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Multiple Intelligences, the Mozart Effect, and Emotional Intelligence: A Critical Review

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This article reviews evidence for multiple intelligences theory, the Mozart effect theory, and emotional intelligence theory and argues that despite their wide currency in education these theories lack adequate empirical support and should not be the basis for educational practice. Each theory is compared to theory counterparts in cognitive psychology and cognitive neuroscience that have better empirical support. The article considers possible reasons for the appeal of these 3 theories and concludes with a brief rationale for examining theories of cognition in the light of cognitive neuroscience research findings.

Multiple intelligences (MI) theory (Gardner, 1983), the Mozart effect (ME) theory (Rauscher, Shaw, & Ky, 1993), and emotional intelligence (EI) theory (Salovey & Mayer, 1990) have had widespread circulation in education. All three theories have been recommended for improving classroom learning (Armstrong, 1994; Campbell, 2000; Gardner, 2004; Glennon, 2000; Rettig, 2005), and all three theories have been applied in classroom activities (Elksnin & Elksnin, 2003; Graziano, Peterson, & Shaw, 1999; Hoerr, 2003).

Although MI theory (Gardner, 1983) and EI theory (Salovey & Mayer, 1990) were proposed before the emergence of public Internet use and the ME was postulated just as Internet use began to flourish (Rauscher et al., 1993), education (.edu) Web sites representing these theories have increased at 10 times the rate of increase of professional journal articles on these theories. Table 1 reports a 3-year, six time point snapshot of the increase in both professional journal articles and Web sites. Between June 1, 2003 and December 1, 2005 Google™-accessed MI .edu Web sites increased from 25,200 to 258,000, ME .edu Web sites increased from 1,082 to 12,700, and EI .edu Web sites increased from 14,700 to 220,000. By contrast, between these same two dates, Pubmed database accessed professional journal articles did not even double: MI articles increased from 12 to 17, ME articles increased from 33 to 41, and articles on EI increased from 464 to 801.

In addition to the increase in Web sites and articles outlined on Table 1, there has also been an increase in the number of education workshops on these three theories. In the 6-month period between June 1, 2005 and December 1, 2005, Google™ site:edu workshops identified for MI increased from 10,600 to 48,300, ME workshops increased from 124 to 192, and EI workshops increased from 9,180 to 45,100.

Because these three theories have wide currency in education they should be soundly supported by empirical evidence. However, unfortunately, each theory has serious problems in empirical support. This article reviews evidence for each theory and concludes that MI theory has no validating data, that the ME theory has more negative than positive findings, and that EI theory lacks a unitary empirically supported construct. Each theory is compared to theory counterparts in cognitive psychology and cognitive neuroscience that have better empirical support. The article considers possible reasons for the appeal of these three theories and closes with a brief rationale for examining theories of cognition in the light of cognitive neuroscience research findings.

MI THEORY

MI theory was first outlined by Gardner in 1983. He proposed the existence of seven distinct intelligences: linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, intrapersonal sense of self, and interpersonal. In 1999 Gardner revised his model, combining intrapersonal and interpersonal into a single intelligence and adding another intelligence, naturalistic intelligence, the empathy for, and categorization of, natural things. Gardner (1999) also proposed a possible additional intelligence, called existential intelli-

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TABLE 1
Multiple Intelligences, Mozart Effect, and Emotional Intelligence Article Abstracts Accessed From ERIC, PsycINFO, Pubmed Databases, and Web Sites Accessed Through the Search Engine Google™ and Google™ site:edu

Databases and Web Sites	*June 1, 2003*	*December 1, 2003*	*June 1, 2004*	*December 1, 2004*	*June 1, 2005*	*December 1, 2005*
Multiple intelligences citations and Web sites						
ERIC from 1982	838	883	870	954	954	977
PsycINFO from 1978	173	185	190	218	241	253
Pubmed from 1978	12	14	14	15	17	17
Google search	81,600	108,000	112,000	222,000	637,000	2,160,000
Google site:edu search	25,200	27,500	37,700	83,000	104,000	258,000
Mozart effect citations and Web sites						
ERIC from 1982	10	13	13	17	17	17
PsycINFO from 1978	22	26	30	35	37	38
Pubmed from 1978	33	35	36	37	40	41
Google search	18,900	34,200	38,400	63,800	86,000	316,000
Google site:edu search	1,082	1,310	799	782	845	12,700
Emotional intelligence citations and Web sites						
ERIC from 1982	135	167	179	196	196	217
PsycINFO from 1978	378	434	482	628	755	853
Pubmed from 1978	464	504	524	560	663	801
Google search	198,000	266,000	339,000	761,000	640,000	5,160,000
Google site:edu search	14,700	15,200	15,900	32,600	44,000	220,000

gence, the ability to see oneself "with respect to the further reaches of the cosmos … or total immersion in a work of art" (p. 60). More recently Gardner (2004) proposed two additional intelligences, the "mental searchlight intelligence" and the "laser intelligence" (p. 217). Gardner (2004) claimed that people with high IQ test scores have "a *mental searchlight,* which allows them to scan wide spaces in an efficient way thus permitting them to run society smoothly" (p. 217), whereas specialists in the arts, sciences, and trades are more likely to have a *laser intelligence* that permits them to generate "the advances (as well as the catastrophes) of society" (p. 217). Gardner has not yet theorized a connection between laser intelligence, mental searchlight intelligence, and his eight other intelligences. If he does so he will face the problem of reconciling the use of standard IQ scores as the basis for the mental searchlight intelligence while arguing that MI theory reveals the standard IQ measure to be a flawed concept (Gardner, 1983, 1999).

Gardner (1999) posited that "each intelligence comprises constituent units" (p. 103) and stated that "there are several musical, linguistic, and spatial subintelligences" (p. 103). Similarly, Gardner and Connell (2000) proposed that all eight of the intelligences are supermodules that organize 50 to 100 micromodules (p. 292). Gardner (1999) argued that specifying subintelligences "would be more accurate scientifically, but the construct would be unwieldy for educational uses" (p. 103).

Gardner (2004) asserted that his intelligences were "consistent with how most biologists think about the mind and brain" (p. 214). Gardner (1999) claimed that each intelligence operates from a separate area of the brain, arguing that "MI theory demands that linguistic processing, for example, occur via a different set of neural mechanisms than does spatial or interpersonal processing" (p. 99). Gardner (1999) further posited that if "musical and spatial processing were identically represented" in the cortexes of individuals "that fact would suggest the presence of one intelligence, and not two separate intelligences" (p. 99). Similarly, in addressing the 2004 National Dance Association meeting Gardner claimed that "parts of the brain are dedicated to the arts, and it's a shame not to develop these parts" (Hildebrand, 2004, p. 59). Gardner (1999) asserted that not only are the intelligences brain-based but they are also innate and that if tests for the intelligences were developed, "mathematical, spatial, and musical intelligences would have higher heritabilities than linguistic, naturalist, and personal intelligences" (p. 88). Gardner (1999) concluded that "accumulating neurological evidence is amazingly supportive of the general thrust of MI theory. Research supports the particular intelligences I have described" (p. 99). He also reported that neuroscientists "are in the process of homing in on the nature of core operations for each of the intelligences" (Gardner, 2004, p. 217).

The Lack of Empirical Evidence for MI Theory

To date there have been no published studies that offer evidence of the validity of the MI. In 1994 Sternberg reported finding no empirical studies. In 2000 Allix reported finding no empirical validating studies, and at that time Gardner and Connell (2000) conceded that there was "little hard evidence for MI theory" (p. 292). In 2004, Sternberg and Grigorenko stated that there were no validating studies for MI, and in 2004 Gardner asserted that he would be "delighted were such evidence to accrue" (p. 214), and he admitted that "MI theory has few enthusiasts among psychometricians or others of a traditional psychological background" because they require "psychometric or experimental evidence that allows one to prove the existence of the several intelligences" (p. 214).

Defending the Lack of Empirical Evidence for MI Theory

Chen (2004) defended MI theory against the claim that it lacks empirical support arguing that "a theory is not necessarily valuable because it is supported by the results of empirical tests" (p. 22) and that "intelligence is not a tangible object that can be measured" (p. 22). She also claimed that the novelty of the intelligences requires new measures and that MI theory has already been validated in its successful classroom application. Chen further claimed that MI theory better accounts for cognitive skill profiles in both brain-injured and typical individuals than do IQ measures.

Argument 1: Empirical evidence for MI is not necessary. Chen (2004) claimed that as the 20th century debate over scientific method showed that "the absolute objectivity of any methodology is illusory" (p. 17), therefore concern over the lack of evidence for MI theory is mistaken. However, although both Kuhn and Popper recognized that experimental methods may be subject to bias, nothing in the debate between Kuhn and Popper and their followers argued *against* the need for empirical data collection (Fuller, 2004; Nersessian, 1998). In fact, Kuhn's thesis rested on the observation that "the track records" of validating experiments are the normative basis for evaluating theories (Fuller, 2004, p. 29). MI theory has no such track record.

Argument 2: Intelligence is not a tangible object. Chen (2004) asserted that "intelligence is not a tangible object that can be measured; it is a construct that psychologists define" (p. 22). Yes, MI, like general intelligence, memory, or attention, are defined constructs and not tangible objects. However, defined constructs can be measured if they have clearly specified testable components (Allix, 2000; Ceci, 1996; Johnson & Bouchard, 2005). Although Gardner (2004) admitted that "it is important to identify defining features" (p. 214), he stated that he has not proposed testable components for the intelligences because his "basic paradigm clashes with that of psychometrics" (p. 214). Without defined components the intelligences cannot be tested for validity (Allix, 2000; Fuller, 2004).

Argument 3: MI are novel constructs requiring new measures. Chen (2004) argued that because the MI are not abilities but are instead "biological potential with an emergent, responsive, pluralistic nature" (p. 19), they can only be validated with new measures that identify "the different facets" of each intelligence as it functions over time (p. 20). However, because, as noted previously, Gardner's (2004) paradigm stands against defining testable components ("facets") for his intelligences (p. 214), this may prove difficult.

In addition, Allix (2000) argued that even if Gardner were to generate testable components, the validity of individual intelligences still could not be explored because Gardner has not specified the functional links he has theorized to exist between the intelligences. Gardner (1999) proposed that the intelligences are only "semi-independent" (p. 89), that they function together in development, that the linguistic intelligence operates by receiving input from the other intelligences (Gardner, 1983), and that there is likely to be a "Central Intelligences Agency" that "emerges from other intelligences" (Gardner, 1999, p. 106). Gardner responded to Allix (2000) that "it is difficult to specify how multiple intelligences work synergistically on complex tasks" (Gardner & Connell, 2000, p. 292).

Argument 4: MI theory has been validated by its classroom applications. Chen (2004) claimed that "MI theory can also be validated by evaluating the results of applying the theory in a range of educational settings" (p. 20), and Gardner, too, asserted that the positive outcomes of education methods based on MI can be viewed as empirical support for MI theory (Gardner, 2004, p. 214; Gardner & Connell, 2000, p. 292). However, the successful application of MI theory in education practice (Hoerr, 2003; Shearer, 2004) cannot provide a test of the validity of the intelligences because the act of applying MI theory *assumes* the validity of the intelligences. Moreover, any improvement in student learning under an MI framework is confounded with the positive effects of the novelty of a new method engendered by teacher enthusiasm and student excitement. Furthermore, it is also possible that some MI applications have been successful by serendipity, that is, they have induced improved learning because, coincidentally, some aspect of that method was effective independent of the MI framework of the application.

Argument 5: MI theory profiles cognitive skills better than do IQ subtests. Chen (2004) claimed that MI theory better accounts for cognitive skill profiles of typical students, savants, prodigies, individuals with brain injuries, and individuals in specialized professions than do IQ measures (p. 18). However, no empirical research has been published to support this claim (Allix, 2000; Chen, 2004; Gardner, 2004; Sternberg, 1994; Sternberg & Grigorenko, 2004). Equally important, Watkins and Canivez (2004) argued that IQ subtest profiles are not stable, not reliable, do not adequately discriminate "among diagnostic groups and do not covary with socially important academic and psychosocial outcomes" (p. 137). Therefore, if the discriminating power of MI cognitive skill profiles were to be empirically compared with a standard system, it should not be IQ cognitive profiles. The current standard for assessing variation in an individual's cognitive skills is a battery of valid and reliable fine-grained independent measures of specific aspects of skills such as language, perception, memory, attention, and reasoning (See Lezak, 1995, and C. R. Reynolds & Kamphaus, 2003, for examples of batteries).

Summary: The Lack of Empirical Evidence for MI Theory Remains a Problem

None of Chen's five arguments can serve to exempt MI theory from the need for validating empirical data. Nothing in the Kuhn-Popper debate suggested that theories should not be tested by experimental methods. MI are intangible theorized constructs, but, if their components are specified, they can be tested. MI may require new measures, but new measures depend on clearly defined components for the intelligences, and Gardner (1999, 2004) stated that he will not define such components. MI theory cannot be validated through application research because such research assumes the validity of the intelligences and because positive application effects may be caused by confounding independent factors such as novelty and excitement. No published research has reported that the cognitive skill profiles generated by MI are more discriminating than those generated by IQ subtests. Moreover, for reasons outlined previously, IQ subtest profiles are not an appropriate comparison, should such an empirical comparison be conducted.

Cognitive Psychology and Neuroscience Are Not Exploring MI Theory

Gardner asserted that his intelligences were developed "from an evolutionary perspective" (2004, p. 214) and were supported by research (1999, p. 99) and that neuroscientists were "in the process of homing in on the nature of core operations for each of the intelligences" (2004, p. 217). However, there are no publications from cognitive psychologists, cognitive neuroscientists, or evolutionary psychologists to suggest that they have conducted research directed at defining or validating Gardner's intelligences. Research has explored the nature of human perceptual processes such as vision, hearing, smell, and taste, but these processes have not been determined to be a *seeing intelligence*, *smelling intelligence, tactile intelligence,* or the like (Born & Bradley, 2005; Eibenstein et al., 2005; Goodwin & Wheat, 2004; J. H. Reynolds & Chelazzi, 2004). Research has also explored language skills, reading skills, music skills, mathematics skills, reasoning skills, spatial skills, and social skills, but these skills have not been found to be functioning as separate intelligences (Cacioppo & Berntson, 2004; Josse & Tzourio-Mazoyer, 2004; R. C. Martin, 2003; Miller, 1999; Parris, 2005; Peretz & Zatorre, 2005; Shafir & LeBoeuf, 2002; Singer-Dudek & Greer, 2005; see also Gazzaniga, 2004).

The majority of recent cognitive psychology, cognitive neuroscience, and evolutionary psychology research programs on human mental abilities have focused on three core explanatory paradigms for human cognition. These are general intelligence, multiple information processing systems, and adapted cognition modules.

Research Findings for General Intelligence "g" Theory

The theory of g claims that a unitary general intelligence exists that is identified by an IQ test factor g (Geake & Hansen, 2005; Johnson & Bouchard, 2005; Johnson, Bouchard, Krueger, McGue, & Gottesman, 2004; McRorie & Cooper, 2004). Gardner (1983) devised MI theory against this paradigm of a unitary general intelligence. Whether g has two forms, a *fluid* intelligence that reflects mental ability independent of culture and a *crystallized* intelligence that reflects both fluid intelligence and learning, remains a matter of empirical debate (Johnson & Bouchard, 2005). General intelligence has been theorized to reflect overall brain efficiency or the close interconnection of a set of mental skills or working memory.

There are many lines of evidence supporting a general intelligence function. Individual cognitive skills have been shown to be significantly correlated with g (Larson & Saccuzzo, 1989; Watkins & Cavinez, 2004), and g has been shown to predict intellectual performance across different sets of measures (Johnson et al., 2004). Oberauer, Schulze, Wilhelm, and Suss (2005) reported that a substantial portion of g variance is predicted by working memory skill. Colom, Rebolloa, Palaciosa, Juan-Espinosaa, and Kyllonenb (2004) reported that measures of g predicted nearly all the variance in a measure of working memory, and they concluded that g is likely to be working memory, a function of the frontal lobe of the brain that maintains and manipulates information in a limited timeframe.

Toga and Thompson (2005) reported that there is considerable evidence for the heritability of general intelligence, for the heritability of MRI-measured brain volumes, and for the significant positive correlation of IQ measures and brain volumes. McDaniel (2005) reported that a meta-analysis of 37 studies including 1,530 men and women found whole brain volume to be significantly positively correlated with full scale IQ in both men and women, but the correlation between IQ and brain volume was higher in women than in men (p. 343). This sex difference may be linked to the finding that although men, on average, have larger brains than women, women have more brain gray matter than do men (Luders et al., 2005).

Thatcher, North, and Biver (2005) reported that frontal lobe brain activity was positively correlated with IQ. Frontal lobe activity level, as measured by fMRI was also reported to be positively associated with verbal IQ (Geake and Hansen, 2005). McRorie and Cooper (2004) found that motor reaction speed of removing the hand following electric shock correlated significantly with Wechsler full scale IQ and verbal IQ and with a measure of visual search speed. Moreover, it has been argued that the number of cortical neurons combined with conduction velocity of cortical fibers is the best correlate for intelligence in phylogenetic cross-taxon comparisons (Roth & Dicke, 2005).

How do research findings for general intelligence argue against MI theory? Although the empirical evidence for general intelligence does not exclude the possibility of MI, it identifies serious difficulties for MI theory. The significant intercorrelations of IQ subskills (Johnson et al., 2004; Larson & Saccuzzo 1989; Watkins & Cavinez, 2004) argue against the possibility of discrete intelligence-by-intelligence content processing that Gardner (1999) claimed was a requirement of MI theory (p. 99). The findings for a significant positive correlation between intelligence and the size of the human brain (McDaniel, 2005; Toga & Thompson, 2005) and the level of brain activity (Geake & Hansen, 2005) argue against Gardner's (1999) criticism that g is merely the abstraction of a statistical factor (p. 14).

Equally important, because evidence has suggested that g represents working memory, and working memory is the core frontal lobe executive function (Colom et al., 2004; Oberauer et al., 2005), therefore, g is likely to be the same entity as Gardner's (1999) "Central Intelligences Agency," which he defined as the frontal lobe executive function (pp. 105–106). This stands against Gardner's (1999) assertion that "MI theory is incompatible with 'g'" (p. 87). Furthermore, evidence that g may be working memory also argues that Gardner's (2004) proposed high-IQ "mental searchlight" intelligence (p. 217) would be a high g working-memory ability. As there is nothing inherent in working memory that allows individuals "to scan wide spaces in an efficient way thus permitting them to run society smoothly" (Gardner, 2004, p. 217), the definition of the mental searchlight intelligence becomes problematic. Finally, logically, if g is a measure of working memory, then the "Central Intelligences Agency" may *be* the mental searchlight intelligence. If so, then this would need clarification.

Research Findings for Multiple Information Processing Systems

Although much research investigating possible brain processing systems has concentrated on the functions of specific regions of the brain (Born & Bradley, 2005; Squire, Craig, & Clark, 2005), research has identified two large-scale information processing pathways or processing streams in the brain. One pathway synthesizes the perceptual analyses of what we see and hear to answer the question "*What* is it?" In this processing pathway the "it" is an object, animal, person, place, or other element in our environment. The other processing pathway synthesizes the perceptual analyses of what we see, hear, and feel to answer the question "*Where* is it?" (Arnott, Binns, Grady, & Alain, 2004; Himmelbach & Karnath, 2005; Irwin & Brockmole, 2004).

These two processing pathways might themselves seem to be two "intelligences"—the "What is it?" object intelligence and the "Where is it?" place intelligence. However these processing pathways are not functionally isolated from one another. Gardner (1999) asserted that "MI theory demands that linguistic processing, for example, occur via a different set of neural mechanisms than does spatial or interpersonal processing" (p. 99), but the "What is it?" and the "Where is it?" processing pathways are interconnected. For example, Prather, Votaw, and Sathian (2004) reported that touching things activates not only the "Where is it?" pathways but also the "What is it?" processing pathway. Similarly, Himmelbach and Karnath (2005) argued that there is systematic interactive switching between the "What is it?" pathway and the "Where is it?" pathway. It has also been suggested that these two processing pathways may actually be different activity patterns of the same overall anatomical processing stream (Deco, Rolls, & Horwitz, 2004).

Cognitive neuroscience research also has reported that many other cognitive skills share brain processing pathways. Researchers reported evidence for shared and overlapping processing pathways for language and music (Koelsch et al., 2004). Norton et al. (2005) found associations between the music perceptual skills and both nonverbal reasoning and phonemic awareness in children, and they argued that these correlations suggest a shared neural substrate for language and music processing. A research review suggested that the same aggregations of subcortical neurons in basal ganglia and cerebellum, and the same aggregations of neurons in many separate cortical regions together share control of many different complex behaviors including walking, talking, gesturing, reasoning, speaking, tool-making, and comprehending the meaning of sentences (Lieberman, 2002). Evidence has been reported to suggest that brain circuits for emotions share in a distributed network of processing pathways for reasoning, memory, and action (Adolphs, Tranel, & Damasio, 2003; Morgane, Galler, & Mokler, 2005; Phelps, 2006).

The shared and overlapping brain pathways for cognitive skills may be the result of genes that determine shared pathways. Kovas, Harlaar, Petrill, and Plomin (2005) reported that "most of the genes that contribute to individual differences in mathematics ability also affect reading and g" (p. 485). The researchers argued that because reading, mathematics, and g are complex skills, therefore "a great variety of non-specific abilities, such as long-term memory, working memory and attention" (p. 485) must be involved in these skills. Kovas et al. asserted that *generalist genes* are responsible for the "genetic overlap between mathematics, reading, and g" (p. 485). They predicted that future studies will find more *generalist genes* that determine shared pathways for different forms of cognition.

In addition to the "What is it?" and "Where is it?" pathways model, there is another model that has claimed the existence of a set of distinctive functional brain systems. Kahneman (2003) concluded that there are two separate decision-making systems in the brain: System 1 generates fast, intuitive, automatic decision making; System 2 generates slow, effortful, consciously monitored decision making. Kahneman argued that System 1 and System 2 interact, with System 1 as primary: "impressions produced by System 1 control judgments and preferences, unless modified or overwritten by the deliberate operations of System 2" (p. 20). Kahneman further claimed that System 1 judgments improve with practice, such that experts can make System 1 judgments that are both faster and more accurate than they would using the slow, conscious System 2.

Kahneman's (2003) Systems 1 and 2 might, like the "What is it?" and "Where is it?" pathways, also seem to be potential intelligences: the "intuitive intelligence," and the "deliberative intelligence." However, these two systems each process all the varied types of content information—language, music, numbers, social information—that Gardner argued are channeled into the separate intelligences. Moreover, Kahneman's two theorized systems each have only one task—to compute a decision. Conversely, Gardner's MI each have many tasks. For example, the musical intelligence determines "the performance, composition, and appreciation of musical patterns" (Gardner, 1999, p. 42). Neither System 1 nor System 2 is theorized to create, compose, appreciate, or perform.

How does evidence for these processing systems argue against MI theory? Evidence for the neural processing systems reviewed here argues against the core of MI theory in two important ways. First, the evidence for the functional overlap of the "What is it?" and the "Where is it?" processing pathways, along with the evidence for the shared and overlapping neural pathways for emotion, music, language, logic-mathematics, spatial, body sense, and social skills (Koelsch et al., 2004; Lieberman, 2002; Morgane et al., 2005; Norton et al., 2005) argue against Gardner's (1999) theoretical provision that each intelligence must have its own separate neural processing pathway (p. 99). Second, the basic operating plan of the "What is it?" and "Where is it?" pathways and System 1 and 2 works in a manner that is the direct opposite of the basic operating plan theorized for the MI. Each multiple intelligence is a multipurpose processor that operates on a single content. Conversely, the "What is it?" and "Where is it?" pathways and System 1 and 2 are each unipurpose processors operating on multiple contents.

Research Findings for Adapted Cognition Theory

Evolutionary psychologists have proposed the existence of innate cognitive modules that generate specific adaptive behavior patterns (Cosmides & Tooby, 1992; Cummins, 2002; Gallistel, 1998; Hauser & Spelke, 2004). Gallistel argued that "Because different representations have different mathematical structure and because they are computed from sensory inputs with widely differing properties, learning mechanisms must be domain- or problem-specific" (p. 55). Gallistel speculated that there may be 100 human domain-specific cognition modules wherein each evolved to solve a different environmental computational problem.

Many unique neural computational devices have been found in animals (Burghardt, 2002; Hauser, 2000). Research on possible human adapted cognition modules is not as extensive but is increasing. Evidence has offered support for the existence of a range of adapted cognition modules including one for detecting social cheating (Cummins, 2002; Velicer, 2005), one for knowledge of number (Gelman & Gallistel, 2005; Xu, Spelke, & Goddard, 2005), and one for the mental imitation of others through automatic firing of mirror neurons (Fadiga, Craighero, & Olivier, 2005; Mottonen, Jarvelainen, Sams, & Hari, 2005; Rizzolatti & Craighero, 2004).

Social cheating occurs in many species. Cheating bacteria do not make the beneficial extracellular compounds that their noncheating neighbors do (Velicer, 2005). Insect queens engage in social cheating when they steal workers from other colonies to tend their own larvae. Birds engage in social cheating when they deposit their eggs in other nests thus avoiding the effort of raising their own chicks. Although humans are unusual in their altruistic cooperation (Fehr & Fischbacher, 2003), human social cheating includes theft, sexual infidelity, and shirking group work. Evidence has suggested that humans are better at detecting cheaters than they are at solving parallel detection problems that do not involve cheating (Gigerenzer & Hug, 1992).

Evidence that human number knowledge may be innate has been accumulating (Hauser & Spelke, 2004). Studies have reported that children's acquisition of number knowledge is separate from their initial language development (Xu et al., 2005) and that number knowledge exists in primates (Gelman & Butterworth, 2005).

In addition to cheater detection and number knowledge, still another proposed adapted cognition module is that of the mirror neuron system. The mirror neuron system was first discovered in monkeys, but there is now clear evidence that humans have a mirror neuron system (Rizzolatti & Craighero, 2004). When we observe the behavior of another person, mirror neurons automatically fire, triggering neurons in our brains to copy or "mirror" the observed person's mouth movements (Mottonen et al., 2005), gestures, and actions (Rizzolatti & Carighero, 2004). However, because this firing is below the threshold needed to engage our muscles, we rarely explicitly mimic those we observe (Fadiga et al., 2005). The mirror neuron system of mental imitation enables us to more easily understand the emotional state of those around us and also learn complex behaviors from others.

Adapted cognition theory has engendered a lively debate (Butler, 2005). Hernandez, Li, and MacWhinney (2005) argued that modules are not innate but emerge in development. Lickliter and Honeycutt (2003) argued that it was unlikely that adapted cognition modules could sit dormant in the brain waiting to be activated by life experience. Bjorklund (2003) countered that most adapted cognition modules are likely to be *architectural,* resulting from genes that determine the structure of brain regions, or *chronotopic,* resulting from genes that determine critical periods of development.

Bjorkland posited that very few adapted cognition modules, such as the module for number, would be *content-representational,* that is resulting from genes that determine specific innate knowledge. In another entry in this ongoing debate Kanazawa (2004) argued that g itself is an adaptive module that evolved to enable humans to solve new or more general problems in the environment, and other modules such as the detection of social cheating and number knowledge evolved to solve specific recurring problems in the environment.

How do research findings for adapted cognition theory argue against MI theory? The research findings for the adapted cognition modules of detecting social cheating, number knowledge, and the mirror neuron system might seem to suggest that such modules are themselves "intelligences," thus indirectly supporting Gardner's construct of MI. However, adapted cognition modules operate both more narrowly and more broadly than do Gardner's intelligences. For example, mirror neurons do nothing more than activate an observer's brain circuits for those motor patterns that are being enacted by the observed individual. This narrow function argues that mirror neurons are not an "intelligence." At the same time, however, because mirror neurons are activated by a very wide range of behaviors including facial motor movements of others, gesturing, grasping, touching, and tool use (Rizzolatti & Craighero, 2004; Mottonen et al., 2005), the mirror neuron system operates over a much broader range of content than that identified by Gardner for each of his intelligences.

More specifically, evidence for the module of number knowledge might appear to provide support for Gardner's logical-mathematical intelligence. However, the numerosity module is a much narrower cognitive specialization than Gardner's logical-mathematical intelligence. The module includes only counting using the natural numbers (1, 2, 3, 4, …) and estimating the numerosity of objects in groups (Gelman & Butterworth, 2005). Neither logic nor mathematics as a system of operations on numbers is included in the number knowledge module. Equally important, because numerosity estimations could occur in all of Gardner's intelligences, the numerosity module operates much more broadly than was theorized by Gardner for his intelligences.

Like the mirror neuron system and number knowledge module, the theorized social cheating detection module also involves processing that would operate across most of Gardner's theorized intelligences and would also, nonetheless, focus on a problem much narrower—who is cheating?—than that assumed by Gardner for each of the MI.

In fact, adapted cognition modules are theorized to have evolved to aid us in solving quite specific recurrent problems in our environment. Mirror neurons can help us learn what our neighbor is doing and feeling by providing automatic mental imitation of our neighbor's behaviors. Innate numerosity skill can assist in quickly counting resources or elements of danger. Social cheating detection can help us discern unjust access to resources.

Although Gardner argued that MI are evolved brain specializations (1999, p. 88; 2004, p. 214), he claimed that "each intelligence probably evolved to deal with *certain kinds of contents* in a predictable world" (1999, p. 95). Thus, the linguistic, musical, logical-mathematical, bodily-kinesthetic, spatial, personal, and naturalistic intelligences were not theorized to each solve a specific environmental problem but to each deal with a different general content. If MI are innate brain specializations, as claimed by Gardner, and if they have not each evolved to solve a particular recurrent problem in our environment, why did they evolve? For example, if the musical intelligence is a cognitive brain specialization that evolved to determine "skill in the performance, composition, and appreciation of musical patterns" (Gardner, 1999, p. 42), what recurrent human environmental problem did music performance, composition, and appreciation evolve to solve? Despite Gardner's (1999) assertion that once an intelligence "emerged, there is nothing that mandates that it must remain tied to the original inspiring content" (p. 95), nothing in MI theory answers the following question: How could the *content* of music *inspire* the evolution of the musical intelligence as a distinct brain specialization?

Summary: Cognition Research Evidence Does Not Support MI Theory

Albeit neuroscience researchers have not claimed that individual human perceptual processes such as taste or vision are intelligences or that innate skills, such as spatial navigation, or learned skills, such as music composition, are intelligences, nonetheless, this provides no evidence against MI theory. However, the empirical evidence reviewed here does argue that the human brain is unlikely to function via Gardner's MI. Taken together the evidence for the intercorrelations of subskills of IQ measures; the evidence for a shared set of genes associated with mathematics, reading, and g; and the evidence for shared and overlapping "What is it?" and "Where is it?" neural processing pathways and shared neural pathways for language, music, motor skills, and emotions suggest that it is unlikely that that each of Gardner's intelligences could operate "via a different set of neural mechanisms" (Gardner, 1999, p. 99). Equally important, the evidence for the "What is it?" and "Where is it?" processing pathways, for Kahneman's two decision-making systems, and for adapted cognition modules suggests that these cognitive brain specializations have evolved to address very specific problems in our environment. Because Gardner claimed that that the intelligences are innate potentialities related to a general content area, MI theory lacks a rationale for the phylogenetic emergence of the intelligences.

MI theory should not be taught without consideration of the absence of empirical validating evidence for MI theory or without consideration of alternate evidence-based models of human cognition.

THE ME THEORY

Beginning in 1993 a series of studies reported that experiencing Mozart might generate improved spatial skill. Rauscher et al. (1993) reported that college students scored eight to nine points higher on a spatial IQ test after listening to 10 min of a Mozart piano sonata. In 1995 the same group found that college students improved 62% in their ability to mentally unfold a folded abstract figure after listening to the same Mozart sonata. Rauscher et al. (1997) then reported that preschool children given 6 months of piano instruction showed significant improvement in spatial tasks. In 1998, Rauscher, Robinson, and Jens described finding that even rats improved maze learning with exposure to a Mozart sonata. In 1999 Graziano et al. reported finding improved math skills in children who had been given music and spatial training sessions. Hetland (2000) found that children given music lessons improved in spatial reasoning for up to 2 years after the music lessons were over.

In 2004 Jackson and Tlauka reported finding that both a Mozart sonata and a piece by Philip Glass improved study participants' ability to negotiate through a fixed space. In 2005 Jausovec and Habe reported that listening to a Mozart sonata improved study participants' performance on a set of spatial rotation tasks but slightly impaired their performance on number tasks. The researchers also reported that participants' brain waves were altered in the direction of greater cortical activity while listening to this sonata. The research findings from 1993 onward led to the conclusion that experience of music, and especially of Mozart's music, whether for a brief time or over a longer period, whether listened to or played, significantly improved spatial cognitive skills.

Research even suggested Mozart as medicine. Hughes, Daaboul, Fino, and Shaw (1998) reported that playing a Mozart sonata to 29 patients with seizures caused a reduction in epileptiform activity in 23 patients. The researchers argued that the superior pattern structure of Mozart's music was likely to be reorganizing the abnormal neuronal firing of seizures. Jenkins (2001) argued that the high level of long-term periodicity (e.g., repeated sequences of note patterns) in Mozart's music operated both to decrease seizure activity and to enhance spatial skills. Kimata (2003) reported that listening to Mozart, but not to Beethoven, reduced skin wheals in patients with latex allergies.

The ME sparked tremendous interest in educators and the public. In a state budget address, Governor Zell Miller of Georgia requested $105,000 to provide a tape of classical music for each of Georgia's 100,000 newborns to help their brains develop better (Gavin, 2000). A small CD industry claiming mental improvement through listening to classical music emerged (Rauscher, 2002). Music educators, journalists, music companies, and even politicians extended the findings of the researchers to mean that listening to Mozart can make you smarter (Campbell, 2000; Gavin, 2000), thus creating a "scientific legend" version of the researchers' original claim (Bangerter & Heath, 2004).

When asked whether children's spatial skills might be better improved directly through practice rather than indirectly through music, Rauscher (2002) argued that music brings joy into our lives and offers "free" improvement of spatial skill—that is, the enhancement of skill without any practice. Music does provide pleasure for most people. Menon and Levitin (2005) found that listening to music activates the connections between several brain systems and strongly modulates activity in brain structures (amygdala, hypothalamus, insula, and orbitofrontal cortex) and brain chemical pathways (dopamine) that determine our feelings of pleasurable reward. Although music is rewarding, does it really offer free improvement in spatial intelligence?

The ME and Evidence for the Basis of the Learning Process

When we learn something that we can recall again and again, it is represented in our long-term memory. Cognitive neuroscience research suggests that much of what is typically learned in a classroom depends on a combination of the incremental enhancement of *procedural skill memory* for sequences of behaviors, such as knowing how to write words, and of *declarative content memory* for knowledge, such as knowing why bacteria are important (Eichenbaum, 2004; Willingham, 1998). Cognitive neuroscience research has discovered six processes that influence the establishment of long-term procedural and declarative memory. These processes are *repetition* of the procedure or information (Squire & Kandel, 2000; Wickelgren, 1981), *excitation* at the time of learning (LeDoux, 2002; McGaugh, 2004; Phelps, 2006), association of *reward* with the material to be learned (Wise, 2004), *eating* carbohydrates before or during learning (Korol, 2002; Rampersaud, Pereira, Girard, Adams, & Metzl, 2005), sufficient *sleep* after a learning session (Walker & Stickgold, 2006), and *avoidance of drugs of abuse and alcohol* (Grant, Gonzalez, Carey, Natarajan, & Wolfson, 2003; Marinkovic, Halgren, & Maltzman, 2004).

Although researchers have found that the process of consolidating long-term memory does take place "for free" while we sleep (Walker & Stickgold, 2006) and that some learning takes place outside of focal attention while we are consciously attending to other to other tasks (Yi & Chun, 2005), there is no evidence, other than evidence for the ME, to suggest that significant cognitive skill improvement can take place without one of the first two memory enhancement processes: repetition of that skill or excitement associated with the skill activity.

Repetition induces learning. In a review of research on human learning, Wickelgren (1981) concluded simply that "practice makes perfect," and stated that "learning curves are almost always continuous incremental functions of study time" (p. 38). Squire and Kandel (2000) summed up the findings for the neurobiology and psychology of learning with the conclusion that improvement of procedural skills and enhancement of content memories depends on "the number of times the event or fact is repeated" and "the extent to which we rehearse the material after it has first been presented" (p. 71). James and Gauthier (2006) reported that learning improved following repetition and was associated with a time-shifted increase in relevant brain activation. A. Martin and Gotts (2005) found that, although object identification improved with repetition of images of the object, object learning was impaired when individuals' frontal lobe activity was disrupted during the repetitions.

Excitement induces learning. Emotional arousal enhances memory formation by positively influencing the period of neurobiological activity called consolidation that establishes a memory in the brain (McGaugh, 2004; Phelps, 2006). LeDoux (2002) outlined that we "remember particularly well … those things that arouse our emotions" and that heightened emotional excitation engendered by hormones and amygdala activity strengthens both conscious and nonconscious memory formation (p. 222). Many animal studies have demonstrated that the arousal-linked hormones including epinephrine and corticosterone support the consolidation of long-term memory (LeDoux, 2002). Nielson, Yee, and Erickson (2005) found that human learning was significantly enhanced by an emotionally arousing videotape, and Cahill, Gorski, and Le (2003) reported evidence that human cortical arousal, with increased epinephrine, enhanced human memory consolidation. McGaugh's (2004) review of research on the brain basis of emotion and memory led him to conclude that "emotionally significant experiences, whether pleasant or unpleasant, activate hormonal and brain systems" through which "our emotionally exciting experiences become well remembered" (p. 18).

Because the ME claims that spatial skills of children and adults and even the spatial skills of rats improve after music experience without repetition of the spatial material, and without any increased emotional excitation (Rauscher et al., 1993, 1995), therefore, the ME theory contradicts the current cognitive neuroscience understanding of the basis of skill improvement.

Cortical Arousal May Be the Source of the ME

It is interesting to note that evidence has been reported to suggest that the ME may actually be the result of positive emotional arousal of study participants (Husain, Thompson, & Schellenberg, 2002; Jausovec & Habe, 2005; Thompson, Schellenberg, & Husain, 2001). Thompson et al. tested study participants' spatial abilities after they sat in silence and after they listened to a brisk upbeat Mozart sonata and a slow sad Albinoni adagio. The participants' performance on the spatial task was better following the Mozart than following the silence but not better following the Albinoni. The authors concluded that the ME is a result of positive arousal. In a subsequent study, Husain et al. (2002) reported that four versions of the same Mozart sonata (fast, slow, major, minor) had differing effects on spatial skill. Spatial task scores were higher for subjects who listened to the fast version and the major version of the Mozart sonata. The higher scoring subjects were in a more positive emotional state, suggesting that positive emotional arousal was likely to be the source of the ME. Jausovec and Habe (2005) reported that listening to a Mozart sonata enhanced participants' performance on a set of spatial rotation tasks while increasing participants' brain wave activity. The researchers theorized Mozart's music selectively increases brain activity in certain areas that results in the binding of sensory stimuli into a unitary whole.

If these findings are upheld, they suggest that listening to Mozart improves spatial learning for a brief period because music, and particularly some of Mozart's fast tempo, major key compositions, can cause positive emotional arousal and increased cortical activity.

Other Proposed Brain Mechanisms for the ME

Several other brain mechanisms for the ME have been proposed. Rauscher (2002) suggested that the ME might work either through transfer of learning from the music domain to the visual-spatial domain or through changing the physical structure of the brain. Although no evidence for the cross-domain transfer of learning from music to spatial skill has been found (Schellenberg, 2003), certain types of skill learning have been shown to result in an increase in brain tissue dedicated to that skill. The brains of violinists, for example, had more brain tissue representing their fingers than did the brains of nonmusicians (Schlaug, 2003), and expert musicians had greater left hemisphere activation in response to music than did nonmusicians (Schlaug, 2003). However no correlation was found between representation of fingers in the brain and visual-spatial skill (Schellenberg, 2003), and professional musicians were not shown to have a significantly greater spatial skill than nonmusicians (Schlaug, 2003).

Schellenberg (2003) wondered whether priming—an initial firing of neurons in a brain circuit that makes a subsequent firing more rapid and more likely—could be the source of the ME, but he discounted priming because it was not clear how hearing musical notes could prime spatial patterns. However, given the evidence for overlapping neural processing of music and other cognitive skills, as reviewed here previously, it may be that music can prime overlapping pathways for in spatial information processing.

Some Research Disconfirms the ME

Contrary to the evidence reported for the ME, a considerable number of studies have reported evidence disconfirming the

ME (Chabris, 1999; Husain et al., 2002; McKelvie & Low, 2002; Nantais & Schellenberg, 1999; Steele, 2003; Steele, Bass, & Crook, 1999; Steele, Brown, & Stoecker, 1999; Thompson et al., 2001; Twomey & Esgate, 2002). Chabris reported that a meta-analysis of 16 ME studies found no change in IQ or spatial reasoning ability. Chabris also reported that a replication of the Rauscher et al. 1995 study found no significant change in spatial IQ. The experiments of researchers Steele, Bass, and Crook (1999) and Steele, Brown, and Stoecker (1999) also failed to replicate the ME. Similarly, McKelvie and Low reported that, compared to control participants, there was no improvement in the spatial IQ scores of two groups of children who listened to a Mozart sonata. Twomey and Esgate reported that they could find an ME only in nonmusicians, and Fudin and Lembessis (2004) criticized the original Rauscher et al. (1993) study as flawed in its methodology. Steele pointed out that the rats studied by Rauscher et al. (1998) were unlikely to have improved their maze learning from hearing a Mozart sonata because rats are deaf in the womb and are born deaf, and adult rats are deaf to the majority of tones in a Mozart sonata.

Summary: What is a Reasonable Interpretation of the ME?

The present available evidence does not support the belief that the ME is a newly discovered mechanism that can improve spatial skill without practice or emotional arousal. The evidence disconfirming the ME suggests that there is no effect at all. The evidence confirming the ME, however, suggests that Mozart's music may be a pleasant means of inducing emotional arousal and may thus provide a brief improvement in spatial-temporal skills precisely because it induces such arousal. It may also be that, despite Schellenberg's (2003) conclusion that music cannot prime spatial processing, cortical arousal stimulated by music can prime cortical circuits for spatial processing where the circuits for music and spatial processing overlap (Koelsch et al., 2004).

In sum the evidence to date does not justify advocating music as means to improve spatial skills "for free." The ME theory should not be taught without consideration of the disconfirming evidence or without consideration of the possibilities of the mechanisms that may underpin the ME.

EI THEORY

Salovey and Mayer first outlined the construct of EI in 1990. In 1995 Goleman popularized a version of their construct in his book *Emotional Intelligence.* Goleman's idea of a unitary "emotional intelligence" consisted of five domains: knowing one's emotions, managing one's emotions, motivating oneself, recognizing emotions in others, and handling relationships. In 1997 Mayer and Salovey outlined four EI components: regulating emotions, understanding emotions, assimilating emotion in thought, and perceiving and expressing emotion. Goleman expanded his model (1998, 2001; Goleman, Boyatzis, & McKee, 2002), and he redefined EI as the ability to develop competence in four domains: self-awareness, self-management, social awareness, and relationship management. Each of these four domains was theorized to have multiple subskills. The central claim was that every person is a leader in some manner, and every leader's main obligation is to create resonance, that is, to "prime good feelings in those they lead" which in turn will generate the best behavior in others (Goelman et al., 2002, p. ix).

In 1999 Mayer, Caruso, and Salovey published the Multifactor Emotional Intelligence Scale, which included the factor scales of perception of emotion, understanding emotions, and managing emotions, as well as a general EI factor. The researchers argued that their EI construct was a valid intelligence because it operationalized a set of abilities, it was correlated with standardized verbal intelligence, and adults showed higher EI scores than did adolescents. In 2003 Brackett and Mayer compared several EI measures, the Mayer-Salovey-Caruso-Emotional Intelligence Test, the Emotional Quotient Inventory, and the self-report EI test, and concluded that only the first of these three measures was differentiable from personality measures. In 2005 Kemp et al. introduced a new measure of EI, the Brain Resource Inventory for Emotional Intelligence Factors, which was designed to measure internal emotional capacity, external emotional capacity, and self-concept. Kemp at al. reported that a low EI score on their measure was correlated with low frontal lobe arousal. In 2005 Tett, Fox, and Wang reviewed 33 studies of six different self-report measures of EI, and concluded that EI could successfully be measured by self-report scales.

The Association for Supervision and Curriculum Development endorsed Goleman's construct of EI by inviting Goleman to give a keynote address at an annual meeting (Pool, 1997) and by developing and selling an inquiry kit on EI based on Goleman's 1995 book (Robbins & Scott, 1997). Goleman et al. (2002) argued that EI should be taught in schools. They claimed that "if education also included those emotional intelligence abilities that foster resonance" then young people would reduce their "violence and substance abuse" and communities would have higher levels of social caring (p. xiii). Hartley (2004) reviewed EI as part of educational leadership. Kelly, Longbottom, Potts, and Williamson (2004) observed that the application of EI theory in a classroom yielded beneficial emotional and social changes in the class and contributed to enhancing the school ethos.

Problems With the Empirical Evidence for EI Theory

Emmerling and Goleman (2003) argued that "by Kuhn's criteria, the emotional intelligence paradigm would seem to have reached a state of scientific maturity" (para. 6). However Kuhn's idea of scientific maturity required both that a scientific community accept the theory and that there be empirical evidence validating the theory (Nersessian, 1998). No research has yet validated the notion of a unitary EI. Matthews, Zeidner, and Roberts (2002) reviewed a wide range of empirical research on EI and concluded that there was no supporting evidence for a unitary EI either in "brain function, in basic information processing, in high-level interactions of person-environment interaction, or by reconceptualizing existing personality traits" (p. 539). Zeidner, Matthews, and Roberts (2004) concluded that a good deal of evidence proposed to support EI was based on anecdotal observations and self-report surveys. Locke (2005) claimed that EI was defined too broadly to ever be adequately tested. Matthews, Zeidner, and Roberts (2004) reviewed the evidence for EI theory and identified critical unresolved problems. They asserted that there were too many conflicting EI constructs, that EI was not successfully differentiated from personality constructs and general intelligence, and that there was no validation of the claim that EI was critical for real-world success.

Many Conflicting Constructs of EI

Matthews et al. (2002) reported that because the construct of EI was so often redefined by researchers, as a result, different studies identified very different skills as part of EI. Matthews et al. (2004) outlined eight different conceptualizations of EI. These included temperament, character, aptitudes for processing emotions, adaptiveness, acquired implicit skills, acquired explicit skills, insightful self-awareness, and good emotional person-environment fit (p. 181). The researchers concluded that "differing definitions and neglected conceptual problems have led to considerable confusion" (p. 181). They argued that the confusion would be resolved in part when the overlap between different EI constructs was determined. They noted, however, that it would be extremely difficult to determine such overlaps because different EI measures had been used to validate the different EI constructs. They called for consensus debates as a means of possible resolution.

EI has not Been Differentiated From Personality Plus IQ

Matthews et al. (2004) argued that another critical problem for EI theory was that EI has been found to be correlated with both personality measures and standard intelligence measures. Thus, it has been difficult to determine exactly how EI differs from some combination of IQ and personality factors (Matthews, Zeidner, & Roberts, 2005). Davies, Stankov, and Roberts (1998) found that subjective measures of EI did not seem to assess anything other than factors already measured by existing valid personality inventories. Schulte, Ree, and Carretta (2004) reported that the components of EI showed a high significant positive correlation (.81) with five major personality factors (warmth, conscientiousness, sociability, neuroticism, and openness) in combination with g general intelligence. They suggested that EI theory adds little to understanding human behavior. Barchard and Hakstian (2004) reported that their factor analysis of EI abilities yielded only one factor that was autonomous from IQ and personality and that was emotional congruence. Lopes, Salovey, Côté, and Beers (2005) reported that after controlling for personality traits, and for verbal and fluid intelligence, only one EI trait remained, emotional regulation skill. They concluded that their findings raised "questions about the cohesiveness of emotional intelligence as a domain of ability" (Lopes et al., 2005, p. 117).

Goleman et al. (2002) argued that the repeated findings for significant positive correlations between EI and IQ were flawed because study samples did not include individuals with either very high or very low IQ scores. They also argued that positive correlations between EI test scores and IQ test scores were irrelevant because only those individuals with higher IQs become leaders. These arguments are unsupported claims and are not compelling.

The Claim That EI Determines Real-World Success Has Not Been Validated

Pool (1997) reported that Goleman told members of the Association for Supervision and Curriculum Development that "a person's IQ predicts only a small part of career performance—ranging from 4 to 20 percent. But recent studies have shown that emotional intelligence predicts about 80 percent of a person's success in life" (p. 12). Similarly, in 1998 Goleman claimed that "IQ alone at best leaves 75 percent of job success unexplained, and at worst 96 percent" (p. 19), and he claimed that "more than 80 percent of general competencies that set apart superior from average performers depend on emotional intelligence" (p. 320).

Goleman derived his first claim, that IQ explains less than 75% of job success, from a 1995 review article by Sternberg, Wagner, Williams, and Horvath, in which the authors concluded that "between 75% and 96% of the variance in real-world criteria such as job performance cannot be accounted for by individual differences in intelligence test scores" (p. 923). Goleman changed the phrasing of the authors' conclusion slightly, turning their phrase "real-world criteria such as job performance" into the phrases "career performance" (Pool, 1997, p. 12) and "job success" (Goleman, 1998, p. 320). This is a small change but it alters the meaning significantly, making job/career success the sole outcome not predicted by IQ, thus significantly narrowing Sternberg et al.'s (1995) claim. Equally problematic, the original 75%–96% success prediction percentages were not correlations obtained from a specific empirical study: The 75%–96% range was a review judgment of the 1995 authors.

Goleman derived his second claim, that EI explains more than 80% of success in life (Pool, 1997, p. 12) or, alternatively, more than 80% of job competencies that distinguish superior employees (Goleman, 1998, p. 320), from an unpublished privately commissioned study (Goleman, 1998, p. 31). This study determined that 21 key job competencies existed, and Goleman decided that only three (analytical thinking, conceptual thinking, and technical expertise) were not EI competencies. Goleman concluded that because he judged 18 of 21 job competencies to be EI competencies and because 18 equals 85.7% of 21, thus EI explained 85.7%, or more than 80% of life success (Pool, 1997, p. 12) or more than 80% of job skill competencies of superior workers (Goleman, 1998, p. 320). These conclusions were mistaken.

First, to claim that more than 80% of life success depends on EI, the 80% figure must from derive from a significant and very high positive correlation ($r > .90$) between data from reliable, valid measures of life success and data from reliable measures of EI in the same population. Goleman's 80% figure is not derived from such a correlation. It is simply a restatement in percentage form of his judgment that 18 of 21 job competencies are EI competencies. Second, to make the claim that more than 80% of superior job skill competencies are EI competencies, there must be evidence that each identified competency is a true job competency and evidence that the total range of possible job competencies is included in the 21. Moreover, there must be a reliable, replicable, nonsubjective method for then determining which job competencies are EI competencies. However, Goleman reported no empirical evidence from the privately commissioned study for the validity of the 21 job competencies or evidence that 21 job competencies determine all of job success. His selection of EI job competencies from among the 21 overall job competencies cannot be replicated.

Collins (2002) studied the job success of 91 executives and found EI competencies predicted no variation in job success over and above cognition and personality traits. Barchard (2003) reported finding that some measures of EI predicted academic success but that none of these measures showed incremental predictive validity for academic success over and above cognitive and personality variables. Matthews et al. (2002) found that, although some skills theorized to be part of EI were correlated with aspects of success, it was not clear that these skills determined EI, and the correlations were associations not causal effects (p. 229).

Alternatives to EI Theory: Theories of Multiple Socioemotional Skills

Research in social psychology and social neuroscience suggests that there is unlikely to be a unitary "emotional intelligence" (Cacioppo & Berntson, 2004; Insel & Fernald, 2004; Phelps, 2006). First, evidence has suggested that emotion and cognition are intertwined in human mental function (Adolphs et al., 2003; Phelps, 2006). Second, evidence has suggested that human emotional and social competence depends on multiple evolved brain adaptations. Basic social attachment in all mammals depends on a system of the hormones oxytocin, vasotocin, and vasopressin operating in brain-body circuits (Insel & Fernald, 2004). The human ability to feel and express emotions and to comprehend and empathize with the emotions of others depends on circuits in a variety of brain regions, including the previously discussed mirror neuron system (Adolphs et al., 2003; Rizzolatti & Craighero, 2004). Humans also have neocortical and subcortical circuits specialized to distinguish faces, facial expressions, and social gaze (Batty & Taylor, 2003). Emotions are also communicated through language, and research has reported evidence for a panoply of brain circuits involved in language processing, most notably left hemisphere neocortex and basal ganglia tissues (Allman, Hakeem, & Watson, 2002; Josse & Tzourio-Mazoyer, 2004). Personality research has also suggested that there is a core set of emotion-related temperament components, called the "big five" aspects of personality—warmth, conscientiousness, sociability, neuroticism, and openness (Paris, 2005).

Attachment, empathy, face and emotion recognition, language, and aspects of personality all have been found to contribute to social-emotional skills (Cacioppo & Berntson, 2004; Insel & Fernald, 2004; Paris, 2005). Logically, then, because these traits and skills contribute to social-emotional skills, they should be considered as factors contributing to any comprehensive theorized construct of an EI.

Summary: The Problems With EI Theory are Unresolved

Landy (2005) argued that EI cannot be considered a scientific theory because some datasets proposing evidence for EI cannot be evaluated because these datasets are privately owned. For example, as noted previously, Goleman's core claim for the validity of EI derives in part from a privately commissioned study: This study was conducted by the McBer division of the Hay Group, a Boston MA business consulting firm, and this study has not been published. However, the majority of research on EI is not in proprietary databases, and this available evidence has clearly identified a lack of conclusive supporting data for EI, either as a single construct or as a defined set of specific abilities. In particular, the problems for EI theory identified by Matthews et al. (2004)—no unitary EI paradigm, inadequate differentiation of EI from personality traits plus IQ and no evidence that EI predicts job or life success—have not been solved.

Moreover, social psychology and social neuroscience research has outlined a more complex and varied array of human social-emotional skills than those proposed in EI theory. The validity of EI remains to be determined. Therefore, EI theory should not be taught without a consideration of its lack of empirical validity.

WHY ARE THESE THREE UNPROVEN THEORIES SO POPULAR?

All three theories have been criticized. Allix (2000) argued that crucial "cognitive matter is missing from Gardner's overall conception" because Gardner "is unable to specify coherently how the *algorithms*, which carry out intelligent computations, are realized" (p. 283). Sternberg and Grigorenko (2004) pointed out the lack of evidence for MI theory. Steele, Bass, and Crook (1999) concluded that "there is little evidence to support basing intellectual enhancement programs on the existence of the causal relationship termed the Mozart effect" (p. 368). Jones and Zigler (2002) argued against the ME, and Bangerter and Heath (2004) concluded that the ME had "become a scientific legend" (p. 610). Matthews et al. (2002), Landy (2005), Locke (2005), and others have pointed out serious problems with EI theory. Why does this criticism have so little effect on the influence these theories wield?

Four Contexts: Fraud, Anxieties, Absent Evidence, and Ignoring Evidence

Stich (1990) argued that belief in unfounded ideas occurs in four contexts: when unfounded evidence is created as an explicit *fraud,* when sound evidence is subject to *distortion by anxieties* or wishful thinking, when sound evidence is *absent,* and when sound evidence can be *easily ignored*. For the first, there is no evidence to suggest that any of the three theories reviewed here was created as an explicit fraud. For the second, Bangerter and Heath (2004) reported that although they found that interest in the ME was "higher in states that are experiencing problems in childhood education, it does not directly demonstrate the role of anxiety in mediating this interest" (p. 616). The idea of applying MI, ME, and EI theory to educational practice might, arguably, be interpreted as "wishful thinking" in that these theories have not been validated, and yet they have been recommended for the improvement of classroom learning (Armstrong, 1994; Campbell, 2000; Elksnin & Elksnin, 2003; Gardner, 2004; Glennon, 2000; Graziano et al., 1999; Hoerr, 2003; Rettig, 2005).

For the third Stich context, as reviewed in detail previously, consistent sound evidence is lacking for all three theories. Gardner acknowledged the lack of empirical evidence for MI (Gardner, 2004; Gardner & Connell, 2000), but he and others have discounted the need for empirical validation as the narrow focus of psychometricians (Chen, 2004; Gardner, 1999, 2004; Shearer, 2004). Many studies failed to replicate the ME, but others found supporting evidence; thus, the pattern of evidence is inconsistent. EI has many competing constructs, but none of them have been validated.

Stich's fourth context occurs when sound evidence is easy to ignore. Much of the sound evidence from psychology and neuroscience that argues against the likelihood of MI, ME, and EI theories is easy to ignore because this evidence has not been published to address the claims of MI, ME, and EI theory.

Three Reasons: *Credo Consolans,* Immediate Gratification, and Easy Explanations

Shermer (1997) argued that there are three major reasons that people believe in ideas lacking sound supporting evidence: *credo consolans,* an unproven idea may be comforting if it predicts a good outcome, makes us feel powerful, or makes us feel in control; *immediate gratification,* an unproven idea may be attractive if it offers instant solutions for difficult problems; and *easy explanations,* an unproven idea may be accepted if it offers a simple story about something that is difficult to understand.

MI, ME, and EI theory each provide a *credo consolans* for educators because each offers the promise of control over a complex and invisible process—the act of learning—and each predicts a good outcome for students if applied in educational practice. Second, each theory also suggests the possibility of the immediate gratification of a quick solution for a difficult problem. If Mozart can improve everyone's nonverbal intelligence, just play Mozart's music in every class (Campbell, 2000) and to every newborn baby (Gavin, 2000). If we each have eight different intelligences, just teach to all the eight intelligences (Armstrong, 1994), and students' varied learning problems will be addressed. If we each possess an "emotional intelligence," then training this EI will reduce students' classroom problems and improve society (Elksnin & Elksnin, 2003).

In accord with Shermer's third reason, MI, ME, and EI theory may be popular because each offers an easy explanation of cognitive processes. MI theory offers the easy-to-understand explanation that cognitive processes are divided into separate intelligences, each defined simply by the content that it learns and processes. Thus, MI theory adherents can believe that they understand the way cognitive functioning is organized in the brain. However, as has been reviewed previously, this belief is unjustified.

The ME theory offers the easy-to-understand explanation that spatial skill will improve without effort if we just listen to music. EI theory offers the easy-to-understand explanation that human cognition is divided into EI and IQ and that EI may be more important than IQ for life success. Moreover, Goleman's (1998) evidentiary claims for EI mirror Dale Carnegie's (1936/1990) easy-to-understand *How to Win Friends and Influence People.* Like Goleman, Carnegie asserted that only 15% of job success was due to professional knowledge, whereas 85% was due to the ability to be positive and enthusiastic in dealing with other people.

Contagious Transmission of Ideas

Lynch (1996) argued that the "contagious" mass transmission of an idea, belief, or theory can occur in a variety of contexts, including the contexts in which an idea triggers believers to teach the idea to others, an idea simply makes sense to many of those who are exposed to it, or an idea is thought to offer rewards to the holder of the idea.

The explosion of Web sites reported on Table 1 suggests that all three theories simply do make sense to many people, and the increasing number of educational workshops suggests that these ideas are triggering individuals to teach others these theories. Furthermore, all three theories offer educators who believe in the theory two possible rewards: the reward of more effective teaching and the reward of an easy-to-understand model of cognition.

Folk Psychology

Geary and Huffman (2002) and Malle (2004) argued that because human thoughts and actions are so variable our brains have evolved to be open to constructing many folk psychology theories of behavior. Thus, MI theory, the Mozart theory, and EI theory may appeal to us because we have an innate predisposition to find simple models of human behavior appealing. In reviewing *Working with Emotional Intelligence,* Bennis (1998) argued that Goleman's notion of EI was sound because it "confirms what we know in our bones" (p. 50). Petrides, Furnham, and Martin (2004) reported finding that both men and women believed that men have less EI than women do and that all study participants believed in the distinction between EI and the non-EI of IQ or rationality. Similarly, the ME may be attractive because many of us already believe that music has special powers to influence states of mind (Cross, 2003).

Human Differences Versus the Belief in Human Equality

Still another possible reason for the appeal of these theories is the tension between the awareness of human differences and the belief in human equality. The notion of g or general intelligence has been associated with an inherently unequal meritocracy within society (Ceci, 1996, pp. 230–232). Paying attention to the conventionally determined intelligence of students has been identified as a problem for teaching (Kincheloe, 1999), and MI theory, in particular, has been praised for addressing this inequity by allowing for students to have the wide range of eight distinct intelligences in which to express distinctive talent (Chen, 2004; Shearer, 2004). EI has been invoked to identify individuals who have a high emotional quotient in contrast to a relatively lower IQ, as well as a means to address the deficits of the 15%–22% of students believed to have social-emotional problems (Elksnin & Elksnin, 2003). The ME, too, has been argued to be a means to reduce differences in school functioning (Gavin, 2000; Hetland, 2000; Schellenberg, 2004).

Blau, Moller, and Jones (2004) asserted that, in general, "colleges, schools, and teachers, use tests for competitive, sorting purposes, and students and parents themselves consider that tests distinguish between winners and losers" (p. 431). Flynn (1999) argued, however, that there was no sound evidence that testing had driven the United States toward an IQ meritocracy wherein "heritability of IQ plus social trends render inevitable a society in which good genes for IQ are highly correlated with class" (p. 5). Conversely, Verma (1999) argued that IQ testing had contributed to inequality of educational opportunities for students in Britain.

Kincheloe (1999) proposed that educational psychology's idea of human intelligence should be "grounded on a democratic vision of inclusivity" that "moves psychologists to document and validate types of reasoning and intelligence that differ from those now recognized by the field" (p. 1). Although Kincheloe criticized Gardner for tending to see "the purpose of his cognitive work as helping elite students reach a higher level of achievement" (p. 23), nonetheless, Kincheloe approved MI theory as more democratically inclusive than IQ testing, and he lauded Gardner for asserting that MI theory reveals that nearly every typical person can attain impressive skill in one or another intelligence (p. 22). Similarly, Barrington (2004) claimed that MI theory provided an inclusive pedagogy that should be employed at the university level to address problems engendered by the wide variation in skill levels of students in colleges.

Sternberg and Grigorenko (2004), like Kincheloe (1999), argued that a different, more open and inclusive vision of intelligence was needed in education, and their solution was to define a new intelligence, successful intelligence, which they conceptualized as "the use of an integrated set of abilities needed to attain success in life, however an individual defines it, within his or her sociocultural context" (p. 274). They argued that their theory was "complementary to" Gardner's MI (Sternberg & Grigorenko, 2004, p. 279) but asserted that successful intelligence theory, unlike MI theory, "has been subject to many controlled studies seeking empirically to validate it, while Gardner's theory has not" (Sternberg & Grigorenko, 2004, p. 279). Sternberg and Grigorenko (2004), like Kincheloe (1999), argued that it is important to "modify in a constructive way the entire teaching-learning process" (p. 279) through a new view of human cognition different from the narrow definition provided by IQ test scores.

Clearly there are many possible reasons for belief in the MI, ME, and EI theories. However, regardless of whether these theories confer a *credo consolans,* or claim to provide redress for the unjust effects of IQ test scores, and despite the beneficent excitement that these theories have generated in educators, nonetheless, commitment to these theories is ultimately harmful to education.

WHY THESE THEORIES ARE HARMFUL

Jorgenson (2003) claimed that educators have shown a "carelessness in misinterpreting and decontextualizing the findings of brain research" amounting to "educational malpractice" (p. 368). Unfortunately, the lack of sound empirical support for MI, ME, and EI theories suggests that their continuing acceptance in education might also be considered educational malpractice. However, because educators would have to expend a great deal of effort to uncover the lack of evidence for these theories, this malpractice is less the fault of educators and more the fault of theory apologists. In fact, the promulgation of these theories in education poses several serious forms of harm to the field.

First, teaching these theories harms educators. Educators are harmed because they are being taught insufficiently supported theories of human cognition. Teachers' beliefs about how students learn are strongly influenced by their educational training (Hofer, 2002). Training teachers to believe that there are eight sorts of content intelligences, an easy musical route to improved spatial skill, or a division of the mind into emotional and nonemotional intelligence is training teachers in theories that stand against what is known about cognition from empirical research. Thus, teaching these theories damages teachers' epistemologies of the learning process itself.

Second, these theories harm students. Gresham's law is a maxim that claims bad money drives out good money (Li, 2002). As applied to ideas it argues that bad notions crowd out good notions. Because the theories reviewed here lack sound empirical support they are unlikely to have productive value in enhancing student learning beyond that created by the excitement of incidental novelty or the power of inadvertent repetition. Excitement and repetition can be better introduced in learning when attended to directly in planning learning activities. In other words, when these theories are used as a basis for educational practices they are replacing other classroom practices that may be of greater benefit for students.

Finally, the acceptance and promulgation of these theories does harm to the field of education. One of the core goals of education is the discovery of valid ideas supported by a preponderance of sound evidence. The National Research Council's (2000) standard for science education states that high school students should learn that a scientific theory must be logically consistent, open to change, based on current scientific knowledge, and "must abide by the rules of evidence" (p. 20). More broadly, Hogan (2005) argued that "If the search for truth is discarded from the purposes of human learning, then … the integrity of learning … is lost (p. 187). The MI theory, the ME theory, and the EI theory are not supported by a preponderance of sound evidence. The enthusiastic following these theories have garnered from educators stands in sharp contrast to a foundation goal of education.

COGNITIVE NEUROSCIENCE CONSTRAINTS ON THEORIES OF COGNITION

Byrnes (2001) argued that "By itself, brain research cannot be used to support particular instructional practices. It can, however, be used to support particular psychological theories of learning, which in turn can be used to design more effective forms of instruction" (p. 185). But how do we decide which psychological theories of learning and cognition *are* supported by brain research?

This article provided a sketch of the cognitive neuroscience research findings for general intelligence, for the "What is it?" and "Where is it?" neural processing pathways, for the shared genetic basis for different cognitive skills, for the lack of narrow neural content processing boundaries, for Kahneman's two decision-making systems, for adapted cognition modules, for the role of repetition and emotional arousal in memory formation, for role of emotion in cognition, and for the multifocal neural basis of human emotion and sociability.

These brain research findings suggest several plausible empirical constraints for psychological theories of cognition and learning. It is these constraints that can be used to determine which learning theories and practices are best supported by neuroscience research. As Stern (2005) argued, although "Neuroscience alone cannot provide the specific knowledge to design powerful learning environments," nonetheless neuroscience findings offer a means to evaluate theories by providing "insights into the abilities and constraints of the learning brain" (p. 745).

The first plausible constraint based on the findings outlined here is that psychological theories of cognition should be predicated on shared and overlapping neural processing pathways for a wide range of cognitive content, wherein aspects of emotion and cognition are intertwined. As presently formulated, the proposed mechanisms for MI theory, for the ME theory, and for EI theory do not respect this constraint. MI theory defines each intelligence as operating within a separate neural processing pathway, and EI theory argues that emotion-cognition and non-emotion-cognition are separate functions. Although the ME theory suggests the possible overlap of music and spatial processing in the brain, it excludes emotional arousal as a causal factor.

A second plausible constraint is that theories should respect the crucial role that both effort (repetition) and excitation play in creating long-term memory for information. Standing against this constraint, the ME theory argues that music experience improves spatial skills without effort or emotional arousal. MI theory posits that the effort needed to learn different content skills depends on a priori intraindividual variation in the seven or eight intelligences. Similarly, EI theory argues that individuals vary a priori in their EI, and therefore some individuals need little effort to have a high EI.

With the notable exception of general intelligence, cognitive neuroscience research findings also suggest a third plausible constraint: Cognitive specializations should be theorized as narrow or unipurpose computational devices that address specific recurrent human life problems. (In fact, even some researchers generating evidence for g theorize that g may have evolved to support novel problem solving that could not be addressed by existing specific information processors; Kanazawa, 2004.) Standing against this constraint, MI theory defines each intelligence as a multipurpose processor solving no particular problem but focused on a single domain of content. Similar to MI theory, and despite the evidence that suggests that the emotions we experience do contribute to solving the recurring life problems of decision making (Adolphs et al., 2003; Phelps, 2006), of pair-bonding, and of social group formation (Insel & Fernald, 2004), nonetheless, EI is theorized to be a multipurpose processor solving no particular problem but focused on one domain: social skills.

CONCLUSION

Because MI theory, the ME theory, and EI theory are not supported by sound or consistent validating empirical evidence, and because these theories do not respect the constraints provided by cumulative empirical evidence from cognitive neuroscience research, these theories should not be taught without providing the context of their existing empirical support. Enthusiasm for their application to classroom practice should be tempered by an awareness that their lack of sound empirical support makes it likely that their application will have little real power to enhance student learning beyond that stimulated by the initial excitement of something new.

Of course, future research may shed new light on these theories, and students, teachers, researchers, and theorists should remain open to new evidence.

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