

Reframing a Constructivist Model of the Development of Mental Representation: The Role of Higher-Order Operations

Ulrich Müller

University of Massachusetts

Bryan Sokol

University of British Columbia, Vancouver, Canada

and

Willis F. Overton

Temple University, Philadelphia

The purpose of this article is to suggest a model for the development of mental representation. First, the fertility of empiricist and constructivist models of mental representation is explored. It is concluded that the constructivist model provides a better ground for building a theory of mental representation. Next, Piaget's constructivist account of the emergence of mental representation is presented and evaluated. Because Piaget's account proves insufficient in explaining the emergence of mental representation, the authors suggest a modification of Piaget's account. According to this proposal, higher-order operations are necessary for the development of mental representation. This proposal serves as the basis for reinterpreting several findings of Piaget's studies on representational development. © 1998 Academic Press

Although mental representation is generally accepted as a significant feature of cognitive functioning, its origin and development are currently topics of some debate. Among the myriad voices vying for the definitive word on the matter, two sides can be identified as taking shape. Although not often explicitly recognized, these two sides fall into line under the guiding banners of opposing philosophical traditions—Empiricism and Constructivism. The first section of this article highlights some of the basic tenets of these two

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Correspondence concerning this article and reprint requests should be addressed to Ulrich Müller University of Massachusetts, Center for Adoption Research and Policy, 55 Lake Avenue North, Worcester, MA 01655.

philosophical positions, primarily as a means for determining the one with the most fertile ground for theory development and modification, as well as for the subsequent promise of fruitful empirical work. In this same section, a familiar metaphor in cognitive and developmental science—that comparing the human mind to a computer—is scrutinized with a critical eye. Because, in the end, the empiricist model is seen as ploughing too quickly by issues needing a certain ample amount of working over, the alternative constructivist model is held up as the best suited soil upon which to build a theory for the development of representation. In the second section, consequently, we lay out some of the basics of Piagetian theory, often considered the mainstay of constructivist philosophy in developmental science. The strong links of Piagetian theory to constructivism should be apparent in such concepts as the complementary functions of assimilation and accommodation, as well as in the subordination of, what Piaget calls, the figurative aspect of knowledge to the operative aspect. The third section, in turn, elaborates on these concepts and delves into the specifics of how Piaget uses them in his account of mental representation. Certain difficulties become apparent here, however, because of inconsistencies in how he applies these key concepts. Finally, because it seems that Piaget's account is essentially going in the right direction, the fourth section suggests certain modifications meant to place the Piagetian account on a better path. It particularly elaborates on research exploring children's early manipulations of external objects and the productions that these manipulations yield. The growing complexity of these productions suggests the development of higher-order operative structures underlying young children's cognitive abilities. Gaining an understanding of such higher-order operations, it is concluded, provides a more useful framework for conceptualizing children's cognitive development than accounts emphasizing the emergence of representational ability.

PHILOSOPHICAL BACKGROUND

At the most general level, developmental psychologists discuss *representation* as a matter of *re-representation*, that is, the capacity to have one item stand in for another not immediately given by perception (Mandler, 1992; Piaget, 1945/1962).¹ This capacity, for instance, is attributed to infants when

¹ In psychological and philosophical literature, *representation* is a notoriously ambiguous term (Scheerer, 1992, 1993; Scholz, 1992; Shanon, 1991). Examining the history of philosophy and psychology, Scheerer (1990a, b, 1992, 1993) records that the term *representation* is used to refer to (a) any meaningful mental content; (b) re-representation, i.e., acts of thought that process or reproduce mental content which formerly was directly given by perception; (c) processes by means of which the elements of one structure are mapped on the elements of another structure, and which preserve the structure of the represented system in the structure of the representing system (structural isomorphism), and (d) any relation of vicariance or substitution. Piaget (1945/1962), as well as some of his critics (e.g., Mandler, 1992), employs the term *representation* in the sense of re-representation.

they evidence knowledge about the continued existence of hidden objects, or when they imitate a sequence of actions perceived in the past. Getting to the level of a specific definition, however, is a bit more involved. Here, at least three parts to representation must be identified: the representational content, or thing being represented; the medium, or item doing the representing; and, the connection, or relationship between the two (Perner, 1991). For this particular analysis, such a definition works well with only a minor bit of refining. This comes by way of understanding the distinction between the representational content and the representational item as the difference between a *signified* and a *signifier*, respectively (Judge, 1985). Now, although agreement exists over these parts, paths diverge when the specific nature of the relationship between the signified and the signifier is elaborated.

As mentioned in the introduction, the different positions elaborated here can be distinguished as competing models. One is the model described by developmental psychologists such as Baldwin (1906/1968), Stern (1914/1930), Bühler (1919/1930), Vygotsky (1933/1978), Werner (1948), Piaget (1945/1962), and Langer (1980, 1986), all of whom claim that mental representation develops during the second year of life. According to this model, the representational relationship between signifier and signified emerges from successive differentiations and integrations of sensorimotor schemes in the course of the infant's intentionally oriented interactions with the world. In other words, an active agent stands between the signifier and the signified and, more importantly, is viewed as intentionally relating or joining them.

The alternative model, presented by several contemporary developmental psychologists such as Karmiloff-Smith (1992), J. Mandler (1988, 1992), and Perner (1991), claims that mental representation develops very earlier in life, or is even innate. The development of mental representation, in their perspective, is independent of sensorimotor activity and is, instead, best framed in perceptual terms. As a consequence, the role of an intentionally motivated agent mediating the relationship between the signifier and the signified is significantly downplayed, if not absent altogether. The following discussion attempts to show the manner in which these contrasting positions correspond to competing philosophical lines. One position falls within the bounds of the empiricist tradition developed by the likes of Locke and Hume; the other position falls under the constructivist tradition seen in the works of Kant and Hegel.

Empiricism. Three closely related points regarding representation are characteristic of empiricist models: nonintentionality, passivity, and disembodiment. Traditionally, empiricist models have claimed that the representational relationship between the signifier and the signified rests on a notion of mechanistic cause and effect relations, that is, that human minds "causally register the impingements of the world and thereby carry causally produced representations of it" (Gillett, 1992, p. 1). In this sense, representation is nonintentional. Thinking, or thought, is to have the atomic bits and pieces of the

world depicted or represented in the mind, which is contingent upon having them lodged there as the causal outcomes of one's senses being confronted by the world. One's mental contents, or ideas, are just the effects of stimuli external to the mind. The human mind, then, is analogous to a camera passively receiving impressions that mirror the separately identifiable entities, or pieces of reality, conceived to exist in the external world (Lakoff, 1987; Rorty, 1979; Taylor, 1995). Any notion of human agency, or activity, establishing the relationship between the signifier and the signified is omitted. The meaning of a representation is presumed to be encapsulated in its content, thus making it intrinsic to the signifier itself. In turn, the mind is more or less a container for such content, which seemingly hovers in front of the "mind's eye" for inspection (Judge, 1985). Because meaning is suggested in this account to stand somehow "outside" the individual, a mere recipient of the information taken in by the senses (Judge, 1985; Gillett, 1992), it is said to be *disembodied*. Human understanding, here, is independent, then, of any particular experience of the subject as a person somehow situated in the world's affairs (Johnson, 1987; Taylor, 1995).

The presence of such empiricist assumptions in contemporary theories of representation is quite commonplace and can easily be identified. The notions of nonintentionality and passivity are evident in Perner's (1991) highly influential model. For example, he begins by distinguishing between *primary* and *secondary* representations. Primary representations, he claims, are formed "in close and fairly reliable causal connection with the represented world" (Perner, 1991, p. 41). Secondary representation, where the "causal link to the represented world can be suspended," are derived from "this contact with the represented" (Perner, 1991, p. 41). Thus, according to Perner, "the cause of mental representations needs to be understood nonintentionally" (Perner, 1991, p. 24). It should be clear that in Perner's account representations do not function *for* an active mind. Instead, representations assume a controlling function and are explicitly understood as "causally influencing behavior" (Perner, 1991, p. 24). Consequently, the individual is stripped of any real agentic capacity and reduced to being a passive receptacle for sense data.

Another characteristic of recent theories of mental representation is to collapse the division between the representational item and the representational content. That is, the representational content is taken as somehow intrinsic to the representational item itself. This notion highlights the empiricist assumption of disembodiment. For example, Mandler (1992) derives early mental representation from what she terms *image-schemas*. In her theory, she suggests a sort of iconic mentalese where the meaning of an image-schema "resides in its own structure; it does not require other symbols or another system to interpret it" (Mandler, 1992, p. 592). Karmiloff-Smith, in turn, builds on Mandler's theory, endorsing it as "the most thoroughly worked out speculations about the way in which young infants build repre-

sentations that are suitable for subsequent linguistic encoding'' (Karmiloff-Smith, 1992, p. 41). On the basis of the assumption that representational content is intrinsic to representational items, Karmiloff-Smith elaborates on the idea that development basically consists of redescribing input into different representational formats (Karmiloff-Smith, 1992). Through the process of redescription, implicit representations in the mind become explicit knowledge, and then, over the course of further redescription, become accessible as data to consciousness (Karmiloff-Smith, 1992, p. 22). The process of redescription, however, occurs as a product of the mind's own system-internal dynamics (Karmiloff-Smith, 1992, p. 21). Thus, again, no intentionally motivated agent mediates the relationship between signifier and signified. Within each of these theories, representations become entities that take on a life of their own. They function "analogous to persons who can cause one another to act as their representatives" (Judge, 1985, p. 51). Moreover, because thought is presumed to be "encapsulated within the idea, *independently of any act of thinking*, it begins to seem as if the role of the thinker or the person as agent becomes superfluous" (Judge, 1985, p. 51). Finally, by emphasizing the functional role of representations within a representation-using system, while, at the same time, either implicitly or explicitly (Perner, 1991, p. 21) dismissing the notion of intentionality, Karmiloff-Smith, Mandler, and Perner closely follow current theories comparing the workings of the mind to that of a computer. We will argue that this, in turn, further promulgates empiricist assumptions.

Constructivism. A constructivist model stresses three contrasting points: intentionality, activity, and embodiment. According to this model, mental representation develops from the subject's mental activity, or consciousness, as it is directed toward some object or thing. Because such activity involves this directed quality, that is, because one's mental acts are *about* something, it is construed as intentional. In fact, the notion of intentionality highlights that both mental acts and the content constituted by them are inextricably related. Mental content cannot be separated from the mental acts that supply the forms or structures by which the content is organized and understood. Although such mental acts usually pass unnoticed by the subject, nothing can enter the mind without the activity of the mind to make it intelligible (Marbach, 1993; Overton, 1994; Piaget, 1947/1950; Taylor, 1995). This intelligibility, in turn, always occurs within the broader context of the individual's experiences and interactions with others. For this reason, an empiricist account, which focuses narrowly on the passive registration of sense data, cannot adequately capture the development of representation. Indeed, it presents a methodological solipsism, suggesting that any rational individual acting alone could recognize a thing for what it is.

In the constructivist model, on the other hand, representational meaning cannot simply reside in representative items (i.e., signifiers), that is, be encapsulated in some sort of Lockean ideas caused solely by external stimula-

tion. Instead, meaning depends upon the intentionally directed activity of an agent who refers such items to certain objects, and thus makes them meaningful. Because representational meaning depends upon the mental structures underlying the activity (Gillett, 1992), it is not simply given by the world; rather, it is actively constructed by the mind in relationship to human understanding and social interaction (Dewey, 1929/1989; Johnson, 1987; Overton, 1994). The relationship between the signified and the signifier, then, is made, not given. Representations possess their intentional quality, or directedness, by virtue of this twofold understanding of human activity: the activity of the individual forging meaningful relationships toward her own ends and the activity of a larger community of human beings (of which the individual is a part) creating shared forms of meaning. Both activities inform and influence each other. The capacity for representation lies ultimately in these activities which are ostensibly part and parcel of human existence, not in accumulating further representations or simple depictions of the world. As Taylor expresses it: "The notion that our understanding of the world is grounded in our dealings with it is equivalent to the thesis that this understanding is not ultimately based on representations at all, in the sense of depictions that are separately identifiable from what they are of. . . ." (1995, p. 12). Instead, understanding and meaning are "embodied," that is, contingent upon subjects being embodied agents who are engaged in, or acting upon, the world. Through these embodied interactions, human beings construct the mental structures, which, in turn, organize experience and make further understanding possible.

Minds and computers. Insofar as psychological models of representation are rooted in competing philosophical traditions, a proper evaluation of the models requires taking into account these philosophical perspectives. Although neither model is without problems, theoretical dilemmas persist particularly for accounts founded within the empiricist perspective. This is evident in the prevailing computational theory of the mind (also called the *physical symbol system* hypothesis), which implicitly assumes the empiricist principles just discussed (Taylor, 1995) and is of major influence on contemporary theorizing.

In such a computer-based model, the human mind is treated as a syntactical machine (Overton, 1994). The mind manipulates its own internal symbols, or representations, according to formally expressible principles, or rules, inherent to the system (i.e., the brain). This understanding is analogous to a computer arranging bits of information according to the rules of its program. The mind's internal representations are like the computer's machine code, and the computer program captures the formal principles guiding their manipulation. Mental processes, in turn, are described as the causal sequences of these formally structured representations, which the computer is able to simulate (Smythe, 1992). The formal principles are understood to constitute the syntax of the mind, and semantic distinctions are constituted in the ar-

rangement, or form, of the internal symbols. Meaning is a matter of getting the arrangement right, which, consistent with the empiricist model, is located in a correspondence with sensory input.

The human mind may be presented as active in this account, but only insofar as it causes symbols to move according to the pre-given, internal constraints inherent in the brain's structure. In this reactive manner, the mind's inherent passivity is made to appear active. Further, the activity is not intentionally directed. It is merely part of the cause and effect sequence beginning outside the mind and constrained by the formal principles inherent to the mind.

The meaning of internal representations, although dependent upon their proper arrangement, is not actively constructed by the mind in this model. Meaning resides outside the person, in the pieces of the world, which the mind, in turn, reproduces in its own symbols. According to this model, internal representations in the computational system, i.e., the human mind, serve as particular sorts of encodings for the external world as registered by the senses. Although the encoding relationship can be explained to originate in a variety of ways (e.g., transduction, connectionist training, analogical correspondence; see Bickhard, 1993), it is essentially a matter of correspondence between something "out there" in the world and the symbols "inside" the human computational system. A common way to present this correspondence is according to isomorphic patterns between the internal patterns of the system, such as neural activity, and some designated item or event pattern in the external environment (Bickhard, 1993; Bickhard & Terreen, 1995). It is not clear, however, how such a notion of pattern isomorphy, or any correspondence-based theory more generally, is capable of introducing a meaningful representational relation into a nonintentional system.

Because the computer model asserts that representation can be explained through the uninterpreted properties of formally structured symbols which function independent of any assigned meaning, it falls into the dilemma of adequately grounding meaning. Indeed, the manner in which meaning is derived in an empiricist model like the computer model is frequently challenged (Bickhard, 1993; Harnad, 1990; Plunkett & Sinha, 1992; Smythe, 1992). Computing systems eliminate meaning in the formalization process, leaving only a series of signals with rules for their manipulation (Kramer-Friedrich, 1986). Consequently, formalized symbolic structures, like the isomorphic patterns indicated above, require an independent account of their meaning (Smythe, 1992).

More specifically, the mere covariation of internal patterns with external patterns, in itself, cannot yield a meaningful relationship. Reproducing patterns across different mediums could go on endlessly; they have no meaning as signs without an independent agent interpreting and using them (Kramer-Friedrich, 1986). The internal pattern alone carries no knowledge of any particular isomorphic relationship. Even if this relationship is said to origi-

nate in “the close causal contact with the world to be represented” (Perner, 1991, p. 6), some form of epistemic access to the correspondence is required. Indeed, the sorts of correspondences just mentioned exist only by the virtue of some external observer who identifies and offers them a meaningful interpretation. Searle seeks to capture all this in the brief slogan: “semantics are not intrinsic to syntax” (Searle, 1994, p. 210; also see Searle, 1980). Expanded, this means that no arrangement of signals, no matter how rule bound or closely tied to some other physical pattern, can yield meaningful content all by itself. The content that one gathers from some observed correspondence necessarily involves some form of knowledge, or understanding, of what is involved, as well as a pragmatic dimension, of actually making use of the knowledge. Both of these aspects of the representational activity are inextricably tied together in the human agent who actively makes use of signifiers in reference to certain features of the world (Judge, 1985).

For the representational relationship to rest solely upon the type of causal contact that Perner and other empiricist models suggest, either an internal homunculus must exist as interpreter (Heil, 1981) or the effect (i.e., signifier) must somehow be contained in, or carried by, its cause (i.e., signified). Because the former notion of some “inner person” running the show, implies a return to 16th-century modes of understanding, the latter proves to be a more reasonable option to consider. It must be clear, however, that a cause and its effect are two distinct terms defined by an agent who understands their connection. To suggest that one implicitly contains or carries the other is implausible. An effect, in itself, cannot signify its cause (Cassirer, 1929/1957; Gillett, 1992; Judge, 1985). Indeed, if it did, all causal relationships would present themselves as representational ones (e.g., any reflex behavior would represent its unconditioned stimulus). In other discussions this issue has been expressed as a sort of “multiplicity of correspondences” problem (Bickhard, 1993). In fact, because the implausibility of the conclusion just reached is rarely recognized, the signifier–signified distinction, set up here to parallel the cause and effect one, is rather muddled. In the end, the signifier is mistakenly accepted as intrinsically containing its content devoid of any agent who separately understands and makes the connection between the two. Dewey, for one, mixes few words in characterizing such a mistake, calling “the notion that sensory affections discriminate and identify themselves [as signifiers], apart from discourse, as being colors or sounds, etc., and thus ‘ipso facto’ constitute certain elementary modes of knowledge . . . is inherently so absurd,” and blaming the problem on “certain preconceptions about mind and knowledge” (Dewey, 1929/1989, p. 212). Insofar as this “absurdity” is allowed to stand, then, computational models of representation rest upon the empiricist-related mistake of treating internal symbols, or signifiers, as independent carriers of meaning and information.

It appears that in accepting the computer as a model, or metaphor, for the human mind, empiricist approaches to cognition have failed to confront basic

questions regarding the similarities and dissimilarities between the two (MacCormac, 1986). Instead, they have presupposed the adequacy of the relationship, treating the activities of the human mind and the computer as interchangeable phenomena (Aanstoos, 1987; MacCormac, 1986). No doubt this approach has advanced a great deal of research. Indeed, insofar as the computer metaphor carries a theory-constitutive role in cognitive science (Boyd, 1979), much effort has gone toward demonstrating the efficacy of computer simulation models. Still, metaphors allow one to understand only certain features of the concept or phenomenon under examination. A metaphor is intended to highlight such features. But in doing so, other features are often hidden or distorted (Lakoff & Johnson, 1980). To the extent that the computer metaphor asserts a "totalizing" position in cognitive science, it is clear that certain critical issues have been glossed over, or as Searle remarks on these matters: "[T]here seems to be a peculiar philosophical hiatus" (1994, p. 205).

A clearer understanding of the term "information," for example, is evidently needed in addressing the relationship between the computer's functioning and human cognition, particularly since both are often claimed to be information processors. Here, though, it is worthwhile to apply a distinction often missed, or at least overlooked, as insignificant. Human beings engage in, what most might agree to be, "informing processes;" that is, they possess the ability to transmit or communicate meaningful content through the use of signs or symbols. This, indeed, seems to be at the heart of what it means to "inform" and goes some distance in contributing to one's understanding of the term "information." Information, in the sense implicated by computer technology, however, as already suggested, consists of nothing more than a set of production rules, specifying the parameters for the most efficient performance of certain operations and prespecified signal manipulations. In "mechanizing" the informing process, the activity most often exhibited by human beings must be laid out as a formal calculus and, the signs being exchanged, must be reduced to empty "bits" of data in order to be properly arranged and rearranged.

The subtle irony of this mechanization process must not be lost. Signs, as one theorist states, "whose meaning can be dispensed with . . . no longer possess the quality of informing. For a sign to have the ability 'to inform' is necessarily tied to its ability 'to mean'" (Kramer-Friedrich, 1986, p. 22). Computers, then, do not engage in information processing in the same sense that humans do (Searle, 1994). In fact, the informational content derived from the computer's processing rests on its tie to human usage. Not only does this draw out the previously mentioned pragmatic dimension of symbolic structures (i.e., the active use of symbols by human beings), it also elaborates on the criticism that computational-based models conspicuously lack semantic content.

Taking stock of this series of points means seriously questioning the cur-

rent paradigm shaping the field of cognitive development and, more specifically, reevaluating how contemporary views about the human mind take shape. It should be clear by now that even saying that both computers and the mind are alike because they follow some series of rules, or are somehow constrained, in their respective treatments of “information” is not so straightforward. First, having spent some effort highlighting the danger of injecting the “devices and moves” of external agents into explanations or descriptions of physical events (Heil, 1981), one should be sufficiently leery of accepting a formal description of the so-called rules underlying the mind’s activity. Clearly, cognitive researchers must “take care to avoid confounding the character of our descriptions with the mechanisms” actually presumed to be at work (Heil, 1981, p. 327). Presenting a workable description, in other words, does not necessarily give one the “real” or “true” state of affairs about how the mind functions. Second, the notion of “following” rules, itself, is suspect in this claim. Unlike human beings, who consult a rule as a standard by which to evaluate their performance or activity as being somehow on or off track, a computer neither follows nor breaks rules (Baker & Hacker, 1984). Although, a computer operates “as if” it were following rules, it is not literally following anything because of the causal constraints established in it by its program (Hyman, 1991). The sense, then, in which a computer follows a rule is rather empty, because, unlike a human being, the computer “has no intentional content intrinsic to the system that is functioning causally to produce the behavior” (Searle, 1994, p. 216). For these reasons, empiricist accounts of a computational mind face serious challenges.

PIAGET’S GENERAL APPROACH

The sorts of issues raised in the first section are avoided within the constructivist approach because different sorts of assumptions—the notions of intentionality, activity, and embodiment—are adopted as a starting point. Piagetian theory particularly elaborates on these, as is especially evident in his conception of mental representation. For Piaget, representations are used intentionally by an active subject possessing a form of intelligence (i.e., a mental structure) developed through embodied sensorimotor activity during the first 2 years of life. The specific account that Piaget develops on the origin of mental representation is discussed in more detail in the third section. Here, however, it is important to highlight some of the basic constructivist themes running through Piaget’s theory of cognitive development. Specifically, the two related distinctions between (a) assimilation and accommodation and (b) the operative and figurative aspects of intelligence underscore Piaget’s allegiance to a constructivist model and demarcate his theory from an empiricist model.

Piaget can be characterized as wanting to emphasize the dynamic interaction that is ongoing between subject and object. This idea is clearest in his

acceptance of the notion that living organisms actively engage their environment. Piaget takes this relationship between an organism (i.e., subject) and the environment (i.e., object) as one of a continual exchange and interaction. Two related notions specifically arise from his description of the nature of this interaction: organization and adaptation. The kind of continual exchange taking place between an organism and its environment presupposes the first term, that is, the organized functioning of the organism. Because the organism itself is viewed as the source of this organization, Piaget understands it as active, self-regulating, and processual (“organizing” organization). Thus, the organism’s structure (“organized” organization) is constantly undergoing modification, or reconstruction. The overall process constitutes the organism’s adaptive function that maintains the equilibrium between it and its environment. The dynamic character of this equilibrium is regulated specifically, according to Piaget, by the complementary functions of *assimilation* and *accommodation*. Briefly put, assimilation is the aspect of an organism’s adaptive activity by means of which elements of the environment are integrated into the organism’s preexisting organizational structures, or schemes. Piaget uses this term to assert the active quality of the organism’s organization: “Assimilation is . . . the very functioning of the system of which organization is the structural aspect” (Piaget, 1936/1963, p. 410). Accommodation, on the other hand, is the aspect of the adaptive activity that provides the particular content for the structuring activity of assimilation. Piaget holds that by accommodating to the environment an organism’s existing organizational schemes are differentiated and modified.

One of Piaget’s basic claims is that the organizational function of assimilation and accommodation are common to both physiological and psychological activity. Psychological functioning (i.e., behavioral and cognitive functioning) extends and surpasses the physiological interactions between the organism and the environment because its functioning does not depend on the material incorporation of the elements with which it interacts (Piaget, 1967/1971). For Piaget, cognitive development is one particular form of self-organizing activity at the psychological level, whereby the organism, in this case a human being, constructs increasingly complex knowledge structures over the course of its continuous and varied interactions with the world and others. Here again Piaget’s emphasis is upon the dynamic interaction between subject and object “poles.” The intelligence exhibited by human beings originates and perpetuates itself, as he claims, “neither with knowledge of the self nor of things as such but with knowledge of their interaction, and it is by orienting itself simultaneously toward the two poles of that interaction that intelligence organizes the world by organizing itself” (1937/1954, pp. 354–355). Through such interaction, human beings construct more and more complex relationships between their actions and the environment.

Piaget’s notion of assimilation, at the psychological level, particularly highlights the constructivist dimension of intentionality that is implicit in

the behavior of human beings.² Specifically, assimilatory schemes comprise a need and are directed toward specific goals; that is, they refer to the particular elements or objects toward which human activity, and consciousness more specifically, is directed (Piaget, 1965/1971). By assimilating objects to pre-existing behavioral or cognitive schemes the individual confers some kind of meaning on these, whether it be simply of a functional sort or more abstract in nature.

Of course, the activity of assimilation never occurs without its complementary counterpart of accommodation. Thus, both aspects must figure into intentional acts. Structures do not exist independently and prior to their content: they are “developed through interaction with the objects to which the action being formed applies” (Piaget, Grize, Szeminska, & Vinh Bang, 1968/1977, p. 171; Piaget, 1936/1963, p. 416). The structuring activity of assimilation is that aspect of any experience that provides the necessary logical form or structure into which psychological material is integrated, whereas accommodation is that aspect of any experience that provides the particular material for such structures. In this respect, Piaget’s notion of assimilation and accommodation corresponds to Husserl’s conception of the *noetic* and *noematic* poles of intentional acts. Husserl held that each mental phenomenon is constituted by two aspects: it is *both* consciousness of “something” (i.e., the objective aspect of consciousness, or noema) and “consciousness” of something (i.e., the subjective activity constituting objective experience, or noesis) (Marbach, 1993). Again, the emphasis upon the relationship between subject and object should be clear: “Assimilation refers to the way in which the subject subsumes a particular object under a specific category [noetic side of the relation], accommodation to the object (noematic) side of the relation” (Mays, 1977, p. 55). The terms assimilation and accommodation, which specify and constitute the broader notion of adaptive activity in the human being, turn on the most salient sources underlying this activity, respectively, the individual subject and the world in which she lives.

Closely paralleling this understanding of assimilation and accommodation are Piaget’s notions of *operative* and *figurative* aspects of intelligence. The

² Piaget (1936/1963, p. 148) holds that intention is “determined by consciousness of desire, or of the direction of the act, this awareness being itself a function of the number of intermediary actions necessitated by the principle act.” According to Piaget, in intentional actions, means, as secondary values, are subsumed to the ultimate value, or end. Consequently, he attributes “true intentionality” to sensorimotor actions that are characterized by means-end coordinations, as, for example, setting aside an obstacle to attain another object. However, even reflex actions are goal-directed in the sense that they satisfy direct bodily needs. Arguably, reflex actions are located between the goal-directedness of biological self-organization, which they extend, and true intentionality (as characterized by means-end coordination), in which they result. The formation of new, higher needs and values is an integral part of sensorimotor (and representational) development (Piaget, 1936/1963, pp. 42–46, 169–171, 1954/1981; see also Gehlen, 1940/1988).

relation between the two is manifest in the development of richer meaning structures.³ At each developmental level, systems of meanings are formed by the relation between signifiers and signifieds. According to Piaget, the accommodatory aspect of activity produces signifiers, which, in turn, provide the data on which the structuring activity of assimilation acts. Consequently, Piaget (Piaget, 1961/1969; Piaget & Inhelder 1966/1971) subsumes signifiers to, what he calls, the figurative aspect of intelligence, which includes such functions as perception, imitation, and imagery (and partly language, see Piaget & Inhelder, 1968/1971, pp. 12–13, and Furth, 1969, p. 141) that yield knowledge of states. In contrast, the operative aspect of intelligence, common to both sensorimotor actions and higher-order mental operations, refers to the transforming and form-giving, or structuring, aspect of knowledge. For Piaget, the operative aspect of intelligence transforms subject–object relationships by inserting the data provided by the figurative functions into increasingly complex structures. In other words, the operative activity of the human mind results in the construction of more and more complex relationships (spatial, causal, logical, etc.) between subject and object. The operative aspect of intelligence, then, is central to understanding the kinds of qualitative changes that occur in Piaget’s account of cognitive development.⁴

The construction of more powerful knowledge structures takes the form of reconstructing the operative structures of the previous knowing level within the framework of new operative structures. Piaget terms this process *reflective abstraction* (Piaget, 1950a, 1950b, 1977a, 1977b). Reflective abstraction is closely related to the process of becoming aware of one’s operatory activities (Piaget, 1974/1976), although at each knowing level the individual is not necessarily fully conscious of the operative structures she uses (Piaget, 1970/1976). Reflective abstraction can be seen as a mechanism that,

³ Meaning always involves human consciousness. Consciousness essentially consists of systems of meaning that become increasingly related to each other and hierarchically arranged, again, through the structuring activity of assimilation. Piaget refers to the structuring activity of assimilation also as *implication in the wider sense* (Piaget, 1936/1963, pp. 399–400, and Piaget, 1954) and *signifying implication* (Piaget & Garcia, 1991).

⁴ In addition to operative knowledge, Piaget introduced in his later writings (Piaget 1979, 1992; see also Davidson, 1988) the concept of *morphisms*, which is closely linked to his notion of pseudo-empirical abstraction (Piaget, 1975/1985, pp. 39–40). Morphisms are instruments for comparing states without transforming them, e.g., placing objects of an equal number into one-to-one correspondences with each other. Morphisms have their roots in generalizing assimilation: by applying the same scheme to two objects simultaneously or successively, the same form is transferred to these objects, and the objects are put in some kind of relationship with each other (Henriques, 1992, Piaget, 1992; Piaget, Grize, Szeminska, & Vinh Bang, 1968/1977). Morphisms are thus form-giving (or “enforming,” see Henriques, 1992, pp. 189–190) instruments. Although morphisms do not transform objects themselves, they transform subject–object relationships “by enriching them so that a large variety of new correspondences become possible” (Inhelder & Piaget, 1980, p. 20). Because morphisms transform the subject–object relationship, we subsume them to the operative aspect of knowledge.

at each level of knowing, abstracts form from content and, in turn, projects this form to a higher level. Thus, the forms of stage n become the contents of stage $n + 1$. With each new and higher stage, the forms become increasingly abstract. Through the mechanism of reflective abstraction, then, development proceeds by way of successively conceptualizing the forms or structures of knowledge underlying previous knowing levels (Boom, 1992; Campbell & Bickhard, 1986; Kesselring, 1981, 1985).

The idea that knowledge has an operative aspect is perhaps Piaget's deepest insight (Bickhard & Campbell, 1989) and sharply distinguishes his theory from empiricist theories of knowledge. Piaget argues that empiricist interpretations of knowledge as a copy over stresses the figurative aspect of intelligence to the exclusion of any notion of an operative aspect (Piaget & Inhelder, 1966/1971). Indeed, for Piaget, the figurative aspect of knowledge is subordinated to the development of the operative aspect. To do otherwise precludes any real sense of developmental change, or as Piaget claims: "To take operations and operational structures seriously consists in believing that the subject can transform reality, whereas the primacy of images and language leads to a fundamentally conservative model of intelligence and man" (Piaget, 1976, p. 28, our translation). Theories of knowledge built solely on "figurative grounds" suggest a model of the human mind as essentially passive, making them susceptible to the sorts of criticisms laid out in the first section. The most salient problem revolves around the issue of how mere perceptions of reality could confer new meanings to objects. By way of example, of what use were mere copies of the perceptual field to the chimpanzees in Köhler's (1927) famous experiments? They remained "slaves of their sensory field" (Vygotsky & Luria, 1930/1994, p. 123) because they lacked operative structures into which they could have inserted, and then reorganized, this purely figurative knowledge.

Furthermore, Piaget puts some distance between his claims and ones falling under nativist approaches by asserting that only the functioning of intelligence is hereditary, not specific knowledge structures (Piaget, 1936/1963, pp. 1–4). Rather than considering human cognition as driven by innate, blind, and rigid fixations, Piaget claims phylogenesis has led to an increasing disappearance of innate fixations that, in the case of human life, has resulted in a "bursting of the instinct" (Piaget, 1967/1971, pp. 366–367). With this, human beings no longer have, contrary to other animals, a fixed, species-specific environment (Berger & Luckmann, 1966; Gehlen, 1940/1988, Herder, 1772/1967). Instead, human beings are characterized by, what Gehlen calls, their "world-openness" (Gehlen, 1940/1988). As a consequence, human beings are free to construct themselves in interindividual, or social, interactions (Piaget, 1967/1971, p. 368). Because the individual and the social group constitute a relational totality, the development of knowledge is intrinsically a social process: "Individual operations and cooperations form one inseparable whole in such a way that the laws of the general coordina-

tion of actions are, in their functional nucleus, common to inter- and intra-individual actions and operations'' (Piaget, 1967/1971, p. 98; see Chapman, 1992; Döbert, 1992; Mays, 1982; Smith, 1995). Cognitive operations are thus necessarily *co-operations*, by means of which human beings construct rational norms, create cultures, and transform the environment to adapt it to their genetic makeup.

THE DEVELOPMENT OF REPRESENTATIONAL THOUGHT

Piaget distinguishes between differentiated and undifferentiated signifiers. He claims that prerepresentational, sensorimotor functioning is based on undifferentiated signifiers, and representational functioning is based on differentiated signifiers. The issue, then, for Piaget is to explain how the child constructs differentiated signifiers. Essentially, he draws on the distinction between the assimilatory and the accommodatory functions (inappropriately, we will argue) to explain the differentiation of signifier and signified (Piaget, 1945/1962, pp. 104, 278). Specifically, the assimilatory function detaches the content or signifieds from objects in the immediate spatio-temporal field and the accommodatory function produces differentiated signifiers. In the end, however, two major difficulties arise in this account. *Undifferentiated and differentiated signifiers*. For Piaget, the transition from prerepresentational, sensorimotor functioning to representational functioning marks a major turning point in cognitive development happening sometime around the second year of life (Piaget, 1940/1967; Piaget & Inhelder, 1966/1969). Whereas sensorimotor actions refer to material objects in the here-and-now, representational acts transcend the boundaries of the immediate spatial and temporal surroundings and refer to objects that are not currently given. Actions such as the retrieval of an invisibly displaced object, the sudden invention of new means in practical problem solving, and pretend play are taken as indicators for the presence of mental representation (Piaget, 1936/1963, 1937/1954, 1945/1963).

The difference between sensorimotor and representational functioning consists in the type of signifier used at both levels. During the sensorimotor stage, signifiers and signifieds are not yet differentiated. Signifieds at this stage are sensorimotor schemes which confer meaning on the elements interacted with. Signifiers constitute a part of the referent (e.g., the visible part of a semihidden object), or a temporal antecedent of the referent (e.g., the opening of the door announces that a person is coming; see Piaget & Inhelder, 1966/1969, pp. 52–53). Undifferentiated signifiers, then, are spatio-temporally linked to their referent and, for that reason, the meaning constituted by sensorimotor actions remains tied to the immediate spatio-temporal surroundings.

Representational acts require the construction of a system of signifiers that are differentiated from their signifieds. Piaget terms such a system the *semiotic function* (Piaget & Inhelder, 1966/1969, p. 51). The semiotic function

subsumes both *symbols* and *signs*. Following in the tradition of de Saussure (1916/1983), Piaget defines symbols, such as mental images, as motivated signifiers (i.e., they resemble the things signified), and signs, such as words, as arbitrary and conventional signifiers. Because schemes are now expressed through differentiated signifiers, children at the representational level are capable of referring to objects and events that are spatio-temporally removed: "Because the connotation [meaning] remains with the symbol when the object of its denotation [reference] is neither present nor looked for, we are able to think about the object without reacting to it overtly" (Langer, 1942, p. 64; also see Bronowski & Brown, 1970; Von Glasersfeld, 1974, 1976).

Taylor (1971) explains this difference between undifferentiated and differentiated signifiers in terms of *disengagement*: "To be able to talk about things is to be potentially aware of them outside of any particular transaction with them; it is to be potentially aware of them not just in their behavioral relevance to some activity we are now engaged in, but also in a 'disengaged' way" (1971, p. 404). Animals lack this capacity. Their behaviors are, to different degrees, driven by instincts that are tightly tied to their environment and that cannot be divided into a series of independent actions to be somehow separately considered or reflected upon. Each instinct forms a self-contained functional cycle. Because these functional cycles cannot be coordinated with each other, each constitutes its own isolated sphere of reality. Objects in an organism's perceptual field are at this level, what Werner (1948) has called, *things-of-action*. They are limited to an instrumental meaning relative to the one or many instinctual behavior patterns activated (Von Uexküll, 1926, 1934/1957). In Von Uexküll's words, "the stimuli of the environment constitute a rigid barrier which surrounds the animal like the walls of a house, closing it off from the entire world outside . . ." (1909, p. 212, our translation). Overcoming this barrier involves loosening, or even cutting all together, the direct tie between the stimulus and the consequent action (Herder, 1772/1967; Werner, 1948). When this tie between a given situation and the organism's actions is severed, the organism's opportunities for different actions afford it a larger degree of freedom, allowing it to become aware of things in a disengaged way and to look at its field of action as a reflective observer, rather than an engrossed participant (Cassirer, 1932/1985). Stating this process in still another way, the capacity for disengagement suggests an activity of progressive distancing between the subject's action and the object (Vygotsky, 1933/1978; Werner & Kaplan, 1963). Whichever way the notion happens to be presented, though, it is exactly the process that Piaget's concept of sensorimotor development is designed to explain.

Detachment of signifieds and construction of differentiated signifiers. The build up to representational acts begins with Piaget's understanding of the nature of the child's initial state of organization. Accordingly, he claims that infants start their life equipped with diffuse, isolated, and global movement patterns involving the whole body and, thus, parts of the body not immedi-

ately relevant to a specific stimulus (“synergies,” see Vinter, 1990). At this initial stage, assimilation and accommodation are themselves not differentiated because accommodations have not yet begun to modify the functioning of the assimilatory schemes. As a consequence, the infant cannot construct meaningful relations between isolated movement patterns. Cognitively, subject and object remain undifferentiated. Through the use of particular schemes in different situations, however, these schemes become increasingly accommodated to different things, or objects, and become progressively differentiated and coordinated among themselves. Thus, the coordination and differentiation of sensorimotor schemes serves the purpose of breaking from the immediacy that characterizes the relationship between perception and stimulation during the first few months of the child’s life (Piaget, 1937/1954).

As long as actions and objects are not distanced from each other in this way, a particular percept appears as an extension of the child’s own action. To the extent that things are inserted into a network of coordinated schemes, they are detached from any one scheme. For example, by applying visual schemes to different things, these are gradually differentiated and organized among themselves, enabling the child to distinguish between different perceptual qualities. Although such visual perception plays an essential role in sensorimotor development, its role is limited. The meaning of perceived elements depends on the child’s overall cognitive organization, which involves the coordination and differentiation of many other active schemes, not just visual ones. Consequently, as long as visual schemes are not coordinated with grasping schemes, the perceptual object is not exteriorized and solidified. On the other hand, when these two schemes are coordinated, the refference of the movement is fused with the perceptual object and acquires new and richer meanings (“functional tone”). In this manner, the “world-as-sensed” becomes objectified (Piaget, 1936/1963; Von Uexküll, 1926, 1934/1957). Because this process of objectification consists of particular things, or objects, being simultaneously assimilated to various coordinated schemes, perceptual objects begin to acquire multiple properties that are assumed to persist across various contexts of experience. For example, on seeing bells hanging from the bassinet, an infant anticipates that bells have the potential capacities of being “shakeable” and sounding. “The bells are beginning to take on an ‘in-itself’, i.e., a being transcendent to the ongoing action although this being still refers to the actions of shaking and listening” (Wiggins, 1981, p. 146).⁵

⁵ Crossmodal matching in very young children is often viewed as evidence against Piaget’s theory. For example, Bertenthal (1996, pp. 441–442) claims that the coordination of sense modalities is “the bedrock of Piaget’s (1954) theory of sensorimotor development. Yet, current evidence suggests that this form of associative learning is unnecessary.”

By way of response, four issues should be considered. First, sensorimotor development should, for epistemological and psychological reasons, not be equated with associative learning

It should now be clear that, according to Piaget, each assimilatory scheme entails other possible schemes and, because they are all part of an overarching organization, the potential of becoming coordinated with each other (Piaget, 1936/1963, p. 245). Novel constructions in these early stages of development actually arise accidentally as the child gropes toward achieving a particular goal. Upon the successful completion of this process, the child becomes aware of her actions—a process that Piaget calls *recurrent consciousness*—and then retroactively begins to reorganize these actions (Piaget, 1936/1963, p. 180; see coordination of vision and grasping, pp. 88–122, and also means–ends coordination, pp. 153–185). This awareness, of course, is not of a fully blown, or adult-like, quality. Rather, instead of the child being explicitly aware of schemes qua schemes, she is simply aware of her actions as properties of, and relations between, objects. Piaget, accordingly, carefully attempts to qualify this type of awareness as one based on the projection of sensorimotor schemes into material things (Piaget, 1936/1963, p. 240).

Further differentiation and coordination of sensorimotor schemes lead particularly to a differentiation between means and ends and, correlatively, to establishing an increasingly complex relationship between objects that results in the construction of such basic categories as space, time, causality, and object (Piaget, 1937/1954). For example, in order to remove a cushion that is placed in front of an object, the child must realize for herself that the cushion, in fact, is placed in front of the object (space), that she must remove it before grasping the object (temporal series), that the object behind the cushion still exists (object-permanence), and that in order to remove the cushion she must grasp it (spatialized and objectified causality).

In the course of sensorimotor development, undifferentiated signifiers become more flexible in their use, and the child learns to perform such acts of recovering a hidden object, or even to anticipate the occurrence of certain events. However, it is not necessary to invoke a fully fledged representational account to describe these actions. Rather, undifferentiated signifiers give rise to a sort of “prevision,” or attitude of expectation (Piaget, 1936/1963, pp. 183, 232, 247–252). Piaget, by way of analogy, describes their functioning in terms of a marginal awareness of obstacles in a cluttered street that

(Piaget, 1936/1963). Second, crossmodal matching and sensorimotor coordination suggest very different processes (Simoneau & Décarie, 1979). The coordination of sensorimotor schemes is meant to describe a qualitative enrichment of the object's meaning. Cross-modal matching, on the other hand, demonstrates the convergence of stimulus patterns that are successively presented to different sense modalities. Third, Piaget never claimed that the senses are not united at birth; in fact, the very functioning of the reflexes requires the unity of senses. The idea that the senses are united at birth was quite common among developmental psychologists at the time when Piaget wrote his books on infancy (e.g., Stern, 1934/1938; Werner, 1934/1978; see Prinz, 1990, on the history and for an interesting treatment of crossmodal matching).

is yet enough to “permit us to steer a bicycle or an automobile with enough prevision to adapt ourselves to the barely outlined movements of another person without needing to picture them to ourselves in detail” (Piaget, 1936/1963, p. 252).

According to Piaget, the increasing flexibility, mobility, and consolidation of schemes permits the structuring activity of assimilation to be accelerated and, at sensorimotor stage VI, to become interiorized. From this stage on, the coordination of schemes occurs spontaneously: “the structuring activity no longer needs to depend on the actual data of perception and, in the interpretation of these data, can make a complex system of simply evoked schemata [schemes] converge” (Piaget, 1936/1963, p. 343). The schemes can be recombined mentally and remain in a state of latent activity before they enter into external acts. For example, Piaget’s daughter, Lucienne (Piaget, 1936/1963, Obs. 180), uses the opening and closing of her mouth as a signifier to understand a problem such as a box opening that is too narrow to remove a chain that it contains. From this, she is able to anticipate the solution: the opening has to be widened in order to get the chain out of the box. Piaget interprets the opening and closing of the mouth, which Lucienne had practiced in imitating her father (Piaget, 1945/1962, Obs. 50a), as a differentiated signifier on which several other schemes converge—an instance of the process that Piaget calls *reciprocal assimilation*. Differentiated signifiers are used to evoke other sensorimotor schemes (understood as other signifieds) that combine mentally, due to the increased speed of assimilatory structuring.

According to Piaget, differentiated signifiers are constructed by the accommodatory function. Concomitant to the differentiation and coordination of schemes, the activities of assimilation and accommodation themselves become further differentiated. During the second year of life, the detachment of actions from immediately given stimuli results in pretend play. Pretence, according to Piaget, is best characterized as the primacy of assimilation over accommodation because objects are freely assimilated to the child’s needs. At the same time, accommodation becomes more active and directed toward novelty as such, which manifests itself in activities like the imitation of novel behaviors:

Accommodation of the schema [scheme] to the model is the incentive and . . . gives rise to recognitive and reproductive assimilation. . . . This accommodating effort is directed not towards the utilitarian aim of assimilation to the child’s own activity, but towards the production of a copy or an equivalent. (Piaget, 1945/1962, p. 277)

Imitative actions indicate that accommodation becomes dissociated from assimilation, and that assimilation is subordinated to accommodation (Piaget, 1945/1962, p. 277). Piaget suggests that the primacy of accommodation over assimilation, which is characteristic of imitation, accounts for the construction of differentiated signifiers. Deferred imitation particularly reflects a sig-

nificant shift in the relationship between a signifier and its signified. Because in deferred imitation an absent model is evoked by means of an action (Piaget, 1945/1962), it indicates the first signs of distancing between signifiers and signifieds. For example, Piaget's daughter, Jacqueline, when placed in her playpen, imitates the temper tantrum she had observed a boy throwing in his playpen on the prior day (Piaget, 1945/1962, Obs. 52). Through this action, Jacqueline provides herself, though perhaps not consciously (Piaget, 1945/1962, p. 70), with a signifier (imitative action) that is differentiated from that which it signifies (absent model). Later, with the interiorization of such an imitative action, a mental image results, marking the beginning of mental representation (Piaget & Inhelder, 1968/1973).

Deferred imitation is but one manifestation of the semiotic function. Symbolic play, mental imagery, verbal evocation of absent events, drawing, and language are still other manifestations (Piaget & Inhelder, 1966/1969). All of these, however, are at least partly dependent upon the activity of imitation. Mental images, for example, arise from the interiorization of exploratory perceptual activities such as perceptual comparisons, analyses, and anticipations (Piaget, 1945/1962; Piaget & Inhelder, 1966/1971) that imitate, or trace, the contours of objects. Images are thus due to the refference produced by evoked perceptual activities. Significant to this account is the notion that mental images are not just extending sensations, as postulated by the empiricist tradition, but are, in fact, symbols that are necessarily schematized, or part of a broader active organization ("schema"; Piaget & Inhelder, 1966/1971, p. 366, p. 382; Dean & Youniss, 1991; Scheerer, 1984). Indeed, the further development of mental imagery depends on the development of such broader operational structures (Piaget & Inhelder, 1966/1971; for empirical evidence supporting Piaget's theory of imagery, see Dean, 1991).

Finally, although Piaget's studies on infancy and mental representation seem conspicuously devoid of any emphasis upon social factors, he does point out the importance of social interaction and communication for the development of representational thought: "Outside this social relation there is no apparent reason why pure representation should follow action" (Piaget, 1937/1954, p. 367; see Sinclair, 1982, 1987). With the emergence of representation, the child's knowledge must be reflectively coordinated with the perspectives of other people. This is one of the reasons why the conceptualization of sensorimotor schemes is not a simple transferral of knowledge to a higher plane, but involves a laborious reconstruction (Piaget, 1937/1957, 1945/1962). For this reason, the child faces new problems in acquiring an understanding of categorical forms such as space, time, object, and causality on the representational plane, although the child already possesses these forms on a practical level (Piaget, 1937/1954). For example, at the end of the sensorimotor stage the child has already acquired a practical (Euclidean) concept of space and is capable of mastering detour problems (Piaget, 1937/1954, Obs. 117; see Fischer & Bidell, 1991). The solution of the same detour

problems on a purely representational plane, however, will initially pose major difficulties (Piaget, Inhelder, & Szeminska, 1948/1960).

To summarize, representational thought results from the synthesis of detached signifieds, or representational content (representation in the *broad sense*), with differentiated signifiers, or representational items (representation in the *narrow sense*) (Piaget, 1945/1962, p. 67). With the coordination and differentiation of sensorimotor schemes, the structuring activity of assimilation, i.e., the operative aspect of knowledge, becomes more and more complex, which leads to the increasing detachment of the child's actions from immediately given stimuli. Such a detachment of meaning manifests itself specifically around age 1 1/2 when children begin to engage in pretend play. While pretend play is characterized by the primacy of assimilation over accommodation, Piaget introduces the primacy of the accommodatory function to characterize children's imitative actions. The interiorization of deferred imitation serves to differentiate signifiers. Representational acts, then, originate from the coordination of these two complementary functions—detached signifieds as produced by the assimilatory function and differentiated signifiers as produced by the accommodatory function (Piaget, 1945/1962, p. 3). Overall, Piaget frames the development of mental representation in terms of the semiotic function as an improved state of balance, or equilibrium, in the mind's symbolic activity, as constructed by acts of assimilation and accommodation (Piaget, 1945/1962; see Fetz, 1981).

Evaluation of Piaget's account. For Piaget, the semiotic function is a tool and only as good as the intelligence it serves (Furth, 1969). Accordingly, building up the relationship between the signifier and the signified to achieve a representational status requires the development of the operative aspect of intelligence. Piaget's specific accounting of this process, which is based on the interiorization of deferred imitation, however, faces certain difficulties (Bickhard & Campbell, 1989; Judge, 1985; Marbach, 1987, 1993; Voneche & Vidal, 1985). In particular, two related issues of Piaget's account require modification. Both involve the introduction of higher-order operative knowledge structures.

The first difficulty with Piaget's account revolves around the claim that through deferred imitation the child "becomes capable of evoking absent models and consequently of supplying 'signifiers' for the assimilating activity, provided that the latter is capable of connecting them with present data" (Piaget, 1945/1962, p. 278). Piaget, however, does not adequately resolve the issue of how assimilatory activity connects the signifier (present imitative behavior) with the signified (previously observed model). In order to establish the link between a signifier and its signified, the child must be able to identify the present behavior with the past event; that is, the child must already be able to think. Without signifiers, according to Piaget, there is no thinking (Piaget, 1970/1972; Piaget & Inhelder, 1966/1971). Consequently, Piaget presupposes thinking in order to explain how the link between signi-

fier and signified becomes established, when, at the same time, signifiers are needed to explain the very onset of such thinking.

Basically, this problem arises from Piaget's suggestion that the differentiation of signifiers and signifieds results from the differentiation of the functions of assimilation and accommodation. Certainly, the coordination and differentiation of sensorimotor schemes allows for the objects of knowledge to take on greater complexity, but to describe this process as a differentiation of the functions of assimilation and accommodation is inconsistent with the idea that assimilation and accommodation function as complements—accommodation always provides the material, or data, for the structuring activity of assimilation. Consequently, the subject is always immediately related to some object, although, from the observer's perspective this immediate relationship is already mediated through a network of schemes. In other words, with the coordination and differentiation of schemes, the mental content become increasingly mediated through, but not differentiated from, the structuring activity of assimilation: in the course of development, initial immediacy becomes mediated immediacy (Kesselring, 1981).⁶

The derivation of differentiated signifiers from the accommodatory function produces further problems as well. To construct differentiated signifiers, Piaget suggests that the accommodatory function is somehow dissociated from the assimilatory function. But if this were the case, say with imitation particularly, infants would imitate what they do not understand, a possibility that Piaget explicitly rules out (Piaget, 1945/1962, pp. 79–86). Moreover, if differentiated signifiers (“interior copies of the external object,” Piaget, 1945/1962, p. 70) were produced by the accommodatory function, these signifiers would be devoid of any meaning because such meaning is provided by the structuring activity of assimilation. Piaget seems to overlook that the construction of representative items, or differentiated signifiers, is an intellectual accomplishment in itself that must be explained by development of new knowledge structures, or, specifically, higher-order operations. His notion of interiorization does not achieve this. In fact, Piaget uses the concept of interiorization for both the speeding up of the structuring activity of assimilation (Piaget, 1936/1963) and the process of transforming motor gestures into mental images or “interior copies” of the object, i.e., the internalization of the accommodatory function (Piaget, 1945/1962; see Furth, 1969). Just because interiorization consists of the speeding up of assimilatory activity or the internalization of the accommodatory function, it cannot account for the construction of new, higher-order operative structures. Only already existing functions can be interiorized. The interiorization of the representational function, thus, presupposes its construction.

⁶ In addition, the idea that accommodation has primacy in imitation (Piaget, 1945/1962) contradicts Piaget's own statement that “accommodation is always secondary to assimilation” (Piaget, 1975/1985, p. 6). Furthermore, as Kesselring (1981, p. 99) points out, even imitation can have a playful function (parody).

The second difficulty with Piaget's account of the origin of mental representation is that he invokes the figurative aspect of intelligence to explain the construction of higher-order relations between subject and object. For example, Piaget attributes the advance from stage V to stage VI in the development of the object concept, i.e., the understanding of invisible displacements of objects, to the fact that infants have acquired mental representations that allow them to deduce the itinerary, or displacement sequence, of the object (Piaget, 1937/1954, p. 85).⁷ Similarly, the progress from stage V to stage VI in the construction of spatial relations is due to the emergence of mental representation (Piaget, 1937/1954, p. 204). For example, infants at stage V construct an objective group of displacements that allows them to understand the relations between positions and displacements among objects (Piaget, 1937/1954, Obs. 116–117). This objective group is still limited to displacements directly perceived, however, because infants are incapable of coordinating their own spatial displacements with the displacements of objects; i.e., they are incapable of understanding themselves as being in space (Piaget, 1936/1963, Obs. 168, Piaget, 1937/1954, Obs. 118–123; see Chapman, 1988, p. 111). Again, Piaget claims that the emergence of representation at stage VI ("representative groups," Piaget, 1937/1954, p. 205) accounts for the capacity to understand the objectivity of one's own spatial position and for the deduction of displacements not directly perceived.⁸ Within Piaget's own framework, however, the figurative aspect of intelligence in itself is incapable of constructing more complex relations between the subject and object. In order to be consistent with his overall epistemological framework, the operative aspect of intelligence, not the figurative, must account for the construction of new, higher-order knowledge structures.

A MODIFIED CONSTRUCTIVIST ACCOUNT OF REPRESENTATIONAL DEVELOPMENT

We will present our modification of Piaget's account in two parts. First, we will discuss recent research on infants' spontaneous manipulation of objects and of the products this activity. This research particularly sheds light on the development of the operative aspect of knowledge. Drawing on these findings, the following discussion presents a reinterpretation of certain activities like the retrieval of invisibly displaced objects, the sudden invention of new means, and deferred imitation. It is argued that these activities are better explained by the development of the operative aspect of intelligence, and

⁷ Piaget himself remarks that solving the successive invisible displacements of a receptacle under another screen (Piaget, 1937/1954, Obs. 66) requires the simultaneous processing of the dual nature of the receptacle in which the object was hidden: it becomes an object for search while remaining a receptacle. A successful search behavior involves a "multiplication of relations" (Piaget, 1937/1954, p. 84).

⁸ Piaget pursues the same line of argument with regard to the development of representative causality and representative time (see Piaget, 1937/1955, p. 293, and p. 345, respectively).

not by the emergence of representation. This line of analysis is in accord with Sugarman's claim that "what seems critical for development . . . is not whether children extend their operations into the not-here-and-now, as is often assumed, but what type of relation they impose on input, be it 'present' or not" (Sugarman, 1983, p. 135). In the second part of our proposal, we suggest that the development of higher-order operations, as manifested in infants' manipulatory behavior, is a necessary prerequisite for the development of mental representation as evidenced in pretend play and language.

Operative development. Research into infants' manipulatory behavior supports the positions that logical and physical abilities are constructed from sensorimotor activity. It also confirms the importance of coordinating such manipulatory activity in order to achieve the detachment of actions from the immediate visual field, which in human infants becomes more advanced than in monkeys and apes (Antinucci, 1989a; Natale, 1989; Poti & Spinozzi, 1994). Moreover, this research provides new insight into the development of logical-mathematical, physical, and spatial cognition (Forman, 1982; Langer, 1980, 1986; Sinclair, Stambak, Lézine, Rayna, & Verba, 1989; Sugarman, 1983). In particular, it emphasizes the important role that an infant's progressively stabilizing external productions play in cognitive development during the first two years of life (Langer, 1980, 1986). Such stable products actually represent potential actions, or acts that are "frozen in time" (Forman, 1982), and (as imitative actions of other people, see Sinclair, 1987) serve as the means that allow the infant to detach her actions from the product and become aware of the relations that were implicit in her construction of it. In other words, external products become the means through which the infant objectifies her knowledge structures. This process is succinctly described by Forman:

Action is compressed into a production and is thereby transformed from a temporal expression to an atemporal expression. One might reason that instead of action becoming internalized as Piaget mentions . . . action is [first] externalized. More precisely, in order for internalization of action to occur, the child develops means to make static representations of those actions. The external product then becomes an index of all those actions that were successively used to create the production. (Forman, 1982, p. 121)

Such a notion of objectification is especially in keeping with Piaget's later writings where he stressed the importance of external material in the construction of knowledge: "The subject never achieves clear knowledge of his own actions except by way of their results on objects" (Piaget, 1975/1985, p. 45). This process of objectification is actually described in his concept of *pseudo-empirical abstraction*. According to Piaget (Piaget, 1974/1980, p. 92), pseudo-empirical abstraction is the way in which reflective abstraction functions during the initial stages of development: by ordering and grouping concrete objects, infants enrich these objects and subsequently abstract the logical-mathematical relations from them (Piaget, 1975/1985, p. 44). In

other words, through pseudo-empirical abstraction, infants retrospectively become aware of and abstract forms from object relations that they produced more or less incidentally (see Sugarman, 1983, pp. 99–102). By reflecting on such objects, actions and operations that were formerly in a state of virtual or implicit organization become explicitly coordinated and reorganized.

The logico-mathematical relations of specific interest here involve the development of classification, exchange operations, correspondences, and order operations (Langer, 1980, 1986; Sugarman, 1983). In the first year of their life, infants' development in the logical domain is characterized by, what Langer (1980, 1986) calls, *first-order operations*. First-order operations include operations performed on single elements, the composition of one set, and transformations of single sets. Through operating on elements and single sets, infants already begin the construction of certain basic logical relationships (e.g., set, equivalence, order, reversibility). For example, in uniting two objects into a two-object composition, and then exchanging one object for another object within this composition, infants generate an inferential relation (equivalence) between two successive constructions. In the course of the first and second year of life, the products constructed by such first-order operations increase in size and stability. In the second year of life, infants begin to exhaustively group all items of a given type. For example, they sort all geometrical forms that are identical in color into one group. When they accomplish this, they can be credited with the cognitive organization that allows them to construct a similarity relation between objects, although still only one relation at a time. Sugarman (1983) terms this a *single iterative phase*: individual elements are related to one another because of their functional properties or their visual similarities. Children compare objects on one dimension and realize that an object (x) is like a or not like a . This kind of understanding manifests itself also in the construction of correspondence relations: infants contain different mobile objects (e.g., spoon) in the same recipient object (e.g., cup; Langer, 1980, 1986; Sinclair et al., 1989; Sugarman, 1983). Children, thus, duplicate the mobile objects (spoons), but not the recipient objects (cups). They are able to look for objects of only one type at a time (mobile objects) and, as soon as they get hold of a mobile object, move to the same cup where they placed another spoon shortly before.

During the second year of life, first-order operations develop in power. At the same time, children begin increasingly to compose two sets simultaneously, which provides them with the opportunity to construct logical relationships between both sets. Langer (1980, 1986) calls operations that establish relationships between two sets *second-order operations*. The cognitive organization that initially underlies second-order operations allows children to flexibly shift between different relations. For example, infants become capable of composing two sets of objects by manipulating objects from both groups (Gopnik & Meltzoff, 1987, 1992; Langer, 1986; Ricciuti, 1965; Sugarman, 1982, 1983). However, infants rarely switch from one class to the

other class while constructing these groups (Langer, 1986; Sugarman, 1983). Rather, they first group all the objects belonging to one class and then the objects belonging to the second class, which implies that at one point of time objects are evaluated in terms of their similarities and differences on only one dimension. Successive grouping of objects into two different groups involves a flexible shift from one similarity relation to another similarity relation. This cognitive organization may be described as follows: an object (x) is like a or not like a —shift to another dimension b —an object (x) is like b or not like b (Sugarman, 1983).

A similar cognitive organization can also be observed in exchange operations, correspondence operations, and ordering operations. Infants start exchanging objects between sets by adding one object from one set to another set (Langer, 1986, pp. 75–76). As regards the construction of correspondences, infants begin to compose a one-to-one correspondence between the containers (e.g., cups) and the contained objects (e.g., spoons), and they also spatially integrate these pairs of corresponding objects (i.e., they bring them together, see Langer, 1986; Sinclair et al., 1989; Sugarman, 1983). The successive execution of composition and integration indicates that children can flexibly shift from one relation to another relation. Successive execution of composition and integration does not require children to realize that discrete units are all related in the same way. Rather, they can treat them as unanalyzed wholes (construct one spoon–cup unit, then another, etc., then put similar things together).

At the end of their second and in their third year of life, children recursively shift between groups when they construct two groups (Sugarman, 1983). Their advanced sorting behavior suggests that they have judged an object as not belonging to one class, but still consider it as a possible member of another group: what is not like a is or may be like b (Sugarman, 1983). The iterations that were previously executed successively become coordinated, and children order objects according to two schemes at once, thereby generating a single higher-order scheme in which they have established relations on relations (Langer, 1986). Children now make comparisons on two dimensions simultaneously, although these comparisons are still made on a step-by-step basis, i.e., inductively (Sugarman, 1983). Similar progress can be seen in children's exchange operations. Children construct two sets of objects in one-to-one correspondence, and then transform these sets by substituting objects from both sets for each other (Forman, 1982; Langer, 1986; Sugarman, 1983). Thereby, infants “preserve the equivalence relation between two sets while transforming them. These infants are constructing equivalences upon equivalences by mapping substitution operations upon correspondence operations” (Langer, 1994, p. 202). In constructing correspondence relations, children now start to coordinate the execution of composing and integrating units. They look for an object of one type (e.g., doll),

combine this object in a particular way with another object (e.g., put the doll into a ring), produce another subunit like the first (e.g., put another doll into a ring), arrange the generated subunits spatially, and then continue to construct another pair like the first (Sugarman, 1983). These children simultaneously analyze and interrelate the subunits they construct.

Children's capacity to combine and order objects by size undergoes similar changes (Greenfield, 1991; Greenfield, Nelson, & Saltzman, 1972; Sinclair et al., 1989; Sugarman, 1983). Presented with several cups of different size, one-year old children will simply pick up one cup and pair it with several cups successively. For example, they will put one cup in or on another cup and take the same cup and put it on or in another cup. Their strategy is indicative of the single iterative phase. Next, when children are about 18 months old, they start to put several objects into one larger cup by bringing each new cup to the already nested cups (*pot* method, see Greenfield et al., 1972). The *pot* method implies a successive shift from one relation to another relation because after having been nested each cup changes its role from an active object to a passive receptacle (for a different interpretation, see Greenfield, 1991, and Sugarman, 1983, p. 164). Finally, in their third year of life children start to use the *subassembly* method for nesting cups: they move the already nested cups around and any cup can simultaneously figure as either the receiving cup into which a smaller cup is put, or as the active cup that is put into another cup. The subassembly method reflects children's capacity to reverse flexibly the active-passive roles of the cup, and thus the capacity to coordinate two relations simultaneously (Sugarman, 1983).

Concurrent to operations in the domain of logico-mathematical cognition, causal *functions* are constructed in the domain of physical cognition, including means-ends transformations such as pushing one object against another. During the first year of life, infants construct first-order causal functions. For example, infants use one object as a means to push another object, or they use one object as a means to block and stop another object that is rolling in front of them (Langer, 1986, 1994). In the former action, infants vary ends with means ("Rolling is dependent on Pushing," $X \Rightarrow Y$); in the latter action, they vary means with ends ("Blocking is dependent on Rolling," $Y \Rightarrow X$; see Langer, 1986, p. 373). First-order causal functions are confined to the construction of one-way dependencies between objects ($X \Rightarrow Y$ or $Y \Rightarrow X$). During the second year of life, infants become capable of constructing second-order causal functions that coordinate first-order causal functions. Second-order causal functions construct two-way dependencies between causes and effects. An object comes to have more than one use in an action sequence like pushing and stopping. For example, infants push one object with another object to make it roll; then they use the object they just used for pushing to block the rolling object and make it stop; then they push the object again to make it roll. Through the coordination of the actions of

pushing and blocking, infants construct the second-order causal function: "Moving is a function of Pushing as Stopping is a function of Blocking" (Langer, 1986, 1994).

Arguably, second-order operations, not representation, underlie logical search in invisible displacements tasks. If representation were invoked to explain this achievement, it would be difficult to explain why the reconstruction of spatial concepts on the representational plane poses difficulties (Piaget, Inhelder, & Szeminska, 1948/1960). According to Piaget (1937/1954, 1947/1950, 1950; see Chapman, 1988; Kesselring, 1981), objective space and object permanence are interdependent. The permanent object is an invariant that results from the reversible composition of a group of displacements; the group of displacements, in turn, could not exist without such an invariant. Both presuppose the coordination and differentiation between changes of state and successive displacements of an object. This is evident during sensorimotor state III. At this stage, infants do not understand that the different states or appearances of an object all belong to the same object. For example, when Piaget's son, Laurent, was presented with his bottle such that the nipple of the bottle was invisible, he did not recognize it (Piaget, 1937/1954, Obs. 78; see Uzgiris & Hunt, 1975). In order to assign the different appearances to one object, infants must coordinate the rotation of an object in one direction with the reversal of the rotation of that object. By coordinating a rotation and its inverse, the object's original state is rediscovered, and infants learn to differentiate between an object and the state into which the object is changed. As a result, infants realize that an object is independent of its states or appearances. The object is not itself one of those appearances, but the invariant according to which its appearances are related. Object identity is constructed through first-order operations: the different appearances constitute variables that are mapped onto one object (see Langer, 1980, p. 373, on identity of discontinuous objects).

Object permanence is still limited and tied to infants' actions, since the reversibility established at this level remains quite simple (Piaget, 1937/1954, p. 154). These limitations manifest themselves in tasks requiring the temporal coordination of spatial displacements such as the A-not-B task. Here an object is shifted from a location A, at which the infant previously found the object, to a location B (Piaget, 1937/1955, Obs. 171). Infants will search for the object at location A, where they previously found the object, even though they witness the object disappear at location B. Corresponding to infants' failure to understand successive displacements of objects are their failures to retrieve an object placed on another object and to use a support as an intermediary to move an object toward themselves that is placed on that support (Piaget, 1937/1954, Obs. 101, Obs. 103). These failures indicate that infants do not understand that an object may be moved from location to location, and that one location may hold more than one object. Rather, infants map an object onto a fixed location, or one location onto one object,

without relating object–location mappings to each other. In the second year of life, infants relate the locations of objects to each other by aligning them side by side and by stacking one object on top of another object (Forman, 1982). By stacking objects onto each other, infants realize that one position can hold more than one object. Whereas stacking leads to the construction of only one location, aligning blocks side by side results in the formation of two locations. For example, infants construct horizontal alignments by placing on the right of the center block (A) a block (B') that is symmetrical to a formerly placed block (B) to the left. In placing block B', infants transpose the spatial relation between A and B, and the location where block B' is placed becomes a potentially "fill-able" location. In this manner, infants coordinate relations between object–location mappings, i.e., second-order operations. As a result, space becomes objectified and objects become spatialized; that is, infants grasp that each object can have several possible locations. Because success in invisible displacement tasks can be due to empirical learning, successful solution of these tasks alone is not a good indicator of infants' capacities to coordinate object–location relations with each other (Berthenthal & Fischer, 1983; Corrigan, 1981; Natale & Antinucci, 1989; Piaget, 1937/1954). Rather, the logic used by infants in their search behavior appears to be a better indicator of this capacity (Natale & Antinucci, 1989; Sophian, 1986, Sophian & Sage, 1983).

The sudden invention of new means (Piaget, 1936/1963, Obs. 180–181) can also be explained in terms of developing operative structures, and thus does not require an appeal to the emergence of mental representation. It is likely that the sudden invention of new means involves the capacity to process a scheme into two different directions simultaneously: from the goal to the means and from the means to the goal. For example, when Jacqueline, holding a blade of grass in each hand, wants to leave the room and close the door behind her, she first puts the grass on the floor between the door and the threshold. However, upon realizing that pulling the door toward her will simultaneously chase away the grass, she picks up the grass and places it outside the door's zone of movement (Piaget, 1936/1963, Obs. 180). This action requires successively coordinating two directions: in order to close the door (goal) she must put down the grass (means), and from this goal, she must "reason" backward to the means. Such double-directedness, characteristic of the sudden invention of new means, is prepared by tertiary circular reactions (Piaget, 1936/1963, pp. 289, 295–297). Piaget himself writes that sudden invention of new means is "founded upon representation or the awareness of relationships" (Piaget, 1936/1963, p. 339). Representation and awareness of relationships, however, are not the same thing.⁹

⁹ Piaget attributes the inability to understand the objectivity of one's own spatial position to the absence of representations (Piaget, 1937/1954). However, the observations cited by Piaget (Piaget, 1937/1954, Obs. 118–119) as examples of failures to understand the objectivity of one's own spatial position, indicate, from our perspective, a failure to flexibly shift from

Finally, self-recognition in the mirror as measured by the Rouge Test (Brooks-Gunn & Lewis, 1984) also seems to require cognitive capacities that can be described in terms of second-order operations. Self-recognition in a mirror develops after infants have acquired an integrated body scheme. Following Baldwin (1906/1968), Piaget believes that social imitation contributes to infants' construction of body schemes, and, in particular, of schemes of body parts that are not directly visible (Piaget, 1945/1962, 1960, 1970/1972; see on the importance of social imitation for self-recognition, Hart & Fegley, 1994). Body schemes of invisible body parts are constructed through mapping visual features on corresponding proprioceptive feedback provided by facial muscles.¹⁰ In the mirror-self-recognition test, particularly, the red spot placed on an infant's nose violates the correspondence relation she has constructed between the mirror image and her integrated body scheme. In order to reestablish the mirror-reality correspondence relation, the infant must operate on the established correspondence relation between body scheme and mirror image, and infer that the mismatching visual features in the mirror image belong to her own body (Gergely, 1994; Mitchell, 1994). This requires more than a one-way mapping of mirror-space to real space, as, for example, in the use of the mirror as a tool to locate objects behind one's back (Chapman, 1987; Fischer & Berthenthal, 1978). Rather, in order to recognize the mismatch in the mirror, children must understand a two-way mapping: the mapping direction from face to mirror must be coordinated with the mapping direction from mirror back to the face.

Interestingly, only great apes seem to be capable of mirror self-recognition (Mitchell, 1994; Parker & Mitchell, 1994), as well as logical search in invisible displacements tasks (Natale & Antinucci, 1989). Because, at this time, chimpanzees alone have been shown to develop rudimentary second-order operations (Langer, 1994; Poti & Antinucci, 1989; Spinozzi, 1993; Spinozzi & Natale, 1989), it is reasonable to assume that the above-mentioned capacities are linked to second-order operations. The fact that second-order operations and self-recognition show a similar ontogenetic pat-

one relation to another relation. For example, when Lucienne after pulling a hoop over her head, tries to do the same thing with a lid, her erroneous attempt is not due to difficulties in representations (Piaget, 1937/1954, p. 200). Rather, like other children of the same age do in constructing correspondences, Lucienne is only capable of focusing on one dimension at a time (here the mobile object and not the "recipient object," i.e., her head).

¹⁰ Meltzoff (1990) argues that the coordination between vision and proprioception is already present at birth because newborn infants are capable of facial imitation. The interpretation of newborn imitation has been a disputed topic for over a century (Anisfeld; 1991; Ewert, 1983). The two findings that facial imitation in newborns is limited to tongue protrusion (Anisfeld, 1996) and that facial imitation disappears a few months after birth only to reappear later when infants are about 1 year old (Abravanel & DeYong, 1991; Guernsey, 1928; Maratos, 1982) raise the question of whether these occurrences are indeed based on the same processes (see Anisfeld, 1991, 1996, Prinz, 1990, and Vinter, 1990, for alternative explanations of newborn imitation).

tern (Povinelli, Rulf, Landau & Bierschwale, 1993) further supports this assumption.

With the emergence of second-order operations, then, cognition becomes "bi-leveled." For Langer particularly, who defines representational cognition as a second-order mapping, the onset of second-order operations marks the beginning of representational thought: "In this view, symbolization is not the hallmark of representation. Nor is language essential to the origins of representational cognition. Mapping first-order cognitions onto each other produces representational cognition" (Langer, 1986, p. 15). Following the definition adopted in this article, however, bi-leveled cognition is not tantamount to grasping the relation between signifier and signified as a representational one. Without mental representation, cognition remain tied to the here-and-now and continue to depend on concrete material objects for objectification. The confines of the immediate surroundings can only be transcended with the added construction of differentiated signifiers through second-order operations.

Representational development. With the development of sensorimotor coordination, the child's actions become increasingly detached from objects. The elements of second-order operations, for example, are no longer individual objects, but are relations between sets (Langer, 1986). Vygotsky (1933/1978) recognized this increasing detachment between actions and objects and described it as a change in object/meaning and action/meaning ratios. In other words, early in development, meanings are subordinated to objects and actions. With development, these ratios are reversed and meaning becomes increasingly detached from immediate objects and actions. The development of deferred imitation, pretend play, and language can be taken as an indicator of this change in the object/meaning and action/meaning ratios. We suggest that differentiated signifiers originate in pretend play and language, and that pretend play and language develop as a function of operative development.

Deferred imitation indicates the increasing detachment of sensorimotor schemes from immediate stimuli (Werner & Kaplan, 1963). It specifically arises in situations where infants experience the absence of certain sensations that were connected with a particular previous situation (Bonnet, 1983). Thus, in the case of Jacqueline imitating an observed temper tantrum, the presence of the playpen is the likely trigger for her action, without Jacqueline being cognizant of her imitating an earlier model. Thus, it is not necessary to invoke mental imagery to explain Jacqueline's deferred imitation. Moreover, invoking mental imagery in this situation would result in the problem of having to explain why Jacqueline is not satisfied with simply imaging the previously observed action, but also must act it out.

When the sensorimotor schemes have become consolidated and have acquired a variety of meanings, they easily become elicited outside their normal context. These deferred imitations then become part of *routines* (or pragmatic

propositions, see Langer, 1983, 1986; see also Piaget 1945/1962, pp. 93–97), which are well-differentiated and integrated action sequences, executed in short time spans. When detached from their usual goals, routines become the elements of pretend play. In pretend play, objects and actions are subordinated to the meanings infants intend to express. In this manner, play provides the opportunity to further detach meanings from immediate actions and to transcend the immediate here-and-now. It is likely that the development of operative knowledge contributes to the evolution of pretend play (Langer, 1986). Initially, the meaning expressed in pretend play is closely tied to the actions that express these meanings. The actions serve as signifiers, and consequently, “the symbol is not yet freed as an instrument of thought” (Piaget, 1945/1962, p. 120). Only gradually does the meaning become detached from external action (McCune, 1987, 1995). A first step into this direction is taken when infants start to map recursively the same pretend action scheme onto new objects (McCune, 1987; Piaget, 1945/1962, p. 121). For example, when Jacqueline pretends to drink and eat, and then turns to apply the same pretend scheme to other members of the family (Piaget, 1945/1962, Obs. 65), she recursively uses different objects as the recipients in her pretend activities. Theoretically, the recursive mapping of the same scheme to different objects involves first-order operations. A new level of pretend play is reached when children start integrating several pretend actions into a sequence. For example, children may pretend to drink from a cup, then pretend to pour liquid into the cup, and finally offer this “drink” to their doll (McCune, 1995). They not only shift the role of the recipient of the action here, but also flexibly shift the role of the cup from a prop for pretend drinking to a receptacle for pouring and back to a prop for pretend drinking. These complex pretense activities hint at the emergence of second-order operations, because children successively coordinate two different relationships with each other. The next level in the development of pretend activities is reached when children start to plan their pretend in advance. Advanced planning of pretend activities is indicated by children’s search behavior prior to pretend play (a child picks up a doll, searches for a bottle, feeds the doll; McCune, 1987, 1995). Their planning behavior demonstrates that children coordinate the phase of collecting particular objects with the phase of executing their play activities, which implies that they are able to coordinate different relationships simultaneously.

During the second year of life, pretend play activities free themselves from the immediate context and increase in complexity, arbitrariness, and degree of conventionalization (Langer, 1983, 1986; McCune, 1987; McCune-Nicolich, 1981; Musatti & Mayer, 1987; Sinclair et al., 1989). Certainly, these developments contribute to language acquisition (Langer, 1986). However, because in pretend play the meaning of a signifier is subordinated to children’s intentions, these signifiers have a “disconcerting mobility” (Piaget, 1945/1962, p. 220). We suggest that it is the stable convention gov-

erning the use of words (“the fixity of the sign,” Piaget, 1945/1962, p. 220) which allows children to set up semantic contrasts and to grasp that signifiers can be used as denotative symbols or referential terms.

Language is a representational system, and its mastery requires more than isolated signifier–signified mappings. Language is constituted by signifier–signified couplings that receive their meaning only through relationships to other signifier–signified couplings (Barthes, 1970; de Saussure, 1916/1983). In other words, differentiated signifiers are semantically contrastive, deriving their values in opposition to other signifiers in the system (Clark, 1987; Dore, 1985; Nelson & Lucariello, 1985; Piaget, 1945/1962). Children’s production of first words at about 12 months does not yet require that they understand the relationship between signifier and signified as a representational one. Instead, first words are isolated word–object mappings and simply give evidence that infants, by using first-order operations, can recursively map one word onto different objects (Antinucci, 1989b; Bloom, Broughton, & Lifter, 1985; Lifter & Bloom, 1989; Sugarman, 1983). First words are still an integral part of the infants’ whole actions and are used as requests and give expression to affect (Dore, 1985; Nelson & Lucariello, 1985; Piaget, 1945/1962; Stern, 1914/1930). To form a part of a small system of words, these first words must be detached from their context of utterance and the action (and gesture) they accompany, and related to other words (Goodwin, 1985; Piaget, 1945/1962; Sinclair, 1989). The organization of a lexical system is clearest in the child’s discovery that “every thing has a name” (Stern, 1914/1930). Several developments are symptomatic of this fundamental discovery, including the vocabulary spurt, infants’ questions concerning the names of things, and the use of words to refer to objects not currently given (Corrigan, 1979; Piaget, 1945/1962; Stern, 1914/1930).

In order to rapidly map words onto objects, children must realize that an object (x) is called a or not a , and if it is called not a , they must flexibly shift to another potential name b . This understanding involves a flexible shifting from word to referent and vice versa, as well as from one word–referent relation to another. Theoretically, the vocabulary spurt presupposes the emergence of second-order operations (Sugarman, 1983). There is empirical evidence to support this claim: second-order classifying and the vocabulary spurt occur at approximately the same age (Gopnik & Meltzoff, 1987; Gopnik & Meltzoff, 1992). Second-order operations alone, however, are not sufficient to grasp the representational relation between signifier and signified. It is necessary that infants realize that a sound or a combination of sounds is intended as a sign; this, in turn, requires that they be capable of differentiating between psychological causality (i.e., intentionality) and physical causality (Piaget, 1937/1954, pp. 287–288; see Desrochers, Ricard, Décarie, & Allard, 1994; Ricard, Décarie, Desrochers, & Rome-Flanders, 1994). In addition, social interaction between infant and caregiver plays a crucial role in the acquisition of language (Bruner, 1983; Hörmann, 1981, 1986; Werner &

Kaplan, 1963). For instance, in the course of their interactions, infant and caregiver develop a shared system of meanings. As a result, infants, on a prelinguistic, or even nonlinguistic level, understand what the caregiver means. This knowledge can then be used to establish corresponding relations between the intentional structure of the situation in which language occurs and the structure of the language utterance (Hörmann, 1981, 1986).

With the understanding of the representational relation between signifier and signified, language development is just beginning. Language develops over the course of single-word mappings. At the time of the vocabulary spurt, single-word productions constitute "paradigmatic choices that designate options among contrastive items" (Dore, 1985, p. 34). Children begin to construct linear relations between words when they successively, but with an apparent pause between, utter two related words (Goodwin, 1985; Sinclair, 1989). The simultaneous coordination of two relations is necessary for the production of two-word sentences that are syntagmatically related, i.e., words belonging to different classes are related to each other (Nelson & Lucariello, 1985; Sugarman, 1983). Two-word sentences express a further distancing from actions because the temporal sequence of words does not mirror the temporal sequence of actions: the relations between meanings are hierarchical and not temporal (Sinclair, 1989). As becomes clear, with the onset of representation, children act on language; i.e., language serves as the material for the objectification of meaning and now mediates the direct relationship between subject-object that prevailed on the sensorimotor plane (Judge, 1985; Sinclair, 1989).

The reconstruction of the world through language requires a similar process of detaching actions from their objects, just as it occurred in the acquisition of language. However, now the objects are no longer concrete material things, but symbols denoting and referring to these things. Once the representational relation is grasped, the operations that have already been acquired on the sensorimotor level must be constructed on the representational plane. At the beginning, signifiers are spatio-temporally differentiated from their referent and serve as vehicles of reference by which meaning can be expressed. Signifiers, however, are not differentiated from their signified, but projected into the object signified: children consider words to be part of the object signified (Piaget, 1945/1962, p. 228; Vygotsky, 1934/1962, p. 129). In addition, children can think about (or think of) different situations, but they cannot think that something is the case; i.e., they cannot assign truth values to their propositions (see Perner, 1991, pp. 76–77). Although children can describe what they see or have seen, predication still consists of affirming or denying properties from objects. As a result, truth or falsity depend on whether an object satisfies a predicate. According to Perner (1991, 1992), children on this level are situation theorists: they lack the understanding of the mind as a distinctly representational system. Perner (1991) claims that

it is the lack of such an understanding that is responsible for children's failures to understand that they themselves or others may hold a false belief, which is a prerequisite for intentional deception (Ruffman, Olson, Ash, & Keenan, 1993).¹¹ Furthermore, following Perner (1991, 1992), children's inability to judge that informational accesses is a prerequisite of knowledge and their failure to distinguish between appearance and reality have the same source. For Perner (1991), understanding that the mind is a distinctly representational system requires the emergence of *metarepresentations*.

It should be apparent, however, that from within a constructivist theory the concept of metarepresentations inappropriately characterizes cognitive activity. Subjects can operate on their representations, but not represent them. Consequently, we suggest that success in standard false belief tasks, understanding of intentional deception, and distinguishing between appearance and reality all indicate the emergence of what we call *first-order operations on the representational plane*. The specific operation involved in these accomplishments is negation: a person holds a belief that is false, a person is made to believe something that is false, and an object appears to be something that it is not. In order to succeed in these tasks, children must refrain from denying or affirming a particular property directly from the object, which in this case would result in a contradiction (e.g., the same chocolate cannot be at the same time in the green and blue cupboard, an object cannot be both a sponge and a rock). Rather, they must establish a conceptual relationship between, for example, the past and the present situation to succeed at these tasks, and it is by applying the negation to the proposition, rather than to the object, that they establish such a relationship. In the same manner, correct judgment about the truth or falsity of a true negative sentence ("this is not an apple" when shown a picture of a banana, see Kim, 1985) demands transforming of the concept of *banana* while establishing a conceptual relationship to *apple*. Based on these accounts, then, understanding the mind as a representational system requires the development of operations on the representational plane. In effect, through the development of first-order operations on the representational plane, children establish more complex relations between the representational and perceptual plane. Such first-order operations, in fact, are very similar to Piaget's concept of *functions*, introduced to describe preoperational knowledge structures (Piaget, 1968, 1970/1972; Piaget, Grize, Szeminska, & Vinh Bang, 1968/1977; see Davidson, 1992). Functions constitute a semilogic that allows the construction of covariations between two variables (Chapman & Lindenberger, 1988) but are limited in

¹¹ It should be noted that the understanding of intentionality and the ability to intentionally deceive another person is already present much earlier, at least in part, during the sensorimotor stage (Piaget, 1937/1954, Obs. 152–153a, Obs. 160). However, these earlier capacities remain more closely tied to the context (see also Piaget, 1937/1954, p. 63).

that they operate in one direction only. Consequently, functions lack reversibility (Piaget, Grize, Szeminska, & Vinh Bang, 1968/1977). In a similar manner, 4-year-olds' understanding of the mind as a representational system is limited in that it does not allow the reciprocal coordination of various points of view (Kesselring, 1993).

CONCLUSION

In the first parts of this article, we explored the fertility of empiricist and constructivist approaches to representation. We concluded that the empiricist approach is fraught with problems, and that the constructivist approach is better ground for building a theory of representation. As a prime exemplar of a constructivist approach, Piaget's theoretical framework and his account of the emergence of representation were presented and evaluated. Within Piaget's framework, representations are constituted by the relation between signifiers and signifieds. The use and understanding of the relation between signifier and signified as a representational one presuppose intellectual development on the part of the subject. Piaget suggests that the coordination of sensorimotor schemes precedes, and is a prerequisite for, representational thought by progressively distancing the subject's actions from the object. As a result, the structuring activity of assimilation is interiorized and signifiers and signifieds are differentiated (deferred imitation).

In the third section, we argued that Piaget's account proves to be insufficient in explaining the emergence of representation. Piaget conceives of interiorization as the speeding up of assimilatory activity; mental representations, however, cannot be derived from just speeding up assimilatory activity. Instead, the interpretation of the relation between signifier and signified as a representational one must involve higher-order operations. Consequently, while keeping Piaget's overall framework and his concept of representation, modifications of his account were proposed. We suggested that representational thought results from the construction of differentiated signifiers through second-order operations during the second year of life. According to this proposal, second-order operations should be a necessary, but not a sufficient, condition for representational acts. Furthermore, we made some suggestions about how operational development underlies the representational development in the areas of pretend play and language. Importantly, the proposal emphasized that subjects need some sort of material in order to objectify their knowledge structures. Elaborating on this point, we presented evidence that, during the prerepresentational period, infants' physical constructions serve as material for the objectification of knowledge structures. These, in turn, influence the development of the operative aspect of intelligence: by operating and reflecting on their own constructions, infants bootstrap their knowledge structures. Thus, pseudoempirical abstraction becomes the process by means of which infants construct higher-order operations. Pseudoempirical abstraction, in turn, depends on the coordination and differ-

entiation of sensorimotor actions, which lead to the detachment of meanings from the immediate stimulation.¹²

With the emergence of the semiotic function, symbols and signs constitute the means for the objectification of knowledge structures and allow the expression of these structures outside of any immediate material transaction with objects. In this manner, the process of detaching subject and object continues. Language, for instance, functions as a more flexible instrument of objectification (Baldwin, 1906/1975). In particular, this supports accounts that suggest that when children encounter difficulties in solving a problem, action-accompanying speech can support the conceptualization—the reflective objectification—of their own action (Carpendale, *in press*; Schmid-Schönbein, 1991; Vygotsky, 1934/1962). It becomes clear also that the interactive process of objectification produces constraints on further development (Antinucci, 1989a; Boom, 1992; Langer, 1989). Monkeys, for example, do not construct two sets simultaneously. This cognitive limitation constrains the range of possibilities for relating these sets to each other by second-order operations (Spinozzi & Natale, 1989). Even further logical–mathematical development is constrained by the way knowledge is objectified and externally represented (see Damerow, Englund, & Nissen, 1988, on the influence of external number representations on the development of number invariance in Mesopotamia).

Taking stock, then, of this proposal means that, contrary to what Piaget has suggested and what is generally accepted in developmental research, behaviors such as the sudden invention of new means, retrieval of invisibly displaced objects, and deferred imitation do not necessitate the emergence of a functional representational system. Retrieval of invisibly displaced objects and sudden invention of new means point, instead, to second-order operations, not mental representation. Deferred imitation indicates a shift in the meaning/object ratio and the progressive distancing between subject and object, but, again, not to the emergence of mental representation. Rather than focusing on the absence or presence of representational knowledge, we suggest that it is more useful to study the developmental sequences within

¹² Placed within the larger context of morphological, physiological, affective, social, and behavioral development, the development of mental representation ultimately results from the uniqueness of human ontogeny (Antinucci, 1989a; Gehlen, 1940/1988; Langer, *in press*; Portmann, 1944/1990). As Gehlen (1940/1988) states, “it would be impossible to identify ‘causes’ here because there are no causal relationships between these features; intelligence did not bring about language, an erect posture did not ‘cause’ intelligence, and so on. Precisely these characteristics in precisely this system of interrelationships permit man to exist” (p. 11).

Instead of seeking to explain human development in terms of ultimate causes, Gehlen suggests a more holistic approach of aiming to comprehend the complex relationships between various identifiable conditions: “without A there is no B; without B, no C; without C, no D; and so on. If this sequence ultimately circles back upon itself—without N, no A—then we will have arrived at a total understanding of the system in question without having to resort to the metaphysics of a single cause” (Gehlen, 1940/1988, p. 11).

and across different functions in which the representational capacity manifests itself (e.g., play, language, gestural imitation, drawing, evocative memory). These functions should be studied in line with operative development in order to gain a better understanding of the interdependencies between both. Such studies, we suggest, would prove important. The interaction between different rates and times of onset of different capacities results in different courses of cognitive development (Antinucci, 1989a; Poti & Spinozzi, 1994). A closer study of the temporal relationship between the development of operative knowledge and, for example, language development could provide useful information about normative and anomalous courses of development. Indeed, different developmental courses can result in developmental disparities within and between different cognitive domains, which is likely to have major implications for further development. In fact, research shows that, in human infants at least, structural development within logical-mathematical and physical domains is well aligned. Langer (1989), for example, claims that sufficiently in-phase structures facilitate cross-domain influences, whereas poorly aligned structures limit further development. Based on this, one would expect that in-phase development within physical, mathematical, and protosymbolic domains, as well as across these domains, is a necessary condition for successful cross-domain fertilization and, thus, the development of mental representations. Regardless of the specific directions pursued, however, shifting away from a cognitive framework based on representational activity to one elaborating on the development of first- and second-order operative knowledge holds promising research potential for developmental psychology.

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