

Interrelated and interdependent

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Abstract

The possibilities for building and nourishing connections among the social, cultural, neuroscientific, biological, and cognitive sciences in the service of understanding children and their development are tremendously exciting. Crossing, and integrating across, disciplinary boundaries, especially those disciplines relating to biology/neuroscience, society/culture, cognition, emotion, perception, and motor function has greatly increased over the last decade and hopefully will increase exponentially in the future. All of these aspects of being human are multiply-interrelated and we need to make far more progress in understanding those interrelations.

Developmental science has been influenced more and more by an appreciation of the profound and multilayered interrelations between the ‘intellect’ (our cognitive abilities), ‘heart’ (emotions and motivation), ‘eyes and ears’ (perception), human spirit, physical body, social relations, and culture. A full understanding requires attention to all of these multiply-interrelated facets.

The last decades of the 20th century saw the development and proliferation of initiatives to link cognitive psychology (including cognitive development) with neuroscience. Brain and cognition institutes and multi-disciplinary programs sprang up around the world. Hopefully, the 21st century will see the continued expansion of such initiatives so that social, emotional, and cultural influences and outcomes are equal partners in the initiatives.

Experience affects mind, brain, and gene expression throughout development

Who we are and what we think is a product not only of our genes, but also of our social, cultural, and physical environments, of their interactions with one another, and of their interactions with our genes (Eisenberg, 1999a; Markus & Kitayama, 1991; Petronis, 2004; Scerif & Karmiloff-Smith, 2005; Shweder, 1999). We now know that our brains are far more malleable than previously thought (Buonomano & Merzenich, 1998; Dong & Greenough, 2004; McEwen, 1999), are malleable throughout development (Gould, Beylin, Tanapat, Reeves & Shors, 1999; Sapolsky, 2003), throughout development

are affected by experience (including social and cultural experience; Eisenberg, 1999b; Greenough, Black & Wallace, 2002; Neville & Bruer, 2001; Schlaug, Norton, Overy & Winner, 2005), and that development is a life-long process. Cognition, perception, and emotion are shaped by, and filtered through, one’s current cultural context and cultural background (Choi, McDonough, Bowerman & Mandler, 1999; Doi, 1971; Heine, Lehman, Markus & Kitayama, 1999; Lutz, 1988; Mesquita, Markus, Manstead, Frijda & Fischer, 2004; Nisbett, Peng, Choi & Norenzayan, 2001; Norenzayan, Smith, Kim & Nisbett, 2002; Spencer-Rodgers, Peng, Wang & Hou, 2004). On the one hand, one’s unique genetic make-up mediates how environmental factors affect one’s mind and body (Caspi & Moffit, 2006). On the other hand, genetic expression itself is malleable and is shaped by experience and the environment (Chakravarti & Little, 2003; Foerstner, von Mering, Hooper & Bork, 2005; Gottesman & Hanson, 2005; Meaney, 2003).

Social relations affect cognition, perception, and emotional and physical health

We are social creatures and our psychological and physical health can suffer if we lack fulfilling, caring relationships and/or meaningful connections to a larger social group (Chandler, Lalonde, Sokol & Hallett, 2003; Hawkey & Cacioppo, 2003; Pressman, Cohen, Miller, Rabin, Barker & Treanor, 2005; Sullivan, 1953). Social status affects the stress experienced and one’s responsiveness to it, as well as access to resources which in turn affects one’s

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psychological and physical health (Chen, 2004; Chen, Hanson, Paterson, Griffin, Walker & Miller, in press; Heymann, Hertzman, Barer & Evans, 2005; Krieger & Davey, 2004; Lupien, King, Meaney & McEwen, 2001; Marmot & Wilkinson, 2005). The social audience helps shape the speaker's words and thoughts (Mills, 1972). In turn, the stories we tell others about ourselves help shape who we are (McAdams, 2006; McAdams, Josselson & Lieblich, 2006). The expectations of others for us, their attitudes, and their interpretations of events shape our thoughts, perceptions including self-perception, and actions (Asch, 1965; Darley & Latane, 1968; Mead, 1934; Raz, Kirsch, Pollard & Nitkin-Kaner, 2006; Rosenthal & Jacobsen, 1968; Simons-Morton, 2004). We are also biological creatures and so there is room for neuroscientific insights not only into our cognitive processes and perceptions, which has burgeoned in the last two decades, but also into our emotions (Davidson, 2003; Forbes & Dahl, 2005; Panksepp, 1998) and our social behavior (Adolphs, 2003; Cacioppo & Berntson, 2004; Robinson, Grozinger & Whitfield, 2005; Todorov, Harris & Fiske, 2006).

Physical health and mental health (cognitive and emotional) are intimately interrelated

There is much we have yet to understand about mind-body relations. What we think and feel affects how our bodies function and how our genes are expressed (Epel, Blackburn, Lin, Dhabhar, Adler, Morrow & Cauton, 2004; Miller & Chen, 2006). In turn, the health of our bodies affects how our brains work and how clearly we think (Maier, 2003). Our thinking suffers, our brains atrophy, and our vulnerability to disease increases if we are stressed, providing a powerful mechanism by which one's social situation, interpersonal interactions, and emotions can affect one's cognitive performance, brain tissue, and physical health (Cohen, 1996; McEwen, 2002; Robles, Glaser & Kiecolt-Glaser, 2005; Sapolsky, 1996; Segerstrom & Miller, 2004; Stetler, Murali, Chen & Miller, 2005). Our brains work better, our thinking is sharper, our mood brighter, and our vulnerability to disease diminished if we are physically fit (Callaghan, 2004; Colcombe, Kramer, Erickson, Scalf, McAuley, Cohen, Webb, Jerome, Marquez & Elavsky, 2004; Hillman, Castelli & Buck, in press; Penedo & Dahn, 2005). Indeed, exercise can increase neurogenesis (Stranahan, Khalil & Gould, 2006; van Praag, Christie, Sejnowski & Gage, 1999). Conversely, physical illnesses and ailments (even paralysis) can be psychologically caused (Kozłowska, 2005; Roelofs, de Bruijn & Van Galen, 2006). One's mental state can also play a decisive role in the healing

process of physical illnesses (Benson & Klipper, 1975; Kabat-Zinn, 1990; Kabat-Zinn, Lipworth & Burney, 1985). Sex hormones also play an important role in affecting cognition and in modulating how genes and experience affect the mind, brain, and body. For example, women are generally poorer than men at mental rotation during the phase of their menstrual cycles when their estrogen levels are high but women perform roughly as well as men on mental rotation when their estrogen levels are low (Dietrich, Krings, Neulen Willmes, Erberich, Thron & Sturm, 2001; Hausmann, Slabbekoorn, Van Goozen, Cohen-Kettenis & Gunturkun, 2000). Conversely, women are generally better than men at verbal fluency when their estrogen levels are highest each month and this difference is reduced when estrogen levels are lower (Hampson & Kimura, 1992; Maki, Rich & Rosenbaum, 2002). Sensation and perception also affect our physical well-being. In particular, touch can be not only a source of great comfort and pleasure, but can minimize the effects of stress and promote physical growth and health (Bush, 2001; Evoniuk, Kuhn & Schanberg, 1979; Feldman & Eidelman, 2003; Field, Hernandez-Reif, Diego, Feijo, Vera & Gil, 2004; Weller & Feldman, 2003).

Cognition, perception, and motor behavior are closely interrelated throughout life

Cognition and perception, attention and memory, are multiply interrelated (Awh & Jonides, 2001; Awh, Vogel & Oh, 2006; Bleckley, Durso, Crutchfield, Engle & Khanna, 2003; de Fockert, Rees, Frith & Lavie, 2001; Pratt & Hommel, 2003). Perception and action are also intimately interrelated (Bertenthal & Clifton, 1998; Costall, Bremner & Slater, 2004; Funk, Brugger & Wilkening, 2005; Ganis, Keenan, Kosslyn & Pascual-Leone, 2000; Hommel, 2005; Humphreys, Riddoch, Forti & Ackroyd, 2004; Sharma, Pomeroy & Baron, 2006). Mirror neurons provide a striking example of integration of perception and action at the cellular level. They fire when you perceive someone else doing a particular goal-directed action or when you yourself execute that same goal-directed motor action (Iacoboni, 2005; Meltzoff & Decety, 2003; Rizzolatti & Craighero, 2004). Cognitive development and motor development are also intimately interrelated, displaying marked parallels and multiple points of connection (Diamond, 2000; Paz, Wise & Vaadia, 2004; Rosenbaum, Carlson & Gilmore, 2001). For example, a perturbation in either motor or cognitive development is more often associated with a perturbation in the other than not (Denckla & Rudel, 1978; Gillberg, 2003; Leary & Hill, 1996; Pitcher, Piek & Hay, 2003). We learn what

is relevant for our actions and we learn best when we must actively use what we learn (Gibson, 1986; Olson, 1964).

Emotions affect cognition, perception, brain function, and physical health

Affect affects what we think, how clearly we think, what we perceive and remember, and how we interpret what we perceive (Arnsten, 1998; Bradley, Mogg, White, Groom & de Bobo, 1999; Gray, Braver & Raichle, 2002; Isen, Manstead, Frijda & Fischer, 2004; Kensinger & Corkin, 2003). What we think and perceive also affects how we feel (Ochsner, Bunge, Gross & Gabrieli, 2002; Raymond, Fenske & Westoby, 2005). A great deal of emphasis is placed on assessing children's intellectual abilities and achievements. Too often, little attention is given to nurturing non-cognitive qualities that can be even more critical to a child's success. Motivation, determination, drive, a positive self-image, belief in oneself, a sense of security, excellent social skills, and/or 'emotional intelligence' can be far greater determinants of success than intellectual brilliance (Abedi & O'Neil, 2005; Ainsworth & Bell, 1970; Blair, 2002; Duckworth & Seligman, 2006; Dweck, Mangels, Good, Dai & Sternberg, 2004; Goleman, 1995; Kreitler, Zigler, Kagan & Olsen, 1995). Negative emotions, such as sadness, anger, or fear, adversely affect one's cognitive functioning and one's bodily health (Carney, Freedland, Miller & Jaffe, 2002; Goleman, 2003; Kiecolt-Glaser, McGuire, Robles & Glaser, 2002). Early emotional experiences, especially early stressful experiences (including prenatal stress), play critical roles in affecting adult behavior, neuropsychiatric disorders, and physical health (Avishai-Eliner, Brunson, Sandman & Baram, 2002; Day, Koehl, Deroche, Le Moal & Maccari, 1998; Evans, Gonnella, Marcynyszyn, Gentile & Salpekar, 2005; Grunau, 2002; Gunnar & Cheatham, 2003; Heim, Plotsky & Nemeroff, 2004; McEwen, 2003; Mirescu, Peters & Gould, 2004; Pollak, 2005; Sanchez, Ladd & Plotsky, 2001).

Concluding remarks

Finally, I hope that developmental science will continue to move toward appreciating the *equal* importance of the different aspects of the human being, the need to nurture all those different aspects, and the critical influences they all exert on each other and on making each of us who we are. It is with great sadness that I see schools in the US moving to cut critically important programs in the arts or physical education, mistakenly thinking these are nonessential. I also hope that developmental science will

continue to move to embracing all the different ways to study who we are and why we are the way we are. Nomothetic approaches that search for commonalities across people, universal principles and valid generalizations need to be complemented by idiographic approaches that focus on in-depth study and understanding of the individual and individual differences, and of the details of what exactly subjects did and why. 'Scientific', quantitative approaches are excellent for testing hypotheses, but astute, patient observation can be a rich source for generating hypotheses.

We need to pay more than lip service to the complexity of human experience. We must keep our minds open to observations and developments in related but currently separate fields of study and actively promote interdisciplinary approaches and collaboration. The possibilities for building and nourishing connections among the social, cultural, neuroscientific, biological, and cognitive sciences in the service of understanding children and their development are tremendously exciting.

I would like to close with a quote from an editorial in *Science* by Alan Leshner:

[N]o field stands alone. Progress in any one domain is absolutely dependent on progress in many other disciplines . . . My greatest concern is that our scientific institutions are not well positioned to promote the interdisciplinarity that characterizes so much of science at the leading edge. Academic institutions are still organized primarily into discrete fields of learning. Review and reward systems based on eminence or publication within one's own disciplinary 'silo' may penalize interdisciplinary work. The increasing number of cross-departmental, interdisciplinary research centers in universities is welcome, but most academics are still evaluated for tenure and promotion within their departments. (Leshner, 2004, p. 729)

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