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BOWLBY'S "ENVIRONMENT OF EVOLUTIONARY ADAPTEDNESS: RECENT STUDIES ON THE INTERPERSONAL NEUROBIOLOGY OF ATTACHMENT AND EMOTIONAL DEVELOPMENT

ALLAN N. SCHORE

UCLA DAVID GEFFEN SCHOOL OF MEDICINE

- Narvaez, Panksepp, & Schore (2010): “American culture may be deviating increasingly from traditional social practices that emerged in our ancestral ‘environment of evolutionary adaptedness.’”
- John Bowlby (*Attachment*, 1969):
  “In the case of biological systems, structure takes a form that is determined by the kind of environment in which the system has been in fact operating during its evolution…This environment I propose to term the system’s ‘environment of adaptedness.’ Only within its environment of adaptedness can it be expected that a system will work efficiently.”

- Chapter 4, Man's Environment of Evolutionary Adaptedness.
- "[W]hen we come to consider with what instinctive behaviour - or, more properly, with what behavioural systems mediating instinctive behaviour - humans may be endowed, a first task to consider is the nature of the environment within they are adapted to operate."
- "The only relevant criterion by which to consider the natural adaptedness of any particular part of present-day man's behavioural equipment is the degree to which and the way in which it might contribute to population *survival* in man's primeval environment."

- “The concept of “man’s environment of evolutionary adaptedness “ outlined here is, of course, a version of…“Man’s ordinary expectable environment…Not a single feature of a species’ *morphology, physiology, and behavior* can be understood or even discussed intelligently except in relation to that species’ environment of evolutionary adaptedness.”
- Then refers to “the behavioural systems that tie the child to mother.” “[B]ehavioral systems responsible for maternal behavior in a species will work within certain ranges of social and physical environment and not outside them…”

- Chapter 11, “The Child’s Tie to its Mother: Attachment Behaviour:
- [T]he child’s tie to his mother is a product of a number of behavioural systems that have proximity to mother as a predictable outcome…attachment behaviour is regarded as what occurs when certain behavioural systems are activated. The behavioural systems themselves are believed to develop within the infant as a result of his interaction with his environment of evolutionary adaptedness, and especially of his interaction with the principal figure in that environment, namely the mother.”

- Bowlby: “In the case of biological systems, structure takes a form that is determined by the kind of environment in which the system has been in fact operating during its evolution.”
- In modern terms, biological structure = *morphology and physiology* of developing brain that is evolving during the period of attachment, infancy.
- EEA = the social-emotional relational environment provided by primary caregiver which shapes, for better or worse, the experience-dependent maturation of the brain systems involved in attachment. Operates at nonverbal implicit levels.

- Bowlby gives some clues as to specifically which developing brain systems are influenced by the environment of evolutionary adaptedness: those involved in “attachment systems mediating instinctive behaviour” that contribute to “population *survival* in man’s primeval environment.”
- My work in interpersonal neurobiology indicates attachment shape connectivity of early developing right brain, dominant for control of vital functions supporting survival (Schore, *Pediatrics in Rev.*, 2005).
- Current neuroscience now describing primacy of developing right brain structure-function relations over pre- and postnatal stages of life.

- MacLean (*Zygon*, 1996): “For the mother the experience during pregnancy of the formless life within, could become after birth a sense of exteriorization and extension of the self that physiologically derives to a large extent from the right hemisphere.”
- Trevarthen (*Neuroscience and Biobehavioral Reviews*, 1996): “The right hemisphere is more advanced than the left in surface features from about the 25th (gestational) week and this advance persists until the left hemisphere shows a postnatal growth spurt starting in the second year.”

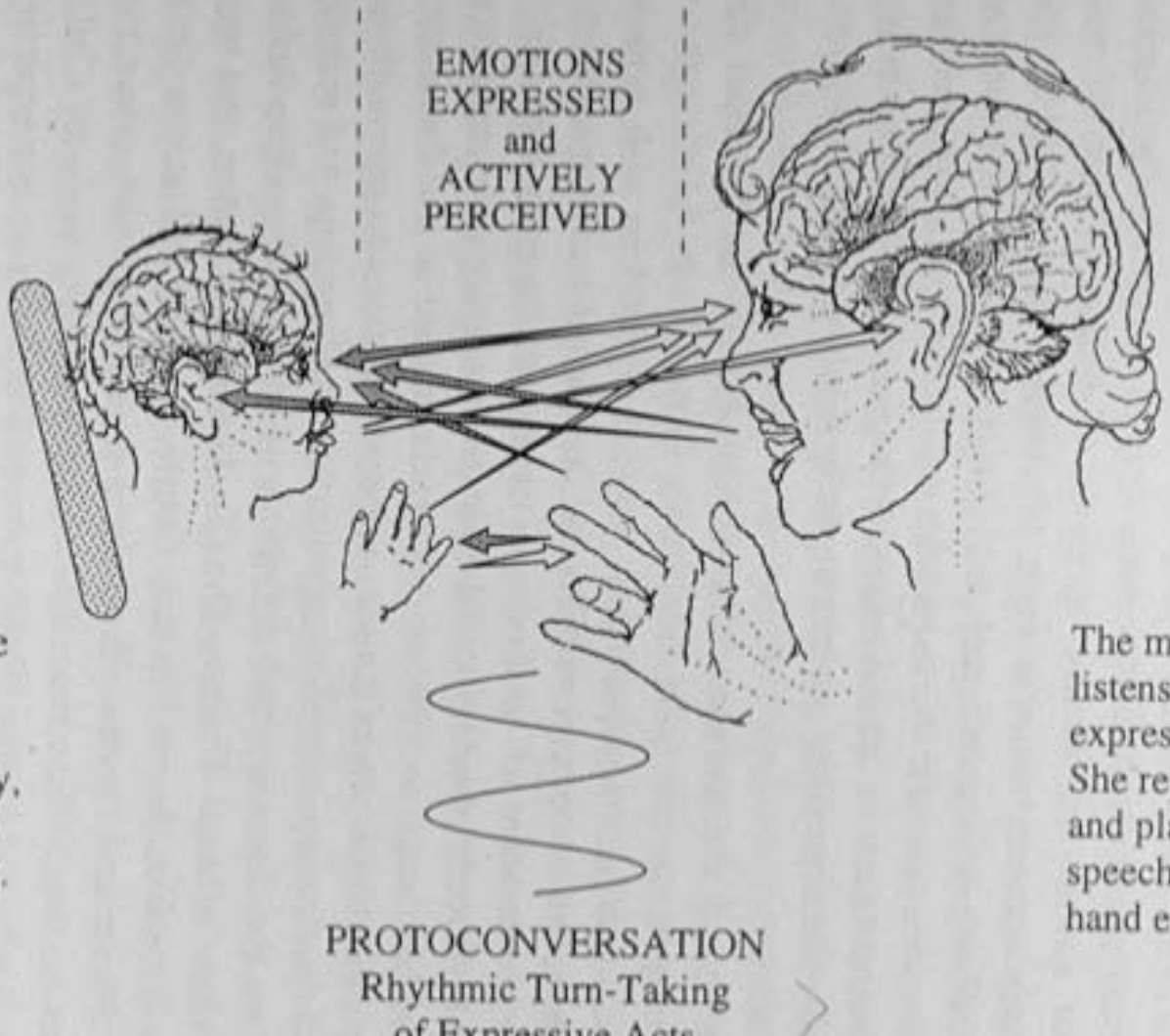
- Schleussner et al. (*Early Human Development*, 2004) report “an earlier maturation of certain right than homologous left hemispheric brain areas during fetal brain development.”
- Kasprian et al. (*Cerebral Cortex*, 2010): “The prenatal origin of hemispheric asymmetry: an *in utero* neuroimaging study.” Show at 26 gestational weeks fetuses right superior temporal sulcus appears earlier and is deeper than left.
- “Our structural data further support the findings of functional neuroimaging studies indicating an earlier maturity of right hemispheric function.”

- Walker-Andrews & Bahrick (*Infancy*, 2001):
- “From birth, an infant is plunged into a world of other human beings in which conversation, gestures, and faces are omnipresent during the infant’s waking hours. Moreover, these harbingers of social information are dynamic, multimodal, and reciprocal.”
- Brown and Jaffe (*Neuropsychologia*,1975): “The right hemisphere can be considered dominant in infancy, for the type of visual and acoustic communication which is relevant for the prelinguistic child.”

- Bowlby (1969): mother-infant attachment communications are “accompanied by the strongest of feelings and emotions, and occur within a context of “facial expression, posture, tone of voice, physiological changes, tempo of movement, and incipient action.”
- Schore (1994): during mutual gaze episodes of *visual-facial, tactile-gestural, and auditory-prosodic* affective communications the psychobiologically attuned caregiver regulates infant’s internal states of arousal.
- Winnicott (1986): “The main thing is a communication between the baby and the mother in terms of the anatomy and physiology of live bodies.”

- Ovtscharoff & Braun, 2001 (*Neuroscience*): "The dyadic interaction between the newborn and the mother constantly controls and modulates the newborn's exposure to environmental stimuli and thereby serves as a regulator of the developing individual's internal homeostasis.
- The regulatory function of the newborn-mother interaction may be an essential promoter to ensure the normal development and maintenance of synaptic connections during the establishment of functional brain circuits."

Primary Inter-Subjectivity



The baby, attracted to the mother's voice, face expressions and hand gestures, replies playfully, with affection; imitating, and provoking imitations.

The mother watches a
listens, anticipating th
expressions intuitively
She replies sympathet
and playfully, with 'm
speech, touches and fa
hand expressions

PROTOCONVERSATION
Rhythmic Turn-Taking
of Expressive Acts

- Massive synaptogenesis in brain growth spurt that spans last trimester of pregnancy through 2nd year.
- Matsuzawa et al. (*Cerebral Cortex*, 2001): MRI study shows volume of brain increases rapidly during first 2 years. Normal adult appearance is seen at 2 years; all major fiber tracts at age 3. Infants under 2 years higher right than left hemispheric volumes.
- Knickmeyer et al. (*J. Neuroscience*, 2008): "Total brain volume increased 101% in the first year, with a 15% increase in the second…The volume of the subcortical area (including brainstem) increased by 130% in the first year and by 14% in the second year." [instinctive systems]

- Schore (*Development and Psychopathology*, 1996): "The self-organization of the developing brain occurs in the context of another self, another brain."
- "The infant's early maturing right hemisphere, which is dominant for the child's processing of visual emotional information, the infant's recognition of the mother's face, and the perception of arousal-inducing maternal facial expressions, is psychobiologically attuned to the output of the mother's right hemisphere, which is involved in the expression and processing of emotional information and in nonverbal communication."

- RH visual-facial attachment communications
- Tzourio-Mazoyer et al. (*NeuroImage*, 2002): PET study of 2-month-old infant looking at image of a woman's face; activation of infant's RH.
- Grossmann et al. (*Social Cognitive and Affective Neuroscience*, 2007): 4-month-old infants presented with images of a female face gazing directly ahead show enhanced gamma electrical activity over right prefrontal areas.
- Nakato et al. (*Human Brain Mapping*, 2009): near-infrared spectroscopy research reveals 5-month-olds' RH responds to images of adult female faces.

- RH auditory-prosodic attachment communications
- Mento et al. (*Eur. J. Neurosci.*, 2010): EEG study of auditory pitch processing in preterm infants born at 30 gestational weeks: “These findings suggest that the earlier right structural maturation in foetal epochs seems to be paralleled by a right functional development.”
- Telkemeyer et al. (*J. Neurosci.*, 2009): NIRS of 2-6 day neonates show “responses to slow acoustic modulations are lateralized to the right hemisphere.”
- Homae (*Neurosci. Res.*, 2006): “Prosodic processing in 3-month-old infants is subserved by the right temporoparietal region.”

- RH auditory-prosodic attachment communications
- Grossmann et al. (*Neuron*, 2010): “The developmental origins of voice processing in the human brain.”
- NIRS study of emotional prosody. 7-month-old infants respond to emotional voices in a voice-sensitive region of the right superior temporal sulcus. Happy prosody activates the right inferior frontal cortex.
- “The pattern of finding suggests that temporal regions specialize in processing voices very early in development and that, already in infancy, emotions differentially modulate voice processing in the right hemisphere.”

- RH tactile-gestural attachment communications
- Nagy (*Infant Child Develop.*, 2006): study human neonates in their first 3-96 hours of life, and find a "lateralized system for neonatal imitation."
- "The early advantage of the right hemisphere (Chiron et al.,1997; Schore, 2000; Trevarthen, 2001) in the first few months of life may affect the lateralized appearance of the first imitative gestures."
- Sieratzki & Woll (*Behav. Brain Sci.*, 2005) on touch and RH: "The emotional impact of touch, the most basic and reciprocal mode of interaction is also more direct and immediate if an infant is held to the left side of the body."

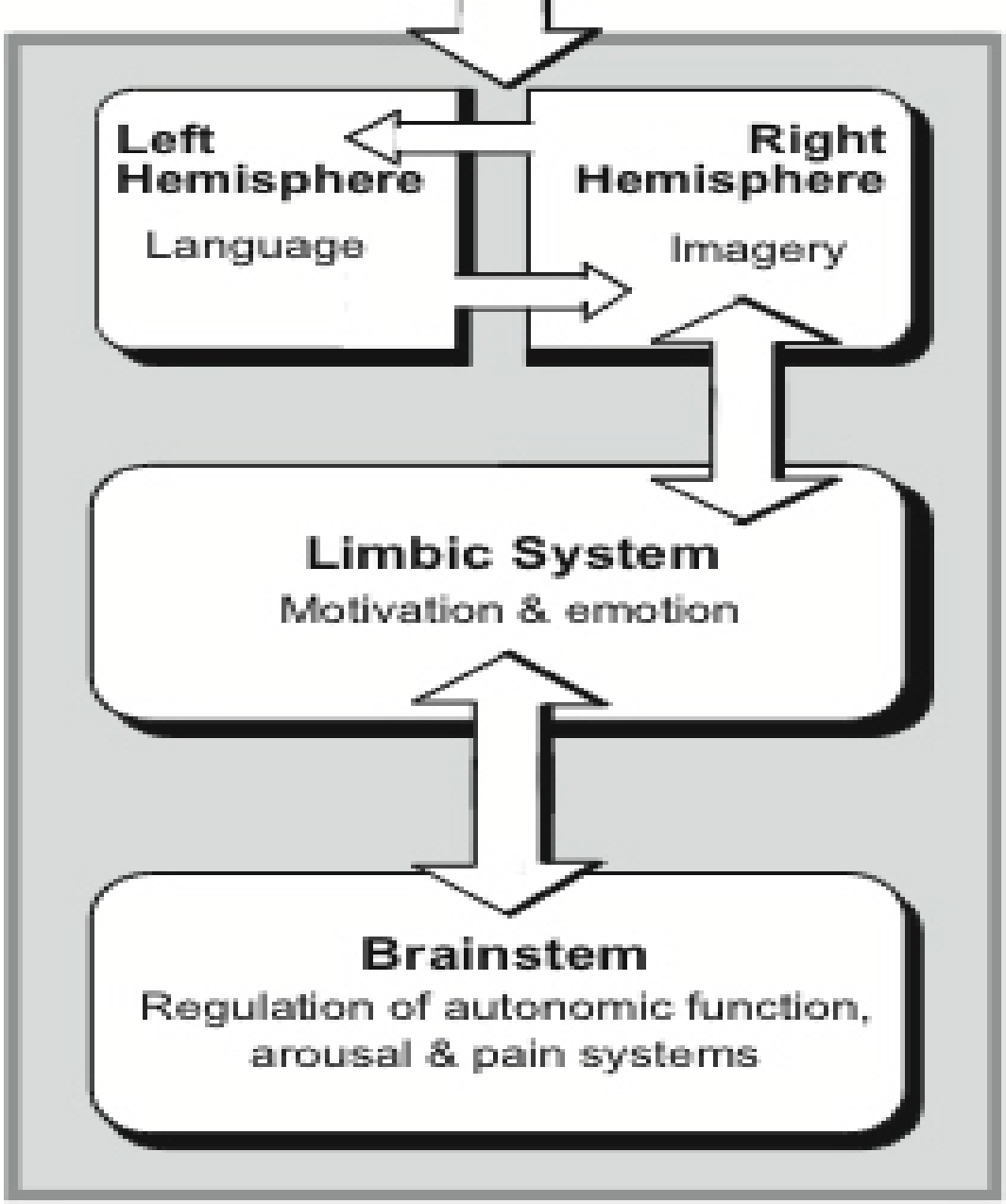
- RH tactile-gestural attachment communications
- Montirosso, Borgatti, & Tronick (2010): observe left-sided regulatory gestures when infant stressed.
- “Infants cope with the emotional distress caused by unresponsive mothers through self-regulation behaviors associated with a greater activation of the right hemisphere. In sum, this finding supports the view that during a stressful condition there is a state-dependent activation of the right hemisphere.”
- “More generally these findings suggest that the right hemisphere is more involved in the social and biological functions regarding infant caregiver emotional bonding (Schore, 2005; Siegel, 1999).”

- Schore (1994): attachment impacts developing RH.
- Sieratzki & Woll (*Lancet*, 1996): “The role of the right hemisphere is crucial in relation to the most precious needs of mothers and infants.”
- Chiron et al. (*Brain*, 1997): “The right brain hemisphere is dominant in human infants.”
- Braun (*Laterality*, 2002): “The right and left human brain hemispheres differ in macrostructure, ultra-structure, physiology, chemistry, and control of behavior.”
- Howard & Reggia (*Brain and Cognition*, 2007): “Earlier maturation of the right hemisphere is supported by both anatomical and imaging evidence.”

- Lenzi et al. (*Cerebral Cortex*, 2009): fMRI study of mother-infant emotional communication offer data "supporting the theory that the right hemisphere is more involved than the left hemisphere in emotional processing and thus, mothering."
- Noriuchi et al. (*Biol. Psychiatry*, 2008): activation of mother's right orbitofrontal cortex during moments of maternal love triggered by viewing video of own infant.
- Minagawa-Kawai (*Cerebral Cortex*, 2009): near-infrared spectroscopy study of infant-mother attachment at 12 months, "our results are in agreement with that of Schore (2000) who addressed the importance of the right hemisphere in the attachment system."

- Schore (1994): bodily-based attachment transactions imprint right brain, which is deeply connected into emotion processing limbic system and ANS.
- Helmeke et al. (*Neuroscience*, 2001): “The functional maturation of limbic circuits is significantly influenced by early socio-emotional experience.”
- Dapretto et al. (*Nature Neuroscience*, 2006): “Typically developing children can rely upon a right hemisphere-mirroring neural mechanism - interfacing with the limbic system via the insula - whereby the meaning of imitated (or observed) emotion is directly felt and hence understood.”

- Porges (2007): “Consistent with the views that the right hemisphere appears to play a greater role in affect, especially the adaptive expression of negative affect, the right hemisphere also appears to have a greater role in regulation of cardiac function presumably via shifts in vagal regulation.”
- McGilchrist (2009): “The right hemisphere, is…more closely in touch with emotion and the body (therefore with the neurologically ‘inferior’ and more ancient regions of the central nervous system)…”
- Panksepp (2008): “Cognitive science must re-learn that ancient emotional systems have a power that is quite independent of neocortical cognitive processes.”


Left Hemisphere
Language
Right Hemisphere
Imagery
Limbic System
Motivation & emotion
Brainstem
Regulation of autonomic function, arousal & pain systems

- Gunnar (2000): maternal care within attachment relationship shapes the infant's hypothalamic-pituitary-adrenocortical (HPA) axis.
- Wittling et al. (*Acta Physiologica Scand.*,1997): RH regulates HPA axis and mediates human stress response; RH central to the control of vital functions supporting *survival* and enabling the organism to cope with stresses and challenges.
- Sullivan & Dufresne (*Brain Research*, 2006): Optimal stress regulation is dependent on "right hemispheric specialization in regulating stress - and emotion-related processes."

- Subsequent to child's formation of an attachment to mother in 1st year, forms another, to father in second.
- "The biorhythmicity of man with infant and woman with infant" affords the infant to have "interactive, state-sharing, and state-attuning experiences with two different kinds of caregivers" (Herzog, 2001).
- Father critically involved in male and female toddler's aggression regulation [vs. mother and fear regulation]
- RH ends its initial growth spurt in middle/end of second year, as LH begins its own. Later less intensive growth spurts; adaptive functions accessed over lifespan.

- Schore (1991-2010): attachment shapes experience-dependent maturation and thereby the lateralization of the “emotional” right brain. Attachment mechanism is expressed later in lifespan in implicit nonverbal affect communication and interactive stress regulation.
- Brancucci et al. (*Proc. Royal Soc. London B*, 2009): “[T]he neural substrates of the perception of voices, faces, gestures, smells, and pheromones, as evidenced by modern neuroimaging techniques, are characterized by a general right-hemispheric functional asymmetry.”

- Schutz (*Neuropsychology Review*, 2005): "The right hemisphere operates a distributed network for rapid responding to danger and other urgent problems. It preferentially processes environmental challenge, stress and pain and manages self-protective responses such as avoidance and escape."
- Uddin (*SCAN*, 2006): "The emerging picture from the current literature seems to suggest a special role of the RH in self-related cognition, own body perception, self-awareness and autobiographical memories"
- These adaptive right brain functions are initially imprinted in right brain-to-right brain affective communications during critical periods of infancy.

- Rotenberg (*Behavioral and Brain Sciences*, 2004):
- "The main functions of the right hemisphere…the ability to grasp the reality as a whole; the emotional attachment to the mother (Schore, 2003); the regulation of withdrawal behavior in the appropriate conditions (Davidson, 1992); the integration of affect, behavior and autonomic activity (Schore, 2003) are the basic functions of *survival* (Saugstad, 1998) and for this reason are the first to appear."
- These adaptive functions of an efficient lateralized right brain only evolve in an optimal early relational environment of evolutionary adaptedness.

- However, if primary caregiver chronically dysregulates the child's arousal and affective states this inhibits right brain maturation.
- Severe alterations of EEA lead to enduring inefficient capacities for coping with interpersonal stressors, and predisposition to later psychiatric disorders. Large number of studies demonstrate brain alterations associated with less than optimal early maternal care.
- Helmeke et al. (*Neuroscience*, 2009): lack of paternal care in infancy significantly associated with "delayed and partly suppressed development of orbitofrontal circuits," including OFC-amygdala connections.

- Pre- and postnatal affective transactions also impact maturation of systems involved in immunocompetence in developing brain; thereby risk for not only later-forming psychiatric but medical disorders.
- Shirtcliff, Coe, & Pollak (*PNAS*, 2009): “Early childhood stress is associated with elevated antibody levels to herpes simplex virus type 1.”
- Danese et al. (*PNAS*, 2007): “Childhood maltreatment predicts adult inflammation in a life course study.”
- Batten et a. (*J. Clin. Psychiatry*, 2004): “Childhood maltreatment as a risk factor for adult cardiovascular disease and depression.”

- Extreme deviations in the EEA: Schore (2010) Synopsis. *The Impact of Early Life Trauma on Health and Disease: The Hidden Epidemic*.
- "Recent models of early life trauma are altering their focus from deficits in later maturing conscious, verbal, explicit and voluntary behavior, to impairments of early maturing nonconscious, nonverbal, implicit and automatic adaptive social emotional functions.
- Developmental neuroscience is now moving from studies of later maturing left brain conscious verbal cognitive processes into the early preverbal development of adaptive emotion processing right brain systems in pre- and postnatal periods."

- Schore (1994): attachment shapes experience-dependent maturation and lateralization of right brain. Early right brain lateralization an interpersonal neurobiological measure of EEA; indicator of development of “the social brain.” Severe alterations of EEA alter developmental trajectory of right brain.
- Simian-Tov et al. (*J. Cog. Neuroscience*, 2008): “Functional hemispheric lateralization is considered crucial for brain efficiency; it enhances neural capacity by allowing separate, parallel, and specialized processing in the hemispheres…A central role was ascribed to the right hemisphere in perception and processing of… emotions…”

- Mento et al. (*Eur. J. Neurosci.*, 2010):
  "[T]he RH would sustain the functions necessary for the *survival* of the species, such as visuospatial or emotional processes. Consequently the earlier and faster development of the neural substrates underlying these functions is needed to prevent possible impairment during infancy and childhood."
- "[E]arly alteration of the normal hemispheric asymmetry in terms of functional development in extremely immature infants has recently been related to several neurocognitive developmental impairments during childhood and adulthood."

- Schuetze and Reid (*Laterality*, 2005):
  "Although the infant brain was historically reported to be undifferentiated in terms of cerebral lateralisation until 2 years of age, evidence has accumulated indicating that lateralised functions are present much earlier in development."
- In the first two years evolving right lateralized visual-facial, auditory-prosodic, and tactile-gestural functions of "the human social brain" can be assessed over the pre- and postnatal stages of infancy to appraise the ongoing status of emotional and social development.

- Allman (2005): “The strong and consistent predominance for the right hemisphere emerges postnatally.”
- Grossmann et al. (*Neuron*, 2010): in postnatal periods, “responses to voices and emotional prosody…might thus serve as one of potentially multiple markers that can help with an early identification of infants at risk for neurodevelopmental disorders.”
- Montirosso et al. (2010): call for study of different gestures with simultaneous measurement of brain functions.” “Such studies would also be useful with samples of high risk-infants whose behavior and brain organization may be compromised.”

- Pinkernelle et al. (*Developmental Neurobiology*, 2009): “[E]nvironmental factors contribute to the development of hemispheric asymmetry, as shown here on the cellular and network (dendrites) level. In general, hemispheric lateralization appears to be characteristic for the adequate function of sensory cortices and also for prefrontal and limbic regions.”
- Evaluation of right lateralized nonverbal emotional communication and affect regulation could be used diagnostically as markers of attachment development, complexity of right brain maturation, infant mental health, and targets of early relational intervention.

- Schore (*Infant Mental Health J.*, 2001):
- "*Adaptive* infant mental health can be fundamentally defined as the earliest expression of efficient and resilient strategies for coping with novelty and stress, and maladaptive infant mental health as a deficit in these same coping mechanisms."
- "The former is a resilience factor for coping with psychobiological stressors at later stages of the life cycle, the latter is a risk factor for interruptions of developmental processes and a vulnerability to the coping deficits that define later-forming psychopathogies."

- Schore (1994): “The child’s first relationship, the one with the mother, acts as a template, as it permanently molds the individual’s capacities to enter into all later emotional relationships.”
- Assessments of infant mental health and social-emotional development in the first year must evaluate right brains of both members of an attachment dyad = “the environment of evolutionary adaptedness.”
- Bowlby’s concept of EEA represents the psychological space that a particular culture creates to optimize the emotional attachment bonding between mothers and infants, the evolutionary mechanism of attachment. This space can either be expansive or constrictive.

- Fonagy and Target (*Attachment & Human Devel.*, 2005): “If the attachment relationship is indeed a major organizer of brain development, as many have accepted and suggested (e.g., Schore, 1997, 2003), then the determinants of attachment relationships are important far beyond the provision of a fundamental sense of safety or security (Bowlby, 1988).”
- Brain development directly impacted by attachment transactions in the first 2 years is the development of the right moreso than the later maturing left brain.
- EEA supports or inhibits experience-dependent maturation of right brain. This conference suggests the latter.

- Schore (*Infant Mental Health J.*, 2001): "[T]he earliest stages of humanhood are critical because they contain within them the representation of our possible futures - they model the potential developmental extension of our individual and collective social identities… When and where shall we place our current resources so as to optimize the future of human societies?…How much should we value the very beginnings of human life, in tangible social program dollars?"