bias in that it attempts to uncover logic or paradigms underlying various empirical approaches to understanding giftedness as a construct that represents real psychological phenomena, natural or cultural (Simon, 1969), rather than a social fabrication or invention. Furthermore, it still adheres to the scientific doctrine that assumes that within a research community commonly accepted procedures and criteria for judging the adequacy and validity of specific knowledge claims are possible (Phillips & Burbules, 2000). Framed as such, it represents one of many possible ways of looking at giftedness and gifted education (cf. Ambrose, 2000; Coleman, Sanders, & Cross, 1997).

Although there seems to be some consensus as to what kinds and levels of behavior or performance can be properly labeled or classified as "gifted," different opinions abound as to how to explain this unique human quality. In ancient civilizations "giftedness" was seen as some form of divine intervention (Grinder, 1985). With the advances of modern science, particularly genetics and psychology, this mysterious quality has started to be demystified. However, the debates and arguments about the nature of giftedness have reemerged recently. Some champion the view of giftedness as genetically based (e.g., Gagné, 1999), while others question the empirical warrant for the "nature" argument (e.g., Howe, Davidson, & Sloboda, 1998), and still others make a strong "nurture" argument for explaining exceptional performances (e.g., Ericsson, Nandagopal, & Roring, in press).

This polarization can be understood in a larger context of the nature-nurture debate in developmental psychology. For example, Kail (2000) postulates a *developmental cascade* whereby increases in speed of processing lead to increased working memory capacity which, in turn, gives rise to human intelligence. Pascual-Leone and Johnson (2004) provide a similar neuro-biological account of the development of mental capacity and the conscious life. These more or less "nature" versions of development emphasize the primacy of biological "hardware." In the same vein, neo-nativists in contemporary developmental psychology ascribe to an *epigenesis of mind* that is content- or knowledge-rich; children are biologically predisposed to pick up certain information and have their own privileged domains and related intuitions (see Carey & Gelman, 1991).

In contrast, social constructivists, in the tradition of Vygotsky (1978), emphasize the primacy of human activities and cultural contexts in development. They argue that higher mental functions, including reasoning and logic, are enculturated through the support of cultural symbol systems, resources, and tools, thus refuting the explanation of intelligence as residing in the head, locked within the impermeable skin. According to this view, the mind is empowered by culture, and thus *transcends* the biological constraints. In other words, although the human brain ("hardware") provides the necessary apparatus for higher mental functions, cultural programs (D'Andrade, 1981, 1995) provide rich content-related resources for the mind ("software") responsible for our intelligent behavior. Moreover, culturally engendered activities can lead to biological adaptations (in the form of micro-evolution in individual development). Schlaug (2001), for example, pointed out that structural and functional adaptation occurs during the musical development of professional musicians, suggesting that the "hardware" of the brain changes along with changes in the "software" of the mind in the face of adaptive challenges and through experience and practice.

Given the contested nature of the issue, my proposed solution is to introduce the concept of *level of analysis* as a first step of intertheoretical dialogue. Level of analysis is a key concept in science when attempting to tackle a complex phenom-

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non. For example, the human system can be analyzed at the group level or individual level. An individual person can be analyzed at the psychological or biological level. A biological existence can be analyzed at the cellular or molecular level. These processes can go on and on, until one reaches the point where decomposition is no longer possible or meaningful. Any complex system can be treated as a hierarchical, multilevel system, subject to different levels of analysis and explanation. A system is hierarchical in that one element is nested within another element, differing in either temporal or physical scales and in levels of organizational complexity. For example, structural and functional properties of an organism at the cellular level can be quite different from those at the molecular level (see Wachs, 2000 for a discussion of features of General Systems Theory). At each level, various theoretical concepts are postulated, explanatory principles are articulated, and investigative techniques are developed. Consider Jennifer's case. One can look at the individual level to see what processes are involved in producing an exceptional performance (e.g., how deep insights into biology came about) and what seems to distinguish her, cognitively, emotionally, and motivationally, from her peers (i.e., what are characteristics of a typical third grader?). This is the level of analysis we are most familiar with: psychological-level explanations (see Robinson & Clinkenbeard, 1998). We might call this first-order reduction; that is, an observed individual difference phenomenon is explained in terms of psychological traits, abilities, and dispositions. Thus, giftedness can be explained as something possessed by an individual, genetically or through experience and development.

Now consider a different level of analysis. Many researchers attempt to explain the existence of superior traits, abilities, and dispositions in terms of differences in brain structures and functions (e.g., O'Boyle, 2000), and further to genetic differences (Hill et al., 1999). We might call these efforts second-order reduction, as more remote or distal biological-level causes are invoked to explain the phenomenon in question.

While the key of reductionistic approaches is to decompose, the key of emergentist approaches is to emphasize organization; that is, one can see human living systems as starting very simply (e.g., a fertilized egg or zygote) and gradually transforming into an ever more complex, multilayered, self-directed, intentional being, with emergent higher level properties (including gifts and talents) that cannot be fully explained by lower level constituents in isolation (Wachs, 2000). First, see the following description of emergent goals, skills, and motivation:

*When small children begin to play with building blocks, they rarely have a plan or a goal to guide their actions. They will place the blocks more or less randomly next to or on top of each other until some combination of shapes suggests a particular form that the children will then seek to approximate — at this point we might say that they have a "goal" or plan to direct their actions. This goal will typically change with every new block they place along the others, as new possibilities are suggested by the developing structure. The reward that keeps the children going is the feedback that tells how closely they are able to match what they do with what they want to do....Neither the goal nor the rewards could be specified in advance, because both emerge out of the interaction. (Csikszentmihalyi, 1978, p. 207)*

If one replaces "blocks" with biology, the quotation can explain Jennifer's emergent competence and interest in biology just as well. In contrast to the reductionist explanations, emergentists seek to understand Jennifer's superior reading ability and biological knowledge as emergent qualities of the cumulative interaction of her as a developing child of unique propensities and a specific impinging environment, including a topic or knowledge domain, her parents, relevant books available in the home library, and school teachers who first recognized her potential (see Robinson, 2000). Unlike reductionistic approaches which tend to attribute gifted performance to individual characteristics, emergentists argue that, to the extent Jennifer is engaged in reading and biology early on, these activities also organize and shape Jennifer's perception and cognition as well as her emotion and motivation, leading to the emergent talent (Barab & Plucker, 2002). In this sense, gifted and talented behaviors and attributes are not possessed but *achieved*.

The emergence can be understood vertically and horizontally. *Vertical or contextual emergence* means that some lower level components are *organized* into higher level emergent properties as a result of organism-environment interaction. Thus, several components or characteristics of the child and her environment may contribute to an emergent talent. *Horizontal or temporal emergence* means temporal changes and integration in behavioral and psychological characteristics as a result of organism-environment interaction. Thus, Jennifer's "gifted" behavior has a dynamic quality: some elements emerge earlier than others, and each phase of its development shows different degrees of organization and complexity (see Gruber, 1986, 1998). Vertical emergence and horizontal emergence in some way resemble emergence and epigenesis, respectively, in Simonton's (1999, in press) emergent-epigenetic theory of talent development. However, vertical emergence includes exogenous factors, such as environmental resources and support, thus differing from Simonton's emergence, which concerns mainly the possession of genetically based traits essential for a specific talent.

Although emergentism is a relatively new term in the field of gifted education, it has historical roots in British philosophy. Alexander (1920, as cited in McLaughlin, 1999) stated the principle of emergentism most succinctly: The higher level quality emerges from the lower level of existence and has its roots therein, but it emerges there from, and it does not belong to that lower level, but constitutes its possessor a new order of existence with its special laws of behavior. (p. 267)

The emergentism I depict here has a further connotation of interactionism or constructivism (in contrast to nativist views of gifts and talents) in that only by exposure and transactional experience with certain environments can specific forms of superior human potential emerge and take shape (Barab & Plucker, 2002). For instance, without the cultural invention of chess, we don't know what kind of "natural talent" Bobby Fisher or Garry Kasparov would possess. Emergentism shares a family resemblance with modern dynamic systems theory and general system theory in that both are concerned with the emergent organizational and developmental properties of a complex system that cannot be fully predicted by its initial state or lower level principles (Wachs, 2000; see also Fischer & Pare-Blagoev, 2000 for a discussion of development as a dynamic process).

# Reductionism and Emergentism as Competing Paradigms of Intellectual Functioning

Having sketched a contrasting picture of reductionism and emergentism in terms of their characteristic ways of thinking about human development in general and talent development in particular, I now attempt to explicate some basic tenets of these two competing approaches. The argument that human functioning is a complex system that can be treated as a multi-level phenomenon, amenable to different levels of analysis and subject to different levels of explanation, is not disputed by either reductionism or emergentism. Thus, for the purpose of this discussion, I suggest four levels of analysis for human functioning in general and gifted and talented behavior and performance in particular. The framework is adapted from theories of human cognitive architecture (Newell, 1990; Pylyshyn, 1984) and activity theory (Leont'ev, 1978). It is proposed to illustrate differences between reductionism and emergentism and by no means implies superiority to other conceptual frameworks of the same sort (e.g., Siegler & Kotovsky, 1986).

## The Reductionist Slant:

### Biological- and Operational-Level Analysis and Theory

As shown in Figure 1, of the four levels of analysis, the biological level is the most basic of the functioning system, because it provides an infrastructure (neuro-biological substrates) that makes higher mental functions possible (i.e., biological constraints). The operational (or computational) level provides a psychological-level description of any latent or active internal programs, modules, or operations that support goal-directed human actions (e.g., reading, reasoning, problem solving). A classical example of an operational-level theory of individual differences in intellectual functioning is Carpenter, Just, and Shell's (1990) anatomy of performance on Advanced Progressive Matrices. Operational-level properties can be innate or epigenetically pre-determined (e.g., biological intuition or perceptual speed). In that case, they have a direct connection to biology (i.e., hard-wired). Furthermore, individuals differ in the ease with which they can acquire these modules and programs. These differences are often seen as genetically and epigenetically predetermined, and thus are sine quo non of the meaning of "giftedness" (Gagné) 2004. For example, if one administers an IQ test to Jennifer and then finds she has a high IQ score, all four levels of explanations are possible. However, the field has a long history (since Terman, 1925) of giving preference to biological-

level explanations (i.e., it is largely genetically determined). Genetic researchers would argue, based on quantitative behavioral genetic research (e.g., twin studies) and molecular behavioral genetics (e.g., mapping of human genomes), that there may be a strong genetic component in Jennifer's IQ score. The psychometric tradition, informed by factor analytical technique (Carroll, 1993), sometimes coupled with analysis of cognitive components responsible for such performance (see Gustafsson & Undheim, 1996), would infer strong internal programs or fluid and crystallized abilities, with or without further inference regarding their origins (e.g., whether they are genetically or experientially based; see Cattell, 1971). Based on such biological-reductionistic or cognitive-reductionistic views, higher level explanations are derivative and epiphenomenal to lower level systems. On both counts, intentional-level or activity-level analysis does not hold any explanatory power as far as high ability or giftedness is concerned.

## The Emergentist Slant:

### Intentional-Level and Activity-Level Analysis and Explanations

Intentional-level properties are those consciously accessible mental contents such desires and intentions, and the subjective meaning and valence of an event, and self-awareness and self-knowledge. Reductionism sees subjective contents as either nonessential or sufficiently explained by the operational-level system; for example, intellectual interest is seen as derivative of individual differences in intelligence (Cattell, 1971; but see Gottfried & Gottfried, 2004 for an alternative perspective). Emergentism, however, would strongly argue for the functional autonomy of subjective contents which are engendered as an interaction of the inner environment (operational-level and biological-level properties) and the outer environment (activity-level properties), and which exert a causal influence on competence. A good example of intentional-level theory is provided by Gruber (1986), who characterizes talent development as inextricably connected with the evolving self, a progressive organization of intentions.

Activity-level descriptions constitute the largest unit of analysis, encompassing all lower levels yet adding another dimension, the functional context. According to activity theory, an activity "frames" the nature and structure of an activity regardless of individual perceived intentions and goals at the moment (Leont'ev, 1978; Oerter, 2000). In this sense, Jennifer's home environment has already shaped her intellect in a nontrivial way, long before Jennifer formed some intent to pursue an interest in biology. Furthermore, competence changes when context changes (e.g., Barab & Plucker, 2002).

In contrast to the reductionist emphasis on operational-level and biological properties, activity-level analysis stresses the primacy of experience and activity. Many operational-level modules and internal programs are acquired through experience and practice, thus having links to intentional-level (e.g., motivation) and activity-level properties (e.g., availability and accessibility of an activity or subject). An example of activity-level theory is provided by Pea (1993), who argued that intelligence is not in the head but distributed between the individual as an agent who desires and pursues an activity and the environment that provides resources and

## A Schematic Representation of Reductionist Versus Emergentist Approaches to Human Functioning

Methods	Human Functioning Hierarchy	Theory
<b>Emergentism</b> (Complex units of analysis; Multilayered, nested, higher level organization)	<i>Activity Level</i>	(e.g., Barab & Plucker, 2002)
	<i>Intentional Level</i>	(e.g., Gruber, 1986)
	<i>Operational Level</i>	(e.g., Carpenter et al., 1990)
<b>Reductionism</b> (Simple units of analysis; Decomposable, constituent, lower level components)	<i>Biological Level</i>	(e.g., Gagné, 1999)

Figure 1

support (e.g., available conceptual and technological tools) for the activity. Thus, Jennifer's ability is not an inherent property of her mind but a result of her curiosity, the desire to understand and master on the one hand, with available resources in her immediate and mediated environments on the other hand.

To further illustrate the differences between reductionist and emergentist approaches, I will discuss major theories of intelligence in terms of their leanings toward either reductionism or emergentism, as these theories are often used as theoretical foundations for the conceptions of giftedness (e.g., Sternberg, 2003; see Figure 2).

As shown in Figure 2, different theories of intelligence occupy unique niches on the reductionism-emergentism continuum. The closer a theory is to the slant of reductionism, the more emphasis the theory places on nature or genetic differences; conversely, the closer to the slant of emergentism, the more weight environmental events and contexts carry. However, the schema of four levels of analysis is "finer-grained" than the (nature/nurture) dichotomy. For example, we are able to see that Sternberg's (1985) three subtheories are distributed across different levels of analysis. The componential subtheory is reductionist, while experiential and contextual subtheories are nonreductionist or emergentist (see also Dai & Sternberg, 2004 for an integrative account of intellectual development). Cattell's (1971) theory is also distributed depending on whether it is crystallized or fluid intelligence (but cf. Lohman, 1993). Ceci's (1996) bio-ecological theory, by stressing *proximal processes* (i.e., complex, reciprocal interactions between individuals and their immediate environment) in intellectual development, is emergentist par excellence, though he acknowledges that sometimes genes can set proximal processes into motion (see Papierino, Ceci, Makel, & Williams, in press). Perkins and Grotzer's (1997) eclectic view of three types of intelligence (neural, experiential, and reflective) reflects a balanced treatment of the topic. While acknowledging the genetic influences, they nevertheless stress the role of domain-specific experience and

metacognition (i.e., managing one's own thinking), which are modulated by culture (Perkins & Ritchhart, 2004).

The schema also allows us to identify the ambiguous status of specific parts of these theories. For one, Gardner's (1983, 1993) theory, influenced by Fodor's (1983) notion of modularity (among others), assumes seven or eight independent higher-order mental functions. As these mental functions are assumed to have dedicated, hard-wired neurological mechanisms, the theory is highly reductionistic. However, Gardner (e.g., Gardner, 1997; Gardner, Hatch, & Torff, 1997) later seemed to soften this stance. Largely influenced by Csikszentmihalyi (e.g., Csikszentmihalyi & Robinson, 1986), he stressed the mediating role of symbol systems, which mediate biological proclivities and culturally defined human pursuits (i.e., domain), and the social organization of human endeavor in these domains (i.e., field) in shaping these intelligences, an apparent emergentist argument. For another, Sternberg's (1985) componential subtheory postulated metacomponents, such as problem representations and allocation of processing resources. However, it does not seem clear whether these metacomponents are subject to intentional-level control or can be activated without intention and self-awareness. By postulating this framework, clarification of these fine points is made possible.

### Reductionism and Emergentism as Differing Ways of Carving the Nature of "Giftedness"

Reductionism and emergentism can be seen as ontological (the nature of existence or being) and epistemological (the nature of knowing) convictions, or core beliefs and commitments about a specific phenomenon or construct such as "giftedness" (for a general discussion of the role of core commitments in science, see Lakatos, 1978). An example is the

organized statements made by Gagné (1999), who proposed a model in which giftedness as a natural endowment gets translated into talent or expertise through systematic training or learning activities. Living in a reductionistic world is living in a simplified world where the complexity of the world is only a façade that can be explained by relatively simple laws and principles. Physics is the most successful example of reductionism in science. It is always controversial, however, whether psychological phenomena such as giftedness are amenable to such kind of reductionism without grossly oversimplifying the matter. Living in an emergentist world means willingness to tolerate much more ambiguity and uncertainty engendered by an increasingly complex, open, and sometimes intractable system of human development.

The ontological commitment leads to differences in epistemological beliefs; that is, can higher level explanations be reduced to lower level explanations without substantial loss of information and explanatory power? Or to look at the main issue in our field, can we simplify the complex phenomenon of gift-

**A Mapping of Major Theories of Intelligence in Terms of Their Loci at Four Levels of Analysis**

Theory	Reductionism ← → Emergentism			
	Biological Level	Operational Level	Intentional Level	Activity Level
Binet (1911)		Orientation,	Adaptation, Criticism	
Cattell (1971)	Fluid intelligence	Crystallized intelligence		
Gardner (1983, 1993, 1997)	Multiple intelligences	?		
Sternberg (1985)		Componential subtheory	Experiential subtheory	Contextual subtheory
Carroll (1993)	← General abilities (e.g., GI) → Broad and narrow abilities?			
Pea (1993)	Desires	→ Affordances Resources		
Ceci (1996)	Bio	← Proximal Processes → Ecological		
Perkins & Grotzer (1997)	Neural intelligence	Experiential intelligence Reflective intelligence		

Figure 2

ed performance or potential by reducing it into simpler elements or should we maintain the integrity of complex human functioning epitomized in such a phenomenon?

Personal epistemologies of giftedness lead to different methodological preferences. Using Siegler and Kotovsky's (1986) taxonomy of psychological analysis (see Table 1), reductionists tend to prefer trait-level (at the operational and biological levels) explanations. Along with the tradition of differential psychology, reductionists in the field think of giftedness in terms of a very small subset of the population, based on cross-sectional distributions on some key measures of intelligence (Lohman, 2001). Giftedness is thus defined as the possession of a certain trait or a constellation of traits, which in turn may have biological roots. The task of researchers is to map out those traits. Since traits by nature are stable and displayed across situations, reductionists prefer simple research designs such as causal-comparative design, which enables them to map out discrete components, intellectual or "nonintellectual." An overwhelming majority of the research in the field is conducted in this manner (see Robinson & Clindenbeard, 1998; Steiner & Carr, 2003 for reviews).

### Levels of analysis of giftedness adapted from Siegler and Kotovsky (1986, p. 424)

- I. Elementary information processes (EIP; e.g., encoding, rate of retrieval)
- II. Processes that operate on products of EIPs (e.g., selective combination, inhibition)
- III. Rules and strategies (e.g., faster learning from experience, innovative in strategy use)
- IV. Trait-level description (e.g., intelligence, metacognition, high need for achievement)

**Note.** Note that this taxonomy of levels of analysis is largely based on the grain size and timescale of behavior or performance, thus differing from the one I propose in the article.

Table 1

Emergentists, on the other hand, prefer *situated* analysis of proximal processes (Ceci, 1996), a more up-close look at the human potential in authentic context (Barab & Plucker, 2002). What they obtain is a more intimate look at intentional- and activity-level experiences. Since they believe in the dynamism of human functioning, they prefer larger, complex units of analysis, often including functional contexts and adhering to the holistic principle of human functioning. This difference echoes what Tannenbaum (1997) recently labeled as static versus dynamic conceptions of various dimensions of giftedness. By emphasizing the dynamic nature of performance, emergentists emphasize doing and the making of giftedness in specific functional contexts rather than treating giftedness as an absolute state of being (i.e., a trait or a unique configuration of multiple traits for a specific form of giftedness). Parsing genetic and environmental variations in terms of percentage of the variance in intelligence measures explained by genetics versus environment would be meaningless for emergentists because at the individual level, gene expressions are always mediated through the environmental experiences. Once mediated, they have their unique forms of organization and structural and functional properties, no longer the raw genetic materials.

## Reductionism and Emergentism as Conceptual and Research Tools

An apparent advantage of reductionism is its simplicity. When many explanations are possible, one goes with the simple, most parsimonious one. As a revealing historical anecdote, Darwin rebutted Galton's *Hereditary Genius* by arguing that "men did not differ much in intellect, only in zeal and hard work," and Galton commented that "the rejoinder that might be made to his remark about hard work, is that character, including the aptitude for work, is heritable like every other faculty" (cited in Gould, 1981, p. 77). However, if we accept the premise of the multilevel system of intellectual functioning and development, then Galton's reductionism seems too greedy, because many mediational steps were skipped. Besides, Galton's view of genetic inheritance of psychological traits has proved primitive and oversimplistic (see Simonton, in press; see also Plomin, DeFries, Craig, & McGuffin, 2003; Plomin & Walker, 2003).

I suggest that both reductionist and emergentist approaches pay attention to *levels of analysis* when they attempt to make reduction or assert relative functional autonomy. In keeping with the practice of invoking *bridge laws* when multilevel analysis is involved in scientific analysis (McCauley, 1999), reductionist efforts should satisfy a basic *principle of sufficiency* as a bridge law; that is, lower level conditions are sufficient for higher level patterns. For example, Kyllonen and Christal (1990) found high correlations between measures of reasoning and measures of working memory. They suggested that variations of performance on reasoning tasks are almost equivalent to variations in working memory capacity. This is interlevel reduction because reasoning can be seen as an intentional-level mental action, while working memory capacity is an operational-level variable, not consciously accessible to the intentional agent. Or to use Siegler and Kotovsky's (1986) taxonomy (see Table 1), working memory is a Level I construct, while reasoning is a Level II or III construct. Kyllonen and Cristal's study then can be seen as a successful reduction, provided that the measures involved were valid. It suggests that the ability to reason is significantly constrained by the working memory capacity (see Just & Carpenter, 1992, for similar interpretations of findings on reading comprehension).

It is important to note that the sufficiency rule for reduction does not exclude other causes responsible for the observed pattern, making the knowledge claim conditional rather than universal or unconstrained. For example, with deliberate practice, people can circumvent working memory constraints by recourse to long-term working memory and retrieval of intermediate knowledge (Ericsson, 1998; Ericsson & Kintsch, 1995). A person with an average IQ can reason at a highly sophisticated level in a domain of his or her expertise (Ceci & Liker, 1986), suggesting that reasoning can be supported by domain knowledge and thus does not necessarily rely on elementary information processing strengths, such as working memory capacity. This expertise effect brings to the forefront the *principle of necessity* proposed by Sternberg (1986) as another bridge law for reduction. The principle of necessity states that an ability (e.g., working memory capacity) can have generality on a variety of performance occasions, but may or may not be *necessary* for a specific task in question. Explicitly articulating these bridge laws for reduction forces us to specify mechanisms at different levels of analysis



for higher level behavior or its development, rather than resorting to some magic explanatory power of native intelligence or "giftedness."

Reduction efforts should also distinguish two types of explanations. One type of explanation concerns individual differences (e.g., what makes one a good reader), and the other explaining normative performance (e.g., what it takes to read). For example, Lohman (1994) pointed out that attempts to reduce individual differences in cognitive ability tests (e.g., mental rotation tests) to cognitive performance components (e.g., latency) has not met with much success because they often leave large residue variances unexplained. It is possible that translating trait descriptions into process explanations may be a misinformed approach because process theory is often developed to explain general mechanisms, not individual differences. In contrast, Kosslyn et al. (2002) recommend treating general mechanisms as underlying individual differences, thus making individual difference constructs (traits or trait-like qualities) more theoretically based, rather than purely descriptive. They especially highlight general biological mechanisms as underlying psychological differences, thus bridging two levels of analysis: biology and psychology. Many reduction efforts to understanding individual differences in intellectual functioning have been made along this line. O'Boyle and his colleagues (e.g., O'Boyle, Benbow, & Alexander, 1995; Alexander, O'Boyle, & Benbow, 1996) identified unique hemispheric activation for intellectually gifted children (though they also found gender differences among gifted children; e.g., O'Boyle et al., 1995). Haier and his colleagues (Haier et al., 1988; Haier, Siegel, Tang, Abel, & Buchsbaum, 1992) found variations in glucose metabolism rate for people with high and low IQs in learning and performance. These efforts are worthwhile as they may help establish a biological basis (may or may not be based on genetic differences) for high-level functioning. Again, the principles of sufficiency and necessity should be used to understand biological constraints when specific functioning or development is concerned. It is also important not to automatically equate biological correlates of intellectual performance with biological or neural causation (Sternberg & Kaufman, 1998).

Incidentally, regarding the prevailing assumption about the genetic basis for "giftedness" in the field, it seems unlikely that we will be able to identify a common set of "gifted" genes, something equivalent to chromosome abnormality for children with Down's syndrome, although efforts in this direction have been made (e.g., Hill et al., 1999). Gershwind and Galaburda (1987) postulated a now famous developmental explanation for "the pathology of superiority," arguing that "[s]ince the influences that produce delays in the left hemisphere will lead to final greater extent of other cortical regions, this process may be a mechanism of giftedness (p. 15)." Although there might indeed be a *pathology of superiority* for some gifted children (e.g., see West, 1991, for a discussion of dyslexia, giftedness, and creativity; see also Obler & Fein, 1988), it is questionable whether every exceptional human competence has a unique underlying neurological condition. Precisely because "gifted" children as identified in education are, in fact, an extremely heterogeneous group in terms of their abilities and proclivities (Dai, Moon, & Feldhusen, 1998; Robinson & Clinkenbeard, 1998), the term "gifted" should be rid of its magic explanatory power and should only be used *descriptively*, to denote various types of exceptional performance or potential (but see Gagné, 1999, in press, for an alter-

native argument for the use of terminology and nomenclature in the field). The causal-comparative paradigm in the field (comparing the "gifted" and the "nongifted" on certain attributes of interest) is problematic, to say the least. Nothing "causal" can be determined or inferred in such descriptive research. The argument that the differences found between the "gifted" and "nongifted" groups affirm the causal role of "giftedness" is tautological.

Compared to reduction efforts, mindful emergentist endeavors are still rare in the field, although there have been many developmental accounts of gifted and talented performance (e.g., Bloom, 1985). Simonton's (1999) emergent/epigenetic model of talent development is a theoretical exposition in the spirit of emergentism, though it does not include environmental experience and support as necessary components. Feldman's (1986) conception of giftedness is the closest to the spirit of emergentism in its emphasis on "a coordination of forces, only some of which are individual qualities and characteristics" (p. 302). There are successful empirical efforts of the emergentist nature. Gruber (1986, 1998), for example, showed the power of the organization of intentions and the role of the self in transforming human knowledge and making epoch-making discoveries. Holton (1981) shows, based on his review of the history of science, that the driving force underlying new scientific findings are not pure logical deduction or induction (and related reasoning ability), but growing personal convictions about the nature of a phenomenon. Such personal convictions are thematic (what Holton called *themata* and Csikszentmihalyi called *life themes*) and subjective (or phenomenological) rather than purely rational and objective, as traditionally believed. In general, the phenomenological approach, which focuses on *lived experience* (*Lebenswelt*), stresses the irreducibility of human experiential life and intentionality (see Cross, 2003 for a critique of reductionism in the field). Thus, much exceptional human performance can be explained at the intentional level, alleviating the need to invoke lower level explanations. The burden of emergentism is to explain what are emergent qualities that can only be explained at the higher levels of the human functioning hierarchy, and why the organized whole is larger than the sum of its parts.

## Reductionism and Emergentism as Part of a Dialectical Process of Inquiry

The synthesis of the thesis (reductionism) and antithesis (emergentism) is not only possible but necessary to go beyond the biological versus cultural primacy (nature/nurture) dichotomy. Wherever reductionism (the sufficiency or necessity rules) fails, emergentism (functional autonomy, emergent new properties and new laws at the higher levels of organization) will assert itself, and vice versa. The tension between the two may help us solve some of the puzzling questions in the field. A case in point is the ambiguous status of metacognition. Metacognition, one's awareness and capability of managing one's own thought processes has long been seen as one of the hallmarks of intellectual giftedness (e.g., Robinson, Zigler, & Gallagher, 2000; Shore, 2000). Yet reductionistic efforts to pinpoint metacognitive differences between the gifted and "nongifted" have received mixed results (see Alexander, Carr, & Schwanenflugel, 1995; Kanevsky, 1995; Shore, 2000; Steiner & Carr, 2003 for

reviews). It is instructive to note that, in the developmental literature, metacognition is considered as a normative, emergent characteristic of thinking even for preschoolers (Kuhn, 1999; Karmiloff-Smith, 1992), not unique to gifted children. Here arises a critical question for defining giftedness: should we conceptualize the metacognitive differences between the two groups as quantitative or qualitative (Shore, 2000)? A further point, more pertinent to my concern with levels of analysis, is that metacognition may be subject to multiple constraints. Whether one goes "meta" may be situational, depending on task motivation (Bouffard-Bouchard, Parent, & Larivee, 1993), knowledge about the task in question (Ceci, 2003), emotional reactions to events (e.g., surprise about the discrepancies between expectations and occurrences; see Kagan, 2002), personal epistemologies and values (Kuhn, 2002), and social contextual influences (Perkins & Ritchhart, 2004). In other words, metacognition may not be a unitary construct, denoting some mental capacity. On the other hand, sometimes the lack of metacognition indeed seems to indicate an organic deficiency, a problem of capacity or structure that is not easy to remedy (for instance, in the case of mental retardation; see Campione & Brown, 1978). The question then is: does absence of a quality at the lower end of the intelligence spectrum necessarily mean an abundance at the upper end? It seems that neither emergentism nor reductionism can fully explain individual differences in metacognitive competence. Thus both have their respective role to play in understanding human potential. Ultimately, a synthesis is needed to resolve such a paradox.

### Implications of Reductionism and Emergentism for Gifted Educators

For most of us who have worked in the field of gifted education for a while, the most familiar conceptions of giftedness are reductionistic ones. Indeed, reductionistic thinking is so deeply entrenched in the field that we almost take it for granted. Therefore, emergentism provides a necessary antidote (e.g., Barab & Plucker, 2002). Consider how we make identification. If reductionism works well, then status information such as IQ test scores will provide an efficient way of identification. If emergentism holds more explanatory power, then much more consideration should be given to developmental and contextual factors when identification is made, more authentic functional contexts should be considered, and dynamic testing and assessment should be used. Action information (current performance levels and interests) may be as important as, or more important than, context-free status information, such as IQ (Lohman, in press; Renzulli & Reis, 1997). Also, consider how we design educational programming for gifted children. Reductionist models of gifted education are efficiency-focused, often run without an adequate articulation of what educational service is intended to achieve, other than providing extra educational opportunities. What the field needs are developmental models bridging the gap between schoolhouse giftedness and creative productive giftedness (Renzulli, 1986), between initially demonstrated potential to adult accomplishments (Dai & Renzulli, 2004). In essence, to argue for emergentism is to argue that giftedness reflects higher level organization of mental functions and thus cannot be merely a natural endowment. Giftedness is not a fixed state of being but a dynamic quality that is con-

stantly in the making, with new organized complexity that cannot be reduced to its constituents.

In conclusion, reductionism versus emergentism as a framework has the potential to translate ideological differences regarding the nature of giftedness into a more scholarly and intelligible discourse, guiding scientific research with more conceptual clarity and methodological rigor. Since gifted education is a practical field rather than a scientific discipline, the ultimate test of the utility of reductionist and emergentist models of giftedness is their capability of providing a sound theoretical basis for practice so that hidden or manifested potential of children like Jennifer are properly identified and nurtured to the best of our knowledge.

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