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IMPLICATIONS OF CURRENT ADVANCES IN DEVELOPMENTAL NEUROSCIENCE FOR EARLY INTERVENTION PROGRAMS

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"Early intervention outcomes of interest go beyond the child's cognitive functioning to include also child developmental gains in emotional, behavioral, communication, and social spheres, as well as parent/family benefits in improved well being, teaching and parenting, and health care" (Baker & Abbott Feinfield, "Early intervention", Current Opinion in Psychiatry, 2003).

Current significant increase in the basic and clinical sciences of interdisciplinary studies of normal and abnormal development. Also emphasis on social and emotional development Theme of lecture - very recent advances in psychiatry, infant mental health, attachment theory, developmental psychopathology, and developmental neuroscience can now be incorporated into models of early intervention

The interdisciplinary study of "infant socialemotional development, caregiver-infant interactions, and contextual influences on infant and family development" defines the field of infant mental health.

Recent advances in infant mental health integration with neuroscience, "Contributions from the decade of the brain to infant mental health," *Infant Mental Health Journal*, 2001 Recent advances in psychiatry - movement into early prevention and into mental health as well as mental illness

 Mental health as positive psychology, maturity, subjective well-being, resilience, and social-emotional intelligence. Emotional intelligence "will emerge as the most important single dimension of mental health" (G. Valliant, "Mental health", American Journal of Psychiatry, 2003, 160, 1373-1384). Recent advances in psychiatry - integration with affective neuroscience and developmental psychology leading to progress in neuropsychiatry and infant psychiatry

"The association of mental health with maturity is probably mediated not only be progressive brain myelinization but also by the evolution of emotional and social intelligence over time" (Valliant, 2003). Recent advances in attachment theory - Attachment theory, which is now "the dominant approach to under-standing early socioemotional and personality development during the past quartercentury of research" (Thompson, 2000)



Bowlby (1969): Attachment communications occur within a context of "facial expression, posture, tone of voice, physiological changes, tempo of movement, and incipient action". Mother-infant relationship is "accompanied by the strongest of feelings and emotions

Bowlby (1969): Attachment behavior is "vital to the survival of the species." The infant's "capacity to cope with stress" is correlated with certain maternal behaviors. The attachment relationship shapes the individual's capacity to regulate socialemotional stress at all later stages of life. Recent advances in the psychobiology of stress is now being incorporated into attachment theory:

"An individual's response to stressful stimuli may be maladaptive producing physiological and behavioral responses that may have detrimental consequences, or may be adaptive, enabling the individual to better cope with stress. Events experienced early in life may be particularly important in shaping the individual's responsiveness in later stages of life" (Kehoe et a., 1996).

The interdisciplinary field of developmental psychopathology, an outgrowth of attachment theory, studies "the interrelationship of normal and pathological development in children and adults" (Development and Psychopathology) Identification of protective factors (secure) attachment; resilience etc.) vs. risk factors (insecure attachments; coping deficts etc.) for psychopathology Brain research and developmental psychopathology (Suomi, Tucker, Schore etc.)

Bowlby: "In the fields of ethology and psychopathology attachment theory can be used to frame specific hypotheses which relate different family experiences to different forms of psychiatric disorder and also, possibly, to the neurophysiological changes that accompany them". «"Attachment relationships are formative

because they facilitate the development of the brain's self-regulatory mechanism, which in turn allow the individual to perform effectively in society" (Fonagy & Target, 2002) Neuroscience is now exploring the evolution of brain structures that process and regulate emotional and social information.

"The mother functions as a regulator of the socio-emotional environment during early stages of postnatal development...subtle emotional regulatory interactions, which obviously can transiently of permanently alter brain activity levels...may play a critical role during the establishment and maintenance of limbic system circuits (Ziabreva et al., Journal of Neuroscience, 2003).

Recent advances in affective neuroscience: "The self-organization of the developing brain occurs in the context of a relationship with another self, another brain" (Schore, 1996), "Because emotion systems coordinate learning," the broader the range of emotions that a child experiences the broader will be the emotional range of the self that develops. By coordinating parallel plasticity throughout the brain, emotional states promote the development and unification of the self" (LeDoux, The Synaptic Self, 2000).





The right brain hemisphere is dominant in human infants

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Summary

The development of functional brain asymmetry during childhood is confirmed by changes in cerebral blood flow measured at rest using dynamic single photon emission computed tomography. Between 1 and 3 years of age, the blood flow shows a right hemispheric predominance, mainly due to the activity in the posterior associative area. Asymmetry shifts to the left after 3 years. The subsequent time course of changes appear to follow the emergence of functions localized initially on the right, but later on the left hemisphere (i.e. visuospatial and later language abilities). These findings support the hypothesis that, in man, the right hemisphere develops its functions earlier than the left.

Keywords : hemispheric specialization; cerebral functional imaging; SPECT; child; brain development

Abbreviations: mCBF = hemispheric mean cerebral blood flow; OM = orbitomeatal (level); <math>rCBF = regional cerebral blood flow; SPECT = single photon emission computed tomography

Recent advances in developmental neuroscience: the infant brain "is designed to be molded by the environment it encounters." Attachment experiences with the social environment overlap the brain growth spurt Infant MRI study (Matsuzawa et al., Cerebral Cortex, 2001), infant MRI: 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



The right hemisphere can be considered dominant in infancy, for the type of visual and acoustic communication which is relevant for the prelinguistic child" (Brown & Jaffe, Neuropsychologia, 1975). Influences from the social environment are imprinted into the biological structures that are maturing during the human brain growth spurt, which extends fro the last trimester of pregnancy through the last half of the second year.

Early interpersonal affective experiences directly influence the experience-dependent maturation of the early developing regulatory systems of the right brain, which is dominant for the processing of socialemotional information, affect regulation, and attachment functions.

Attachment is now defined as the interactive regulation of emotion, and internal working models, which encode strategies of affect regulation, operate at nonconscious levels

 Emotion is initially regulated by others, but over the course of early development it becomes increasingly self-regulated as a result of neurophysiological development "The best description of development may come from a careful appreciation of the brain's own self-organizing operations." (Cicchetti & Tucker, 1994) In one sense we can consider the whole of child development to be the enhancement of self-regulation" (Fonagy and Target, 2002) Early prevention: alterations in the early social-emotional environment alter the psychological and biological trajectory of the developmental of the self

Affect Regulation and the Origin of the Self

The Neurobiology of Emotional Development



"Learning how to communicate represents perhaps the most important developmental process to take place during infancy." (Papousek & Papousek, 1997).

- Early proto-attachment: maturing motor and developing sensory capacities, especially smell, taste, and touch.
- Infant brain milestone at 8 weeks:rapid metabolic change occurs in the primary visual cortex of infants
- The mother's emotionally expressive face becomes the most potent visual stimulus in the infant's environment (and vice versa)



Attachment processes as dyadic communications:

Affect synchrony: the dyadic regulatory mechanism for establishing and maintaining positive affective states within the attachment bond of emotional communication

Highly arousing, affect-laden, short interpersonal events that expose infants to high levels of cognitive and social information. To regulate the high positive arousal, mothers and infants synchronize the intensity of their affective behavior within lags of split seconds (Feldman)

- These experiences provide young infants with a large amount of episodes – often around 20 per minute during parent-infant interactions - in which parents make themselves contingent, easily predictable, and manipulatable by the infant.
- In such attachment transactions the secure mother, at an intuitive, nonconscious level, is continuously regulating the infant's shifting arousal levels and therefore emotional states





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 In these communications the crescendos and decrescendos of the psychobiologically attuned mother's affective state must be in resonance with similar crescendos and decrescendos of the infant's internal states of arousal. "Synchrony develops as a consequence of each partner's learning the rhythmic structure of the other and modifying his or

her behavior to fit that structure."

(Brazelton)

An amplification of positively valenced states especially occurs in moments of affect synchrony when external sensory stimulation frequency coincides with the organism's genetically-encoded endogenous rhythms.

Interactive repair: the dyadic regulatory mechanism for recovering from negative affective ruptures of the attachment bond. The "good-enough" caregiver is responsible for the reparation of dyadic misattunements and ruptures in the attachment bond of emotional communication. Dyad moves from positive to negative back to positive affect

The more the contingently responsive mother tunes her activity level to the infant during periods of social engagement, the more she allows him to recover quietly in periods of disengagement, and the more she attends to the child's reinitiating cues for reengagement, the more synchronized their interaction.



«Over the course of the first year the regulatory processes of affect synchrony that amplifies states of positive arousal and interactive repair that dampens states of negative arousal are the fundamental building blocks of attachment and its associated emotions. In securely attached infants distress does not endure for long periods beyond the conditions that elicit them; rapid recovery to positively toned emotions is typical (Gaensbauer & Mrazek).

Affect regulation is not just the dampening of negative emotion; also an amplification of positive emotion.

«Attachment, the dyadic regulation of emotion (Sroufe), is not just the re-establishment of security after a stressful negative state; also an interactive amplification of positive affect, as in play states. Regulated affective interactions with a familiar, predictable primary caregiver create not only a sense of safety, but a positively charged curiosity that fuels the burgeoning self's exploration of novel socioemotional and physical environments.
Resilience in the face of stress is an ultimate indicator of attachment capacity and of infant (and adult) mental health.

Resilience: The process of reexperiencing positive affect following negative experience may teach a child that negativity can be endured and conquered. The capacity of the child and the parent to transition from positive to negative and back to positive affect.

"The roots of resilience...are to be found in the sense of being understood by and existing in the mind and heart of a loving, attuned, and self-possessed other" (Fosha)





Imprinting, the learning process that mediates attachment, is defined as synchrony between sequential infantmaternal stimuli and behavior Attachment, the interactive regulation of emotion, represents the regulation of biological synchronicity between organisms

 "When the child is held and hugged, brain networks are activated and strengthened and firing spreads to associated networks; when the child is sung to, still other networks are strengthened to receive sounds and interpret them as song. The repeated appearance of the mother provides a fixation object as in imprinting." (Epstein, 2001, Brain and Cognition).



Primary Inter-Subjectivity

EMOTIONS EXPRESSED and ACTIVELY PERCEIVED

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

> PROTOCONVERSATION Rhythmic Turn-Taking of Expressive Acts

The mother watches and listens, anticipating the baby's expressions intuitively. She replies sympathetically and playfully, with 'motherese' speech, touches and face and hand expressions

The intrinsic regulators of human brain growth in a child are specifically adapted to be coupled, by emotional communication, to the regulators of adult brains" (Trevarthen). Spontaneous emotional communication (Buck, 1994): "a conversation between limbic systems. It is a biologically-based communication system that involves individual organisms directly with one another: the individuals in spontaneous communication constitute literally a biological unit (and) represent an attachment that may satisfy deeply emotional social motives." Buck lateralizes this to the right limbic system



"The right hemisphere can be considered dominant in infancy, for the type of visual and acoustic communication which is relevant for the prelinguistic child" (Brown & Jaffe, Neuropsychologia, 1975).

"The emotional experience of the infant develops through the sounds, images, and pictures that constitute much of an infant's early learning experience, and are disproportionately stored or processed in the right hemisphere during the formative stages of brain ontogeny" (Semrud-Clikeman & Hynd, 1990).



Right hemisphere dominant for mutual gaze, "the process during which two persons have the feeling of a brief link between their two minds" (Wicker, NeuroImage, 1998).





Fig. 1. Consecutive frames from video recordings showing a baby's left mouth opening while smiling (left) and right mouth opening while babbling (right). Mean LI scores for all of the babies were as follows: babble = +0.88 (red), nonbabble = -0.08 (yellow), and smile = -0.82 (blue).



Hypothalamic

Region



Substantia Nigra/ Retrorubral Fields Region

Temporal Lobe Association Cortex

79-50-25-6--25-50-75

Functions of the right hemisphere (Devinsky, 2000):

- Identify a corporeal image of self and its relation to the environment,
- Distinguish self from nonself
- Recognize familiar members of the species
- Emotionally understand and react to bodily and environment stimuli
- «Recall autobiographical information
- Relate self to environmental reality and to the social group
- Maintain a coherent, continuous, and unified sense of self

Adaptive capacities of the right hemisphere:

- Dominant for the implicit nonconscious reception, expression, and communication of emotion
- Stores a vocabulary for nonverbal affective signals such as facial expressions, prosody (the emotional tone of the voice), and gestures, (Bowlby's description of the attachment system)
- Important for broader aspects of communication beyond linguistic processes
- Attachment and affect regulation
- Empathy and trust



Visual stimuli 10040404

STS

FG

Emotional response

Amy Center

Pic Killer

INS

AM

Right hemisphere-to-right hemisphere affect communications, at nonconscious levels, mediate the attachment mechanism, and shape the critical period experience-dependent maturation of the right brain Right hemisphere: locus of Bowlby's control system of attachment. Stores, in implicit-procedural memory, an internal working model of the attachment relationship that encodes strategies of affect regulation for coping with interactive stress.

A secure emotional attachment facilitates the transfer of regulatory capacities from caregiver to infant. «In securely attached individual the internal working model encodes an implicit expectation that homeostatic disruptions will be set right, allowing the child to self-regulate functions which previously required the caregiver's external regulation. In this manner emotion becomes self-regulated as a result of neurophysiological development.

The functioning of the "self-correcting" right hemispheric system is central to self-regulation, the ability to resiliently regulate emotional states through interactions with other humans interactive regulation in interconnected contexts, and without others, autoregulation, in autonomous contexts Secure attachment: a strategy of "open and direct communication of intentions and feelings together with negotiation and compromise" (Crittenden, 1997).

"Positive (formation of emotional attachment) or negative (e.g., maternal separation or loss) emotional experiences may carve a permanent trace in a still developing neuronal network of immature synaptic connections, and can then extend or limit the functional capacity of the brain during later stages of life" (Helmeke et al., Journal of Neuroscience, 2003).

"The vital task of establishing a personally relevant universe and the solace derived from it depend on right hemispheric functioning. If this function is indeed lost in the insecurely attached, much has been lost." (Henry)

FFECT Dysregulation

AND DISORDERS OF THE SELF

ALLAN N. SCHORE

FFECT Regulation

AND REPAIR OF THE SELF

ALLAN N. SCHORE

V Right Hemisphere

Δ

6

Approximation to the Cycles of Neocortical Organization in Left and Right Hemispheres, according to Thatcher, 1994

10

YEARS

12

Figure 4: Brain growth cycles continue asymmetrically throughout childhood, correlated with changes in the balance of functions in the two hemispheres

« "A biological risk factor (initial right hemisphere dysfunction), when combined with a psychosocial risk factor (severe early abuse) predisposes to serious violence" (Raine, 2002). Treatment and intervention studies need to begin much earlier in life than hitherto in order for success to be maximized in preventing violence" (Raine et al., 1997).

"If it were to turn out that the left hemisphere is more influential in most of our scientific inquiries than the right (which seems highly likely), might that constitute a biasing on the types of scientific perspectives we cultivate? To what extent might investigators' own personalities influence the types of inquiries, theories and methodologies they support and pursue?...Progress toward an understanding of affective processes may be slow and theoretically lopsided...if selectively pursued by individuals enriched in left hemisphere skills but impoverished in those of the right" (Panksepp, Brain and Cognition, 2003, p. 11).

Attachment = the interactive regulation of emotion (Schore, 1994; Sroufe, 1996) 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" (Ovtscharoff & Braun, 2001, Neuroscience).

ENDURING EFFECT OF TRAUMATIC ATTACHMENT ON RIGHT BRAIN DEVELOPMENT

Figure 5 | Activation of the right (non-dominant) anterior insular cortex associated with different subjective feelings. a | Recall-induced anger, in which activation is also visible in the right orbitofrontal, anterior cingulate (ac) and interceptive (S2) cortices (reproduced from REE 123 © 2000 Macmillan Magazines Ltd). in, insular cortex; mb, mammillary bodies. b | Regression analysis of subjective ratings of the intensity of cooling the hand (reproduced from REE 5 © 2000 Macmillan Magazines Ltd). c | Activation after exposure to graded disgust in computer-generated faces (reproduced from *Nature* (REE 124) © 1997 Macmillan Magazines Ltd). d | Activation elicited by subjective ratings of trustworthiness in faces (reproduced from REE 129 © 2002 Macmillan Magazines Ltd). e | Activation elicited by subjective ratings of subjective rates in faces (reproduced from REE 129 © 2002 Macmillan Magazines Ltd). e | Activation elicited by sexual arousal (reproduced, with permission, from REE 128 © 1999 Kluwer Academic Publishers).

RIGHT HEMISPHERIC CONNECTIONS INTO THE LIMBIC SYSTEM

- RH is deeply connected into the limbic system, the CNS circuits that rapidly processes emotional information.
- The limbic system derives subjective information in terms of emotional feelings that guide behavior

The limbic system functions to allow the brain to adapt to a rapidly changing environment and organize new learning.

SCHORE'S RIGHT BRAIN DUAL CORTICOLIMBIC-AUTONOMIC CIRCUITS

Damasio: "recognizing emotions from visually presented facial expressions requires right somatosensory cortices"

We recognize another individual's emotional state by internally generating somatosensory representations that simulate how the individual would feel when displaying a certain facial expression."

- «RH: emotional-imagistic processes impact the neurobiological substrate of moral development, empathy and trust Is the substrate of affectively-laden autobiographical memory Stores an internal working model of the attachment relationship which encodes strategies of affect regulation
- Model of "the implicit self" is stored in right brain implicit-procedural memory

Self-recognition and the right prefrontal cortex

Julian Paul Keenan, Mark A. Wheeler, Gordon G. Gallup, Jr. and Alvaro Pascual-Leone

Although the anatomical and functional substrates subserving face recognition have been subject to extensive investigation, the underpinnings of self-face recognition are not well understood. Given the evidence that own-face recognition has been demonstrated by a select number of species, it is intriguing to speculate whether self-face recognition is accomplished via a 'self-network' or simply a 'face-network' within the brain. Furthermore, the relationship of self-recognition to other selfprocesses, such as self-evaluation and autobiographical retrieval, are not clearly defined. However, data from fMRI, ERPs and repetitive transcranial magnetic stimulation as well as from split-brain studies and patients with focal lesions, indicate that the prefrontal cortex, with possible right hemisphere lateralization, may be a preferential component in self-recognition. Studies using these methods, as well as PET, have indicated that the self-processes of self-evaluation and autobiographical memory preferentially engage networks within the right frontotemporal region. Although it is highly improbable that there is a 'self-recognition' or 'self' center, it appears that there may be a bias for the processing of 'self' within the right prefrontal cortex.

Acts as a recovery mechanism that efficiently monitors and autoregulates the duration, frequency, and intensity of not only positive but negative affect states ADAPTIVE FUNCTIONS OF THE RIGHT BRAIN ("RIGHT MIND") The functioning of the "self-correcting" right hemispheric system is central to selfregulation:

Interactive regulation - the ability to flexibly regulate emotional states through interactions with other humans in interdependent, interconnected contexts
Autoregulation - ability to regulate psychobiological state without others in autonomous contexts

One major role of the right frontal lobe is "affectively burning in" information, i.e.giving experience a personal quality, essential for humor, awareness ad episodic memory. This brain region, once considered to be functionally "silent", appears to be critical for the highest human behaviors (Stuss)

In attachment transactions "the mother initially provides an external regulating mechanism for many of the physiological mechanisms that the infant possesses but does not regulate itself. These effects are mediated by effects of the mother on the infant's neurobiological processes. At some point in development the infant becomes self-regulating through the development of internal regulatory mechanisms entrained to the stimuli that the mother provides (Kraemer, A psychobiological theory of attachment, 1992)

Central thesis: experiences required for the experience-dependent maturation of the systems that regulate brain organization in the first two years of life are specifically the social-emotional communications embedded in the affect regulating attachment relationship between the infant and the mother