Reflections on Psychoanalysis and Neuroscience: Normality and Pathology in Development, Brain Stimulation, Programming, and Maturation

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Abstract: *This paper examines briefly three areas of possible enquiry at the interface between psychoanalysis and the neurosciences. It concentrates on the second of these areas, dealing in detail with the essential role that postnatal stimulation (maternal or otherwise) plays in early life, in combination with embryological–anatomical forces in brain organization, maturation, and development. It goes on to describe, by way of examples, four identifiable biological mechanisms known to be involved in these processes (i.e., increased dendritization, vascularization, myelinization, and hormonal and enzymatic changes that affect brain development and its final "quality"). It explores the close and constant interplay between postnatal external stimulation, brain development, learning and the organization of the "mind" (and ego functions), and brain functions such as vision, as essential to acquiring the best brain structure possible, capable of functioning at a great degree of efficiency. In so doing, it highlights the essential organizational role of external stimulation as usually contained in mother–child interactions. Many relevant clinical examples are offered as the arguments are developed.*

There are, in my opinion, at least three important and distinct areas of enquiry, correlation, and research at the interface between psychoanalysis and the neurosciences. They are closely related and, at the same time, distinctly differentiated from one another.

I

First, there is the need to identify the neuroanatomical sites in the brain that are the basis for what is referred to as ego (mental) functions. Yet, the identification of such structures still does not explain the neurobiological processes that must occur at a multiplicity of anatomical sites for the functions to take place. Such precise elucidation might be difficult at this stage in the development of the neurosciences but it should become increasingly possible in the not too distant future.

Freud himself was very aware of the fact that one day many of the psychoanalytic tenets would find their roots in the language of the neurosciences. He made numerous statements to this effect at various times in his life. Thus, to give but one example, he said in the *Introductory Lectures on Psycho-Analysis* (1916–1917) that, "The theoretical structure of psycho-analysis is in truth a superstructure, which will one day be set upon its organic foundation" (pp. 388–389). This was a prophetic statement. Indeed the biological basis of what we call the mind and its many functions are finding their anatomical basis in various brain structures or combinations thereof. Similarly, we are beginning to understand somewhat better the multitude of neuroelectrobiochemical processes at the root of thought, consciousness, dreaming, and many other functions of the mind. Advances in the technology of radiological neuroimaging have allowed scientists to observe the brain in action in a number of different and experimental situations. We can thus determine what areas of the brain may be involved at any particular time, when we are exercising certain functions such as thinking and imagining, or when we are experiencing certain emotions. These methods allow us to look at the functioning brain, and though the techniques involved still have many limitations, they have opened previously unimaginable windows into what is going on in the brain at various times.

In their book *Clinical Studies in Neuro-Psychoanalysis* (2000), Kaplan-Solms and Solms have de-

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scribed another interesting and clinically meaningful way to utilize data from the study of brain damaged patients undergoing psychotherapy, as another method for the elucidation of brain function and its mental correlates. The work of Mark Solms, expanding over 15 years, and that of his wife (Karen Kaplan-Solms) and others, is representative of the significant progress made in our understanding not only of brain function but also in providing a more scientific rationale for many psychoanalytic propositions. Their hypotheses are based on the psychoanalytic study of patients with localized cerebral lesions. They recognize that their views are likely to evolve as they continue to test them against their clinical data. Kaplan-Solms and Solms follow a method developed by Luria (1973), called "dynamic localization," which allows them "to study the psychological functions that constitute the human mental apparatus as we conceive of it in psychoanalysis and . . . dynamically localize the major constituents of Freud's psychological model in the anatomical structures of the brain" (p. 251).

Simply stated, the time has come when it is increasingly possible to correlate brain functions with mind activities and some psychoanalytic propositions.[1] Indeed large numbers of psychoanalysts and neuroscientists are joining together for the purpose of mutual fertilization and enrichment. In so doing, psychoanalysis has strongly come to the foreground as providing the best set of theoretical formulations concerning the workings of the mind and by implication of certain aspects of brain function (Kandel, 1999; Kandel, Jessel, and Schwartz, 2000). Psychoanalysis has thus become more legitimate to neuroscientists, many of whom think it has much to offer. It will seem that through these correlations our understanding of mind, mental phenomena, and ego functions will not only continue to increase but also will be more based in and supported by the hard sciences.

II

Second, as important and significant as all the above is, there are several other areas of no less interest. Progress in such areas as I am referring to now will yield great gains not only to our understanding of the mind–brain coupling but also may allow us to procure the best outcome in terms of the final quality of each individual brain—and consequently of the derivative called the *mind.* What I am referring to is the fact that the human brain (the anatomophysiological basis of the set of functions we define as the mind) cannot attain the optimal potential of its genetic blueprint through anatomic and embryological maturational forces alone. We have known for many years that human brain development requires many forms of external stimuli in order to reach its genetic potential. Without such external stimulation the innate maturational forces of the brain fall far short of achieving their biological purposes.

We need to remember that, comparatively speaking, the human infant is born with an extremely immature, incomplete brain, taking one and a half to two years to reach the level of maturity that is typical at the time of birth for other mammals. Given that the adult brain weighs 1200 to 1300 grams, while at birth it only weighs approximately 300 to 350 grams, we can understand the enormous potential importance of mother–child interaction, as the provider of essential stimulation, during the earlier stages. Significantly, by 2 years, the child's brain will have trebled its weight to reach 900 to 1050 grams–roughly three-quarters of its total adult weight. Let us mention as well, that we are aware that brain development in some ways never stops, at least not for as long as we are able to continue to learn, and that certain maturational processes actually continue into young adulthood. As Andreasen (2001) rightly states, "Each of us is a unique person and has a unique brain primarily because each of us has had a different combination of life experiences that has shaped who we are. Furthermore, as we live each minute of each day and each day of each year, we make choices that change our brains and ultimately change who we are. Our brains are constantly rewiring themselves so that we very literally 'change our minds' " (p. 331). In the end, the brain will consist of 100 billion neurons all active at the same time. Each one of these neurons establishes synaptic connections with up to 100,000 other neurons, giving an approximate total number of synaptic connections in the range of 10^{27} and a number of possible combinations of synaptic connections in the range of $10^{1,000,000}$ (Edelman, 1992; Edelman and Tononi, 2000).

It would then seem logical to conclude that the first two years are a particularly critical period, and that if the right kind of stimulation is not provided during this phase the result may be a structure which, though not necessarily "damaged,"[2] has certainly not

[1] This field has actually exploded and the present journal is the best testimony to it. Solms's recent series of videotapes from his Anna Freud Centre Lectures (*A Beginner's Guide to the Brain,* 2000) provide an excellent introduction to the subject.

[2] I am referring to brain damage as understood by the clinical neurologist.

developed to its full potential.[3] If we take into account the possibility of cumulative effects of this type, leading to nonoptimal development in multiple areas of the brain, it is not unreasonable to think that the final product may be one of less quality. Thus, granting that embryological maturational forces will push brain development in the anatomophysiological sense to its completion, "such forces (though genetically determined) need, in order to complete their tasks, the collaboration of specific forms of environmental stimulation" (p. 428). In other words, the genetic developmental embryological forces cannot unfold the anatomophysiological blueprint to its ultimate potential without the essential contribution of environmental factors. This environmental contribution is in the nature of a diversity of stimuli that must reach the brain. The function of these stimuli is to trigger and stimulate those genetic embryological mechanisms to complete this task (Nagera, 1968). We know today that much of the external stimulation that is required for development to proceed normally is provided in the multiplicity of interactions in the unique relationship between the mother and her infant. The work of René Spitz (1945) and Provence and Lipton (1962) clearly demonstrated long ago what happens to development when children are raised in the understimulating conditions of orphanages or foundling homes.

Studies of child development and child psychoanalysis have shown for many years that raising human infants outside the family model in such institutions leads to disastrous outcomes. Observation after observation, study after study by workers in the field have demonstrated this. Naturally, poor family situations too may lead to somewhat similar results.

I have mentioned in another publication (Nagera, 1972) that Spitz (1945) quite clearly demonstrated in addition the marked developmental differences between the children of professionals, growing up in their parental homes (family model), and children raised in institutions. The first group (children of professionals growing up at home) showed an IQ equivalent of 133 as the average for the first four months of life (an average that was maintained toward the end of the first year of life). The children raised in the foundling home showed an initial developmental quotient of 124, as the average for the first four months of life (similar to the first group), but, in sharp contrast with the first group, that average of 124 deteriorated markedly to 72 by the end of their first year of life. Spitz's follow-up studies, though limited in nature, tended to show that this drop in developmental quotient and its behavioral manifestations are irreversible once a certain amount of time has elapsed.

Similarly, Provence and Lipton (1962) showed, by means of direct observation of infants, the appalling damage to the personality, and more especially to ego and intellectual development, resulting from growing up under conditions of deprivation and understimulation (i.e., lack of sufficient human contact and interaction during the early stages of the child's development).

Though it seems to be possible to "undo" some of these developmental lags by placing such children in more suitable environments (a good foster home, for example), at the appropriate time, as I wrote elsewhere (Nagera, 1972), it seems to me that in another sense many such children are irreversibly and permanently damaged. I mean now that although they will catch up to "normal" levels, at least in many gross areas such as language and motility, normality has such wide variations that we may have a "normal" human being who is permanently condemned to function at the lower end of normality, in terms of his intelligence. Thus, though "normal," our deprivational child-rearing practices (lacking essential stimuli) may have blunted his original genetic potential to such a point that the best outcome is an IQ of 80, while genetically, and given more favorable circumstances in babyhood, he might have reached an IQ of 120 (p. 186).[4]

Spitz compared, in addition, the development of infants raised in a foundling home with the development of infants raised in a nursery attached to a women's prison. Both institutions provided adequate levels of cleanliness, food, and medical care. The babies in the prison nursery were all cared for by their prisoner mothers, who tended to shower affection on their infants in the limited time allotted to them each day. In contrast, nurses cared for the infants in the foundling home, each nurse being responsible for several babies. As a result, children in the foundling home had much less contact with other humans than those in the prison's nursing home.[5]

[3] A situation that might be considered "brain damage" if we were to use a different criterion than the one typically used today.

[4] It will follow that no sensible society can afford to damage hundreds of thousands of its children by mass producing and officially condoning, institutionalizing, and supporting child rearing practices such as day care, known to produce such disastrous results. Yet, this seems to have been the case for many years in the former iron curtain countries, apparently with very detrimental results.

[5] In my opinion less human contact in this context should be understood as less opportunity for certain necessary forms of brain stimulation.

In the prison nursing home the cribs were open, so that the infants could observe the activities in the ward, other babies playing, and their mothers' and the staff's comings and goings. In marked contrast, the babies in the foundling home had the sides of their cribs covered by sheets, which essentially reduced to zero the infant's opportunity to receive stimuli and observe or interact with the environment. Consequently, it can be said that the infants in the foundling home suffered from sensory and social deprivation. These two groups of children were followed for several years, and by the end of the first year the motor and intellectual performance of those in the foundling home had fallen well below that of children in the prison nursing home.

The children in the foundling home, after a relatively short period, developed the *hospitalism* syndrome and displayed symptoms of anaclitic depression. They were very withdrawn and engaged in a multiplicity of autoerotic activities such as various forms of rocking or tongue sucking. They were markedly retarded developmentally, and showed little curiosity and no joy, crying easily, particularly when approached by a human object. Their immune systems seemed highly compromised, and since Spitz's observations it has become clear that ordinary infectious diseases of childhood decimated the population of children in these institutions.

By their second and third years, the children in the prison nursery were very similar to children raised in normal families at home. They were active, walked well, and were talkative. In contrast, the development of the children in the foundling home was still delayed. Very few children in the foundling home were able to walk or speak.[6]

Kandel et al. (2000) refer to the work of Spitz, adding that his observations were carried one important step further in the 1960s with the studies of monkeys reared in isolation by Harry and Margaret Harlow (Harlow, 1958, 1959). The newborn monkeys of Harlow were isolated for 6 to 12 months, after which period they remained physically healthy but behaviorally devastated. These monkeys crouched in corners of their cages and rocked back and forth like autistic children, did not interact with other monkeys, did not fight, play, or show any sexual interest. Kandel et al. (2000) remarked on how a 6-month period of social isolation during the first 18 months of life produced these persistent and serious disturbances in their behavior. Yet, isolation of an older animal for a comparable period of time lacked such drastic consequences. They concluded that:

> It is plausible that the devastating consequences of early social deprivation are caused by structural defects in brain development, much as early visual deprivation results in changes in the organization of the visual cortex. . . . Moreover studies in the development of ocular dominance columns suggests how other, more complex sensory experiences might change the circuitry and structure of the growing brain. Studies of sensory development in general provide a striking example of how genetic factors and experience acting at successive stages in the maturation of the brain can alter neural development [pp. 1128–1129].

Observations such as those already described by Spitz (1945, 1946a,b), and those of Provence and Lipton (1962) as well as many others such as Bowlby (1960, 1961); Ribble (1943, 1944); Burlingham and Freud (1942, 1944); Caldwell (1967); Escalona (1967); Pavenstedt (1967); Robertson (1953); Robertson and Robertson (1967, 1968); Tynes (1967); and Winnicott (1965) were essentially explained as the result of a lack of sufficient human contact and interaction. Essentially, all these authors' assumptions were correct, though they had not explicitly made the link between the lack of stimulation and nonoptimal anatomophysiological development of the brain structures.

As already stated, given that the human brain at birth is significantly immature, and given that we now know that its final maturation is partly dependent on certain forms of external stimulation, the study of such stimulation (frequently provided in the context of the mother–child relationship and interactions) acquires extraordinary importance. Only through the understanding of such phenomena will it be possible to create the conditions that make the human brain achieve its full potential.

Furthermore, it seems to me that there is sufficient evidence available to consider and describe at the very least some of the biological mechanisms involved or implicated in such stimulation. In "Day Care Centers" (1968) I identified four such biological mechanisms that later research has continued to confirm. In the *first biological mechanism*, external stimulation "seems to favor significant increases in a progressive and more complex arborization of dendrites during the first few months of life" (p. 429).

[6] One could possibly say today that what Spitz observed was, at least in part, living proof of neurological disarray due to the lack of appropriate stimulation.

Conel's studies of the cerebral cortex of babies (1939) found progressive arborization of dendritic processes during the few months following birth. This seems to suggest that such developmental maturational processes as lead to appropriate and better dendritization may particularly occur during a limited phase after birth, making this phase a critical period. Zhu (2000) has recently shown how an important part of brain growth and maturation in mammals occurs during the first few weeks of postnatal development. He sees this in the extensive change in size and dendrite arborization of neocortical neurons during this early period, acknowledging that many of these processes are incompletely understood. He described as well a variety of other changes taking place simultaneously; for example, in the dendritic plasma membrane (pp. 571–587).

More dendrites imply more connections, more synapses and, as Kandel et al. (2000) have reminded us, "chemical synapses can be modified functionally and anatomically during development and regeneration, and, most important through experience and learning" (p. 34). And later in the same context: "Anatomical alterations are typically long-term and consist of growth of new synaptic connections between neurons. It is this potential for plasticity of the relatively stereotyped units of the nervous system that endows each of us with our individuality" (p. 34).

Similarly important is the fact that Pally (2000) reminds us of: "With regard to brain development it is a matter of 'use it or lose it' " (p. 7). In the neonatal period, a process of pruning begins, eliminating excess neurons and dendrites. The neural paths that are used remain while those that are not used die off, a fact that further points to the importance of sufficient and appropriate early stimulation (Diamond, 1988).

The *second biological mechanism* I wish to point out seems to work by:

> [I]ncreasing the degree of vascularization in certain anatomical structures of the brain. . . . The relationship between function, functional capacity, and the degree of vascularization of an organ . . . is a well established medical fact. . . . Comparative anatomical studies of the brain of different species clearly show the relation between the excellence of a function in a given species and the degree of vascularization of the area of the brain controlling that function. Craigie (1955), for example, found that the "more acute sense of hearing of snakes probably is reflected in vascularity of the cochlear nucleus, notably in excess of that of other reptiles, and the mobility of the tongue is suggested by a capillary supply in the hypoglosal nucleus about twice as rich in snakes and lizards as in the turtle and the alligator [p. 28].

The importance of all this for child and brain development is highlighted when we consider that the process of vascularization of some areas of the brain may be far from completed at birth. That there may be a direct correlation between external stimulation (of certain types) of specific areas of the brain (after birth) and the final degree of vascularization that such areas will attain is suggested by the work of Rao (see Craigie, 1955). Rao removed the eyes of rats at birth and when they reached maturity he proceeded to study the capillary beds in the visual centers, concluding that there was a marked retardation of development of the blood vessels as a result of the removal of the eyes sometime before they would normally have begun to function. He felt that this was "due to the absence of that portion of the functional activity in visual correlation centers of the brain which would normally have been stimulated by impulses coming through the optic nerve [had he not removed the eyes]" (Craigie, 1955). Though the above applies to rats, the same seems to be true of human babies. Mali and Raiha (cited by Craigie, 1955) examined premature infants at birth and concluded that the density of the meshes in the cerebral capillary beds is considerably less at birth than in later life.

The *third mechanism* seems to work by favoring the process of myelinization. Here again, there is hard evidence from animal experimentation suggesting clearly that environmental stimulation has significant effects upon ultimate structure and function. Langworthy's studies of kittens (1933) showed that myelinization is significantly influenced by neuronal function (i.e., light stimulation). By blindfolding the kittens from birth, he demonstrated histologically that the optic nerve of the blindfolded eye shows less myelinization than the contralateral *stimulated eye*.

Sontag (1941) stated that, "animal experimentation suggests that the myelinization of specific nerves can be accelerated by stimulation of the nerves, and there is, of course, considerable relationship between the function of nerve fibers and its state of myelinization" (p. 1001). Kennard (1948) has apparently made similar observations in human infants. "Premature human babies whose eyes were exposed to light since birth show more mature optic nerve development than other full term infants of an equivalent age at the time of their death."

Kandel et al. (2000) acknowledge how difficult it was to demonstrate direct links between the development of the nervous system and the development of complex behavior, but that research on the formation of the ocular dominance columns provided an important link between these two realms. They similarly point out that the "binocular vision necessary to perceive form and depth develops after birth. Psychophysical studies show that stereoscopic vision (*stereopsis*) develops during the same period as the maturation of the ocular dominance columns and that stereopsis is absent following manipulations that block the formation of appropriate binocular inputs on cortical neurons" (p. 1128). These authors think that the postnatal period is "probably a critical period in the development of stereopsis because sensory experience is critical in the development of the neural structures underlying the behavior" (p. 1128).

Kandel et al. remark as well on how just "as the development of the brain's sensory apparatus depends on sensory experience at certain stages, so too does development of social behavior depend on social experience at specific periods of neural development" (p. 1128).

As early as 1959, in their paper "Some Aspects of the Neurophysiology of the Newborn and Their Implications for Child Development," Richmond and Lipton had concluded that studies of this type "seem to give support to the contention that, even after the fetal stage, environmental stimulation (or lack thereof) can modify developing structure in the central nervous system" (p. 82).

The *fourth biological mechanism* I have in mind points in the direction of the role that external stimulation may have in important biochemical or hormonal processes taking place in early infancy. In my paper on "Day Care Centers" (1968) I pointed to a significant example of this kind.

> More recent studies suggest that maternal deprivation (in the pup rat for example) creates biochemical imbalances that alter some enzymatic and hormonal systems. Butler, Suskind and Shanberg (1978) described pup rats separated from their mothers and placed in an incubator for periods of an hour or more showed a reduction of 50% of ornithine decarboxylase (ODC) in their brains and hearts. ODC is the first step in the synthesis of polyamines and is generally increased in those tissues undergoing rapid growth and differentiation. This enzyme activity reaches an acme in the periods of maximum synthesis of DNA and RNA and goes to lower levels when the period of rapid growth in the rats comes to an end [p. 432].

By ligating the breast glands of the mother, while allowing the interaction of the pup rats and the mother, they demonstrated that the diminution of ODC was not due to lack of nutriment. Under this condition there was no diminution of ODC in the brain of the pup rats. Their studies seem to suggest that it is the active interaction of the pup rats with their mothers that is necessary to maintain polyamine metabolism within normal limits in the pup rat's brain during periods of rapid development.

Kuhn, Butler, and Schanberg (1978) described how an interruption in the mother–child relationship in the rats constitutes a "stress" situation with adverse results for the pup rats from the biochemical, physiological, and behavioral points of view. Shanberg and Butler were able to ascertain that ornithine decarboxylase is markedly reduced as rapidly as an hour after the maternal deprivation and that it increases rapidly again where the contact is reestablished. They concluded that the changes in ODC are directly associated with the presence or absence of maternal ministrations. They concluded as well that ODC diminution is mediated by variations in serum concentration of other hormones. Their reports suggest that a diminution in secretion of one or more of the hormones of the anterior pituitary is involved in the biochemical sequelae that follow the stress of the maternal deprivation. With this in mind they measured the concentration of the growth hormone in the pup rats deprived of their mothers, finding that it was much less than in the control rats. Their experiments support the hypothesis that maternal deprivation determines a neuroendocrine reaction that includes a diminution in serum of the level of the growth hormone and that this in turn is responsible for the diminution of ODC in the rat's brain.

This information is consistent with clinical studies on human subjects indicating a reduced response of the growth hormone to the ARGININA stimulation test when administered during maternal deprivation. According to Butler, Suskind and Shanberg (1978) this could be the mechanism implicated in the lack of development observable in the maternal deprivation syndrome in human beings.

The similarities in the neuroendocrine response to maternal deprivation in pup rats before weaning, to the neuroendocrine profile observed in cases of failure to thrive in the human baby, suggests that the separation of pup rats from their mother may be somewhat of an appropriate model for this human disorder.

Hofer (1995) identified maternal behaviors (in rats) influencing the pup rat functions; that is, mother's milk maintains the heart rate of the pup, while licking maintains the pup's body temperature and activity level, all of which will decrease upon separation of mother and pup. He described as well (1996), how separation of the human infant from his mother involves distress behaviors, physiological changes, and dysregulations.

Cummins, Livesey, and Evans in their 1977 study concluded that the differences in the brain development of rats that is achieved by means of an enrichment or impoverishment of sensory stimulation in their living environment, represents a retardation or insufficiency in the developmment of their neurons, a development that is dependent in the amount of sensory stimulation provided by the environment.

If pup rats are separated *after weaning* and placed in a sensory-enriched environment or an impoverished one, the rats in the enriched envrionment acquire brain cortices larger and more complex than those of the deprived rats. The larger development is seen in a greater depth of the cortex, more dendritic branches, and more glial cells. These authors propose that the increase in development is due to social interactions and to the richness of stimulation provided by the objects available for exploration; all of this seems to stimulate in a nonspecific manner the cortical elements, and gets finally translated into a biosynthetic activity. These authors believe that during autogenesis the development of some neurons can be described as dependent on the environment, or that, in other words, they develop optimally only if they receive the necessary amount of stimulation from it.

Diamond (1988), quoted by Pally (2000), confirmed the above and demonstrated that throughout life every part of the nerve cell (in rats), from soma to synapse, alters its dimensions in response to environmental stimulation (pp. 10–11). She told Pally, in a personal communication, that it was just as important to stress that decreased stimulation diminishes nerve cells' dendritic arborizations. She cautioned about the ability of an enriched environment to change the atrophy caused by an early impoverished one, thinking that that could only happen in infancy. As such our Head Start programs may come too late (p. 11).

The possible significance of all this for human development is evident. Research in this area is imperative because it very likely holds the key to the secrets not only of many aspects of human development, but perhaps also of various types of mental illness.[7]

III

Third, we need to consider that the brain is already being programmed while in the process of maturation, a development that is very far from completion at that point.[8] There is a mutual interaction of various processes that occur simultaneously. There can be little doubt that they are bound to influence one another in very many significant ways, that is, at one and the same time by further developing the hardware (through the stimulation being received) while creating the software that will allow the function assigned to that structure to become operative. In other words, we must keep in mind that external stimulation leads to further brain development or maturation, while at the same time it leads to learning and to a kind of programming of the brain and finally to the establishment perhaps of a given and specific function resulting from all these various simultaneous and progressive interactions. Let me utilize now as an integrative example of how the above takes place, the role of pre- and postnatal neural activity in the formation of visual circuitry. Kandel et al. (2000) discussed the role of neural activity in the formation of visual circuitry during pre- and postnatal development, considering the significance of this early neural activity for later visual perception. They decided to focus on this specific system because studies of the effects of experience on visual perception have been particularly informative in furthering our understanding of how experience shapes neural circuitry throughout the brain.

In chapter 56 of their book, Kandel et al. (2000) described how:

> Molecular cues guide the initial formation of the afferent pathways of the visual system: the axons of mammalian retinal ganglion neurons are directed in the optic nerve to their target cells in the lateral geniculate nucleus, and the axons of these cells are guided to specific layers of the visual cortex. . . . *Once formed, however, these visual circuits are refined by interactions between the organism and its environ-*

[7] This opens the possibility that some problems considered to be of a genetic origin may in fact obey a mechanism similar to those described above.

[8] The process of programming the brain continues throughout life, as long as we retain the capacity to learn. The difference is that many of the processes being described here may have come to an end.

> *ment.* The influence of the environment is usually more profound at early stages of post-natal development than in adulthood [p. 1115; emphasis added].

The authors state that the effect of sensory experience on the brain, and the ability of that experience to shape perception, first became evident in people born with cataracts (opacities of the lens) that interfere with the optics of the eye but do not interfere directly with the nervous system. Cataracts are easily removed surgically. In the 1930s it became apparent that the common practice of removing congenital binocular cataracts between the ages of 10 and 20 resulted in permanent impairment of the ability to perceive shape and form. Even long after the cataracts were removed, these patients had difficulty recognizing shapes and patterns. Similar results were obtained in more controlled studies of newborn monkeys that were raised in the dark for the first 3 to 6 months of their lives. When these monkeys were later introduced to a normal visual world they could not discriminate even simple shapes. It took up to several months to teach them to distinguish a circle from a square, whereas normal monkeys learn this distinction in days. "Today, partly as a result of such studies, congenital cataracts are usually removed in infancy" (p. 1116). Kandel et al. further referred to an important experiment of Hubel and Wiesel (1977). These authors raised a monkey from birth to 6 months of age with one eyelid sutured shut, which deprived the animal of vision in that eye. "When the sutures were removed and the eye was exposed to light, it became clear that the animal was blind in the deprived eye. The blindness was largely cortical. . . . Not only had the deprived eye lost its ability to drive most cortical neurons, but this loss was irreversible" (p. 1126). This all goes to show that vision (i.e., actual perception or more accurately apperception), is not an innate given but a function that must be learned from the very beginning of life, so that the sensory impressions we receive cannot only connect with and activate the visual cortex but also perceptions need to acquire meaning slowly and gradually. If similar mechanisms apply to the human infant, as we are bound to assume, it follows that in the developmental scheme of things relating to brain maturation and learning, the first step that we must ensure is that the internal maturational embryological forces unfold as ideally as possible. That, as we have shown, requires external stimulation of the kind and quality "usually" contained in the mother–child relationship interactions. This tends to ensure a better quality of infant's brain (given the child's genetic endowment). But that condition, essential as it obviously is, is not enough in the human species. As we have seen with vision, most human behavior, ego functions, and controls are learned, a most important difference from all other species. In the latter, most behavior is controlled instinctually. In other words, it is controlled automatically by innate mechanisms in the brain that trigger off adaptive responses after the reception of the significant signals and stimuli from the environment. Self-preservation, mating behavior, preservation of the species, or food gathering are frequently regulated in this manner. Not so with the human infant.

To start with, the human brain is enormously superior in functional capabilities to that of any other species. Evolution has not provided it with the clear instinctual patterns of behavior described above and observed in other species. When the time comes—since the human infant is helpless and dependent on parental care and teaching for an inordinately long time—it must use its intelligence to deal with the environment, with dangers, with other people. Its specially developed brain has provided it with the capacity to learn to solve problems in a variety of ways. In other words, it can choose "intelligently" from several alternatives, the most adaptive response in a given set of circumstances. It is not restricted, like other species, to a single stereotyped solution. It has the capacity for language development as a tool of communication. It can, and indeed has, established innumerable forms of social organizations and cultures. It can store and teach its descendants that culture. It can modify the environment to suit its needs, and for this reason it has to a large extent the greatest capacity for survival, in terms of evolution, of any species known. Perhaps by the same token, it possesses the greatest capacity for destruction, both intraspecies and of the environment.

All these differences clearly demonstrate that the human infant must start learning from birth, and at an incredible pace, if it is going to join in an adaptive healthy manner its social group and its organization. This learning is predicated on an active and constant interaction *from birth onward* with human objects.[9] To use a comparison, it is not enough to have acquired the best computer possible (the best brain possible for a given child); it is also necessary to program it wisely and efficiently. The best computer, if mishandled and

[9] The intensity of the contact needed to achieve this aim can be assumed to be *generally lacking* under the institutional conditions of foundling homes, orphanages (and, most likely, in ill-advised day care centers) as Spitz's and others' observations have demonstrated.

badly programmed, will be an inefficient piece of equipment.

We have enough evidence in the field of human development to know that the best programmer of the human brain and, as such, of human behavior is a good mother–child interaction in the first few years of life. Once that basic and early programming has been achieved, many others (in the forms of teachers, etc.) can participate successfully in the further programming of the human brain.[10]

Another important consideration in this regard is that the role of stimulation by a constant object early on in life may be highly desirable. We do know that in many other ways, constancy of ministering to the child is of great importance for normal development in the emotional–psychological sense. The child's brain, at the same time that it is developing and acquiring more complex capabilities, needs to be exercised and exposed to innumerable experiences, not only so that it will receive essential stimuli and continue to mature and grow, but also so that it may recognize and organize itself, learn slowly to distinguish (given its capacity to think) inside from outside, self from object, and the body parts under its control and command, as that control is progressively acquired. Similarly, the child must go successfully through the process of separation-individuation, if normality is to be achieved, and it must learn to use its ego apparatuses as these become structured and available, as well as understand the innumerable complexities of its environment. Most important, it must learn very early to establish controls over its own primitive reactions and feelings. To further complicate the problem, all these developments must take place in a situation where the infant is not excessively subjected to undesirable forms of stimuli. Thus, in the earliest stages, it is imperative that the child (the child's brain) not be subjected to overwhelming, traumatic forms of experiences that it cannot handle and that are enormously disruptive in terms of personality organization. Such stimuli, capable of overwhelming the necessary homeostatic equilibrium in the child, can come from outside; for example, excessive handling or mishandling, excessive cold or heat, multiple sources of unorganized sounds and other undesirable stimuli impinging on the baby for prolonged periods of time, or enforced separations. Such stimuli can also come from the inside, such as when the baby is left to suffer from hunger or pain.

Getting further into the possible role of the constancy of the object and granting that the ideal background for human and brain development requires neither excessive nor insufficient stimuli but a happy medium, it would seem logical to assume that a sufficient constancy of the stimulating object will help the infant to more easily organize its experiences, to understand its world. An example may clarify this. When a newborn baby is sufficiently hungry its pleasure–pain equilibrium—its homeostatic equilibrium—is disturbed. A disturbing feeling interferes with well-being. This automatically leads to clear signs of distress that are picked up by the mother. This, in turn, activates the behavior of the healthy mother, who immediately relates to the baby's needs. Usually, a mother has a uniform, somewhat ritualized and stereotyped procedure while going about getting ready to satisfy the baby's hunger and thus alleviate or remove its distress. She might go and see her baby, talk to it, manipulate it to ascertain the cause of the cry or other signals released by the infant (it might be wet or uncomfortable for a variety of reasons). Then she may go to the kitchen to fetch bottles and prepare the baby's milk. All this time the child is receiving a variety of sensory stimulation: the steps of the mother while she moves about, her voice if she talks to him or her (this tends to be stereotyped too), opening the refrigerator, closing it, sounds produced by the handling of bottles, glasses, spoons, pans. The baby which was disturbed by its first few and new experiences of hunger, learns that, after all these stimuli, satisfaction arrives and hunger and distress disappear.

Naturally, once the baby has established these links in its mind (after a few good experiences of satisfaction) one can observe how its crying stops automatically as soon as it can hear the noises of mother's activity in the preparation of the food. Thus, at this point, the internal distress is not a frightening, disturbing experience of discomfort, but one that is associated with the coming relief and satisfaction. In short, despair becomes hope. Further, the baby has made, in a primitive form, the first connections between cause and effect, has learned that control pays, that waiting and being attentive can bring rewards. Obviously, these first steps in the organization of the mind and of the inner world of feelings and affects, of learning and knowing something for the first time, are possible or more feasible and easier if the object who ministers to the child is constant. The stereotyped routine and the sameness of the behavior allow the baby to find

[10] None of this should be taken literally. *Programming* is a graphic word of some explanatory value, but as a term it possesses connotations that are inappropriate and insufficient to describe human development. Still, it expresses graphically some of the problems at hand.

its bearings, to know the situation, or rather to identify it as similar to previous experiences and consequently to predict the outcome. A constant change of caretakers, with different ways and different manners of ministering to the baby, in short, the lack of sameness at the appropriate times will, I think, make it much more difficult for it to find its bearings, to learn about the situation, to predict the outcome, to acquire early control structures, to be confident and relaxed in the face of internal distress. Clearly, sameness, familiarity, and the repetition of similar experiences lead to learning, to primitive understanding, and to organization, in the brain and the mind. Without this early and primitive process of organization and integration, later learning becomes difficult. Constantly changing the caretakers (i.e., the system by means of which we attempt to teach the child something is disruptive) makes the mastery of the tasks more difficult, confusing, and hopeless.

This simplified example, relating to feeding and its significance for mental organization and structuring, can be multiplied ad infinitum in terms of what happens constantly in the context of the mother–child interaction. It is for these reasons that I believe that in early stages of the process of the organization of the mind the existence of essentially one caretaker for the child—the existence of sameness in certain experiences though not in all—is of enormous significance. After the ego structure (the brain) has achieved a certain level of organization, the child is able to deal with more complex tasks, even if some of the variables involved are changed frequently. The need for constancy of the caretaker still exists at somewhat later stages but that need is then based on factors other than the need for organization of the mind, for brain maturation, and for the organization of our first mental processes. These new factors concern the development of object-relatedness, its quality, and the special dependence that is thus created between infant and mother.

Day-care situations, for example, introduce a multiplicity of different caretakers to deal with the same basic needs of the very young baby, precisely at the very time when he or she is in the greatest need of predictability of certain experiences. What I am trying to convey here is that there might be significant qualitative differences in the brain stimulation contained in these multiple interactions. In other words, that certain types of stimuli needed by the brain[11] may be more desirable and effective, not only in terms of learning but also of brain maturation in certain areas if sufficient sameness in the repetitive stimuli is provided. Perhaps what was observed by the many authors mentioned earlier in institutions and foundling homes is not only related to the lack of sufficient stimuli (quantitatively speaking) but to qualitative problems as well due to the many caretakers providing somewhat similar but still different and confusing stimuli, due to their different personal styles.

Think, for example, of the interesting electroencephalographic findings during the first three months of life that seem to throw some light on the peculiar developmental processes of this period and on the enormous importance of the presence of an empathic mother during this time. As we know, the electroencephalographic pattern characteristic for most of the first three months is the delta rhythm, which, in the adult, corresponds to a state of marked somnolence. These delta waves disappear only at moments when the baby becomes attentive in a special fashion (more frequently during the second and third months), at which points their functional capacity is heightened and alpha waves replace the delta rhythm.[12] The type of stimuli that causes the very young infant to emerge from its usually somnolent state can be presumed to be an increase of its internal needs, or some form of discomfort. At this point an empathic mother will come to her baby. The communication and interaction between mother and infant thus take place during a stage of heightened alertness and functional capacity on the infant's part. It seems plausible that the baby's experiences under these very special functional conditions are of particular significance and that the contacts and interactions between the baby and its mother at such points (when the alpha wave displaces the delta pattern) not only facilitates and encourages the child's ego development but also marks the beginning of an increasing awareness of the object.

I think it significant that the institutionalized child and the child at a day-care center will frequently miss this opportunity for contact and interaction with another human being when they are in a state of increased functional alertness. One reason for this is that such states are of very short duration, especially if no appropriate interaction follows. Also, they are quite likely to go unnoticed by staff members responsible for a large number of babies, and who consequently must devote most of their time to coping with feeding

[11] I refer to this need as "brain hunger" for clarity purposes.

[12] Oswald (1966) remarked that "the alpha rhythm is an indication that the brain is functioning at one particular level of efficiency, alertness or 'vigilance.' . . . When the alpha rhythm is lost in drowsiness, the brain is functioning at a lower level of effectiveness" (p. 21).

and changing. Further, these occasional states of alertness during the first few weeks of life usually charm mothers, who respond intensely and in kind to the child, as all those who have had the opportunity to observe babies and their mothers will confirm. Interestingly enough, this response is not likely to be elicited in anybody other than the child's mother.[13]

I believe that this type of interaction may have a perpetuating effect: Such states of alertness tend to arise more frequently when the child is responded to. Thus the mother's response leads to increased alertness and to the wish for more contact.[14]

It seems too that by the second and third months specific aspects of the mother's behavior and certain types of stimulation and play will have an arousing capacity similar to that of the internal needs of the baby. Conversely, a lack of response to these early occasional states of alertness in the institutionalized child probably contributes to, and perhaps determines, his later more withdrawn attitude and lack of alertness. What is contained in these interactions and many others, in the form of brain stimulation, is something that is not understood as well at the neurobiological level as it is at the psychological–emotional–development level. Further research and observations in these areas may clarify the true significance and meaning of such interactions in terms of brain maturation and development.

Schore (1994) and Stern (1985) have referred to similar phenomena. Schore postulated a sensitive period between 6 months and one year for the development of circuits in the prefrontal cortex that will regulate high positive affective states. Within that sensitive period, infants must engage in mutually responsive face-to-face interactions with caretakers, including gazing, vocalizations, and smiling. Schore believes that these arousal states induce the sprouting of dopamine-releasing axon terminals connecting the midbrain with the prefrontal cortex.

Though I have highlighted the special value, during the first three months of life, of the infant–mother interaction during the states of alertness, the value of the ministrations of the mother at other times should not be underestimated. Many such ministrations take place when the functional condition of the baby's brain is of the somnolent type (delta-wave pattern).[15] Naturally, their impact on the baby is of a different quality. At such times things happen to the baby when it is not alloplastically oriented (as in the state of alertness). Nevertheless, the ministrations of the mother under the delta-wave conditions do provide it with a wide range of new sensory stimulation that make contributions to the functional awakening and the gradual development of its brain and of its different ego apparatuses and structures. Through these ministrations the mother manages to provide much of the necessary and basic conditions of minimum comfort and well-being, without which brain and ego development will not proceed normally.

One may remark too on the possible implications that understimulation will have at different developmental stages (i.e., the possibility of delays in the typical developmental milestones—smiling, hand–eye and ego integration, holding up the head, babbling, sitting, crawling, walking, talking) and the impact that such early developmental delays (and what they signify) might have in the final organization of the brain, ego functions, the personality and its quality. However, such a task will lead us too far afield. Furthermore, the paucity of our knowledge in this regard may make the effort unrewarding at this time.[16]

Nevertheless, Kandel et al. (2000) remark on how a "particularly striking illustration of the close relationship between neural development and learning is evident in *imprinting,* a form of learning in birds that was examined in detail in the classical work of Konrad Lorenz" (p. 1128; Lorenz, 1935). Kandel et al. remark on how birds become attached, or imprinted, after birth, to almost any prominent moving object in their field of vision, typically their mother. Imprinting is clearly important for the protection of the hatchling. "Although the attachment is acquired rapidly and persists, such imprinting can occur only during a critical period soon after hatching. In some species this critical period lasts just a few hours" (p. 1128). I'll add that in this area there are significant differences between the birds (geese in Lorenz studies)

[13] After all, mothers gain as much pleasure as the child does from these interactions. A healthy, empathic mother takes enormous pride in her infant, in what she does for him or her, in the baby's little achievements as they occur, and she radiates back this pleasure and warmth to the child. It is of course not possible to expect that quality and warmth in the communications between a stranger and an infant.

[14] Furthermore, the mother has been prepared for this response biologically and psychologically by her nine months of pregnancy. That pregnancy and that infant have an emotional and psychological value to her (in a normal situation) that is unique and cannot easily be replicated by somebody who is "doing a job" and is dealing with many infants simultaneously.

[15] Feeding of very young infants often takes place under this condition.

[16] There is as well the whole open issue of the retranslation of biological processes into the language of the mind (i.e., things we perceive as thoughts, images, fantasies, memories, etc.). The same is true of the reverse of this, i.e., how sounds, gestures, language, etc., coming from objects outside ourselves, get to be retranslated into the biological processes that need to underlie them in order to acquire meaning and become accessible to us. But for the time being these may have to remain moot points.

and humans. The imprinting process that takes little more than an instant in the goose as it hatches, takes no less than 14 months in the human infant, and requires myriad interactions between the baby and a reasonably constant object (usually the mother), thus pointing to the enormous complexity of the interactions and learning in the human infant (Nagera, 1968). Kandel et al. (2000) add that an excellent way to show that "certain social or perceptual experiences are important for human development is to study children who have been deprived of these stimuli early in life. Reliable histories of infants who were abandoned in the wild and who later returned to human society describe children without language who are socially maladjusted, usually in an irreversible way" (p. 1128). They conclude that, "It is plausible that the devastating consequences of early social deprivation are caused by structural defects in brain development, much as early visual deprivation results in changes in the organization of the visual cortex" (p. 1128).

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