Contemporary Theories of Intelligence

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Why Intelligence?

The nature of human intelligence has been discussed and debated for literally thousands of years, from at least the time of Plato and Aristotle. One reason for its enduring character is that the development of theories and approaches to the study of intelligence has paralleled the history of psychology: A philosophical foundation, a transition to empirical methods in the late 1800s (many of which were developed to facilitate the study of intelligence), more sophisticated systems theories and measures during the 20th Century, and the development of interdisciplinary approaches and techniques over the past couple of decades.

The topic is also inherently interesting to most people. An understanding of intelligence often provides insight into people's capabilities, provides insight into why various psychological and educational interventions work for some people and not for others, and helps us grasp how affect develops differently based on individual differences in cognitive ability.

Theories of intelligence also form the basis of attempts to measure and quantify human ability and intellectual potential, with far-reaching implications for learning, program design, and team-building, among countless other areas. Although IQ testing certainly has a history of abuse and misuse (see Mackintosh, 1998), cognitive ability testing can be useful when the tests are properly administered and when the scores are properly interpreted (see A.S. Kaufman, 2009). Indeed, global IQ scores remain relatively stable during the course of an individual's lifespan and IQ substantially predicts important life outcomes, such as academic achievement and occupational performance (Deary, Strand, Smith, & Fernandes, 2007; Gottfredson, 1997; Mackintosh, 1998; Naglieri & Bornstein, 2003; Rohde & Thompson, 2007; S.B. Kaufman, Liu, McGrew, & A.S. Kaufman, 2010; Watkins, Lei, & Canivez, 2007). Of course, IQ does not predict everything equally well, and no prediction is perfect, but that does not negate the scientific and practical utility of understanding individual differences in cognitive ability. Indeed, as we discuss below, current models of intelligence emphasize specific cognitive abilities over global IQ scores.

The purpose of this chapter is to identify and critique several contemporary theories of human intelligence. In general, we attempted to identify those theories that are currently having a significant impact within the social sciences, including psychology, cognitive science and education, or those that have potential for having such an impact. With this goal in mind, we do not review classic theories of intelligence, for example the voluminous literature on Spearman's *g* or intellectual assessment. The reader is referred to several excellent overviews of these topics, including Mackintosh (1998) and A. S. Kaufman (2009).

Contemporary Theories of Intelligence

We acknowledge that there are numerous ways to organize the following information (cf. Davidson & Kemp, in press; Esping & Plucker, 2008; Gardner, Kornhaber, & Wake, 1996; Sternberg, 1990). The discussion of the following theories is roughly chronological, although somewhat arbitrary, and the reader should not infer a priority based on the order in which the material is presented.

CHC Theory (Cattell-Horn-Carroll)

The theory of intelligence that is most used in IQ tests is the CHC (Cattell-Horn-Carroll) theory, a combination of the Cattell-Horn theory of fluid and crystallized intelligence (Horn & Cattell, 1966; Horn & Hofer, 1992; Horn & Noll, 1997) and Carroll's (1993) Three-Stratum Theory. Both the Cattell-Horn and Carroll models essentially started from the same point—Spearman's (1904) *g*-factor theory; though they took different paths, they ended up with remarkably consistent conclusions about the spectrum of broad cognitive abilities. Cattell built upon Spearman's *g* to posit *two* kinds of *g:* Fluid intelligence (Gf), the ability to solve novel problems by using reasoning—believed by Cattell to be largely a function of biological and neurological factors—and Crystallized intelligence (Gc), a knowledge-based ability that is highly dependent on education and acculturation (later articulated in Horn & Cattell, 1966, 1967).

Almost from the beginning of his collaboration with Cattell, Horn believed that the psychometric data, as well as neurocognitive and developmental data, were suggesting more than just these two general abilities. Horn (1968) quickly identified four additional abilities; by the mid-1990s his model included 9 to 10 Broad Abilities (Horn, 1989; Horn & Hofer, 1992; Horn & Noll, 1997). The initial dichotomy had grown, but not in a hierarchy. Horn retained the name Gf-Gc theory, but the diverse Broad Abilities were treated as equals, not as part of any hierarchy. These included visualization (Gv), short-term memory (Gsm), long-term retrieval (Glr), and processing speed (Gs).

Carroll (1993) developed a hierarchical theory based on his in-depth survey of factor-analytic studies composed of three levels or Strata of abilities: (a) Stratum III (General), a Spearman-like *g*, which Carroll considered to be a valid construct based on overwhelming evidence from factor analysis; (b) Stratum II (Broad), composed of 8 broad factors, that correspond reasonably closely to Horn's Broad Abilities; and (c) Stratum I (Narrow), composed of about 70 fairly specific abilities, organized by the broad factor with which each is most closely associated (many relate to level of mastery, response speed, or rate of learning).

In recent years, Carroll's hierarchical theory and the Horn-Cattell Gf-Gc theory have been merged into the Cattell-Horn-Carroll or CHC theory (Flanagan, McGrew, & Ortiz, 2000; Flanagan, Ortiz, & Alfonso, 2007). The CHC theory has been particularly influential in the development of recent IQ tests, most notably the Fifth Edition of the Stanford-Binet (Roid, 2003), the Kaufman Assessment Battery for Children – Second Edition (KABC-II; A.S. Kaufman & N.L. Kaufman, 2004), and the Woodcock-Johnson – Third Edition (WJ III; Woodcock, McGrew, & Mather, 2001).

The CHC model incorporates both the concept of a general intelligence (all of the different aspects of intelligence are considered to be related to a common "*g*," although this aspect is not often emphasized; see Flanagan et al., 2007) and the concept of many different aspects of intelligence. Largely because of the influence of CHC theory, nearly all current IQ tests have shifted the historical focus from a small number of part scores to a contemporary emphasis on anywhere from 4 to 7 cognitive abilities. The debate about which is "better," one intelligence versus many aspects of intelligence, still goes on (for a review, see Sternberg & Grigorenko, 2002).

The CHC model proposes ten different broad factors of intelligence: Gf (fluid intelligence; the ability to solve novel problems, ones that don't benefit from past learning or experience), Gq (quantitative knowledge, typically math-related), Gc (crystallized intelligence; the breadth and depth of a person's accumulated knowledge of a culture and the ability to use that knowledge to solve problems), Grw (reading and writing), Gsm (short-term memory), Gv (visual processing), Ga (auditory processing), Glr (long-term storage and retrieval), Gs (processing speed), and Gt (decision speed/reaction time). Of these 10, only 7 are measured by today's IQ tests; Gq and Grw are in the domain of academic achievement, and, therefore, measured by individually-administered achievement tests, and Gt is not measured by any standardized test of anything.

The CHC theory has only two Strata: Stratum II (Broad), which consists of the 10 abilities identified above, and Stratum I (Narrow), which includes more specific abilities similar to Carroll's original theory. A Stratum reserved for a *g*-like general factor is no longer explicitly present in the model (Flanagan et al., 2007).

PASS Model

Luria's (1966, 1970, 1973) neuropsychological model, which features three Blocks or functional units, has also been applied extensively to IQ tests. According to this model, the first functional unit is responsible for focused and sustained attention. The second functional unit receives and stores information with both simultaneous and successive (or sequential) processing. Simultaneous processing is integrating information together; pieces are synthesized together much as one might appreciate a painting all at once. Successive processing is interpreting each piece of individual separately, in sequential fashion.

Luria's model was the theoretical basis of the Kaufman Assessment Battery for Children (K-ABC; A.S. Kaufman & N.L. Kaufman, 1983), specifically Luria's Block 2 distinction between Sequential and Simultaneous Processing. The key contributions of the K-ABC were, first, to finally produce an IQ test built on theory, and, second, to switch the emphasis from the *content* of the items (verbal vs. nonverbal) to the *process* that children use to solve problems (sequential vs. simultaneous). The PASS (Planning, Attention, Simultaneous, and Successive) theory is a cognitive processing theory based on the works of Luria that represents an important expansion of Luria's model to emphasize all three of the blocks and functional units, not just Block 2 (see Das, Naglieri, & Kirby, 1994, for an overview). The PASS theory is also the basis for the Cognitive Assessment System (Naglieri & Das, 1997).

Theory of Multiple Intelligences

Howard Gardner's Theory of Multiple Intelligences (MI Theory) was first published in the seminal volume, *Frames of Mind*, in 1983. This and subsequent editions of his book and theory (e.g., Gardner, 2006) stress the need for educators and psychologists to broaden their definitions of human intelligence. Gardner has defined intelligence as "an ability or set of abilities that permit an individual to solve problems or fashion products that are of consequence in a particular cultural setting" (Ramos-Ford & Gardner, 1997). MI Theory proposes eight intelligences: linguistic, logical-mathematical, spatial, bodily-kinesthetic, musical, interpersonal, intrapersonal, and naturalistic. Gardner (1999a, 1999b) has also explored the possibility of additional intelligences, including spiritual and existential intelligences.

Instead of relying primarily on traditional factor analytic analyses, Gardner based his theory on an analysis of the research literature using eight criteria, namely, (a) potential isolation by brain damage, (b) the existence of idiot savants, prodigies, and other exceptional individuals, (c) an identifiable core operation or set of operations, (d) a distinctive development history (i.e., it should be possible to differentiate experts from novices in the domain), (e) an evolutionary history and evolutionary plausibility (i.e., its precursors should be evident in less evolved species), (f) support from experimental psychological tasks, (g) support from psychometric findings, and (h) susceptibility to encoding in a symbol system (e.g., Gardner, 1997).

Gardner asserts that logical-mathematical and linguistic intelligences are overemphasized in traditional models of human intelligence, with that overemphasis carrying over to the design of teaching and curriculum in most schools (Gardner, 1993). The recent emphasis on educational accountability systems focusing on math and language achievement test scores suggests that, if anything, the bias Gardner observed remains firmly rooted in American education today.

Gardner's theory has been highly influential, especially among educators, and given both the popularity and unique approach to the study of intelligence, the frequent criticisms of the theory are not surprising. These criticisms have ranged from the philosophical (White, 2008) to the empirical (Visser, Ashton, & Vernon, 2006), from the conceptual (Jensen, 2002) to the cognitive (Lohman, 1991), with numerous, additional wide-ranging critiques (Klein, 1997).

For example, Lohman (2001) argues that *g* is largely synonymous with fluid intelligence (*gF*), which in turn represents inductive reasoning ability. Lohman also reviews evidence that a central working memory system underlies inductive reasoning ability; he therefore argues that MI Theory ignores the role of a central working memory system and thus a general inductive reasoning ability that cuts across all of the intelligences.

Another criticism of the theory relates to its validity. Even though assessments exist to test Gardner's various intelligences (e.g., Gardner, Feldman, & Krechevsky, 1998), these assessments have not been associated with high levels of psychometric validity evidence, and the evidence regarding reliability of these and similar measures is mixed (e.g., Plucker, 2000; Plucker, Callahan, & Tomchin, 1996; Visser et al., 2006).

It should be noted that Gardner has been an especially vigorous defender of MI Theory, regardless of the nature of the criticisms (e.g., Gardner, 1998). For example, in the face of consistent criticism of how MI Theory has been applied (or misapplied, as the case may be) to classroom contexts, Gardner (1995, 1998) has noted that such applications are often based on misinterpretations of the theory, and that misapplication of a theory is not necessarily conclusive evidence of the weakness of a theory.

Theory of Successful Intelligence

The theory of successful intelligence comprises four key elements (Sternberg, 1997). The first key element is that "success is attained through a balance of analytical, creative, and practical abilities" (pp. 297-298). According to Sternberg, these three abilities, in combination, are important for success in life. *Analytical intelligence* is required to solve problems and to judge the quality of ideas. Sternberg believes that most tests of general intelligence are assessing analytical intelligence. *Creative intelligence* is required to formulate good problems and solutions, and *Practical intelligence* is needed to use the ideas and analysis in an effective way in one's everyday life.

A second key element is that "intelligence is defined in terms of the ability to achieve success in life in terms of one's personal standards, within one's sociocultural context" (pp. 296-297). Sternberg argues that intelligence testing has primarily focused on the prediction of success in an academic setting. The theory of successful intelligence emphasizes the importance of going beyond just the academic sphere to account for success in whatever goals individuals (or societies) set for themselves. The third element is that "one's ability to achieve success depends on one's capitalizing on one's strengths and correcting or compensating for one's weaknesses (pp. 297-298)." The fourth key element is that "balancing of abilities is achieved to adapt to, shape, and select environments" (p. 298). Intelligence does not involve simply modifying oneself to suit the milieu (adaptation), it also involves the ability to modify the environment to suit oneself (shaping) and, sometimes, to find a new setting that is a better match to one's skills, values, or desires (selection).

Sternberg and his colleagues have achieved success in interventions designed to increase school success by improving analytical, creative, and practical skills (Stemler, Grigorenko, Jarvin, & Sternberg, 2006; Sternberg, Grigorenko, Ferrari, & Clinkenbeard, 1999; Sternberg, J.C. Kaufman, & Grigorenko, 2008). Additionally, they have shown a separation between measures of practical intelligence and analytical intelligence, although the two intelligences overlap to a certain extent (Cianciolo et al., 2006). Furthermore, their measures of creative and practical intelligence predict real world outcomes and measures of high-order cognition such as the SAT and GPA above and beyond analytical intelligence (Sternberg, 2006). However, much as with MI Theory, it still an open question about the extent to which analytical, creative, and practical forms of intelligence are correlated, load on *g*, or represent mid-stratum ‘group factors’ (Brody, 2004; Gottfredson, 2003).

Emotional Intelligence

Theories of emotional intelligence (EI) are based on the observation that individual differences exist in the extent to which individuals can reason about and use emotions to enhance thought (Salovey & Mayer, 1990). Since its inception, EI has been employed to cover a variety of traits and concepts, mixing personality traits with socioemotional abilities (Bar-On, 1997; Goleman, 1998; Petrides & Furnham, 2003), producing what Mayer et al. (2000) refer to as “mixed models” of EI. This state of affairs has spurred various critiques of EI, arguing that EI is too all-encompassing to have scientific utility (Eysenck, 2000; Locke, 2005).

Agreeing with these criticisms, Mayer, Salovey, and Caruso (2008) argue for a four-branch model of EI that offers a more precise, ability-based formulation of the construct. According to their model, EI involves the ability to (ordered from lower-level to higher-level emotional abilities): “(a) perceive emotions in oneself and others accurately, (b) use emotions to facilitate thinking, (c) understand emotions, emotional language, and the signals conveyed by emotions, and (d) manage emotions so as to attain specific goals (p. 506).” To measure these abilities, the Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT) was developed (Mayer, Salovey, & Caruso, 2002). The MSCEIT consists of eight tasks, including two tasks for each branch of the EI model.

Correct answers are identified by pooling experts (i.e., emotion researchers), which show strong agreement with each other (Mayer, Salovey, Caruso, & Sitarenios, 2003). Research suggests that the MSCEIT correlates moderately with verbal intelligence as well as the Big Five personality dimensions of Openness and Agreeableness (Brackett & Mayer, 2003; Mayer & Salovey, 1993, Petrides & Furnham, 2001; van der Zee, Thijs, & Schakel, 2002) and predicts various important outcomes such as social competence, quality of relationships, interpersonal sensitivity, work relationships, drug use, deviancy, aggressiveness, and psychiatric symptoms (see J. D. Mayer et al., 2008, and Mayer, Roberts, & Barsade, 2008). Many of these relations hold after controlling for measures of general intelligence and personality.

The EI model of Mayer, Salovey and Caruso (2000) has received various criticisms (Brody, 2004; Oatley, 2004 Oatley, 2004; Zeidner, Matthews, & Roberts, 2001; Zeidner, Roberts, & Matthews, 2004). Brody (2004) argues that the MSCEIT tests knowledge of emotions but not necessarily the ability to put the knowledge to use. Brody also questions the predictive validity of the MSCEIT, arguing that the MSCEIT does not fit the characteristics required to demonstrate adequate evidence of validity.

Speaking to this point, Schulte, Ree, & Carretta (2004) administered the MSCEIT, the Big Five personality dimensions, and a measure of general intelligence. Multiple regression analyses with all of the personality variables and *g* entered into the equation showed that a model consisting of *g*, agreeableness, and sex of the participant explained 38% of the variance in EI. Correcting for the reliability of both the EI and Agreeableness measures increased the variance-accounted-for to .81. Other studies, however, have found very weak relations between particular components of EI measures and measures of both fluid and crystallized intelligence in college samples (Barchard & Hakstian, 2004; Davies, Stankov, & Roberts, 1998; Mayer, Caruso, & Salovey, 2000; Roberts, Zeidner, & Matthews, 2001). Therefore, just like Gardner and Sternberg's theories, the extent to which EI (both a common factor and each of the specific abilities that are hypothesized to comprise EI) can provide incremental validity above and beyond general intelligence and the Big Five personality dimensions remains to be established.

Multiple Cognitive Mechanisms Approach

Recent evidence suggests that the general cognitive ability factor (*g)* may not be comprised of a single cognitive mechanism but instead is supported by multiple, interacting mechanisms that become associated with each other throughout the course of development (see Conway, in press; S.B. Kaufman et al., 2009; van der Maas et al., 2006). Three cognitive mechanisms that have received the most attention are working memory, processing speed, and explicit associative learning.

Working memory involves the ability to maintain, update, and manipulate information in the face of distraction and competing representations. Participants who score higher on working memory tasks demonstrate an increased ability to control their attention while maintaining their task goals in the presence of interference and this ability is strongly correlated with *g* (Conway, Cowan, & Bunting, 2001; Conway, Jarrold, Kane, Miyake, & Towse, 2007; Engle & Kane, 2004; Engle, Tuholski, Laughlin, & Conway, 1999; Heitz, Unsworth, & Engle, 2004; Kane, Bleckley, Conway, & Engle, 2001; Unsworth, Schrock, & Engle, 2004). There is also neurological evidence for substantial overlap between the processes evoked by measures of *g* and the processes evoked by measure of working memory: both tasks tend to activate the lateral prefrontal cortex (PFC) as well as left and right parietal regions (Duncan & Owen, 2000; Gray, Chabris, & Braver, 2003; Gray & Thompson, 2004).

Another cognitive mechanism associated with *g* is processing speed, which involves the speed at which rather simple cognitive operations can be performed. Participants with higher *g* scores tend to respond faster in simple and choice reaction time paradigms (Deary, Der, & Ford, 2001) and are faster at perceiving whether two similar line segments are the same or different, a task referred to as the inspection time task (Deary, 2000; Grudnik & Kranzler, 2001). In the Horn-Cattell theory of intelligence (Horn & Cattell, 1966), processing speed was referred to as “perceptual speed” (Gs) and in Caroll’s three-stratum theory of intelligence (Carroll, 1993), processing speed was referred to as “general speediness”. Analysis of the factor structure of the WAIS (a widely-administered IQ test) reveals that processing speed is one of four second level factors consumed by *g* (Deary 2001).

A third cognitive mechanism that has recently been associated with *g* is explicit associative learning, which involves the ability to remember and voluntarily recall specific associations between stimuli (S.B. Kaufman et al., 2009). Early studies found very weak associations between associative learning and *g* (Malmi, Underwood, & Carroll, 1979; Underwood, Boruch, & Malmi, 1978; Woodrow, 1938, 1946). These earlier findings were most likely due to the difficulty level of the associative learning tasks that were administered. Further research, using more difficult associative learning tasks involving multiple response-outcome contingencies, has shown substantial correlations with *g*, sometimes statistically independent of working memory and processing speed (Alexander & Smales, 1997; S.B. Kaufman et al., 2009; Williams & Pearlberg, 2006; Tamez, Myerson, & Hale, 2008; Williams, Myerson, & Hale, 2008).

Parieto-frontal Integration Theory

According to the parieto-frontal integration theory (P-FIT), the neural basis of intelligence is distributed throughout the brain. Jung and Haier (2007) reviewed 37 neuro-imaging studies of intelligence involving both functional and structural MRI imaging techniques and various measures of psychometric intelligence. They identified some consistency in the brain regions that relate to intelligence. Although Jung and Haier found evidence that related regions were distributed throughout the brain, they also found that brain activations relating to intelligence were mostly in the parietal and frontal regions.

The researchers identified brain region activations based on stages of information processing. In the first stage, temporal and occipital areas aid the individual in acquiring visual and auditory sensory information. These regions facilitate recognition, imagery and elaboration of visual inputs as well as analysis and elaboration of the syntax of auditory information. In the second stage, sensory results from the first stage are sent to regions in the parietal cortex for integration and abstraction. In the third stage, which consists of problem solving, evaluation, and hypothesis testing, the frontal lobes interact with the parietal areas implicated in the second stage. Once the best solution in this stage is obtained, the anterior cingulate becomes involved in the final stage to inhibit alternative responses. Jung and Haier argue that white matter, particularly the arcuate fasciculus, plays an important role in the reliable transmission of information among the various processing units, especially in moving information from the posterior to frontal regions of the brain. A major tenet of the P-FIT theory is the notion that different combinations of brain area activations can lead to the same levels of cognitive performance. Haier and Jung (2007) suggest that individual difference in cognitive strengths and weaknesses might be accounted for by an individual's unique pattern of P-FIT activations, and the white matter tracts that connect them.

The theory has had some criticism. In the review paper by Haier and Jung, 19 other researchers commented on the theory. While mostly supporting the notion of a distributed network supporting intelligence, the commentators also suggested various tests of the theory and called for more research on larger samples using more varied measures of intelligence than what has typically been studied. Some commentators also discussed linkages between the P-FIT and already existing work on cognitive development, finding both similarities and differences. Jung and Haier (2007) call for more empirical work to address the various criticisms. Indeed, since their 2007 paper, over 40 studies relating to the P-FIT theory have been published (e.g., Colom et al., 2009; Schmithorst, 2009; see Haier, in press, for a review). These have included developmental studies linking intelligence to brain development as well as work on network efficiency. This research has served both to support and extend the P-FIT. Eleven of these newer studies are included in a special issue of the journal *Intelligence* (see Haier, 2009, for an overview).

Minimal Cognitive Architecture

Based on Fodor's (1983) distinction between central processes of thought and dedicated processing input modules, M. Anderson's (1992, 2005) theory of minimal cognitive architecture integrates general and specific abilities in a developmental theory of human intelligence. According to Anderson, knowledge is acquired through two different processing routes. Route 1 involves "thoughtful problem solving", displays large individual differences and is constrained by processing speed. Anderson (2005) argues that "it is this constraint that is the basis of general intelligence and the reason why manifest specific abilities are correlated (p. 280)." The basic processing mechanism of the first route comprises two processors: verbal and spatial. These two processess should be normally distributed, uncorrelated with each other, and have their own unique explanatory powers.

In contrast, the second route for acquiring knowledge in Anderson's model is related to dedicated information processing modules. Such modules consist of the perception of three-dimensional space, syntactic parsing, phonological encoding, and theory of mind. It is this route that is linked to cognitive development as these modules undergo developmental changes in cognitive competence across the life span. Anderson (2005) argues that modular processes can be acquired through extensive practice, but that the common features of both acquired and innate modules are that they operate automatically and independently of the first route and thus are not constrained by central processing mechanisms.

The modular component of Anderson's cognitive theory is intended to allow a reconciliation between Gardner's MI Theory and notions of a general intelligence by acknowledging the importance of domain-specific abilities as well as a central basic processing mechanism. Further, Anderson believes his theory explains how low-IQ individuals can nonetheless be capable of remarkable feats and how various developmental and learning differences such as dyslexia and autism can occur in the presence of an average or even high-IQ (Anderson, 2008).

S. B. Kaufman (in press) has questioned Anderson's notion that there are few meaningful individual differences in route 2. Furthermore, S. B. Kaufman notes that Anderson does not propose more than just processing speed as a central mechanism and does not propose any domain general learning mechanisms (e.g., implicit learning, latent inhibition) underlying route 2, focusing instead on the Fodorian definition of modules. Kaufman argues that by focusing on individual differences in processing speed as underlying one information processing route, and species-typical cognitive modules with minimal individual differences underlying the other processing route, Anderson's model unnecessarily restricts the number of cognitive mechanisms that can be investigated within each information processing route.

Dual-Process Theory

The Dual-Process (DP) theory of human intelligence (Davidson, in press; S.B. Kaufman, in press; S.B. Kaufman, 2009) incorporates modern dual-process theories of cognition (see Evans & Frankish, 2009) into a theory of human intelligence. By assuming that there are meaningful individual differences in both controlled and automatic modes of thought, the theory organizes various constructs relating to human cognition that are at least partially separable and display individual differences that are meaningfully related to a wide-range of socially valued intelligent behaviors (S.B. Kaufman, 2009).

According to the theory, performance across a wide range of intelligent behaviors can be predicted through a hierarchical structure of controlled and spontaneous cognitive processes. Controlled cognitions are goal directed and draw on limited-capacity attentional resources, whereas spontaneous cognitions do not draw on the same pool of limited resources. A core tenet of the theory is that both controlled and spontaneous cognitive processes jointly determine all intelligent behaviors, although in varying degrees depending on the behavior. Further, the dual-process theory predicts that variations in spontaneous cognition will predict individual differences across a wide variety of intelligent behaviors above and beyond individual differences in controlled cognition.

Another key assumption of the dual-process theory is that abilities are not static entities but are constantly changing through the lifespan as the individual continually engages with the world. The more one engages in a mode of thought, the more that individual will develop skills in that modality, which in turn increases the desire for engaging with that skill. Another major tenet of the theory is that neither controlled nor spontaneous cognition is more important than the other, but what is important is the ability to flexibly switch mode of thought depending on the situation (for applications of this idea to creativity, see Gabora, 2003, 2010; Gabora & S. B. Kaufman, 2010; Howard-Jones & Murray, 2003; Martindale, 1995, Vartanian, 2009).

Controlled cognition is at the top of the hierarchy (alongside *spontaneous cognition)*. Controlled cognition consists of a class of cognitive processes that involve the ability and tendency across situations to think about thinking (i.e., metacognition—see Dennett, 1992; Hertzog & Robinson, 2005), reflect on prior behavior, and use that information to modify behavior and plan for the future[1]. Constructs that are part of the

[1] Note that other definitions of "controlled cognition" have been put forward (see Schneider & Shiffrin, 1977).

controlled cognition hierarchy include: central executive functioning, reflective engagement, dissociable components of central executive functioning—updating, cognitive inhibition, and mental flexibility, explicit cognitive ability (the skill sets that lies at the heart of highly *g*-loaded tasks), intellectual engagement, and elementary cognitive tasks that support explicit cognitive ability. What links all of the processes together is that they all draw on a limited pool of attentional resources.

The second main component (alongside controlled cognition) of the dual-process theory is *spontaneous cognition*. At the broadest level, individual differences in spontaneous cognition reflect the ability to acquire information automatically and the tendency to engage in spontaneous forms of cognition. For instance, whereas most people have the ability to spontaneously experience gut feelings and daydreams, there may be individual differences in the extent to which people are willing to engage with them.[2] Constructs that are part of the spontaneous cognition hierarchy include: spontaneous information acquisition abilities (implicit learning, reduced latent inhibition, etc.), spontaneous forms of engagement (affective engagement, aesthetic engagement, and fantasy engagement) and various implicit domains of mind that are universal human domains pertaining to knowledge of people, language, number, animals, music, visual images, aesthetics, or the inanimate physical world.

Other technical details about the theory, including the hierarchical nature of the model can be found in S. B. Kaufman (2009). Thus far, there is support for the theory,

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[2] The distinction between controlled and spontaneous cognition, according to the dual-process theory, is not always the same as that between conscious and unconscious cognition. Spontaneous cognitions can be either conscious, such as when an individual is aware of their vivid fantasies, or nonconscious such as when an individual feels an intuition without knowing what brought about that intuition or when an individual implicitly learns the underlying rule structure of the environment.

from different branches of psychology and neuropsychology. For instance, a recent study found that individual differences in implicit learning predict intelligent behaviors such as language learning and verbal analogical reasoning above and beyond *g* and the cognitive mechanisms underlying *g* (S.B. Kaufman et al., 2010). Since the theory is so new, however, it has not had enough time to garner much criticism or support. Davidson (in press) notes that the theory doesn't explicitly account for human intellectual development. The extent to which the various components of the DP theory increase prediction of intelligent behaviors across a wide-range of situations remains an open question.

Theories of Intelligence

Broadly speaking, we can divide the theories we have discussed into three categories. There are theories that are closely tied to the measurement of intelligence. CHC theory and the PASS model (along with Spearman's *g*) form the theoretical foundation for nearly all commercial tests of intelligence. These contemporary theories demonstrate the potential to bring psychometric, experimental, and neuroscientific research more in line with each other. For instance, the PASS model and the development of related testing instruments are explicitly tied to cutting-edge neuroscience findings. Additionally, tests based on the CHC model are also incorporating the latest research on the cognitive mechanisms related to *g*, such as working memory. Still, there is more work to be done to bring these various perspectives together. Clearly, this work is important, since both the PASS model and the CHC model have the most impact in terms of people's lives effected. Decisions about which students have a learning disability or which students are labeled ‘gifted’ are nearly always made based on these theories (S. B. Kaufman& Sternberg, 2008).

The second class of theories comprises those that have been created, in part, to respond to what is missing in traditional intelligence tests. The theories of Multiple Intelligence and Successful Intelligence argue for additional abilities (from creativity to bodily/kinesthetic ability) to be treated with the same importance as the standard analytic abilities measured by most tests. The theory of Emotional Intelligence offers an entirely new “intelligence” that some argue is as importance as traditionally-conceived intelligence.

The third class of theories (The Multiple Mechanisms Approach and the Parieto-frontal Integration, Minimal Cognitive Architecture, and Dual-Process theories) are grounded in the latest research on cognition and neuroscience. These theories, although advancing the scientific understanding of human intellectual differences, are less clearly tied to practical applications in terms of intelligence testing. This may change, however, as these theories evolve and more tests of the specific predictions of the theories are conducted in applied settings.

Looking Inside the Crystal Ball

Speculating on the future of intelligence theories is a difficult – yet intriguing – task. Throughout the history of the study of intelligence, related theories have largely reflected the emphases in psychology and even the broader society at the time. For example, it is tempting to criticize Galton’s seminal work in the late 1800s as being obsessively focused on an assumption of heredity (and more than a little social

Darwinism), but such a criticism takes Galton's work completely out of its historical and cultural context. At that time in Western society, Galton's conclusions were hardly considered revolutionary (his methods, however, were truly innovative). Viewed from this context lens, then, the current move to interdisciplinary theories that incorporate findings from psychology, cognitive science, neurology, etc., is not surprising, and we expect this trend to continue. However, we also note that truly interdisciplinary systems theories, which combine the cognitive and neurological perspectives with those from sociology, education, and related areas are not in wide circulation, and that this area appears to be a likely future direction for theories of intelligence.

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