5 A case of modern infant research

When parents told me that their babies could reach soon after birth, for years my reaction was to pat them on the head ... and say, 'Yes, your baby is wonderful!'. I was so convinced that the textbooks were right and that reaching began at about five months - not five days - that I simply paid no attention to such reports. I was finally convinced that they had some substance when I saw my own nephew display this behavior at three weeks of age (Bower, 1989, p. 14).

1 Visions of infancy

Recently, several authors have argued that visions of infancy have tremendously developed in the past 10 years (Bradley, 1989; Nossent, 1994). When examined more closely, infant behavior in a wide range of domains, from cognition, movement, and perception to emotion and personality traits turned out to be more like adults. Piontelli (1992), for example, examined the behavior of three single babies and four twins at different phases in their lives: from before birth to four years of age. Even during prenatal scanning, he found it almost impossible not to see the foetuses as persons: 'As my experience developed I was more and more struck by the individuality of movement of each fetus and their preferred postures and reactions. I could no longer regard the fetuses I was watching as non-persons, as each of them seemed already to be an individual with its own personality, preferences, and reactions' (Piontelli, 1992, p. 9). Piontelli suggests that there is continuity in personality from fetus to infant to child. In other domains such as thinking, perception, and recognition, the 'genetically endowed' behavioral abilities of human infants are also far richer and more complex than was implied by traditional accounts. Using new methods of research, the rudiments of thinking (Baillargeon, 1994), recognition (Harris, 1983a), emotion (Harris, 1983b) and personality (Piontelli, 1992), scanning, categorical perception (Spelke, 1990), as well as various associations between different modalities, events, and pieces of information (Diamond, 1985; 1991) have recently been observed in even very young children. According to these researchers, it is impossible to account for their findings without assuming innate constraints on development. In their endeavor to provide a theoretical account of their empirical results, such researchers define 'constraint' as an instructional instead of an emergent condition (for the differences between the two conceptions of constraints, see chapter 3, p. 62). Constraints are 'factors intrinsic to the learner which result in a non-random selection among the logically-possible characteristics of an informational pattern' (Keil, 1990, p. 137). That is, constraints are 'things', or entities, and they are more often referred to as 'innate knowledge' (cf. Gelman, 1990; Karmiloff-Smith, 1992) or 'innate rules and representations' (cf. Gelman & Meck, 1986). The phrase 'it would be impossible to account for these findings without some innate...
constraints on development' can be simply reformulated as 'it would be impossible to account for these findings without assuming innate knowledge - rules and principles - from which development departs'. In other words, the results of modern infant research are taken to support the innateness view.

In this chapter, I want to show that while the methods of research in contemporary studies on infant behavior are sophisticated, the underlying theories are rather poor. They are directed at identifying the exact nature of biological structures that are assumed to determine psychological structures. The underlying conception is variously referred to as 'structural-constraint theory, rational constructivism, or neo-nativism' (Fischer and Bidell, p. 199, 1991). I have called it simply **nativism** because it adopts the zero-option with respect to novelty (the nativistic option states that ontogenetic novelty does not exist, cf. previous chapters). I will discuss the nativistic option with respect to infancy from a process, or epigenetic option perspective, which states that universally occurring cognitive structures stem from fluctuations in the interactional possibilities of the already constructed system with its context. This process or developmental perspective was advocated by Piaget, among others. It implies that the nativistic option holds no promise for developmental psychology. Globally stated, all nativistic theories are based on the assumption that mental structures are determined by biological structures, like the brain, or even a genetic program or DNA. No attempt is made to explain the role of psychology or psychological processes in the emergence of these mental structures. In this way, infancy psychology is reduced to biology. This seems at the very least a remarkable modesty. Infant researchers have 'discovered' that in many psychological domains the infant's skills are much richer than was suggested in the old views. However, since the infant has not lived long enough to acquire these skills through experience, they have declared that the newly discovered behaviors must be explained biologically. This implies that a psychological explanation is not needed. I will try to demonstrate that while today's infant researchers are competent in constructing and analyzing situations in which infants appear to display innate knowledge, but wrong in assuming a linear correspondence between innate responses and the structure of the world (as objectivism assumes). In addition, I will show that the presuppositions of nativism are closely related to those of computationalism, and argue that working from a computational framework automatically leads to nativism. Since the infant researchers themselves provide different arguments, these will also be evaluated in this chapter. My conclusion is that biological explanations are not sufficient. When insights from dynamic systems theory are incorporated, psychology remains the most promising basis for explaining the behavior of the 'competent' infant. Infant researchers have identified reaction patterns in infants that can be explained in terms of rapid self-organizing processes, so removing the need to involve innate knowledge or a learning process.
Let us take a look in a modern infant research laboratory. Researchers are running an experiment on speech perception. An infant is presented with sounds from a loudspeaker. The method of research is the so called 'high amplitude sucking procedure'. The idea is that whenever infants perceive something of interest, they display their interest by altering the frequency with which they are sucking on an electronically scanning dummy convertor. For example, when confronted with a familiar stimulus in a sequence of unfamiliar stimuli or vice versa, they will change their sucking rate. Research using this procedure has revealed a large number of interesting details about infant perception. For example, infants appear to make categorical discriminations between speech sounds on a phonetic (language relevant) basis (Werker & Lalonde, 1988). The phonetic discriminations that an infant is able to make change with increasing exposure to language. For example, infants reared with the English language are sensitive to cues that correlate with clause boundaries for Polish and English at 4 months of age. At 6 months, they still demonstrate sensitivity to cues for clauses in English, but they have lost this sensitivity in Polish (Werker & Lalonde, 1988; Hirsh-Pasek & Golinkoff, 1989). More generally, at 6 months of age, discriminations in the native language are still easy, whereas discriminations in non-native languages have become increasingly difficult, although they can be re-instated by extensive exposure, even in adulthood (Werker & Lalonde, 1988). The early ability to make discriminations about the locations of larger linguistic structures like phrases and clauses is remarkable. It suggests that children possess knowledge of syntactic structures long before they utter their first word, much less their non-syntactic one word sentences (Golinkoff & Hirsch-Pasek, 1990).

In still another room in our laboratory, researchers are running an experiment on visual perception. At one moment, images representing solid bodies passing through each other without losing their integrity are appearing on a screen. Next, a new type of event is displayed on the screen, namely events that are in accordance with reality, that is, events which are physically possible. The observed variable is the amount of time spent looking at the possible and impossible events. Infants spend more time watching impossible than possible events. They appear to be surprised when confronted with the illusion of two solid bodies moving through one another, but they are not surprised when confronted with bodies that do not behave in accordance with the laws of gravity (Spelke, 1988, 1991). According to Spelke, this result is to be expected. Innate knowledge must cohere with physical reality if it is to be of value, and hence to be selected during evolution. There are certain conditions (eg. a space capsule, underwater) in which events do not behave in accordance with gravity. Adults are not surprised at these events. However, there are no conditions conceivable in which solid bodies can move through each other and adults are surprised when this happens. Spelke concludes that 'infants' perceptions of physical objects do not differ fundamentally from the perceptions of adults' (1991, p. 134).

The results of these and comparable studies are considered to lend support to the thesis that infants know more about objects than Piaget assumed (Diamond, 1991). It is often
concluded that the surprisingly rich repertoire of cognitive abilities which have been uncovered in infants and which are so inconsistent with traditional developmental theorizing (especially with Piaget) emerge so early that they must represent genetically determined, innate concepts, like space and time (Spelke, 1991; Baillargeon, 1994; Diamond; 1991 Kellman, 1988; Mandler, 1988). Both Kellman (1988), and Mandler (1988), for example, assume a pre-existing genetically determined system of representations which forms the foundation for cognitive development. They conclude that Piaget's constructivism must be rejected on the grounds of its failure to account for initial cognitive structures. Many infant researchers appear to agree on this point. For example, the development observed in infants between 5 and 12 months of age is not the result of a process of elaborating on the concepts of object and space - as was suggested by Piaget (i.e. Piaget, 1980) - but, instead, stems from the development of the 'ability to demonstrate an understanding of these concepts, the understanding already having been present' (Diamond, 1991, p. 67). However, it could be argued that the child itself is also an object in space and time. To conclude, by using ingenious tasks modern research often reveals new, and sometimes startling information about seemingly precocious skills in young infants. Infant researchers reason that since the precocious behavior cannot be learned or based on experience, it must be innate (Spelke, 1982, 1990). A strong nativist position appears to be the default choice (see Fischer & Bidell, 1991).

Of course investigations carried out by many modern infant researchers are excellent pieces of work that have raised our understanding of infant cognition to a new level of specificity. In principle, this work provides the elements for the articulation of a richer theory of development that describes the relations between the biological system (self-organizing within biological or genetic constraints), and environmental factors. However, as we have just seen, on the basis of the implicit assumption that psychology is determined by biology, the findings from infant research are frequently perceived as supporting a strong nativist position. This approach skips the job of teasing out the relations among possible elements involved in development. One simply assigns a genetic origin to the observed behavior (Fischer & Bidell, 1991). In the following section we focus on one particular experiment by Spelke et al. (1994), and provide an analysis and evaluation of the theoretical underpinnings of the form of nativism it illustrates.

3 Core principles versus asymmetries

Spelke et al (1994) investigated whether infants infer that a freely moving object that is hidden will move continuously and smoothly. After running a great number of trials, their experiments revealed that infants aged 6 and 10 months inferred that the object's path would be connected and unobstructed, in accord with the principle of continuity. In contrast, 4- and 6-month-old
infants did not appear to infer that the object's path would be smooth, in accord with the principle of inertia. At 8 and 10 months, knowledge of inertia appeared to be emerging but remained weaker than knowledge of continuity (Spelke et al., 1994), p. 131).

These findings are taken to illustrate the view that 'common sense knowledge of physical objects develops by enrichment around constant core principles' (p. 131). Spelke et al. postulate a thesis of innate knowledge, called the core knowledge thesis, that states that innate knowledge of certain objects guides the earliest reasoning in the domain of physical objects. This innate knowledge remains central to common sense reasoning throughout development and constitutes the core of adults' physical conceptions. New beliefs emerge with development, amplifying and extending human reasoning and surrounding core physical conceptions with a multitude of further notions. As physical knowledge grows, however, initial concepts are not abolished, transformed or displaced (p. 132).

A constant core principle is, for example, the principle of continuity (a moving object traces exactly one path in space and time). The principle of inertia (a freely moving object does not abruptly change speed or direction in the absence of obstacles), however, is not an instance of innate knowledge, according to Spelke et al. In some situations, reasoning about inertia is correct and in some situations it is not. An example of the latter, children and adults often erroneously judge that an object dropped from a moving carrier will change its direction abruptly and move straight downward. The principle of continuity, on the contrary, will never be violated.

In the experiments concerned, the dependent variable was the mean looking time per trial. The typical pattern was that during the first test there was no difference in mean looking time between the consistent and the inconsistent condition (or sometimes infants spent more time looking at the consistent than at the inconsistent trials), whereas during the last test the differences in mean looking time in accordance with the hypothesis were significant (infants spend more time looking at inconsistent events than at consistent events). Differences of, for example, a mean of 3.6 seconds for the consistent situations against a mean of 4.3 seconds in the inconsistent situation (p. 150), were found after running a great number of trials.

The results are interesting. Although the effects on preferential looking are statistically significant they are weak in terms of their size. On many trials, the infants did not respond as would be expected on the basis of the innate knowledge thesis: even in the experiment that tested the principle of continuity, the differences in mean looking time between the consistent and inconsistent conditions remained small over a great number of trials. The researchers explain the relatively small effect differences in terms of factors like short attention span which disrupted performance (p. 153).
In fact, it seems more plausible to explain the observed differences in terms of small asymmetries in reaction potentials, which are exhibited in small and fluctuating differences in attention, surprise and looking preference (Van Geert, personal communication). Such small innate asymmetries in reaction potentials in perception, do not require explanation in terms of innate concepts, core knowledge or preferences. They can also be explained using concepts derived from the theory of dynamic systems. Small, innate asymmetries, together with experience etc., may be the input for self-organizing processes and bifurcations in development. The process of rapid amplification of existing asymmetries leads to bifurcation, producing stable tendencies in behavior, which can be described from the perspective of the observer (the researcher) in terms of concepts and principles. As such, it does not matter whether or not the innate asymmetries are in conformity with the structure of the world in advance. The physical qualities - the structures of the world - can be understood as attractors, attracting or 'directing' the bifurcations and thus making development adaptive. The level of behavioral adaptativity may select the 'fittest' outcomes of self-organization or, more precisely, bifurcation.

The theory of dynamic systems is not an instance of objectivism. Innate knowledge and principles, on the contrary, are. In the next section I shall explain this assumption. Infant researchers often 'inject' their vision of the world into the infants they study. At present, the computer seems to be the inspiration behind many visions of infancy.

3.1 The computer as a metaphor: objectivism with rules and representations

The heuristic value of the computer and its functioning as a model for human cognition can be clearly seen in the frequent use of concepts like representational structure, rule system, innate rules and principles by many infant researchers. Karmiloff-Smith (1991, 1992), for example, states that the 'human mind has an appreciable amount of innately specified knowledge about persons, objects, space, cause-effect relations, number, language, and so forth' (Karmiloff-Smith, 1991, p. 174). Concepts like 'innate knowledge structures', 'principles and parameters', and 'input-analyzer' (Karmiloff-Smith, 1991, p. 174), are all derived from computationalism, a class of psychological theories in which the human mind is conceived of as a computer - the 'computational mind (Jackendoff, 1987).

According to nativists, organized behavior in unexperienced infants is critically dependent on the pre-existence of knowledge and representations in the developing system. An infant is assumed to be endowed with a knowledge system which contains representations of things in the world like solid objects and possible interactions between these objects, like floating, rolling, and moving through each other. Four assumptions are characteristic of nativism (and computationalism): (1) there is a world which exists independently of man; (2) this world is connected to concepts within man, for instance the phonetic categories, or the cause-effect categories which are assigned to the innate knowledge system of babies; (3)
substantial knowledge stems from this connection, for example, the knowledge specifying the inability of solid objects to move through each other; and (4) the world is structurally stable and intelligible, and can be described by means of logical relations. This last assumption allows thinking to be defined as a process of symbol manipulation in which the semantics are justified by the direct assignment of symbols to events and conditions in the world. In other words, there is an obvious correspondence between the world and our categorization of it. Taken together, the first three assumptions constitute realism; when the fourth assumption is added we hit on objectivism. Qualities of the physical world are assumed to correspond with internal concepts, principles or mechanisms. For example, Leslie (1994) assumes a specialized mechanism (ToMM) that produces domain-specific knowledge, for example agent-centered descriptions that place agents in relation to information. Using such descriptions, causal explanations can be given for the agent's behavior as the result of circumstances that are imaginary rather than physical. Spelke's core principles form another example of knowledge of the world which is injected into the agent. For the moment we may conclude that nativism is an instance of objectivism.

The fourth assumption, in particular, correlates with the unfruitful theoretical foundation of much modern infant research. We shall see that this assumption is problematic, for example because the stable semantics of mental representations cannot explain novelty. While behavior changes under new circumstances, representations remain fixed. Novelty and development are closely linked. If the stable semantics of representations preclude novelty because they are fixed, there is nothing left to develop. As was suggested before, these problems can be avoided by introducing the theory of dynamic systems, in which it does not matter whether innate reaction asymmetries are in conformity with the structure of the world. However, a structured world is helpful because it shapes the self-organizing process in a more or less stable way.

3.2 Let's get physical, I wanna get physical: information theory and computation

The endeavor to get physical - to relate cognition to its assumed biological underpinnings - is realized by identifying biological (brain) structures in which mental contents (rules and representations) are assumed to be localized. In attempts to account for the relationship between body and soul, the relationship between computer and program is proposed as a metaphor. However, as we have seen in chapter 2, whether computational theory constitutes a fruitful starting point for the development of a psycho-biological theory of mind, or whether it is doomed to lead us to another discouraging biologism is open to question (for a more elaborate discussion, see also chapter 6).

By assuming that the information necessary for survival is encoded within the brain before birth and transmitted through information channels like nerves, muscles, organs etc, many infant researchers assign an important role to the concept of information (Diamond,
Soon after birth, infants display sensitivity to information about reality - for example they distinguish between possible and impossible events. It is inconceivable that the sensitivity to information displayed stems from learning and experience (Baillargeon, 1994; Spelke, 1991; Bower, 1989). However, we have seen that the `information displayed' is a statistical effect, that is, the mean looking times after very many trials differ: infants appear to spend a little more time looking at inconsistent events than at consistent events. Explanations in terms of innate computational devices like Leslie's ToMM (1994) and Spelke's core principles (1994) assume a structural or objective correspondence between the innate device and the structure of the world. Such correspondence inevitably leads, first, to an infinite regression of causes (which structure determines the innate device, see chapter 2, 4 and 6), and, second, to the problem that novelty cannot be explained (see chapter 2 and 6). Of course, a statistical effect cannot in itself confirm this correspondence. In contrast, by proposing the existence of innate asymmetries that are 'attracted' by the structure of the world without conforming to it, the theory of dynamic systems offers a feasible way out of the problems that accompany objectivism (nativism). In this theory, physical qualities are perceived as attractors in a process of bifurcation.

For the computer metaphor to be applicable to the results of modern infant research, it must be assumed that the rules which are demonstratably at work are innate. However, infant researchers themselves sometimes come up with still other justifications for their nativistic viewpoint. In the next section, three such justifications (arguments) will be considered before reconstructing and evaluating them into one argument.

4 Assuming nativism: pro's and cons

4.1 Three arguments

According to the first argument, all species - including Homo Sapiens - exhibit some kind of 'innate knowledge' which allows them to perform biologically important activities. For example, a horse is able to stand only half an hour after birth. For what conceivable reason, then, would man be required to learn to stand and walk? Karmiloff-Smith (1991, 1992) has questioned why abilities that other, related mammals display soon after birth should depend, in man, on learning and experience. Indeed, the assumption that human walking behavior, in contrast to that of horses or animals in general, is based on learning and experience, has been questioned. Thelen (1989) showed that infant's walking behavior correlates with the ratio of muscle to fat tissue in their arms and legs. Shortly after birth, infants display the so called walking reflex, which, however, disappears as the amount of fat tissue increases, only to reappear at approximately 12 months of age. By this age, the amount of muscle tissue has increased greatly, so that there is a similar ratio of fat to muscle tissue as there was shortly after birth. It had been assumed that the walking reflex is a primitive remainder of our ancient,
animalistic roots which is abandoned to allow the learning process which takes several
months. Thelen showed that the simple ratio between two variables was the critical factor in
the disappearance and reappearance of the walking behavior, suggesting that in humans just
as in animals, walking is not primarily based on learning and experience. During the first year
of life, the ability to walk is constrained by the limited amount of muscle tissue in relation to
the amount of fat tissue in the arms and legs.

The first argument in support of nativism states that it is highly probable that we tend
to overestimate the role of learning. We do not learn to walk or drink, but rather mature much
more slowly than other mammals. It is wrong to assume that humans have to learn skills that
are available to other mammals almost immediately after birth. Note that this argument may
be valid, even if neither humans, nor other animals possess innate schemes, as nativists
assume. It is the computer metaphor that dictates the existence of pre-programmed - innate -
knowledge. It is highly possible that walking is not guided by an innate scheme or any other
kind of representation. It may be an innate reaction potential of leg-like forms that rapidly
self-organizes by bifurcation into stable movement behavior.

The second argument is a more specific version of the first argument. It deals directly
with the tendency of layman and developmentalist alike to overestimate the role assigned to
learning, even in behavior which is displayed exclusively by humans. The argument is
supported by a steadily growing body of studies of young infants which suggest that they
demonstrate knowledge that cannot be based on learning and experience. In fact, knowledge
in the absence of appropriate learning and experience has been taken to provide support for
the same argument of 'underdetermination' by learning and experience as is found in the first
argument. This time it is applied to behavior which is almost never displayed by animals.
Research that is taken to advance this argument was described in the first section of this
chapter. The argument is compelling, and pleads for a new or adapted vision of infancy (see
also Nossent, 1994, 1995). Again, the observations upon which this argument is based may be
accurate, but the conclusion that infants possess innate knowledge, as nativists assume, does
not necessarily follow.

Just as the second argument was an elaboration of the first one, the third argument is
in fact an elaboration of the second one. It states that not only abilities which infants display
soon after birth, but also abilities that show up much later are underdetermined by learning
and experience (Karmiloff-Smith, 1992). The classical example is language learning, which is
discussed extensively in chapter 3.

The three arguments summarised thus far may be valid as 'conclusions' or statements.
Indeed, behavior is often underdetermined by learning and experience. However, this
conclusion in itself is no argument for nativism. Again, while computationalism imposes pre-
programmed representations that determine behavior, it is not necessary and or even attractive
to assume such an objectivistic correspondence between the organism and the world (see
chapter 2 and 6). The theory of dynamic systems may provide an answer to the
underdetermination of behavior by learning and experience, and a way out of the problems of
an infinite regression of causes. However, nativism is unfortunately, often advanced. For
example, the third argument is used by Pinker and Bloom (1990) to support the assumption of a set of inborn linguistic principles without which language could not possibly be learned as fast and uniformly as it actually is. The idea is that many abilities are encapsulated within the nervous system. If a particular ability does not show up immediately after birth, it will emerge in time when the nervous system has matured enough to run the pre-programmed procedures. Implicit in this argument is the assumed one-to-one correspondence between neural structure and mental ability. Diamond (1991) for example, states that the 'behavioral developments between 5 and 12 months are intimately tied to maturation of frontal cortex' (p. 67). Just like Karmiloff-Smith and Spelke, Diamond (1985) presupposes innate knowledge. She states that structural alterations in the prefrontal cortex are responsible for effectuating this innate knowledge. Maturation of the hippocampus forms a necessary prerequisite for recognition memory as does maturation of the prefrontal cortex for tasks requiring representation memory and tasks requiring inhibition of predominant response tendencies (Diamond, 1985, 1991). In addition, Bjornklund and Harnishfeger (1990) argue that changes in the neurological system result in an increase in the efficiency of inhibition in processing procedures, and thus in an increase in abilities which demand both selective attention and the exclusion of irrelevant task information from the working memory. According to Goldman-Rakic (1987), the enormous growth of cortical synapses between 8 and 24 months of age results in an explosion of cognitive skills in the same period of time. A final example is provided by Konner (1991), who explicitly cites Gesell, stating that 'Motor development sequences are largely genetically programmed' (p. 199). All the infant researchers quoted so far, endorse the argument that the emergence of many abilities in infants appears to be underdetermined by learning and experience. These abilities are, however, not conceived of as also underdetermined by 'the genes' or the 'genetic program', whatever they may be, and so the task of proving the innateness assumption is trusted in blind confidence to biologists.

4.2 Decreasing complexity

Thus far the chapter could be summarized as follows. Nativists argue that infants display knowledge of the world which can not possibly be derived from their experience in that world. Put slightly differently, infant research has shown that specific knowledge, skills and abilities are underdetermined by learning and experience. It is inconceivable that particular forms of knowledge come from experience or learning input. Such knowledge can become manifest either almost immediately after birth (visual perception, the walking reflex), or much later (language). In this section, this nativistic assumption is evaluated, and the connection between it and the computational assumptions is revealed by reconstructing one assumption, that is common to both nativism and computationalism.

The output of any behavior producing device - the behavior of the system - can be derived from two types of factors, namely input factors, and system factors (i.e. the rules or principles for processing the input, for transforming it into behavior or output). If the structure
of the input is displayed in the behavior of the system, the system is said to be determined by the input. In addition, if the structure of the output is expected to have arisen from the effect of a particular learning- or association mechanism on the input, the behavior of the system is said to be determined by experience. However, if the output of the system displays a degree of organization or complexity which was not expected on the basis of either the input or the experience the behavior is said to be underdetermined by learning and experience. It must therefore be determined by rules which are independent of experience and which are located within the system. These rules can be conceived of as behavior controlling knowledge in the system. For example, it is assumed that if an infant avoids a visually perceived cliff without ever having experienced falling down from a cliff, a rule `avoid depth' must be innately available (that is available independent of learning and experience).

Nativists thus take as their starting point the implicit assumption that in principle, the output of a behavior producing device can always be obtained from either the input or the features of the system (rules). In other words, if a system displays complex behavior whose structure does not depend on either input or learning and experience, the complex behavior must be determined by preexisting rules or innate knowledge within the system, because in ontogeny complexity cannot exceed the sum of input, learning and experience, and the features of the system. So, ontogenetic novelty is simply non-existent. Every emerging form can be obtained from the features of the system and/or the environment. Consequently, development is nothing more than the unfolding of a preformed program. However, in the next section I shall show why this assumption, derived from the analogy between man and computer, is erroneous. Computers are closed systems. Their complexity can only decrease over time (when things become defective). In contrast, in the course of evolution biological systems increase in complexity.

4.3 Neg-entropy

The argument of decreasing complexity, the neg-entropic argument, will be presented briefly in the next few sections, and worked out in more detail in chapter 6. The assumption that an increase in complexity during development is impossible is warranted for closed systems. Many manmade systems like clocks and computers, fall within the class of closed systems. In these (entropic) systems, sooner or later the assembly breaks down. The system decreases in complexity, no new wheels or algorithms come into being (unless someone opens the system up to put them in, in which case it is no longer a closed system). However, organic systems are always open systems, continuously regenerating the effects of entropy. In such systems, there is more to existence than finally dying and falling apart, and it is this that sometimes makes it meaningful to speak of development. Complexity emerges in the connections among the elements, or complexity in the arrangement of the connections is maintained or regenerated. In order for complexity to increase, energy is sucked in from the environment. Because of this, these systems are called open systems. For example, the evolution from
single-celled organisms to mammals has been characterised by a great number of reorganizations in which the complexity of the output exceeded the sum of the input and the complexity of the system during the input state. One example is the emergence of blood vessels to regulate intercellular communication in a larger number of chained cells (Kugler, Kelso en Turvey, 1982). On an even larger scale, the development from the big bang, via atoms, molecules, crystals, single-celled organisms, and animals to human cognition displays a consistent increase in the complexity of the organization. Such a progression in organizational complexity, is a highly distinctive feature of developing (organic) systems. Although often criticized by modern nativists, Piaget's theoretical model provides the possibility of accounting for progressive complexity in open systems. Piaget did not endorse the entropic assumption.

The reconstructed general or biological assumptions of Piaget (1980, pp. 23-34) are as follows. First, cognition is self organization by means of assimilation and accommodation in order to remain adaptive in the world. Second, self-organization and self-stabilization - reversed entropy or neg-entropy - are not just heuristics but natural terms (see Breeuwsma, 1993). That is, they are real properties of biological systems which can be described in logico-mathematical schemes. Third, a universal trajectory can be perceived in the process of self organization, in which self-stabilization appears only to disappear again at the transitional phase to a next stage. In this process, differentiation and hierarchical integration account for 'inclusion' and 'generalization'. Fourth, development has direction which goes beyond the Darwinian principles of selection of random mutation (cf. chapter 6). Fifth, and this is Piaget's specific psychological assumption, the form of cognitive structures is a generalization of previously developed schemes, initially senso-motor, and later cognitive schemes. These earlier structures form the logical premises for novel cognitive structures. To conclude the argument, rejecting Piagetian theory on the basis of arguments derived from the entropic assumption inherent in the computer metaphor is not only rather precipitate but also wrong. The entropic argument often can not account for the living.

A view of determination which assumes a one-to-one relation between the input and the output of the behavior producing system (the linear correspondence assumption) can be discerned behind the entropic argument. In contrast, in a neg-entropic model like Piaget's, order emerges out of the blue, or out of chaos. Complexity emerges from simplicity. In the next section, both visions of determination will be placed in a broader (historical) context. Then, the entropic vision behind modern nativism will be shown to be out of date.

5 Newtonian infant research

Let us return to the consequences of nonlinearity for our subject: visions of infancy. It is not necessarily valid to consider the behavior of infants, for instance increases or decreases in the time spent looking at a screen, or alterations in the rate of sucking, as being completely determined by the perceptual system. If this were the case, it is hard to explain why, although
Spelke et al. (1994) found statistically significant evidence of preferential looking, there were many trials on which some of the infants did not respond as would be expected on the basis of the innate knowledge thesis. Under some highly structured conditions, in very supportive environments, a particular behavior may emerge. Under other conditions it may not. Eventually, a completely different behavior may appear. The behavior is displayed because a specific fit between infant and environment, makes the particular functioning possible. It is not the result of triggering an innate behavior producing system. According to Nossent (1994), the fact that infant research continues to reveal competent behavior in increasingly younger infants, stems partly from researchers' skill in providing a better match between the experimental conditions and the behavioral affordances of the infants (p. 93). Provided with appropriate action affordances, infants produce more optimal results. This does not provide evidence for the presence or absence of innate abilities or knowledge. It specifies the possibilities in the relationship between researcher and infant: there is a reciprocity influencing development, called a "joint development" (Nossent, 1994, p. 93). Apparently, researchers are not always aware of the operation of this 'joint development', and they cling to a nativistic account. This has been shown no longer to be plausible. In terms of the theory of dynamical systems, it could be argued that experimenters have become increasingly able to elicit those innate asymmetrical reaction potentials that very rapidly self-organize and bifurcate into more or less stable responses.

Baillargeon (1994), for instance, takes it to be an established fact that infants are surprised when confronted with pictures that do not behave in accordance with reality (illusions). In one of her experiments, infants were shown a scene in which a flat screen is stood up. Next, while the infant watches, a doll (Ernie) is placed behind the screen, so that it is no longer visible. When the screen is subsequently removed there are two conditions. In the possible condition, there is one Ernie. In the illusory condition, there are three Ernies. The funny thing is that Baillargeon discovered an oscillation in the condition eliciting surprise between 3 to 10 months of age. For example, 3-month-olds were surprised when three Ernies appeared, 5-months-olds were not, but 7-months-olds were. Instead of concluding that it is not likely that preformed stable rules determine perception, she concludes: 'despite these superficial differences, however, the examples are all related in suggesting that infants, like older children and adults, actively seek explanations for inconsistencies in their world' (p. 9). A developing 'model of explanation' in the infants must be introduced to explain why innate rules of perception do not function constantly with respect to surprise over illusions between 3 and 10 months of age. Actually, just as with the experiments of Spelke et al (1994), the results were statistically significant but the effect was small and rather unstable. Under very specific conditions (when they are highly alert and cooperative) and adopting a level of significance of .05, groups of infants display more interest in impossible than in possible events. Of course, a great number of infants show the exactly opposite behavior. The results do not suggest stable preformation, or innate rules; they suggest a certain trend in the direction of the variability. It seems more fruitful to view this trend in terms of emergent phenomena which remain to be examined instead of as evidence for innate rules and
knowledge. In fact, during development the organism and its environment become increasingly 'tuned' (adapted) to each other. As the relationship between organism and environment changes, there are changes in the tuning of the organism to its environment, for instance in the differences reported in responses at 3, 5, and 10 months of age.

So during the last decades, a new vision of infancy has emerged from the attempt to get a grip on infants' early abilities, namely the competent infant (Nossent 1994). Along with the new vision, a new researcher has emerged. The new infant researcher looks a little like a clumsy sorcerer, who, after receiving the applause, defers to the nativists behind the screen with a single gesture of his hand. It is theoretically weak to conclude from the results of recent research that infants display innate knowledge. The argument behind the conclusion of innateness relies strongly on computational theory, while computational theory is inadequate for the explanation of development. The key assumption of computational nativism, the entropic assumption, rests on a Newtonian vision of determination, and is no longer self evident with respect to organic (open) systems. Furthermore, stating that an infant resembles an adult in many respects, e.g. is rational from birth, does not mean that one has achieved insight into the process of development. It does not increase our understanding of the tempo at which awareness of object permanence, language, and conservation develop, or of the variability in the age at which these behaviors emerge. Of course, immediately after birth an infant exhibits organized behavior, as does a fetus even before birth (see Piontelli, 1992). However, this behavior does not exist independent of its contextual instantiation. It is not preformed and packed and ready to be used. It stems from the interaction between infant and the environment at many levels of aggregation. The structure in infants' reactions to a visual illusion may also be addressed at the level of interaction between the stimuli and (parts of) the perception systems. It is premature to draw conclusions at the level of rationality from the detection of such interactions. It is possible to conceive of development as the connecting up of many different levels of aggregation, for example the coupling of a rational construct to the physically constrained structures the eye reveals.

It goes without saying that biological mechanisms are involved in the constitution of infant behavior. However, when causality is assigned to pre-existing mental structures (innate knowledge), to autonomous change (maturation), and/or to factors inherited from parents (the genes or genetics), the process of development or the mechanisms of change are overlooked (Thelen & Adolph, 1992). The presumed mechanism of change is located exclusively within the organism, thus presuming a closed system in which the total set of potential behaviors is present in advance. However, infant behavior can not be explained as stemming from a closed system. It displays many of the features of a dynamical process. Infant researchers themselves are components of the dynamics of this behavior producing process. Therefore, it is necessary to account for the role played by the attributions of the researchers themselves in the constitution of infant behavior. In chapter 2 we stated that, although we can be almost certain that neither our dog nor our computer uses thoughts, intentions and planning to control its behavior, that behavior may be perfectly comprehensible in terms of these concepts. Just as laymen assign reason and emotions to their computer ('the wicked thing is in
a bad temper'), infant researchers (being representational theorists) make the error of assigning the semantics of the observer to the system being observed (the infant). Consequently, their own knowledge of the world is injected into the infant, and they explain the infants functioning by lending the infant their own understanding, a process which makes their theory circular (cf. chapter 2). Or as Kagan (1984) has pointed out: The behavior of the infant is so ambiguous it is easy for the culture's beliefs about human nature to influence observers' interpretations of what they think they see'. Developmental psychologists at the turn of the twentieth century, for example, would probably have agreed with Baldwin that the child is the father of man; the child is preceding prehistoric man (Baldwin, 1960). Stanley Hall (1883) compared the mental state of infants to that of animals: primitive and based on reflexes and instincts. In short, unambiguous understanding of human behavior is impossible. Universal infant behavior, independent of the conditions under which it emerges, simply does not exist. It is impossible to read out the semantics of infant behavior because behavior is derived from a sequence of actions and reactions on a multitude of levels (psychophysiologic, motor, vocal emotional, social etc.). Behavior is process. It is not entity. Developmental psychological knowledge contributes primarily to insight into the scientific visions of thinking, reason, emotion, sociability etc., and into the projection of these visions onto infant behavior (Bradley, 1989).

6 The epigenetic option (process accounts) and infancy research

We have seen repeatedly how the concept of representation leads to the error of assigning the semantics of the observers to the system under consideration. The concept of representation is also a central notion in Piaget's theory but there it has a rather different meaning. In Piaget's theory, 'representation' is conceived of as 'emergent organization', denoting a configuration or scheme. According to Piaget, ontogenetic changes can only be viewed as processes of development in which complexity increases through self-organization, in which those features of the interacting components that stabilize the system as a whole, that bring it into a state of equilibrium are selected. Novelty becomes a key notion. For example, senso-motor couplings like perceiving and reaching, may become stabilized in a novel single scheme of grasping, which may be a building block for the development of more complex novel skills such as catching a ball and throwing it. These, in turn, may be building blocks in the development of yet more complex skills, e.g. in basketball, etc. An observer, for instance a teacher, may believe that the separate skills of perceiving and reaching stem from an innate scheme of grasping. By bringing the novice into an interactional coupling in which the perceiving and reaching behaviors are perceived as immature manifestations of the innate code for the grasping skill, the higher order skill of grasping may be canalized and so appear a little earlier than it would spontaneously.

However, initially the representation of grasping resides in the observer and not in the observed (the infant). It is wrong to conceptualize of the grasping skill as the manifestation of a skill derived from an innate knowledge structure. Even if a skill is innate, that is present
before or at birth, it does not stem from innate knowledge because it is not specified in any kind of genetic code (if it was, this would lead to an infinite regression of causes, see the preceding chapters). According to Piaget, representations never precede novel skills or cognitive structures. At best they follow novel cognitive developmental products or configurations\(^1\) since they are themselves such products.

Some configurations of components are adaptive and stable, and some are not. For example, the behavior of throwing a ball cannot precede catching it. This denotes, of course, that the system will never stabilize in configurations that are unattainable. At any moment, the degrees of freedom provided by all interacting components temporarily constrain the possible configurations in which it is possible for the system to stabilize. Universality stems from a-specific constraints which continuously shape the developmental process (cf. chapter 6).

In principle, environment and system can not be disconnected (although they can be separated at a specific moment on a functional criterion, of course). What is environment and system at one stage can, at a later stage, have become a single, stable configuration in which what was environment has become part of the system. At the later stage, the environment has become something new: environment is always both relational, and relative. Changes, either external or internal, may either maintain the stability of the system or break down the stability of the ensemble and thus force the system to reorganize. The configuration of elements that will be selected at a certain moment is the easiest and relatively most stable that is attainable at that moment.

In considering the results of infant research, developmental psychologists could explore how stable configurations - for example the surprise of an infant whenever confronted with a particular illusion, or indications of object permanence in infants who in other conditions do not display this ability - change in a self-organizing developmental process, become differentiated and hierarchically integrated on a higher, more generalized, level. Reorganizations of this kind can be distinguished in processes of development, and they provide a much better account of the fluctuations in infants' reactions to visual illusions such as those reported by Baillargeon (1994). Infants of seven months show surprise again because their knowledge has reached a new configuration. At the behavioral level, this newly emerging surprise looks similar to that of 3-month-old children. In terms of development it is the expression of a more complex organizational level of development.

7 Conclusions

In this chapter, the power of nativism to explain human development was disputed by analyzing and evaluating nativistic accounts in contemporary developmental psychology, or more exactly, infant research. In particular, the entropic assumption was analyzed and shown to be inappropriate for describing changes in organic systems: (computational) nativism and development can not be united. However, some influential infant researchers have concluded from their experiments that infants display knowledge which must be assumed to be innate.

\(^1\)Piaget repeatedly calls such configurations
In spite of our criticism, which shows that nativism cannot explain development, infant research has had noteworthy results. As such, it is a nice example of what modern psychological research has been able to uncover. It is regrettable that the real explanation of the results of infant studies is turned over to biology, rather than being sought in their own psychological implications, even if there is not yet a satisfying psychological theory to account for them. The situation is reminiscent of the famous joke about the fool who searches for his watch underneath a lamp-post, since the about place where he had lost it is completely dark. The light that some presumed evolutionary biology would shed on findings of infant abilities and knowledge that are underdetermined by learning and experience has proven much fainter than it seemed at the time of the Chomsky-Piaget debate. Evolution is neg-entropic. Development is not completely derived from evolution, that is evolutionary structures do not completely determine ontological structures. The increase in complexity that is seen in development cannot therefore, be completely accounted for in terms of neg-entropy at the level of evolutionary structures. The conclusion must be that development is (at least partly) neg-entropic as well. Moreover, at present it seems that Darwinian theory is in trouble because it fails to appreciate the importance of putting ontogenetic processes at the heart of evolution (Oyama, 1989, 1990; Ho, 1984). Behavior is conceived of as lying at the heart of evolution, as driving behaving organisms to progression. Piaget stressed that evolutionary theory failed to notice the importance of processes at the individual level. He stressed the self-organizing properties of behavior and argued that it is precisely self-organization which makes the behaving organism exhibit order spontaneously and by doing so, provides the organism with both stability, plasticity, and adaptivity. This does not sound old-fashioned at all today, whereas it did twenty years ago. At present, the only difference between developmental biology and developmental psychology is in the kinds of structure that they try to explain (biological or cognitive). In principle, the level of aggregation no longer distinguishes biology from psychology. It may be difficult to account for the results obtained by modern infant research in terms of a psychological theory. However, to skip to the level of biological structures means neglecting the cognitive level and consequently the psychologist's task. Changes in organic systems (both biological and psychological) are distinguished by their tendency to increase in complexity and order by means of self organization (auto-regulation). In short, the description and explanation of ontogenetic change must be a neg-entropic model of development.

Although Piaget turned out to be wrong in some empirical aspects (see Koops, 1992), it would be premature to discard the complete theory on grounds of arguments derived from (computational) nativists. It is much more promising to investigate whether the newly revealed empirical facts are compatible with Piaget's epigenetic theory or any other epigenetic (second-option) theory. It is to be hoped that infant researchers do not remain fixated for too long on the old fashioned models of explanation which can be summarized under the term nativism. They would be better occupied trying to sharpen models that are able to deal with the plasticity of development.