Theories of the development of human communication

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Abstract

This article considers evidence for innate motives for sharing rituals and symbols from animal semiotics, developmental neurobiology, physiology of prospective motor control, affective neuroscience and infant communication. Mastery of speech and language depends on polyrhythmic movements in narrative activities of many forms. Infants display intentional activity with feeling and sensitivity for the contingent reactions of other persons. Talk shares many of its generative powers with music and the other 'imitative arts'. Its special adaptations concern the capacity to produce and learn an endless range of sounds to label discrete learned understandings, topics and projects of intended movement.

Keywords

Motives, emotions, creativity, infant development, intersubjectivity, cooperative awareness, narrative, ritual, meaning, musicality.

1. Introduction – creating a human self: from intercellular cooperation to the shared imagination of culture

1.1 Making persistent individuals

This paper discusses evidence in human development for *anticipatory adaptations* of body and brain that create learning of communication, particularly the learning of language. Inborn endowments for expressive movement enable human infants to share intentions, experiences and emotional evaluations, including aesthetic and moral feelings about 'self-with-other' experiences long before they speak. Expressive actions of young children motivate shared experience in conversation and eager cooperation in imaginative projects. These actions will mediate in the transmission of artificial practices, beliefs and techniques between individuals throughout life, and build knowledge and skills between generations.

We seek to give a more natural scientific foundation to abstract speculations in psychology and linguistics about how a child is led to master words and to understand what they mean – not only about what purposes and facts spoken words specify, but also how they 'feel' in live transmission. Prevailing theories of innate cognitive programs for discrimination and generation of the semantic and syntactical functions of text ignore the motivating and affective roots. They do not adequately reflect either the knowledge we have about vocal and postural communication in animals, or the development of unique vocal and gestural communication skills in human beings before they are able to speak. They disregard the capacity these expressive ways of moving have for cultivation into symbolic representations of projects, imaginative ideas and acquired knowledge (Merker, 2009a; Trevarthen, Delafield-Butt, and Schögler, 2011). They neglect the functional social space of meaning (Halliday and Matthiessen, 2004) and the poetic/emotional 'languages within language' (Fónagy, 2001), which guide the mastery of communication in early childhood (Bråten, 1998; Bråten, 2009). They regard emotional expression as a manifestation of stresses in regulation of the body and of information processing, not as integral with the causal motivators of adaptive action and experience (cf. Panksepp 1998, 2003; Panksepp and Trevarthen 2009; Trevarthen, 2009).

We examine how the organic or biological and psychological foundations of ideas carried in language emerge before birth in the body-with-brain and its feeling-full activities. We look for the antecedent developmental states and tendencies, from conception through gestation, to trace how the first movements and their intentions and affections become shared as imaginative narrative projects and enriched with consciousness of valued meaning (Bruner 1990; Trevarthen and Delafield-Butt, 2011). First, however, we are concerned with the nature of self-regulating systems in general, and how developing life forms, as *agents*, demonstrate general evolutionary principles of *creativity* and *cooperation*.

1.2 Self-generated activity, context, and cooperative adaptation in natural phenomena

Scientific description and measurement reveals that any enduring substance or system requires *cooperation*, both between its elements, and with its environment. Adaptive, self-organising connectedness and rhythmic harmonies of process and form give rise to a unique organisation in living organisms (Whitehead, 1929; Prigogine and Stengers, 1984). The self-sustaining dynamic relationships between its elements, their mutual active values, are also *creative*. They determine the development or 'ontogeny' of that kind of being – how it will interact with different conditions to sustain its individual being. Anticipatory adaptations cope with probable change in circumstances – as Whitehead says, even inorganic 'organisms' "create their own environment" (Whitehead, 1925, pp. 138).

A living organism sustains its creative form of organisation by processes of growth and activity, challenging its relationship with the environment. From this we infer that the *function of intelligence* in the regulation of the vitality of an animal, including its communication of purposes, feelings and understandings to other individuals in a shared world for cooperative goals, is to create and propagate its ways of moving to use its accessible world in self-sustaining ways. Regulation of vitality and agency of the body is the adaptive function of the animal's nervous system, in all its parts, and as a whole sensory-motor Self (Sherrington, 1906; Merker, 2005; Packard, 2006; Northoff and Panksepp, 2008).

1.3 Ontogenesis of intelligent life forms and their societies

Living organisms grow and survive in epigenetically regulated relations with their surroundings, changing expression of their genes in creative response to circumstances, reproducing bodies and life histories that both 'expect' and 'depend on' environmental opportunities for their vitality (Bateson 1894; Whitehead, 1929; Bateson, 1980). The molecular ecology of genes in living cells can only thrive if the epigenetic systems and the organs of the life form they are within function and develop as they are adapted to do. The dynamic neural regulations in an animal organism have inner and outer aspects of 'self-related processing' (Northoff and Panksepp, 2008), and a child thrives only if it inspires the human world with a love generated by a powerful desire to meet the child's needs for survival and development (Narvaez, Panksepp, Schore, and Gleason, 2011). There is an inborn collaboration between a supportive ecology *inside* each animal, the 'milieu interne' of Claude Bernard (1865), and an arousal of instincts for behavioural engagements with media and agents *outside* the body. These together, the self-maintenance of vital states and the action in the world, provide the essential adaptive structure for psychobiological development and the success of animals and humans and of their societies. Human societies depend on the impulses of young children to find parental companions, and to inspire affection and playful desires for sharing experiences and making them meaningful. The natural motives in child and parent are complementary 'co-adaptations' for the life of human society (Narvaez, Panksepp, Schore, and Gleason 2011).

In the development of this human child the principle of creative and cooperative vitality is repeated over all the scales of organisation of the units of vitality, from beginnings in the fertilized egg, through the tissues and organs of embryo, fetus and developing child, to participation in the social organization of a culture, drawing on accumulated knowledge and skills (Trevarthen, Aitken, Nagy, Delafield-Butt, and Vandekerckhove, 2006).

1.4 Consciousness is the prospective control of agency, generated for coordination and regulation of movement

Animals as embodied and motivated *agents* are coherent and self-regulated. Their bodies are prepared to move with *prospective control* in an awareness of space and time that is created for integrated guidance of their limbs and senses (von Hofsten, 1993; von Hofsten, 2004; Lee, 2005). They act intelligently, with *affective evaluation* of what they are doing in the immediate present, what they may do in the more distant future, and what they remember having done in the past. This 'life world' in action (von Uexküll, 1957) can be elaborated by learning, but it cannot be created by learning – it learns in order to grow. Humans exhibit exceptionally rich 'autonoesis' or the making of a 'personal life history' (Tulving, 2002), as well as cultural 'socionoesis' or the making of a 'habitus' of meaning by 'story-telling' (Bruner, 1990; Bruner, 2003; Trevarthen, 2011a).

The brain is formed to be the generator of an intentional and feeling-full consciousness in an individual. Its spontaneous activity 'knows' ahead in time what any of its movement will do or lead to, 'expects' the effects of stimuli in a 'body-centred world', and can 'project' or 'associate' its experience of vital physiological arousal and need onto items of experience to give situations and objects affecting qualities or feelings (Sherrington, 1906; Lashley, 1951; Sperry, 1952; von Holst and von St. Paul, 1960; Gibson, 1966; Bernstein, 1967; Damasio, 2010). The evidence from embryogenesis confirms that the integrative neural mechanism is mapped early in development to excite prospective movement in integrated command of the form and functions of the body, with its environment-directed effectors and receptors and internal felt needs. In this *behaviour field*, different innate adaptive *modes of activity and awareness* (Trevarthen, 1986a), different 'arousals' of awareness with feeling (Pfaff, 2006; Stern, 2010), guide complementary functions between perceptions – of of objects and agents in the environment, of body movement, and of internal vital physiological need – to give 'self-related processing' (Sherrington 1906; Northoff and Panksepp, 2008; Panksepp and Northoff, 2009).

The actions of the animal sustain physiological wellbeing by guiding locomotion through the media of the surrounding world with selective attention to local objects identified for their life-giving potencies as *good* (*i.e.*, to be sought for and taken up), *bad* (i.e., dangerous, to be avoided) or *neutral* (*i.e.*, safe to ignore). These embodied principles of evaluation can be transmitted as signals to other individuals if they are endowed with the same sensory capacities enabling a sympathetic 'mirroring' of rhythmic patterns of body movement and inner regulatory dynamics (von Uexküll, 1957; Trevarthen, 1986b; Bråten, 2009).

A child's movements powerfully communicate to other human beings the inborn regulatory process of the human mind and their acquired modifications (Aitken and Trevarthen, 1997; Bråten and Trevarthen, 2007; Panksepp and Trevarthen, 2009). They display the 'motor images' which assist the planning of their efficient mastery of the mechanics of a heavy moving body with complex limbs (Bernstein, 1967), the spontaneous 'serial ordering' of their movements in body-related space and time (Lashley, 1951) and the 'prospective control' of the reach and force of their individual actions in this space-time field (Lee, 2005; Lee, 2009). When we move with grace and purpose we assimilate sensory input to guide output of our nervous system by a process that aims to control the future experience of our behaviour. This process becomes communicative by transfer of action-related information between intra- and inter-subjective realms (Trevarthen, 1986b; Gallese, 2001; Sinigaglia and Rizzolatti, 2011; Trevarthen et al., 2011). Learned complexes of gesture become habits of individual action and of cooperation in shared, cultural experience, including the imitative arts of music, theatre and dance, which, with poetry and song, bring the referential communication of language back to its interpersonal and self-sensing foundations (Fónagy, 2001; Malloch and Trevarthen, 2009).

1.5 Communication in the making of animal society, human culture, and language

The principles of animal semiosis, or social signalling, elucidated by Jacob von Uexküll (von Uexküll, 1926) were developed by Sebeok (1977; 1994) as a science of 'semiotics'. They affirm an evolutionary theory of human symbolic communication and the social foundations of language (Halliday, 1978; Rommetveit, 1998), and they elucidate how the special human aptitudes for invention of art and technology grow from the creative and cooperative abilities of expression and response which infants show (Stern, Hofer, Haft, and Dore, 1985; Trevarthen and Longotheti, 1987; Trevarthen, 1990; Reddy, 2008; Stern, 2010). Human beings transform their environment by projects and structures they invent: "The tool kit of any culture can be described as a set of prosthetic devices by which human beings can exceed or even redefine the 'natural limits' of human functioning" (Bruner, 1990). Infants and children are ready for this cultural creativity (Trevarthen, 2011a). They share an imaginative and highly emotional life in intimate and playful attachments with parents, peers and neighbours. Language amplifies and extends the intrinsic impulses and feelings for co-operative functioning, and becomes an historically elaborated descriptive and informative 'tool' for making shared projects more effective by describing flexible inventive forms of social coordination, perspective-taking and joint action (Tylén, Weed, Wallentin, Roepstorff, and Frith, 2010).

Cooperative rituals of art and technique support group mastery of the environment by expanding shared imagination as a history (Turner, 1982; Turner and Bruner, 1986; Donald, 2001). The building of cultural knowledge is aided by carrying messages through many generations in symbolic activities, products and language, transforming intelligence about the uses and qualities of the world and how individuals perceive one another and share purposes and feelings (Darwin, 1872; Vygotsky, 1978; Bruner, 1990; Bråten, 1998; Bråten, 2009). Speech and language depend on new motor skills and a special human enthusiasm for elaborate ritual and vocal learning (Merker, 2008; Merker, 2009a; Merker, in press; MacNeilage 2008; MacNeilage 2011), and on emotional communication in the 'musicality' of gesture and vocalization (Bloom, 2002; Lüdtke, 2011). In art, technology and language, these adaptations expand the capacity for communication of experiences and inventions through different 'loci of concern', from the immediate present realm of space and time, to future events, to remembered pasts, and to imagined, mythical or theoretical times and places (Donaldson, 1992).

2. Cooperative vitality in the creation and nurture of a human communicative self before birth

2.1 The first sixty days: cells cooperate to build tissues and organs of an embryo human being

A human life begins with the creative act of two individuals coming together in intimacy, disengaged from practical concerns, with eagerness for life and joy in the risk of shared bodies, in impulsive activity that sends the sperms of the male toward the ova inside the female. Their hormonal mechanisms and physiological arousal systems are powerfully engaged (Pfaff, 2006). The fertilized human egg joins with a mother's body that is adapted to protect and aid the formations of the body and brain of a new form of primate. The creation of a new human life shows cooperation at all the levels of biological organisation (Trevarthen et al., 2006).

Cells produced by division of the fertilized egg regulate their gene activity by reciprocal, cooperative systems that govern how their populations will divide, migrate, and differentiate (Waddington, 1940). 'Sense data' appropriated between neighbouring cells through diffusible bio-molecules, surface-surface contact, and mechanical tensions activate patterns of genes, which determine how cells will aggregate to form tissues and organs with different functions (Edelman, 1988). The polarised body is formed with sensitive head end and active posterior, and nervous and humoral regulations of a variety of arousals for world-related action and preservation of internal vitality, and their timing (Trevarthen et al., 2006). The central nervous system is integrated as the coordinator of a being that, though still immobile and insensitive, is formed for the joys and fears of a future mobile life in intelligent engagement with the environment (Beddington and Robertson, 1999).

Collaboration between the germ layers of the embryo begins early in embryogenesis, as each tissue "needs the help of its sister travellers…" (Pander, 1817). The endoderm forms the digestive tract that appropriates and digests food; the mesoderm becomes the visceral organs, muscles, and bone that make up the bulk of the body with its transformative and life-sustaining functions; and the ectoderm forms both the skin and all of the nervous tissue of the sense organs, brain, and peripheral nervous system with its sensory and motor components, somatic and visceral (Hamilton, Boyd, and Mossman, 1962). Both brain and skin are adapted for selective engagement with the outside world and for protecting and regulating the energy balance of vitality inside.

3. The Fetus Develops Organs for Life in an Imaginative Cultural World

3.1 Growth of centrencephalic systems for intentions, emotions and conscious agency

According to the 'centrencephalic' theory of consciousness, first presented by Penfield and Jasper (1954), the midbrain, though *anatomically sub-cortical,* is *functionally supra-cortical*. The sub-cortical upper brain stem and midbrain territories between the hypothalamus and superior colliculi are responsible for emotionally charged states of consciousness of our core embodied 'anoetic' conscious agency (Vandekerckhove and Panksepp, 2011), which serve basic generation of action, orientations to experience and emotional appraisals. These primary mental functions ontogenetically and functionally precede cortically-mediated cognitive ones. Cognition may enhance and assist with additional 'tools' for use by this core control system and its expansion in learning adaptation to external realities, but the primary motives and evaluations remain sub-cortically-mediated. Expression of this core consciousness makes intersubjective engagements of action and awareness possible (Watt, 2004).

The centrencephalic theory is confirmed by studies of the growth of intelligent activity and 'self-related processing' in the human embryo. The first integrative pathways of the brain are in the core of the brain stem and midbrain (Windle, 1970), and the earliest whole body movements, though undifferentiated in their goals, are coherent and rhythmic in time (Lecanuet, Fifer, Krasnegor, and Smotherman, 1995). When sensory input develops, there is evidence, not just of reflex *response* to stimuli, but of the *intrinsic generation of prospective control* of more individuated actions, before the neocortex is functional. In the third trimester of gestation, when the cerebral neocortex is beginning formation of functional networks, movements show guidance by touch, by taste and by responses to the sounds of the mother's voice, with learning.

After birth the infant's conscious activity soon exhibits what Sherrington (1906) called 'projicience' of sight and hearing to anticipate the location and properties of objects external to the body, and evaluation or 'affective appraisal' of those properties in relation to vital processes. The former are dependent on neocortex, but the latter are created in subcortical systems. A newborn infant has well-developed coordination of the body, expression of vital needs, and means for selective communication with the affectionate attentions of the mother and by engaging with her complementary adaptations for affectionate response to the infant's needs (Als, 1995). The role of the cerebral cortex, in imaginative identification and memorizing of features of the environment and of objects, and for refined sensory control of complex movements of manipulation and articulation of vocalizations, is critical for adaptation of practical activities and for communication by language learned in the years after birth. But the prenatal development of subjective and intersubjective motives demonstrates that the 'intentional core' and 'seat of consciousness', with emotional regulation of purposeful action and its communication, should not be identified with a learned 'executive' function of the cerebral cortices, as cognitive science proposes. Specifications for a body-centred neural field for perceptual guidance of whole-body action forms a scaffold for higher mental processes and more complex patterns of action, which are laid down in the fetal period by growth of additional structures of body and brain for sensory regulation of movements in an unstimulating, highly-controlled intrauterine environment (Trevarthen, 1985). The first motor, sensory, and interneuronal connections in humans at 35 to 40 days form a basic nerve network in advance of any receptor excitation.

3.2 Fetal syntax: signs of self-generated feelings and imaginative intentions in the first and second trimesters of gestation

After two months gestation the developing child already has body parts adapted for forms of action, awareness and communication characteristic of the human species (Hamilton et al., 1962; Trevarthen, 1985). Organs of selective awareness and communicative expression – mobile head, eyes, face, and vocal system – are differentiated and approximate to their adult forms. The first spontaneous body movements occur at this time (de Vries, Visser, and Prechtl, 1982; Prechtl, 1986). Cycles and rhythmical or pulsating bursts of movement of the early fetus indicate autogenous, *i.e.* 'self-generated', pacemaker systems that will animate perception of time and give tempo to later acts of communication (Wolff, 1966; Osborne, 2009; Trevarthen, 2009).

After three months, information from eyes, ears, nose, and mouth is carried in an impulse code and mapped out in central nerve circuits specified to relate movements in one body-related behavior field (Trevarthen, 1985). The precocious appearance of adaptively organized reaching and touching movements with postural control and accompanied by compensatory eye movements, indicates that the first organized efferent-afferent neural feedback loops, carrying signals from the brain to excite the peripheral motor effect and reflecting back sensations, are those representing a whole-Self-sensing system that controls the coordinated displacement of many body parts. Organized whole-body or body-part movements of the early fetus include 'bicycling' of the legs, turning the body in the womb, reaching to touch the placental and umbilical cord, and reaching to parts of the fetus's own body or a twin fetus (de Vries et al., 1982; Piontelli, 1992; Piontelli, 2010). All confirm that the fetal motor actions are enacted with prospective, Self-sensing control.

It is particularly important in relation to conversational skills that fetal arm movements may be aimed so the hands can feel the face and head (Piontelli, 2010). Studies of fetal behaviour using real-time ultrasonography demonstrate exploratory sensation-testing movements from as early as ten weeks, when innervated areas – lips, cheeks, ears, and parietal bone – are frequently touched by the hands, the fingers of which are themselves richly innervated with sensory fibres. These touches create autostimulatory feed-back; the action creates contact between the fingers and head, giving simultaneously a proprioceptive response, sensation of touch in the fingers, and sensation of touch in the innervated region. This action-generated loop may be considered as the precursor of intersubjective 'self-other' regulatory processes from which communication of mental states develops. Fetuses explore the boundary of the innervated and uninnervated regions at the anterior fontanel of the forehead, testing the differences in feed-back either side of the boundary (Piontelli, 2010, pp. 61-67).

Later in fetal development, other explorations of self and environment can be observed as the hands touch the eyes, the mouth, the uterine wall, and so on. And individual 'habits' appear, such as a propensity to fondle the umbilical cord, scratch at the placenta, or to make twin-directed movements (Piontelli, 1992; Piontelli, 2002; Jakobovits, 2009). Self-touching actions continue throughout life as restless gestural "self adaptors" (Ekman and Friesen, 1969), also very evident in animated face-to-face conversation (Kendon, 1980). They express a dynamic sense of self that communicates changing states of mind.

At two months of gestation the cortex has no neural cells and thalamo-cortical projections are just starting to grow (Larroche, 1981; Hevner, 2000), but there is sufficient sensory and motor nervous connectivity for dynamic proprioceptive motor control (Okado, 1980). At 3½ months, quantified kinematic analyses indicate that fine movements of hands and fingers guided by sensitive touch, show a sequential patterning with modulation of arousal state that may give a grounding for 'narrative imagination', and ultrasound recordings of twin fetuses at 4½ months show regulations that distinguish movements of self-exploration from those directed to a twin, and this is taken to confirm a primary 'social awareness' (Castiello et al., 2010). Certainly, by 5½ months the kinematic form of the arm movements of single fetuses confirms that 'imaginative' and 'self-aware' motor planning is operative (Zoia et al., 2007). This natural history of human movement appears to confirm the suggestion by Lashley (1951, p. 122) that propositional thought may depend on the spontaneous syntactic ordering of movements.

Movements are not only directed to engage with the external inanimate world or the body of the Self. Facial expressions in fetuses and movements of distress and curious exploration give evidence of emotions of discomfort or pleasure that may be adapted for communicating feelings. In the third trimester, separate movements of the facial muscles visualized by 4D ultrasound develop into complexes that define a 'cry face gestalt' or a 'laughter gestalt', expressing emotions that will communicate powerfully after birth in the regulation of parental care (Reissland, Francis, Mason, and Lincoln, 2011). Maternal hunger with depletion of energy supply to the fetus drives 'anxious' patterns of fetal movement. There is consensus in modern paediatrics that by twenty-four weeks the fetus should be considered a conscious agent deserving the same standard of medical care as adults (Royal College of Obstetricians and Gynaecologists, 2010) . The mid-term human fetus has the foundations for the space-time defining functions of intention in action, and for the emotional regulation of aesthetic relations with the objective world and moral relations with other persons.

When considering the emergence of consciousness, it is important to note, however, that the special sense organs, having attained their basic function-specific form in the late embryo, are cut off from stimulation by morphological changes in the early fetal period (Hamilton et al., 1962; Trevarthen, 1985). While a self-regulating mobility is clearly functioning, the organs that will explore the rich variety of experiences after birth have no function. The eyelids grow over the cornea to fuse at 7½ weeks. They reopen at 6 months. The ear ossicles develop within a spongy mesoderm that remains to block transmission until the last fetal months, when a cavity forms around the ossicles. The tympanic cavity remains obliterated by endodermal thickening and swelling and is excavated shortly after birth in association with changes that accompany the onset of pulmonary respiration. Auditory discrimination appears possible only in the last trimester. From the second to sixth gestational months the nostrils are closed by epithelial plugs.

At 6 months, the fetus awakens to a sensible world and the neurological and metabolic processes are sufficiently advanced for survival in an incubator, or with vital support from ventro-ventral contact with a parent's body in 'kangarooing'. The change to this level of competence is a sudden one, the 6-month-old fetus having achieved a characteristic state of sensori-motor readiness, including the fundamental controls for seeing. During the eighth and ninth lunar months, the infant develops muscle tone from lower to upper limbs and assumes a comfortable rest posture, but mobility is less than at early stages of prematurity. This is when the developing child takes the first steps to cooperate purposefully with another human being in regulation of arousal and appraisal of experiences.

Neuroblast production to establish the neocortex is maximum at 20 weeks, mid-gestation (Trevarthen, 2004). Sensory, motor and motivational representations in the cortex, and that will carry cognitive advancements, are mapped out, and its cells impregnated with affinities for connection with their complementary subcortical systems. It is important that the first developing regions – in the parietal, temporal and frontal cortices -- are the same ones that will undergo massive elaboration throughout life. Just these are uniquely enlarged in *Homo sapiens sapiens*, compared to earlier evolved *Homo* (Bruner, 2010). They are the tissues for cultural learning, and they include areas for language learning.

3.3. Fetal sensitivity: rapid brain and muscle development for cultural learning and preparation for engagement in the third trimester of gestation

Between 24 and 40 weeks gestation the human head grows more than the body as the delicately layered neocortical sheet expands. The positions and interconnections of its neurons depend not only upon input from the sensory relay nuclei of the thalamus, but especially from the motivation systems of the core Self already developed (Northoff and Panksepp, 2008). Cortical dendrites proliferate with the support of abundant interneuronal glia cells. These multiply at an accelerating rate toward a climax two weeks after term, accompanying the proliferation of dendrites and the development of synaptic fields (Trevarthen, 2004).

The cortex develops its characteristic folds in the final 10 weeks before birth and the patterning of gyri shows differences between the hemispheres characteristic of humans, which reflect asymmetries in sub-cortical self-regulating systems, the right side of the brain being more self-related or proprioceptive and the left being more discriminatory of environmental affordances and eventually directed to learn adaptive articulations of the hands and of vocal activity (Trevarthen, 1996). Importantly, areas later to be essential for perceiving and producing sounds of words are evident in the left hemisphere at 30 weeks. Complementary enlargements in the right hemisphere are adapted for both visual and auditory evaluations of other persons' expressions and identity.

The late fetus is in a quiescent state, but can be awakened and can learn. At seven months it shows cardiac accelerations and startles to sounds. While general body movements decrease, respiratory movements increase, as do face, tongue movements, smiling, eye movements and hand gestures. All these are forms of action that will serve not only in self-regulation, but in expression of self-related states for intimate communication and for learning language. Fetuses interact with the mother's movements and uterine contractures and, after 25 weeks, can learn her voice, a process that engages the right cerebral hemisphere (DeCasper and Prescott, 2009). There are also motor reactions to rhythmic sounds, such as the bass pulse of dance music, and melodies that the mother attends to frequently or performs on a musical instrument can be learned.

The last trimester is critical for elaboration of asymmetries of cerebral function adapted for cultural learning. First it will be necessary to form an intimate attachment with a caregiver, normally the mother, whose hormonal changes support special affectionate ways of acting that match the newborn's needs. The right hemisphere orbito-frontal system motivates affective communication with the musical prosody of infant-directed parental speech (Schore, 2011), and the left orbito-frontal cortex has a complementary adaptation for generation of affective signals by the infant (Trevarthen, 1996).

Beneath the cerebral cortex the brain generates fundamental rhythms for self-synchrony of movements of body parts and inter-synchrony in exchanges of signals of motives and emotions from other humans (Buzsáki, 2006), including the faster components that become essential for the learning of manipulative skills and the rapidly articulated movements of language or gestural signing (Condon and Sander, 1974; Trevarthen et al., 2011). Brain rhythms enable the fetus to move in coordination with the sounds of music and to learn certain melodies or musical narrations (Malloch, 1999; Gratier and Trevarthen, 2008). They also favour a selective sensitivity to expressive features that identify the mother's voice, which is mediated by the right hemisphere (Panksepp and Trevarthen, 2009; Turner and Ioannides, 2009). Respiratory movements and amniotic breathing appear several weeks before birth, and heart rate changes have been coordinated with phases of motor activity from 24 weeks (James, Pillai, and Smoleniec, 1995). This is indicative of the formation of a prospective control of autonomic state coupled to readiness for muscular activity on the environment, a feature of brain function, which Jeannerod (Jeannerod, 1994) has cited as evidence for the formation of cerebral 'motor images' underlying conscious awareness and purposeful movement.

3.4 Proof of human impulses for self-expression and communication from the development of premature infants.

Infants born four months before term can develop well if given ventro-ventral, skin-to skin contact in 'kangarooing', which compensates for the loss of the intimate amphoteronomic support provided within the mother's body (Als, 1995). Comparisons with traditional artificial intensive care confirm that kangaroo care benefits both infant and mother for intimacy of interaction and maternal feeding, reduces maternal distress, and leads to better development of communication through infancy (Tallandini and Scalembra, 2006). A recording made of a prematurely born infant in intimate body contact of 'kangarooing' with the father's body demonstrates that vocal expression and exchange by simple 'coo' sounds is possible at 32 weeks, and the timing of the alternating sounds of infant and father matches that of normal syllables and phrases in fully articulate speech (Trevarthen, 1999).

From the eighth month and through the first six weeks after full term birth, the neonate's mind is in a quiescent state, well-coordinated but mostly in a deep sleep, able to cooperate with support, comforting and breast feeding, but with limited curiosity for the new much richer environment.

4. The infant's initiative toward cultural learning and language

4.1 Infant intentional communication as groundwork for the interpersonal and practical functions of language

Immediately after birth, a healthy full-term infant may be attractively active, alert and responsive – orienting to the mother's voice, showing interest and affection with well-directed movements of the whole body, of the eyes and face and of the gesturing hands. The baby may imitate expressions of head and eyes, face and mouth, voice or hands, and become involved in a dialogue with an attentive and affectionate parent, actively seeking a gently regulated imitative exchange with a responsive partner (Nagy and Molnar, 2004; Nagy, 2011). Accurate observations prove that the infant has innate prospective awareness and curiosity as a coherent self, and special intuitions for sharing activities and experiences. Human beings are born with both 'subjectivity' and 'intersubjectivity' (Trevarthen, 1979; Trevarthen, 1998; Nagy, 2008). Demonstration of the capacity for active interest and communication has transformed neonatal care (Brazelton, 1979). The increased activity in response to approach by a parent who offers eye-contact, gentle touching and the modulated vocalizations of motherese, the seeking of communication and imitative responses between them, confirm that the human brain is innately convivial and adapted for learning language (Papoušek, 1994). Cyclic sequences of movement become orchestrated to make 'narratives' that express internal regulations of vitality with an innate time sense (Wittmann, 2009).

Within a few weeks the 'protoconversational' behaviour is more quickly regulated by improvements in visual and auditory awareness and, in interaction with the adult behaviours this development attracts, the infant can take a precisely regulated part in a rhythmic exchange of visible and audible signals of vitality and relational emotions. The capacity for this sustained communication has been called 'primary intersubjectivity' (Trevarthen, 1979). By three months an intimate attachment with the mother is consolidated by increased playfulness with body movements and sounds, and games with the infant become attractive to the father and other family members as well. The play takes increasingly ritual forms in body games and song that attract interest and attuned response from the infant. A 'proto-habitus' of performances develops through the first semester, and the infant starts to adapt to the particular cultural forms of body expression and voice, learning to reproduce 'performances' for appreciation by others (Gratier, 2003; Gratier and Trevarthen, 2008). The baby becomes increasingly demonstrative, seductive and self-conscious as 'self-other' awareness grows (Reddy, 2008). This is a development of an 'anoetic' emotional consciousness of self and of other persons that requires no rational or articulate 'theory of mind', the later development of which is artificial and optional (Panksepp and Northoff, 2009).

By seven months more vigorous and more rapid rhythmic movements begin – banging with the hands, but also syllabic babbling, which appears to be the innate repetitive motor function that made learning of speech possible, as Darwin proposed (Darwin, 1871; MacNeilage, 2008; MacNeilage, 2011). The infant is also demonstrating a more intense awareness of the quality of response from a partner who seeks intimate communication, showing wary attention or distress and withdrawal if approached too directly by a stranger who 'does not know the game' (Trevarthen, 2005; Reddy, 2008). This manifestation of heightened temperament in sociability appears just before a striking change at 9 months in the infant's willingness to share a task that requires shared actions on objects in cooperative work (Trevarthen and Hubley, 1978; Hubley and Trevarthen, 1979). In preceding weeks, eagerness to look for, grasp and manipulate has been incorporated in person-person-object games with 'toys'. The infant's capacities to express shifting interests with movements of head, eyes and hands being recruited in intersubjectively created rituals of narration (Merker, 2009b). This joint performance has clear foundations in the spontaneous indicative and narrating movements of pointing with eyes and hands evident from birth (Trevarthen et al., 2011).

Throughout early development, a matching hierarchical set of rhythms of movement facilitates coordination of motives and actions between infant and adult. Perturbation tests prove that the infant is sensitive to both the affective quality of a parent's expressions and to their contingent timing (Murray and Trevarthen, 1985). The spontaneous movements of the infant demonstrate self-synchrony between body parts, and in communication infant and parent show precise inter-synchrony (Condon and Sander, 1974). Musical acoustic analysis of vocal exchanges in proto-conversations and singing play has demonstrated that the rhythmic and melodic patterns of music originate in an innate 'communicative musicality' that makes possible the close cooperation of human companionship (Merker, 2008). Difficulties due to abnormal development of motive processes in the infant, or to emotional disorder in the mother, are marked by loss of responsive musicality (Cooper and Murray, 1998; Field, 2010), and the principles of this fundamental patterning of human sound making by body movement are applied with benefit in therapy and teaching (Malloch and Trevarthen, 2009). Musical forms of communication support language learning at later stages of life as well (Ludke, 2009).

4.2 Proto-language as a social/emotional advance, animated by development of left hemisphere skills for discretization and serial ordering of learned vocal sounds and gestures of narration.

Infants begin to combine learned vocalizations and gestures after the first birthday to make utterances that imitate simplified adult speech. A normally developing child soon names persons, objects and actions, and responds to words, especially to their own name and the name of familiar persons and pets. By the end of the second year a rapid accumulation of a vocabulary begins and the child begins to use serial combinations of words. From this point one can study the development of true language (McNeill, 1970; Locke, 1993). Clearly it depends on the biological adaptations of the human body and brain for narrating the purposeful and emotionally valued experiences and achievements of life with other speaking human beings (Lenneberg, 1967; Bruner, 1983). It shows systematic distortion in developmental disorders such as autism, which offer additional evidence of an age related process governing the growth and differentiation of intersubjective awareness and shared agency (Trevarthen and Aitken, 2003; Trevarthen et al., 2006; Saint-Georges et al., 2010). The linguist Michael Halliday (Halliday, 1975) developed a socio-linguistic theory sensitive to the expressiveness of non-verbal vocalizations and gestures to chart the progress of his son to fluent use of words through the first two years. He identified these developmental phases:

Birth to 9 months, ‘protoconversation’, changing to ‘conversation’;
10 to 15 months, ‘proto-language’, changing to ‘language’;
15 to 20 months, ‘proto-narrative and dialogue’ changing to ‘narrative and dialogue’,
and, after 20 months, ‘proto-discourse’.

Similar transitions in representations leading to language, with varied interpretations, usually led by cognitive or linguistic theory, have been charted by Bates (1979) and Nelson (1996). Bruner (1990) and Rogoff (2003), who are interested in the interpersonal context of story-making and the learning of meaning, note that the purposes and procedures in narrating with young children may vary greatly across cultures. Gestures add metaphorical richness to conversational speech at all ages (Goldin-Meadow and McNeill, 1999) constituting a component of all languages, complementary to speech (McNeill, 2005). A deaf baby may substitute learning of contrived hand movements for spoken words, mastering hand sign language through comparable ages (Volterra, 1981; Petitto and Marentette, 1991). Donaldson (1992) gives an account of the growth of modes of narrative and explanation by expansion of the imagination and purposefulness or ‘locus of concern’ in late infancy and pre-school years, which development is reflected in the utterances of children before they develop what she calls the ‘construct mode’ of mind around three or four years. Hobson (2002) describes in similar terms how the foundations of thought are built in the affective communications of infancy, and Lüdtke (2011) reviews the evidence that relational emotions play a key role at all stages of semiotic and linguistic development and in language learning and language therapy.

The change from intuitive sharing of actions and feelings in intimate affectionate attachment to family and friends to mastery of the skills of a culture and its speaking is animated by growth of the brain with development of regulation of intentions and awareness in the left cerebral cortex. For several years the creative and cooperative imagination of the child, which was apparent at birth, remains the primary motivator for cultural learning, before formal teaching in the tools of culture and its social institutions can be accepted and effective (Halliday and Matthiessen, 2004; Bateman, Hois, Ross, and Tenbrink, 2010; Trevarthen, 2011b). At no point is development of mastery of language independent of the emotional regulation of human initiative and its sharing. Natural language is an artful tool for extending the innate motives for cooperative awareness and cultural learning, not just an abstract technical system of symbols for artificial representation and logical explanation (Reid, 1764).

5. Conclusion

To understand how language can share intentions, experiences and feelings, and how it must be represented widely in the brain, we recognize that the sense of words is transmitted to a child initially by rhythmically patterned movement of the whole body, and is taken up by perceptive response to other persons' self-related feelings for their experiences and prospects of action. Language is a function of intersubjective resonance of conscious embodied agency and aesthetic and moral emotions. All these requirements have manifestations in a newborn infant, and they can be traced back to species-specific organic and psychological capacities emerging in the human embryo and fetus. We are made for sympathetic cooperative creativity, and we learn words to define its purposes.

A new research field of research focusing on the actions of emotional, embodied communication and their development is challenging developmental psychologists, psychiatrists, cognitive neuroscientists, sociologists, anthropologists and philosophers, as well as language scientists, to combine their knowledge and methods to discover, in detail, how gesture and voice become discretized as syllables, words, and phrases, and how they are serially ordered to make meaningful propositional narrations. We will need to study more closely how movements are made and sensed in affective company for joint meaning-making, and to follow them through all the stages by which language is prepared for, mastered and elaborated. This work promises a new understanding of how language evolved, taking into account its rich embodied origins in the feeling and sharing of states of mind in rhythmic musicality of agency in the human brain and body.

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