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Human beings are distinguished from other living creatures by their language. Comparative evolutionary research and human infancy research of the last few decades have shown what a wealth of communication abilities develop in human beings before spoken language is learned. Non-verbal communication—“body language” as it is also called—is expressed through facial expression, gesture, touch, vocal intonation, and whole body posture. These human expressions of communication exhibit a differentiation and variety that is unique and distinct from communications in the animal kingdom.

As adults we regulate our lives, our information, and our relationships to a large degree through language. Increasingly, we accomplish these things also through communication of digital-electronic symbols. But this symbolic language is always dependent upon a more primordial form of communication that, in a manner of speaking, already connects our physical bodies with each other and produces a fundamental relationship that the French philosopher Maurice Merleau-Ponty once described as “intercorporeity.” (Merleau-Ponty 1960) It is the basis of what I will be examining in this essay: learning in physical interactions, in intercorporeal relationships. Aristotle knew that the human being is a *zoon politikon*, a social being. But we now have additional understanding of what that means: Through association and interaction with others, human beings’ physical organisms, including the brain, are formed.

In the following I will outline the biological, psychological, and social foundations of

learning in intercorporeal relationships. I will begin with a brief look at brain development because the brain presents itself as the matrix, so to speak, for all learning processes that take place during childhood. Then we will trace a few basic features of the steps of development in human social learning.

## Neuroplasticity and Development

Human beings, like no other living creatures, require the presence of their fellow beings in order to develop their abilities. No other species comes into the world with such a malleable, or what is called plastic, brain as the human being. By reason of neuronal plasticity (that is, development of synaptic structures, especially in early childhood), the brain develops into an organ that, as a complement to its environment, fits like a key in a lock. That characterization applies first and foremost to the social environment. Our neurobiological structures require appropriate emotional and

intellectual offerings from our attachment figures in order to develop. In other words: *The human brain is essentially a socially and biographically formed organ.*

In 1949 the American neurophysiologist D.O. Hebb formulated the basic law of synaptic learning: Simultaneously activated neurons strengthen their synaptic couplings and, accordingly, form additional connections. (Hebb 1949/2002) This leads to facilitation, that is, future increased signal transmission. By contrast, connections that are seldom or never used are dismantled, which is the equivalent of forgetting. Compare it to a jungle path that, with frequent use, gradually becomes wider

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until finally it is a comfortable road. However, if it remains unused, it will become overgrown and finally disappear altogether. Frequently used neuronal connections are the same as well-trodden paths, while seldom-activated connections are lost.

A massive surplus of neurons and synapses is formed during the first months of a child's life. Initially, there are nearly double the number of synapses that will eventually be needed. Then, according to their stimulation and use, these synapses are either strengthened or dismantled. Up to the end of the second year of life, this experience-dependent selection process forms the basic, permanent nerve network. However, its microstructure remains alterable throughout life in the form of synaptic connection patterns. In the same way that muscles grow through training but atrophy with inactivity, the capacity of the responsible neuronal network either grows or degenerates depending upon the frequency of its use.

The structure of our brain changes with every use, depending on the stimuli the brain encounters and the relationships it mediates. The human brain represents, as it were, all of the experiences from its past. The younger the child and the more intense the impressions, the more impressionable is the brain. Basically, this applies throughout our lives; through our experiences, we constantly create and change the neuronal structure of our brain, and with it also our dispositions of perception and action. In short, we alter ourselves through our conduct of life.

### Primary Intersubjectivity

With these introductory remarks in mind, I will now turn to my actual theme, which is the development of communication in early childhood. Let us begin with the first year of life.

“In the beginning was relationship,” and the most immediate form of relationship to the world is through the sense of touch. Tactile bodily contact (touching, lifting, rocking, and, of course, breastfeeding) is the first form of communication between mother and child. It conveys not only the experience of being carried, being held, receiving warmth and protection, but also pivotal experiences for the development of trust in the world and in other people. From a biological standpoint, all of these tactile experiences also bring about a release in the mother of oxytocin, a hormone that not only stimulates breast-milk production, but also supports bonding between mother and child. Even in animals, mothers care for their young more intensively if they experience higher levels of oxytocin.

Let us now examine the sense of sight. Here also, infants are biologically attuned to social interactions. For one thing, they have an inborn ability to differentiate between animate and inanimate objects. For another thing, newborns already exhibit a heightened attentiveness to faces. What's more, from the beginning they are also able to accurately imitate adults' gestures such as sticking out the tongue, opening the mouth, wrinkling the forehead, and so forth. (Meltzoff and Moore 1977) They possess an inborn social body schema so that the infant's own body connects with the perception of the other; that is, from the outset, the child experiences both as related. A newborn does not perceive its mother as just an image, or something vis-à-vis, but rather the newborn emulates her expression within itself. Research in the last couple of decades supports the premise that human infants' ability to spontaneously imitate the expressions and actions of others is the foundation for empathy. I will return to this subject later.

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Through numerous comparative culture studies, it has been shown that certain basic patterns of human facial expressions are innate. There is a series of six basic emotions—happiness, sadness, anger, revulsion, surprise, and fear—that are associated with the same facial expressions in all cultures. Associated forms of expression are wrinkling the forehead, nose wrinkling, widening the eyes, crying, smiling, and lifting the eyebrows. About six to eight weeks after birth, infants develop the ability to react to their surroundings with smiling, thereby interacting with other people and forming connections with them. Later on, other culturally influenced emotions and forms of expression appear.

Over and above these forms of imitation and expression, there is also increasing development of *emotional resonance* between infant and mother. She intuitively answers the child's signals and initiatives with appropriate responses of voice and gesture. Mothers unconsciously use simplified manners (baby talk, facial expressions, eye contact, reaction to greeting, and so forth) that are appropriate for the as yet undeveloped repertoire of the child. Two infancy researchers, M. and H. Papousek (1995), describe these and other similar behaviors as "intuitive mothering skills." Mothers (and also fathers) possess biologically-based, unconscious knowledge that affords them the ability, through voice, facial expressions, and gestures, to make themselves understood by the infant, and to appropriately calm or stimulate a child, while letting themselves be guided by the child's signals.

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expression: rhythm, the dynamics of facial expressions, vocalization, and gestural interaction (crescendo, decrescendo, flowing, soft, explosive, and so forth). This leads to the interactive "emotional attunement" that infancy researchers have highlighted. Daniel Stern (1985) speaks about a "shared dance" that mother and infant spontaneously perform together. During this communication process, the child increasingly learns to differentiate between the various signals of the mother's emotional expressions. At the same time, the infant becomes better able to understand and differentiate its own emotions. But, above all, the infant develops the prime feeling of living together with others in a world of emotions and of being connected with them.

If we combine all of these observations of emotional expression and imitation, then we can speak about a primal, and biologically rooted, system of resonance and empathy that is engraved upon a child's early development. We grow up in a primal sphere of communicative "intercorporeality" within which we remain throughout our lives. Whenever two people encounter each other, they are, from the beginning, drawn into an interaction that connects them bodily, creating an intuitive understanding between them. The emotions of the other are immediately understood by their expression, because they elicit in us a mostly unnoticed bodily impression with subtle sensations and emotions. The result is an *intercorporeal resonance*: The other person is literally felt in one's own body. (Fuchs & Jaegher 2009)

### Mirror Neurons

The result of this resonance is empathy. It is the foundation of our social life, the reason communication is even possible in the first place. People constantly empathize with the feelings and expressions of others. They feel and share their joy or their pain; they understand the intention of a hand offered for welcome, and they understand why another reaches for a glass of water. One of the neuronal bases of empathy, the subject of intense research during the last ten years, is called the mirror neuron system. (Gallese et al. 1996, Gallese 2001)

These neurons were first identified in the premotor cortex of monkeys, an area of the brain responsible for organization and regulation of movement. Since then, neuron groups of this kind have been shown to exist in various areas of the human brain. Mirror neurons are activated when we carry out very specific actions such as reaching for an apple or a cup, as well as when we perceive the same action carried out by someone else. The effect can be explained in this way: I understand what it means when you reach for a cup because it indicates a similar movement in my own arm. As far as we can tell today, the system has two main functions:

It creates *resonance* between one's own body and that of the other, thereby making it easier to understand the other's actions.

Resonance of the mirror neurons paves the way for *willingness to act*. The more often an action by another is observed, the lower the threshold for imitation and the easier it is to imitate that action. Imitation in infants also has to do with the activity of mirror neurons. The mirror neuron system seems to be the basis of imitation and model learning; these, in turn, are centrally important human abilities affecting cultural development.

Neuronal mirror systems also play a role in contagious laughing, crying, and yawning.

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At present, further research is being applied to emotional reactions; if one observes, for example, the pain or revulsion of another, a center in the anterior insula is activated which is involved in one's own reactions of pain or revulsion. (Wicker et al. 2003)

Admittedly, this biologically rooted system does not bring about human sociability; the latter is not simply inborn, but rather is based upon typical, recurring interactions with others. The mirror neuron system can be activated by reaching for an apple, for instance, only after the child has grasped the *meaning* of reaching for the object. In the same way, empathy with emotional reactions like revulsion requires an understanding of the situation, such as the connection between odor and revulsion. The mirror system can develop correctly only if it is embedded in a *context of social interactions and meanings*.

### Implicit Memory

Let us go further along early childhood development. How does social learning take place during the first year of life? Memory, in which singular biographical experiences or learned facts are retained, begins to mature only in the second year of life. But there is a very different kind of memory. The vast majority of all we have learned we make use of quite automatically during the course of daily life without its prompting us to remember the past. Through repetitive experiences or practice, abilities and habits have formed that are involuntarily activated during applicable situations: walking, swimming, riding a bicycle, speaking or writing. This also applies to the ability to associate with others at any moment, without having to consciously pay attention to the bodily interaction. In the field of memory research, the term *implicit*—meaning involuntary, automatic—is used to differentiate

this kind of memory from autobiographical memory.

Implicit memory relies upon different brain structures than autobiographical memory; it is subcortically organized and becomes functional much earlier in a child's life. Through implicit memory, infants are able to recognize regularities in repeated experiences, acquire faculties, and learn, already at the age of 3 to 4 months, from events in their environment. Above all, through contact with others, they acquire behavioral patterns that organize their interactions. "Schemes-of-being-with," as Daniel Stern described them, include "Me-with-Mother-breastfeeding," "Me-with-Father-playing-ball," and so forth. This results in what can also be described as *implicit relationship knowledge* (Stern 1998): knowing how to relate to others, have fun together, express happiness, get attention, avoid rejection, and so on. It is, to a certain degree, a "musical" memory, organized in time according to the rhythm, dynamics, and undertones that inaudibly resonate within interactions with others.

Already in the first few months of life, infants demonstrate memory for shared interaction sequences through the way they expect their mothers to react. Babies quickly learn which emotional expressions parents respond to, are spurred to action by, or rather dismiss, for example. This can be very nicely shown through the so-called *still-face* experiment. (Weinberg & Tronick 1996) During play with her infant, the mother is asked to assume a blank facial expression and stare straight ahead for two minutes. Babies usually react with clear irritation and unease—the expected resonance from the mother is absent—and they try every possible way, with gestures and vocalizing, to bring their mother back into the familiar form of contact.

Through this, two groups of children can be differentiated (Field 1984): Infants of sensitive and lively mothers remain active even in the *still-face* situation, and obviously expect to bring their mother back into contact in this way. But

infants of mothers who are more detached and lacking resonance (for instance, because of post-partum depression), react differently; in the beginning they are restless and quickly become passive and helpless. They have not learned to effectively use their behavior to bring about contact. However, if the children do not acquire relationship patterns through which they may enter into secure contact with others, then their bonding with others cannot develop appropriately. Later on they show a marked weakness in bonding. (Field et al. 1988)

So we see that, from the beginning, early interactions are laid down in the memory and brain structures of the child, and thus, in his or her behavioral dispositions.

### Bonding System

We now come to a central concept of developmental psychology that has been the subject of intense research in recent decades: the bonding theory. According to John Bowlby, who first developed this concept as far back as the 1950s, social relationships in early childhood are regulated by "a biologically-based bonding system that fulfills the function of securing the emotional proximity and care from the most important attachment figures." (Bowlby 1982) It includes:

- Biologically anchored, coordinated *signals* such as searching, calling, gazing, crying, clinging.
- The corresponding *driving emotions and needs* for things like security, care, warmth, and affection.
- The attendant *physiological, e.g., neuroendocrine* functions.

The infant's basic needs are fulfilled through this system: The infant is dependent upon the mother's body warmth, her smell, her touch, her loving attention, and appropriate stimulation and calming. These interactions play an irreplaceable role in the emotional and social development of an infant. The child's

early experiences of relationships are stored in the implicit memory and anchored as *secure bonds*. The infant gains the basic trust and secure basis with which to actively explore the world. The first relationships also become inner models that put their significant stamp upon later relationships, well into adulthood. (Brisch et al. 2002)

Conversely, however, insufficient attention, lack of feelings of security, or separation from the mother lead to psychophysical stress reactions in infants, with rising agitation at first, but then increasingly to resignation and apathy. Studies by Rene Spitz in the 1960s with orphanage children are well known. (Spitz 1967) Complete withdrawal of emotional care and attention resulted in the development of serious deprivation syndromes with apathy, depression, and higher death rates. Even less serious relationship dysfunctions—arising, for example, from post-partum depression in the mother—have negative effects on the child’s cognitive and emotional development. (Murray & Cooper 2003) The maturing of the emotional relationship system is an experience-dependent process that is susceptible to disruption from many different causes.

### Secondary Intersubjectivity

I have now presented the early—that is, non-verbal—form of communication and relationship, which is also described as “Primary Intersubjectivity.” (Trevarthen 2001) During the next phase, called “Secondary Intersubjectivity” (Trevarthen & Hubley 1978), verbal-symbolic communication develops: the actual human ability for dialogue. Let us take a closer look at this development.

One crucial step is the development of “joint attention,” whereby the mother and child together turn their attention to an outside object. This ability is developed exclusively in human infants around the age of nine months. At this age, babies begin to turn their attention to outside objects together with adults, and also to make certain that adults are paying

attention by giving them short glances. Babies also soon transition to attracting an adults’ attention through pointing gestures. They will point to a glass so that the mother fills it, to an animal so that she may see it, or to an object their mother is searching for in order to help her. By the same token, babies also now begin to understand the pointing gestures of adults, that is, the meaning of the pointing hand. Pointing implicates a joint relationship to a third object seen or comprehended by both partners. A specifically human form of communication is manifested by the pointing gesture: coming to an understanding about a shared outside point of reference. Here lies the fundamental limit of the mental capabilities of other primates such as chimpanzees, who are unable to develop joint attention. (Fuchs 2008) It is such a radical, new level of development that one speaks of the nine-months-revolution. (Tomasello 2001)

First words are now also combined with pointing gestures. Parents point to an object and name it. And, likewise, the first words children use are often combined with pointing. These are integrated into cooperative activities in which the children are involved and that are structured by the parents: diaper changing, eating in a highchair, riding in an automobile, feeding ducks, building a block tower together, and so forth. The capacity of speech thus develops in the course of shared practices directed toward the environment. The children must recognize that their caregivers use words purposefully, that is, with the intention of describing. They adopt a word for a new object only when the adult’s attention is actually directed toward that object. If the caregiver looks in another direction, or if the voice comes from a recording, the child does not make the connection between the word and the object.

### Adoption of Perspective and Self-awareness

With speech, children learn a fundamentally new medium of communication, along with knowledge of the world and of their own selves.

They are now better able to put themselves in the position of others, comprehend their intentions, and take their perspective into account. But how does a child actually learn to say “I”? How does it come to develop self-awareness? We will see that this phenomenon is also linked to relationships and communication with others.

The infant does, in fact, bring with it a very elementary, bodily sense of self. Already before birth it has basic sensations of touch and movement in which it likewise senses its own self. However, in the first months of life this elementary sense of self develops and differentiates itself, above all, through experiences with others who look at and speak to the infant. The precursor of self-awareness develops with the reflection of one’s self in the eyes of the mother, that is, in being addressed by others. (Fuchs 2013)

The pivotal step on the path to self-consciousness takes place from the age of nine months, when the infant has learned joint attention and begins to grasp the perspective of others. The infant then learns to also see itself “with others’ eyes,” for that is how self-consciousness develops. For example, the child learns what it means to have a name: something like, “I am Monica.” This happens when the child realizes that the name points to itself. The child begins to understand this significance during the second year of life. Interestingly, at first, the child will say: “Monica is playing with dolls” or “Monica did that.” She refers to herself by her own name before she uses the word “I” to designate herself.

Between the ages of one and two, it will also become possible for the child to recognize itself in the mirror. There is a well-known

experiment whereby a red dot is put on the child’s forehead unnoticed. As early as the age of 16 to 18 months, when he looks in the mirror, he will grasp at his own forehead. That means he understands that the image in the mirror represents him. Before that age, the image in the mirror is simply a funny face. Recognizing oneself in the mirror signifies the ability to view one’s self from the perspective of others, in a certain way, to see oneself from the outside. This is a milestone in the development of self-consciousness. (Fuchs 2013)

From the second or third year of life, the child finally learns to utilize the “I” pronoun. Indeed, the “I” stands for “me,” but it is also a changeable word that constantly shifts its location according to who is speaking. Only when the child understands

that everyone alike can say “I” does it grasp the universality of personal perspective. Now, the child has come to understand that it is one among others, that it belongs to a community of people. The structures in the prefrontal brain necessary for this purpose mature with interactive experiences in which others speak to, and treat, the child as a person of its own. Self-consciousness and, likewise, the ability to be considerate of others are socially acquired abilities.

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### Summary

Human beings do not come into the world simply as single beings who must be gradually introduced into community. Right from the

beginning, they are biologically inclined to relationships with others. For the infant, this *bonding system* carries out the task of securing close proximity to, care from, and emotional connectedness with the most important attachment figures. Above and beyond that, with the *resonance and empathy system*, a

biologically based system for a subtle, bodily understanding develops. Upon this basis, human beings, like no other species, develop the abilities of empathy, sympathy, and verbal communication. Within the first year of life the foundation is laid for relationship, bonding, and mutual understanding that is necessary for the development of symbolic-verbal communication during the second and third years of life.

In early childhood development, this symbolic communication appears for the first time in the form of spontaneous gestures and pointing. They are based upon the ability of human beings to establish joint attention—that is, connection with another person—to direct one’s attention to an object and to know that the other person is doing the same, and to form common objectives, intentions, and mutual knowledge. Speech development is likewise based upon the primary motives of human communication, namely, to inform others, help others, and share emotions with them. This altruistic and cooperative primary focus differentiates humans from even the most highly developed primates, since the latter make use of gestures only to secure some advantage for themselves with the help of others. (Tomasello 2009)

I would like to make one last observation about the role of the brain. We have seen that human communication, speech, and self-awareness can develop only through interaction with others. The corresponding neuronal patterns are impressed upon the brain during the course of early childhood development. The brain works like a matrix that takes in the child’s relationship experiences and transforms them into permanent abilities. (Fuchs 2008) Through

this the brain becomes the organ of the mind. However, the mind is a gift from others—the community—and not a product of the brain.

### Final remarks

Finally, let us take a look at the relationship between the neurosciences and education.

Essentially, the relationship between these two fields is just beginning to be known. What can one say with reasonable certainty?

In many cases, learning takes place implicitly, that is, “along the way,” and not through directed feeding of material. It begins with

relationship learning in early childhood, with walking and speaking, and it continues with learning processes in groups whereby social behaviors are learned through shared practice and imitation.

The basic pattern for human learning from early childhood on is *in relationships to others*, specifically, in personal contact with those teaching and with other learners. Relationships

activate the motivation system; neglect cripples it, and, in consequence, increases aggressiveness. No lessons are as well remembered as those combined with meaningful, intensive experiences of relationship.

The years up to the end of puberty are especially sensitive phases of learning. The earlier children begin to play a musical instrument or learn a foreign language, the better. Some abilities are dependent upon

certain windows of opportunity in a child’s development during which they must be cultivated, while others can be learned at any time during one’s life.

Learning is a holistic—that is to say cognitive, emotional, and bodily—process.

... [T]he mind is a gift from others – the community – and not a product of the brain.

Knowledge of neuroplasticity already can support an approach to education that looks upon learning as a development that integrates knowledge, feelings, senses, and practical experiences.



Cognitive, emotional, and physical memories are inseparably woven together, and the various kinds of memory support each other in learning. As a result:

- Children can better retain what is learned when learning takes place in a positive atmosphere and is associated with positive feelings. Thus, a central concern of education should be to create beneficial and wholesome social and spatial environments.
- Facts should be embedded in a familiar frame of reference and connected with emotional and intermodal experiences. History, for instance, must be given a “face” and connected with real people. Patterns and pictures support memory formation (e.g., Sicily is triangular; Italy is a boot).
- Unattractive environments that aren’t true to life hinder learning. By contrast, environments that exhilarate the senses and appeal to the whole body have a stimulating effect. Children retain information more readily when it is presented through multiple senses and when they can approach it practically, through movement and touch.

Admittedly, neurobiology cannot specify upon which image of humankind we should base our education, what goals we should attain as teachers, or what form of education should be provided to our children. Those who expect such fundamental guidance from neurobiology will be disappointed. The brain is a matrix that absorbs what it encounters. But definite answers to the questions of what we should do in the field of education and why we should do it cannot be expected from this field of brain research. In addition, many questions about brain development and the connection between the brain and the mind remain largely unanswered; among them are the nagging questions about how information relates to sense structures, or how higher cognitive functions come into being. At this time, cooperation between education and neuroscience can address only very basic learning processes. That being said, knowledge

of neuroplasticity already can support an approach to education that is not primarily cognitively oriented, but rather looks upon learning as a development that integrates knowledge, feelings, senses, and practical experiences. Learning is more than acquiring knowledge and abilities; it is also the *formation* of the personality, of patterns of experience and relations. Indeed, it goes clear into the organic structure of the body, into the brain. We carry the responsibility for creating educational environments that foster children’s natural tendency to learn in and through relationships.

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