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## 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.

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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 multidisciplinary 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; Hawkley & 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 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 & Cauthon, 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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## References

- Abedi J, O’Neil HF. Assessment of noncognitive influences on learning. *Educational Assessment* 2005;10:147–151.
- Adolphs R. Cognitive neuroscience of human social behaviour. *Nature Reviews Neuroscience* 2003;4:165–178.
- Ainsworth MDS, Bell S. Attachment, exploration, and separation. *Child Development* 1970;41:49–67. [PubMed: 5490680]
- Arnsten AF. The biology of being frazzled. *Science* 1998;280:1711–1712. [PubMed: 9660710]
- Asch, SE. Effects of group pressure upon the modification and distortion of judgments. In: Prohansky, H.; Seidenberg, B., editors. *Basic studies in social psychology*. Holt, Reinhart, Winston; New York: 1965. p. 393-401.
- Avishai-Eliner S, Brunson KL, Sandman CA, Baram TZ. Stressed-out, or in (utero)? *Trends in Neurosciences* 2002;25:518–524. [PubMed: 12220880]

- Awh E, Jonides J. Overlapping mechanisms of attention and spatial working memory. *Trends in Cognitive Sciences* 2001;5:119–126. [PubMed: 11239812]
- Awh E, Vogel EK, Oh SH. Interactions between attention and working memory. *Neuroscience* 2006;139:201–208. [PubMed: 16324792]
- Benson, H.; Klipper, MZ. *The relaxation response*. William Morrow & Co; New York: 1975.
- Bertenthal, BI.; Clifton, RK. Perception and action. In: Kune, D.; Siegler, R., editors. *Handbook of child psychology*. 2. Wiley; New York: 1998. p. 51-102.
- Blair C. School readiness: integrating cognition and emotion in a neurobiological conceptualization of children's functioning at school entry. *American Psychologist* 2002;57:111–127. [PubMed: 11899554]
- Bleckley MK, Durso FT, Crutchfield JM, Engle RW, Khanna MM. Individual differences in working memory capacity predict visual attention allocation. *Psychonomic Bulletin and Review* 2003;10:884–889. [PubMed: 15000535]
- Bradley BP, Mogg K, White J, Groom C, de Bono J. Attentional bias for emotional faces in generalized anxiety disorder. *British Journal of Clinical Psychology* 1999;38:267–278. [PubMed: 10532148]
- Buonomano DV, Merzenich MM. Cortical plasticity: from synapses to maps. *Annual Review of Neuroscience* 1998;21:149–186.
- Bush E. The use of human touch to improve the well-being of older adults: a holistic nursing intervention. *Journal of Holistic Nursing* 2001;19:256–270. [PubMed: 11847871]
- Cacioppo, JT.; Berntson, GG., editors. *Essays in social neuroscience*. MIT Press; Cambridge, MA: 2004.
- Callaghan P. Exercise: a neglected intervention in mental health care? *Journal of Psychiatry and Mental Health Nursing* 2004;11:476–483.
- Carney RM, Freedland KE, Miller GE, Jaffe AS. Depression as a risk factor for cardiac mortality and morbidity: a review of potential mechanisms. *Journal of Psychosomatic Research* 2002;53:897–902. [PubMed: 12377300]
- Caspi A, Moffitt TE. Gene-environment interactions in psychiatry: joining forces with neuroscience. *Nature Reviews Neuroscience* 2006;7(7):583–590.
- Chakravarti A, Little P. Nature, nurture and human disease. *Nature* 2003;421(6921):412–414. [PubMed: 12540911]
- Chandler MJ, Lalonde CE, Sokol BW, Hallett D. Personal persistence, identity development, and suicide: a study of Native and non-Native North American adolescents. *Monographs of the Society for Research in Child Development* 2003;68(2)Serial No. 273
- Chen E. Why socioeconomic status affects the health of children: a psychosocial perspective. *Current Directions in Psychological Science* 2004;13:112–115.
- Chen E, Hanson MD, Paterson LQ, Griffin MJ, Walker HA, Miller GE. Socioeconomic status and inflammatory processes in children with asthma: the role of psychological stress. *Journal of Allergy and Clinical Immunology*. (in press).
- Choi S, McDonough L, Bowerman M, Mandler JM. Early sensitivity to language-specific spatial categories in English and Korean. *Cognitive Development* 1999;14:241–268.
- Cohen S. Psychological stress, immunity, and upper respiratory infections. *Current Directions in Psychological Science* 1996;5:86–90.
- Colcombe SJ, Kramer AF, Erickson KI, Scalf P, McAuley E, Cohen NJ, Webb A, Jerome GJ, Marquez DX, Elavsky S. Cardiovascular fitness, cortical plasticity, and aging. *Proceedings of the National Academy of Science* 2004;101(9):3316–3321.
- Costall, A.; Bremner, G.; Slater, A. From direct perception to the primacy of action: a closer look at James Gibson's ecological approach to psychology. In: Bremner, Gavin; Slater, Alan, editors. *Theories of infant development*. Blackwell Publishing; Malden, MA: 2004. p. 70-89.
- Darley JM, Latane B. Bystander intervention in emergencies: diffusion of responsibilities. *Journal of Personality and Social Psychology* 1968;8:377–383. [PubMed: 5645600]
- Davidson RJ. Seven sins in the study of emotion: correctives from affective neuroscience. *Brain and Cognition* 2003;52:129–132. [PubMed: 12812811]

- Day JC, Koehl M, Deroche V, Le Moal M, Maccari S. Prenatal stress enhances stress- and corticotropin-releasing factor-induced stimulation of hippocampal acetylcholine release in adult rats. *Journal of Neuroscience* 1998;18:1886–1892. [PubMed: 9465013]
- de Fockert JW, Rees G, Frith CD, Lavie N. The role of working memory in visual selective attention. *Science* 2001;291:1803–1806. [PubMed: 11230699]
- Denckla MB, Rudel RG. Anomalies of motor development in hyperactive boys. *Annals of Neurology* 1978;3:231–233. [PubMed: 666263]
- Diamond A. Close interrelation of motor development and cognitive development and of the cerebellum and prefrontal cortex. *Child Development* 2000;71:44–56. [PubMed: 10836557]
- Dietrich T, Krings T, Neulen J, Willmes K, Erberich S, Thron A, Sturm W. Effects of blood estrogen level on cortical activation patterns during cognitive activation as measured by functional MRI. *Neuroimage* 2001;13:425–432. [PubMed: 11170808]
- Doi, T. *Anatomy of dependence: Amae*. Kodanasha International; New York: 1971.
- Dong WK, Greenough WT. Plasticity of non-neuronal brain tissue: roles in developmental disorders. *Mental Retardation and Developmental Disabilities Research Reviews* 2004;10:85–90. [PubMed: 15362161]
- Duckworth AL, Seligman MEP. Self-discipline gives girls the edge: gender in self-discipline, grades, and achievement test scores. *Journal of Educational Psychology* 2006;98:198–208.
- Dweck, CS.; Mangels, JA.; Good, C.; Dai, DY.; Sternberg, RJ. Motivational effects on attention, cognition, and performance. In: Dai, DY.; Sternberg, R.J., editors. *Motivation, emotion, and cognition: Integrative perspectives on intellectual functioning and development*. Lawrence Erlbaum Associates; Mahwah, NJ: 2004. p. 41–55.
- Eisenberg L. Experience, brain, and behavior: the importance of a head start. *Pediatrics* 1999a;103:1031–1035. [PubMed: 10224184]
- Eisenberg L. The social construction of the human brain. *American Journal of Psychiatry* 1999b; 152:1563–1575. [PubMed: 7485618]
- Epel ES, Blackburn EH, Lin J, Dhabhar FS, Adler NE, Morrow JD, Cawthorn RM. From the cover: accelerated telomere shortening in response to life stress. *Proceedings of the National Academy of Sciences* 2004;101(49):17312–17315.
- Evans GW, Gonnella C, Marcynyszyn LA, Gentile L, Salpekar N. The role of chaos in poverty and children's socioemotional adjustment. *Psychological Science* 2005;16:560–565. [PubMed: 16008790]
- Evoniuik GE, Kuhn CM, Schanberg SM. The effect of tactile stimulation on serum growth hormone and tissue ornithine decarboxylase activity during maternal deprivation in rat pups. *Communication in Psychopharmacology* 1979;3:363–370.
- Feldman R, Eidelman AI. Skin-to-skin contact (Kangaroo Care) accelerates autonomic and neurobehavioural maturation in preterm infants. *Developmental Medicine and Child Neurology* 2003;45:274–281. [PubMed: 12647930]
- Field T, Hernandez-Reif M, Diego M, Feijo L, Vera Y, Gil K. Massage therapy by parents improves early growth and development. *Infant Behavior and Development* 2004;27:435–442.
- Foerstner KU, von Mering C, Hooper SD, Bork P. Environments shape the nucleotide composition of genomes. *EMBO Reports* 2005;6:1208–1213. [PubMed: 16200051]
- Forbes EE, Dahl RE. Neural systems of positive affect: relevance to understanding child and adolescent depression? *Development and Psychopathology* 2005;17:827–850. [PubMed: 16262994]
- Funk M, Brugger P, Wilkening F. Motor processes in children's imagery: the case of mental rotation of hands. *Developmental Science* 2005;8:402–408. [PubMed: 16048512]
- Ganis G, Keenan JP, Kosslyn SM, Pascual-Leone A. Transcranial magnetic stimulation of primary motor cortex affects mental rotation. *Cerebral Cortex* 2000;10:175–180. [PubMed: 10667985]
- Gibson, JJ. Perception through active touch. In: Schwartz, S., editor. *Classic studies in psychology*. Mayfield; Palo Alto, CA: 1986. p. 82–85.
- Gillberg C. Deficits in attention, motor control, and perception: a brief review. *Archives of Disease in Childhood* 2003;88:904–910. [PubMed: 14500312]
- Goleman, D. *Emotional intelligence: Why it can matter more than IQ*. Bantam Books; New York: 1995.

- Goleman, D. *Destructive emotions: A scientific dialogue with the Dalai Lama*. Bantam Books; New York: 2003.
- Gottesman II, Hanson DR. Human development: biological and genetic processes. *Annual Review of Psychology* 2005;56:263–286.
- Gould E, Beylin A, Tanapat P, Reeves A, Shors TJ. Learning enhances adult neurogenesis in the hippocampal formation. *Nature Neuroscience* 1999;2:260–265.
- Gray JR, Braver TS, Raichle ME. Integration of emotion and cognition in the lateral prefrontal cortex. *Proceedings of the National Academy of Sciences* 2002;99:4115–4120.
- Greenough, WT.; Black, JE.; Wallace, CS. Experience and brain development. In: Johnson, MH.; Munakata, Y.; Gilmore, RO., editors. *Brain development and cognition: A reader*. 2nd edn.. Blackwell Publishing; Malden, MA: 2002. p. 186-216.
- Grunau RE. Early pain in preterm infants: a model of long term effects. *Clinics in Perinatology* 2002;29:373–394. [PubMed: 12380464]
- Gunnar MR, Cheatham CL. Brain and behavior interfaces: stress and the developing brain. *Infant Mental Health Journal* 2003;24:195–211.
- Hampson, E.; Kimura, D. Sex differences and hormonal influences on cognitive function in humans. In: Becker, JB.; Breedlove, SM.; Crews, D., editors. *Behavioral endocrinology*. MIT Press; Cambridge, MA: 1992. p. 357-398.
- Hausmann M, Slabbekoorn D, Van Goozen SH, Cohen-Kettenis PT, Gunturkun O. Sex hormones affect spatial abilities during the menstrual cycle. *Behavioral Neuroscience* 2000;114:1245–1250. [PubMed: 11142657]
- Hawley LC, Cacioppo JT. Loneliness and pathways to disease. *Brain, Behavior and Immunity* 2003;17:S98–S105.
- Heim C, Plotsky PM, Nemeroff CB. Importance of studying the contributions of early adverse experience to neurobiological findings in depression. *Neuropsychopharmacology* 2004;29:641–648. [PubMed: 15034558]
- Heine SH, Lehman DR, Markus HR, Kitayama S. Is there a universal need for positive self-regard? *Psychological Review* 1999;106:766–794. [PubMed: 10560328]
- Heymann, J.; Hertzman, C.; Barer, ML.; Evans, RG., editors. *Healthier societies: From analysis to action*. Oxford University Press; New York: 2005.
- Hillman CH, Castelli D, Buck SM. Aerobic fitness and cognitive function in healthy preadolescent children. *Medicine and Science in Sports and Exercise*. (in press).
- Hommel B. Perception in action: multiple roles of sensory information in action control. *Cognitive Processing* 2005;6:3–14.
- Humphreys GW, Riddoch MJ, Forti S, Ackroyd K. Action influences spatial perception: neuropsychological evidence. *Visual Cognition* 2004;11:401–427.
- Iacoboni M. Neural mechanisms of imitation. *Current Opinions in Neurobiology* 2005;15:632–637.
- Isen, AM.; Manstead, ASR.; Frijda, N.; Fischer, A. Some perspectives on positive feelings and emotions: positive affect facilitates thinking and problem solving. In: Manstead, SR.; Frijda, Nico; Fischer, Agneta, editors. *Feelings and emotions: The Amsterdam symposium*. Cambridge University Press; New York: 2004. p. 263-281.
- Kabat-Zinn, J. *Full catastrophe living: Using the wisdom of your body and mind to face stress, pain, and illness*. Dell Publishing; New York: 1990.
- Kabat-Zinn J, Lipworth L, Burney R. The clinical use of mindfulness meditation for the self-regulation of chronic pain. *Journal of Behavioral Medicine* 1985;8:163–190. [PubMed: 3897551]
- Kensinger EA, Corkin S. Memory enhancement for emotional words: are emotional words more vividly remembered than neutral words? *Memory and Cognition* 2003;31:1169–1180.
- Kiecolt-Glaser JK, McGuire L, Robles TF, Glaser R. Psychoneuroimmunology and psychosomatic medicine: back to the future. *Psychosomatic Medicine* 2002;64:15–28. [PubMed: 11818582]
- Kozłowska K. Healing the disembodied mind: contemporary models of conversion disorder. *Harvard Review of Psychiatry* 2005;13:1–13. [PubMed: 15804930]

- Kreitler S, Zigler E, Kagan S, Olsen D. Cognitive and motivational determinants of academic achievement and behaviour in third and fourth grade disadvantaged children. *British Journal of Educational Psychology* 1995;65:297–316. [PubMed: 7577560]
- Krieger N, Davey SG. ‘Bodies count,’ and body counts: social epidemiology and embodying inequality. *Epidemiologic Reviews* 2004;26:92–103. [PubMed: 15234950]
- Leary MR, Hill DA. Moving on: autism and movement disturbance. *Mental Retardation* 1996;34:39–53. [PubMed: 8822025]
- Leshner AI. Science at the leading edge. *Science* 2004;303:729. [PubMed: 14764833]
- Lupien SJ, King S, Meaney MJ, McEwen BS. Can poverty get under your skin? Basal cortisol levels and cognitive function in children from low and high socioeconomic status. *Development and Psychopathology* 2001;13:653–676. [PubMed: 11523853]
- Lutz, CA. *Unnatural emotions: Everyday sentiments on a Micronesian Atoll and their challenge to western theory*. University of Chicago Press; Chicago, IL: 1988.
- McAdams, DP. *The redemptive self: Stories Americans live by*. Oxford University Press; New York: 2006.
- McAdams, DP.; Josselson, R.; Lieblich, A., editors. *Identity and story: Creating self in narrative*. American Psychological Association; Washington, DC: 2006.
- McEwen BS. Permanence of brain sex differences and structural plasticity of the adult brain. *Proceedings of the National Academy of Sciences* 1999;96:7128–7130.
- McEwen BS. The neurobiology and neuroendocrinology of stress: implications for post-traumatic stress disorder from a basic science perspective. *Psychiatric Clinics of North America* 2002;25:469–494. [PubMed: 12136511]
- McEwen BS. Early life influences on life-long patterns of behavior and health. *Mental Retardation and Developmental Disabilities Research Reviews* 2003;9:149–154. [PubMed: 12953293]
- Maier SF. Bi-directional immune-brain communication: implications for understanding stress, pain, and cognition. *Brain, Behavior and Immunity* 2003;17:69–85.
- Maki PM, Rich JB, Rosenbaum RS. Implicit memory varies across the menstrual cycle: estrogen effects in young women. *Neuropsychologia* 2002;40(5):518–529. [PubMed: 11749982]
- Markus HR, Kitayama S. Culture and the self: implications for cognition, emotion, and motivation. *Psychological Review* 1991;98:224–253.
- Marmot, M.; Wilkinson, R., editors. *Social determinants of health*. 2nd edn.. Oxford University Press; Oxford: 2005.
- Mead, GH. *Mind, self and society*. University of Chicago Press; Chicago, IL: 1934.
- Meaney, MJ. Plasticity and health: social influences on gene expression and neural development. In: Kessel, F.; Rosenfield, PL.; Anderson, NB., editors. *Expanding the boundaries of health and social science: Case studies in interdisciplinary innovation*. Oxford University Press; New York: 2003. p. 147-174.
- Meltzoff AN, Decety J. What imitation tells us about social cognition: a rapprochement between developmental psychology and cognitive neuroscience. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences* 2003;358:491–500.
- Mesquita, B.; Markus, HR.; Manstead, ASR.; Frijda, N.; Fischer, A. Culture and emotion: models of agency as sources of cultural variation in emotion. *Feelings and emotions: The Amsterdam symposium*. Antony, SR.; Manstead; Nico, Frijda; Agneta, Fischer, editors. Cambridge University Press; New York: 2004. p. 341-358.
- Miller GE, Chen E. Life stress and diminished expression of genes encoding the glucocorticoid receptor and b2-adrenergic receptor in children with asthma. *Proceedings of the National Academy of Sciences* 2006;103:5496–5501.
- Mills, CW. *Language and Education*. Open University Press; Boston, MA: 1972. Language, logic, and culture; p. 59-65.
- Mirescu C, Peters JD, Gould E. Early life experience alters response of adult neurogenesis to stress. *Nature Neuroscience* 2004;7:841–846.



- Neville, HJ.; Bruer, JT. Language processing: how experience affects brain organization. In: Bailey, DB., Jr.; Bruer, JT.; Symons, FJ.; Lichtman, JW., editors. *Critical thinking about critical periods*. Paul H. Brookes Publishing; Baltimore, MD: 2001. p. 151-172.
- Nisbett RE, Peng K, Choi I, Norenzayan A. Culture and systems of thought: holistic versus analytic cognition. *Psychological Review* 2001;108:291–310. [PubMed: 11381831]
- Norenzayan A, Smith EE, Kim B, Nisbett RE. Cultural preferences for formal versus intuitive reasoning. *Cognitive Science* 2002;26:653–684.
- Ochsner KN, Bunge SA, Gross JJ, Gabrieli JDE. Rethinking feelings: an fMRI study of the cognitive regulation of emotion. *Journal of Cognitive Neuroscience* 2002;14(8):1215–1229. [PubMed: 12495527]
- Olson, DR. *Cognitive development: The child's acquisition of diagonality*. Academic Press; New York: 1964.
- Panksepp, J. *Affective neuroscience*. Oxford University Press; New York: 1998.
- Paz R, Wise SP, Vaadia E. Viewing and doing: similar cortical mechanisms for perceptual and motor learning. *Trends in Neuroscience* 2004;27:496–503.
- Penedo FJ, Dahn JR. Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Current Opinions in Psychiatry* 2005;18:189–193.
- Petronis A. The origin of schizophrenia: genetic thesis, epigenetic antithesis, and resolving synthesis. *Biological Psychiatry* 2004;55:965–970. [PubMed: 15121478]
- Pitcher TM, Piek JP, Hay DA. Fine and gross motor ability in males with ADHD. *Developmental Medicine and Child Neurology* 2003;45:525–535. [PubMed: 12882531]
- Pollak SD. Early adversity and mechanisms of plasticity: integrating affective neuroscience with developmental approaches to psychopathology. *Development and Psychopathology* 2005;17:735–752. [PubMed: 16262990]
- Pratt J, Hommel B. Symbolic control of visual attention: the role of working memory and attentional control settings. *Journal of Experimental Psychology: Human Learning and Performance* 2003;29:835–845.
- Pressman S, Cohen S, Miller GE, Rabin BS, Barker A, Treanor J. Loneliness, social network size, and immune response to influenza vaccination in college freshman. *Health Psychology* 2005;24:297–306. [PubMed: 15898866]
- Raymond JE, Fenske MJ, Westoby N. Emotional devaluation of distracting patterns and faces: a consequence of attentional inhibition during visual search? *Journal of Experimental Psychology: Human Perception and Performance* 2005;31:1404–1415. [PubMed: 16366798]
- Raz A, Kirsch I, Pollard J, Nitkin-Kaner Y. Suggestion reduces the Stroop effect. *Psychological Science* 2006;17:91–95. [PubMed: 16466414]
- Rizzolatti G, Craighero L. The mirror-neuron system. *Annual Review of Neuroscience* 2004;27:169–192.
- Robinson GE, Grozinger CM, Whitfield CW. Sociogenomics: social life in molecular terms. *Nature Reviews Genetics* 2005;6:257–270.
- Robles TF, Glaser R, Kiecolt-Glaser JK. Out of balance: a new look at chronic stress, depression, and immunity. *Current Directions in Psychological Science* 2005;14:111–115.
- Roelofs K, de Bruijn ER, Van Galen GP. Hyperactive action monitoring during motor-initiation in conversion paralysis: an event-related potential study. *Biological Psychology* 2006;71:316–325. [PubMed: 16112792]
- Rosenbaum DA, Carlson RA, Gilmore RO. Acquisition of intellectual and perceptual-motor skills. *Annual Review of Psychology* 2001;52:453–470.
- Rosenthal, R.; Jacobsen, L. *Pygmalion in the classroom: Teacher expectation and pupils' intellectual development*. Holt, Rinehart, & Winston; New York: 1968.
- Sanchez MM, Ladd CO, Plotsky PM. Early adverse experience as a developmental risk factor for later psychopathology: evidence from rodent and primate models. *Development and Psychopathology* 2001;13:419–449. [PubMed: 11523842]
- Sapolsky R. Why stress is bad for your brain. *Science* 1996;273(5276):749–750. [PubMed: 8701325]

- Sapolsky RM. Stress and plasticity in the limbic system. *Neurochemical Research* 2003;28:1735–1742. [PubMed: 14584827]
- Scerif G, Karmiloff-Smith A. The dawn of cognitive genetics? Crucial developmental caveats. *Trends in Cognitive Sciences* 2005;9:126–135. [PubMed: 15737821]
- Schlaug G, Norton A, Overy K, Winner E. Effects of music training on the child's brain and cognitive development. *Annals of the New York Academy of Science* 2005;1060:219–230.
- Seegerstrom SC, Miller GE. Psychological stress and the human immune system: a meta-analytic study of 30 years of inquiry. *Psychological Bulletin* 2004;130:601–630. [PubMed: 15250815]
- Sharma N, Pomeroy VM, Baron JC. A backdoor to the motor system after stroke? *Motor Imagery*. 2006 (Epub ahead of print).
- Shweder RA. Why cultural psychology? *Ethos* 1999;27:62–73.
- Simons-Morton BG. The protective effect of parental expectations against early adolescent smoking initiation. *Health Education Research* 2004;19:561–569. [PubMed: 15150137]
- Spencer-Rodgers J, Peng K, Wang L, Hou Y. Dialectical self-esteem and East-West differences in psychological well-being. *Personality and Social Psychology Bulletin* 2004;30:1416–1432. [PubMed: 15448306]
- Stetler, CA.; Murali, R.; Chen, E.; Miller, GE. Stress, immunity, and disease. In: Cooper, CL., editor. *Handbook of stress medicine and health*. CRC Press; London: 2005. p. 131-154.
- Stranahan AM, Khalil D, Gould E. Social isolation delays the positive effects of running on adult neurogenesis. *Nature Neuroscience* 2006;9:526–533.
- Sullivan, HS. *The interpersonal theory of psychiatry*. Norton; New York: 1953.
- Todorov A, Harris LT, Fiske ST. Toward socially inspired social neuroscience. *Brain Research* 2006;1079:76–85. [PubMed: 16480692]
- van Praag H, Christie BR, Sejnowski TJ, Gage FH. Running enhances neurogenesis, learning, and long-term potentiation in mice. *Proceedings of the National Academy of Sciences* 1999;96:13427–13431.
- Weller A, Feldman R. Emotion regulation and touch in infants: the role of cholecystokinin and opioids. *Peptides* 2003;24:779–788. [PubMed: 12895666]