

In Defense of Piaget's Theory: A Reply to 10 Common Criticisms

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The developmental theory of Jean Piaget has been criticized on the grounds that it is conceptually limited, empirically false, or philosophically and epistemologically untenable. This study attempts to rebut these criticisms by showing that most of them (a) derive from widespread misinterpretations of the work of Piaget; (b) fail to appreciate the 2 central issues of his thinking—how new forms of thinking emerge during ontogenesis and how they become psychologically necessary; (c) incorrectly assume that many controversies concerning his theory can be settled empirically or methodologically before they are clarified conceptually; (d) ignore various modifications of Piagetian theory, particularly those advanced after 1970; and (e) forget the dialectical, constructivist, and developmental nature of Piaget's unique approach to human development. Although the authors do not claim there is a "true" Piaget to be discovered, or that the problems with his theory vanish when it is better understood, they do claim that important aspects of Piaget's work have not been assimilated by developmental psychologists.

Great is the power of steady misrepresentation; but the history of science shows that fortunately this power does not long endure. (Darwin, 1872/1962, p. 421).

To understand is to invent, or to reconstruct by reinventing. (Piaget, 1972b, p. 24).

To date, no theory has had greater impact on developmental psychology than that of Jean Piaget (cf. Beilin & Pufall, 1992; Gruber & Vonèche, 1977; Halford, 1989; Modgil & Modgil, 1982). As an anonymous reviewer of a recent manuscript on Piaget observed, "assessing the impact of Piaget on developmental psychology is like assessing the impact of Shakespeare on English literature, or Aristotle in Philosophy—impossible" (Beilin, 1992a, p. 191). Understandably, then, Piaget's theory has been the preferred target of many critics. Considered collectively, their criticisms are that Piagetian theory is empirically wrong, epistemologically weak, and philosophically naive (see Brainerd, 1978a; Siegel & Brainerd, 1978a; Modgil & Modgil, 1982; Siegal, 1991). The specific reasons advanced by these critics are numerous: The stage theory of Piaget is conceptually flawed (e.g., Brown & Desforges, 1977); Piaget is an author of tasks, not of theories (e.g., Wallace, Klahr, & Bluff, 1987); Piaget portrays the cognitive development of children poorly, as a "monolithic, universal, and endogenous" process (Case, 1992a, p. 10); Piaget is concerned only with description, not explanation (e.g., Brainerd, 1978b); the explanations provided by Piaget's theory are false (Fischer, 1978).

Piaget himself believed that to assess the progress of knowledge, either from a psychological or an epistemological viewpoint, one always needs to consider a previous state of lesser knowledge and a future state of greater knowledge (Piaget, 1950/1973b). Therefore, when commenting on his scientific contributions, Piaget (e.g., 1976c) remarked that he had laid down only a rough sketch of human cognitive development and that subsequent research would certainly identify the parts missing from the sketch, the parts that need to be modified, and the parts that need to be discarded.

For some psychologists, however, the time has come to see Piaget mainly as a figure of the past, important in our collective history but irrelevant in our present (e.g., Cohen, 1983; Johnson-Laird, 1983). Halford (1989), for example, has said that "there is little to be gained from 'testing' a theory already known to be inadequate [and that] it would be far better to devote efforts to testing the alternative theories" (p. 351). Broughton (1984) went a step further: When discussing the hypothesis of a postformal stage, he concluded that "the issue is not one of the stage 'beyond formal operations'; it is one of the stage 'beyond Piaget'" (p. 411).

The present study has three main goals. First, to describe 10 major criticisms formulated against Piaget's theory, their conceptual *raison d'être*, and their empirical content. For reasons that will become obvious shortly, we refer to the approach of the critics as an approach *from without* Piaget's theory.

Our second goal is to show, in the same vein as other developmentalists (e.g., Beilin, 1992a; Chapman, 1988a; Smith, 1993), that criticisms that sound convincing when formulated from without lose much of their strength when read from within Piagetian theory (i.e., while we take into account Piaget's own goals, methods, and conceptualizations). These "reversals of judgment" happen for several reasons. Some criticisms derive from widespread misinterpretations of Piagetian theory, an unfortunate situation that we will document and attempt to correct. Others ignore the fact that many developmental issues are primarily conceptual, not empirical. A case in point, largely

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ignored by the critics though, is the distinction between the modality and the truth-value of knowledge (Piaget, 1918, 1924, 1983a, 1986; Piaget & Garcia, 1987; see also Ricco, 1993; Smith, 1993). A few criticisms also reveal the profound differences that separate Piaget's approach to science from contemporary mainstream psychology. For example, the enormous popularity enjoyed nowadays by statistical methods, the primary means of testing hypotheses and constructing theories, would certainly elicit from Piaget the same remarks he advanced 75 years ago:

Psychologists over-generalized their methods and arrived at delightful trivialities, particularly when an army of scientists translated their results into mathematical terms. Through a complicated apparatus of curves and calculations, these psychologists demonstrated the most simple and natural results . . . but only those. (Piaget, 1918, p. 63)

Sixty years later, the neo-Popperian Paul Meehl voiced the same concerns. Asserting, as Einstein had done before, that nature is subtle but not malicious, Meehl (1978) denounced "the illusion of quantitative rigor" (p. 824) that had invaded many areas of psychology. The disparity between the absence of theoretical rigor or conceptual clarity, on one side, and the overabundance of tabular asterisks, like the (in)famous $p < .05$, on the other side, explains, according to Meehl, the slow progress of soft psychology. As we shall see, some of Piaget's critics rely excessively on tabular asterisks at the expense of theoretical risks, particularly when the problems at stake are conceptual.

Our third and more general goal is to illustrate how the interplay between readings from within and readings from without contributes to a deeper understanding of Piaget's theory, its multiple positions, and its rich potential. Although we do not claim there is a "true" Piaget to be discovered, or that Piaget's theory is right and its critics are wrong, we agree with Chapman's (1992) remark that many "aspects of Piaget's work are still insufficiently assimilated or accommodated to in developmental psychology" (p. 39). Thus, if we want to go beyond Piaget and advance improved theories, then we have to know him better from within.

1. Piaget's Theory Underestimates the Competence of Children

One of the most frequent criticisms raised against Piaget's theory is that it yields extremely conservative assessments of the competence of children, particularly of preoperational children. Since 1970 hundreds of psychological studies have tried to show that the "standard" Piagetian tasks often lead to false-negative errors (see, for reviews, Donaldson, 1987; Gelman & Baillargeon, 1983; Halford, 1989; Siegal, 1991). That is, researchers do not ascribe to children competencies that children do have, competencies that are easily revealed when performance factors are controlled properly. These performance factors include language (e.g., Siegel, McCabe, Brand, & Matthews, 1978), contextual variables (e.g., Rose & Blank, 1974), memory requirements (e.g., Bryant & Trabasso, 1971), materials (e.g., Levin, Israeli, & Darom, 1978), the nature of the task (e.g., Baillargeon, 1987), number of objects present (e.g., Gelman, 1972), the type of questions asked and responses re-

quired (e.g., Winer, Hemphill, & Craig, 1988), and a host of other factors (e.g., Au, Sidle, & Rollins, 1993; Gelman & Kremer, 1991; Markman, 1983; Stiles-Davis, 1988).

Psychologists have therefore simplified questions, instructions, scoring criteria, and other procedural details, and in the process have developed new versions of (nominally) the same Piagetian tasks (e.g., Brainerd, 1978a; Bullinger & Chatillon, 1983; Donaldson, 1987; Gelman & Baillargeon, 1983; Halford, 1989; Siegal, 1991). On the positive side, these new tasks have brought to light a remarkably rich, complex, and hitherto unsuspected set of cognitive competencies in the young child. On the negative side, they have provided no evidence that these competencies are equivalent to the logicomathematical and operational competencies in which Piaget (1983b) was interested (see also Chapman, 1988a).

Consider the construction of the object concept (Baillargeon, 1987, 1991; Baillargeon & Graber, 1988; Bower, 1971; K. Miller & Baillargeon, 1990). Researchers who have used the reaction of surprise as a criterion of the permanent object, instead of the active search for the hidden object, as Piaget (1937) initially did, concluded that such construction exists already in infants as young as 3 to 4 months of age, a result that calls "into serious question Piaget's claims about the age at which object permanence emerges and the processes responsible for its emergence" (Baillargeon, 1987, p. 655). However valuable Baillargeon's experiments may be, her conclusion is clearly premature. First, the key concept in Piaget's theory is not age of acquisition but sequence of transformation (Montangero, 1991; Smith, 1991), a distinction elaborated in the next criticism. Second, the competence involved in Baillargeon's (1987, 1991) experiments is probably not the same as that involved in Piaget's (1936, 1937) original studies because experiments that rely on habituation-dishabituation mechanisms indicate that something in a perceptual array has changed but provide no conclusive evidence that a conceptual competence (i.e., object permanence) is responsible for the infant's reaction of surprise. To infer unambiguously a conceptual competence, the experimenter needs to rule out alternative, perceptual-based explanations (see Mandler, 1992). Third, for Piaget (e.g., Piaget & Garcia, 1987), knowledge always involves implication and logical inference, and therefore its presence cannot be inferred only statistically through tabular asterisks and at the expense of theoretical risks (i.e., at the expense of mistaking a perceptual competence for a conceptual one; see Furth, 1992; Langer, 1980). Parenthetically, given that Baillargeon's earliest findings come from infants with a mean age of 17 weeks, it may come as a surprise to many critics that in his studies on the construction of reality, Piaget (1937, e.g., Observation 2) reported that his son Laurent at the early age of 2 months and 27 days already expected a disappearing object (e.g., his mother) to be where it vanished. However, according to Piaget this kind of fuzzy affective permanence should not be confused with a clear manifestation of object permanence.¹

¹ In their haste to show how wrong Piaget was in his estimates as to when certain abilities develop, some infancy researchers have begun to offer absurd arguments about how "brilliant" the young infant is. A case in point might be Kaye and Bower's (1994) recent claim that newborns may well possess their own languagelike system of representation.

But what is most often said by Piaget's critics is that he underestimated the young child's operational competence. As for concrete operations, researchers have concluded that, in contrast with Piaget's data, the 5- to 6-year-old (or even younger) child is already capable of transitive reasoning (Brainerd & Kingma, 1984; Bryant & Trabasso, 1971); numeric reasoning (Gelman & Gallistel, 1978; Sophian, 1988); causal reasoning (Bullock & Gelman, 1979; Leslie & Keeble, 1987); conservation (Acredolo & Acredolo, 1979; McGarrigle & Donaldson, 1974); class inclusion (Markman, 1973; McGarrigle, Grieve, & Hughes, 1978); representation of distance (Bartsch & Wellman, 1988; Fabricius & Wellman, 1993), space, and time (Levin et al., 1978; Stiles-Davis, 1988); and many other instances of concrete operational thought.² The eagerness to show how much Piaget underestimated the competence of the preoperational child has been so strong that some researchers have even questioned the very existence of preoperational thinking: "Is preoperational thought really preoperational?" (Gelman & Baillargeon, 1983, p. 172).

With respect to formal operations, researchers say that the participants in Piaget's studies were more competent than those studied subsequently (Kuhn, 1979; Neimark, 1979) because Piagetian formal tasks (e.g., Inhelder & Piaget, 1955) have proved to be difficult even for late adolescents and adults (cf. Keating, 1980; Moshman, 1979). Other researchers have claimed, contradicting Piaget, that 5- to 6-year-old children are already capable of conditional and syllogistic reasoning, and hence capable of deductive or formal thinking (English, 1993; Ennis, 1982; Girotto, Gilly, Blaye, & Light, 1989; Hawkins, Pea, Glick, & Scribner, 1984). We will return to this issue later.

Despite the technical ingenuity of the studies just mentioned, many of them have grossly misunderstood Piagetian theory. The misunderstandings are readily identified when we analyze the procedures used in these studies and the logical rigor of the inferences drawn by their authors concerning the competencies of the child. In what follows we substantiate the preceding remarks with examples drawn mainly from research on the preoperational and operational stages, although similar analyses can be made with many of the remaining investigations (see Chapman, 1988a).

Consider a typical transitivity task. Children are allowed to see that Stick A is smaller than Stick B and, on a separate occasion, that Stick B is smaller than Stick C. At issue is what children conclude concerning the relative sizes of Sticks A and C. In the original Piagetian version (Piaget, 1964, p. 63), the three sticks are never shown simultaneously—in the first two phases the child sees and compares only two sticks at a time, A with B, and B with C; the third stick remains always out of sight. This apparently minor procedural detail is critical because it ensures that a correct answer in the final test is a truly operational solution. When inferring that A is smaller than C, although A remains hidden, the child shows unambiguously that she or he composed the premises $A < B$ and $B < C$ and did not rely on any figurative or perceptual cue.

Several studies modified the standard procedure, however (e.g., Brainerd, 1974; Brainerd & Fraser, 1975; Brainerd & Kingma, 1984; Brainerd & Reyna, 1990, 1992, 1993; Bryant & Trabasso, 1971; Hooper, Toniolo, & Sipple, 1978). For example, in some studies, at the beginning of the task all sticks were

arranged on the top of the table in order of increasing size, although separated from one another so that the child could not perceive directly their differences in length. Then the experimenter placed side-by-side Sticks A and B and, next, Sticks B and C, so that the child could see that $A < B$ and $B < C$. The sticks were then returned to their original place before the experimenter asked the child to compare A with C. Given that in these studies the stick on the right was always longer than the stick on the left, the final "inference" of $A < C$ was not necessarily operational. To answer correctly, the child needed to know only in which direction (right or left) the sticks increased in size, and this piece of spatial information was clearly provided by the two initial comparisons. Thus, in rigor we cannot rule out explanations of the child's "correct" performance based on preoperational, figurative competencies (see also Chapman, 1988a).

In his review of the literature on the development of transitive inference, Bigelow (1981) cogently argued that the often-cited data collected by Trabasso and his colleagues (Bryant & Trabasso, 1971; Trabasso, 1977) do not show convincingly that 4-year-olds are able to solve Piaget's seriation tasks because the association of objects on the basis of spatial proximity or temporal contiguity present in Trabasso's procedures (e.g., controls for memory and understanding of the premises) may have allowed children to solve the "transitive" problem noninferentially, nonlogically, and therefore preoperationally (for similar arguments, see Chapman & Lindenberg, 1992a, 1992b, and Markovits, Dumas, & Malfait, 1995).

The general issue here is that although many critics claim that their new tasks require operational thought, there is strong evidence that these tasks may be solved with Piagetian preoperational structures such as functions, correspondences, and morphisms. For example, Chapman and Lindenberg (1988; also Chapman & McBride, 1992) studied the performance of 6- to 9-year-old children in both types of transitivity tasks. Following the procedures described by Piaget (1964, p. 63), in the standard task the experimenter avoided any correlation between stick length and spatial position; hence, the conditions theoretically necessary for operational reasoning were met. In the alternate version, the experimenter used the procedure developed by the critics and described earlier. As expected, children performed better on the new task, but their "correct" answers were justified mainly with functional explanations (e.g., "this stick [C] is bigger than that one [A], because it is on the right"), whereas on the standard task correct answers were associated mainly with operational explanations (e.g., "this one [C] is longer, because it is longer than that one [B], and that one [B] is longer than the other one [A]"). This and other results (e.g., the number of objects affected performance only in the standard version) led Chapman and Lindenberg (1988) to conclude that "the two tasks involved different logical structures [a preoperational competence and an operational one]" (p. 546; see also Chapman, 1988a).

The transitivity task also highlights an important method-

² In 1983, two well-known critics (Gelman & Baillargeon, 1983) stated that "over and over again, the evidence is that the preoperational child has more competence than expected [from within Piaget's theory]" (p. 214).

ological difference separating Piaget from his critics. For the critics it is crucial to remove from cognitive tasks all performance requirements that are likely to lower reasoning; for Piaget it was crucial to maintain these requirements in order to avoid mistaking true beliefs for necessary knowledge. We will return to this issue later when we discuss necessary knowledge in greater detail.

The criticism that Piaget underestimated the competence of children raises additional conceptual issues. Critics have often assumed that Piaget was more interested in assessing children's competencies at a given point in time than in analyzing how new competencies emerge and evolve during development. Having misidentified Piaget's goals, the critics proceeded to either downplay or simply ignore distinctions that are critical in Piaget's theory. Examples include the distinction between conservation and pseudoconservation (Piaget & Inhelder, 1966), necessity and pseudonecessity (Piaget, 1981), constituted functions and constitutive functions (Piaget, 1968a), operative and figurative thought (Piaget & Inhelder, 1968b), and deductive and transductive reasoning (Piaget, 1924). When central distinctions become peripheral issues, we are more likely to use tasks that require only perceptual solutions, and therefore we are more likely to ascribe to children the competencies critics say Piaget denied them. Parenthetically, had Piaget tried to grasp fuzzy indicators of operational competencies, for example, he would have been able to report them in children younger than those studied by some of his critics (see Footnote 1).

Some critics have also mistaken conceptual for empirical issues, as when they took the number of simply-true judgments on a simplified Piagetian task as a sufficient condition to attribute to the child an operational competence (e.g., Braine, 1959; Brainerd, 1973a; Gelman, 1972; McGarrigle et al., 1978). But this conclusion relies too much on tabular asterisks—the number of children who “succeeded” in the focal version—at the expense of theoretical risks—the prior distinction between preoperational and operational competencies (see Chandler & Chapman, 1991).

For Piaget the distinction between preoperational and operational competencies is primarily conceptual because an operational competence is defined not only by truth-value criteria but also by logical necessity. In fact, Piaget's three levels of concrete thought—preoperational, intermediate, and operational—map into three different epistemic states of modal understanding—false belief, true belief, and necessary knowledge, respectively (Smith, 1993). Precisely because Piaget wanted to discriminate these different epistemic states, he did not remove from his tasks all performance requirements, used judgments plus explanations (instead of judgments only) as criteria for operational competence, and considered countersuggestions essential to the clinical method (Piaget, 1926).

In summary, without denying that children may well be more competent than Piaget believed, most studies that have challenged his results on classification (Piaget & Inhelder, 1959), number (Piaget & Szeminska, 1941/1980), conservation of quantity (Piaget & Inhelder, 1961/1968a), space representation (Piaget & Inhelder, 1948), time representation (Piaget, 1946), and other domains are generally unconvincing—at least as evidence of operational thought in the preoperational child—

because they have incurred in basic methodological errors and conceptual confusions (see also Chapman, 1988a; Tomlinson-Keasey, 1982; Vonèche & Bovet, 1982). In addition, having concluded that Piaget underestimated the competence of young children, his critics failed to realize how often they were victims of the converse, false-positive error (i.e., of ascribing to children operational competencies that, on further analyses, turn out to be only preoperational). On a more sociological note, it is “highly ironic that a number of otherwise astute investigators, in a shortsighted view of our history, have faulted Piaget for underestimating the cognitive competencies of young children” (Bellin, 1992a, p. 202) when Piaget, more than anyone before him, changed our understanding of the cognitive potential of children.

2. Piaget's Theory Establishes Age Norms Disconfirmed by the Data

Piagetian protocols associate levels of cognitive development with specific age limits. For example, the preoperational, intermediate, and operational stages are typically associated with children 5 to 6, 6 to 7, and 7 to 8 years old, respectively (e.g., Piaget & Inhelder, 1966/1973); formal operations emerge later, typically at adolescence (e.g., Inhelder & Piaget, 1955). According to some psychologists, this correlation between chronological age and operational level is one of the most important and straightforward predictions of Piagetian theory. Consequently, they reason, if one could demonstrate formal thought or propositional logic in elementary school children, then Piaget's theory would be seriously damaged (e.g., Ennis, 1978). Similarly, “it would count against [Piaget's] theory if eight-year-olds typically failed on conservation tasks” (Flanagan, 1992, p. 127; for similar views, see Baillargeon, 1987; Borke, 1978; Donaldson, 1987; Siegler, 1991). Research findings, some of which were summarized previously, have shown that children solve the new versions of the Piagetian tasks earlier than predicted by Piagetian protocols. In the words of Donaldson (1987), “there is now powerful evidence that in this respect [i.e., age limits] he [Piaget] is wrong” (p. 19).

The criticism that Piaget is wrong because “his” age norms are not confirmed by the data illustrates another widespread misinterpretation of Piagetian theory, one that equates it with a chronology of acquisitions. In what follows we describe a representative example of the line of thinking underlying this age-of-acquisition interpretation and then discuss its major flaws when seen from within Piaget's theory (see also Chapman, 1988a; Smith, 1991).

The author who most often has interpreted Piaget in terms of ages at which intellectual competencies are acquired is Robert Ennis. After studying how elementary school children reason when faced with problems of “propositional logic,” Ennis (1982) concluded that “Piaget's claim that children of 11 to 12 and under cannot handle propositional logic is either untestable or false or otherwise defective” (p. 102). To substantiate his conclusion, Ennis pointed to studies showing that elementary school children are already capable of solving problems of con-

ditional reasoning of the type *modus ponens* or *modus tollens*.³ For example, children can conclude correctly that "Mary is at school" from the following logical argument: "If John is at school, then Mary is also at school. John is at school; what can we say about Mary?" (for reviews, see Braine & Romain, 1983; Overton, 1990b).

Other studies also seem to support Ennis's (1982) conclusion (e.g., Dias & Harris, 1988; English, 1993; Giroto et al., 1989; Hawkins et al., 1984). Contrary to Piaget's (1924) claim that children below 11 to 12 years of age are incapable of hypothetical reasoning, these studies suggest that 5 to 6-year-olds have deductive reasoning skills, because when faced with problems similar to the following syllogism—"Bears have big teeth. Animals with big teeth can't read books. Can bears read books?" (Hawkins et al., 1984, p. 587)—children conclude correctly that "Bears can't read books."

To argue from these and similar results that elementary school children are capable of "propositional logic" or "formal thought" is absurd, however. First, to Inhelder and Piaget (1955) the ability to solve a problem apparently on the basis of a logic of propositions in itself does not prove that children are using formal operations, because formal operations are combinatorial, that is, they imply the subject's ability to use or envisage all possibilities: "The specificity of propositional logic is not that it is a verbal logic, but rather a logic of all possible thought combinations" (Inhelder & Piaget, 1955, p. 222). Hence, until the combinatorial property is demonstrated, the claim that young children are capable of propositional logic remains unsubstantiated (see also, Byrnes, 1988; Monnier & Wells, 1980; Ward & Overton, 1990).

Second, as many authors have indicated, problems such as those used by Ennis (i.e., *modus ponens* or *modus tollens*) may be solved with preoperational competencies, that is, by means of transductive reasoning (Knifong, 1974), figurative or intuitive strategies (Matalon, 1990), or a simple matching bias (Overton, 1990a). In the last case, for example, the affirmation or negation of the antecedent leads to the affirmation or negation of the consequent, and reciprocally, irrespective of whether such conclusions violate the rules of logic.

When commenting on experiments similar to Ennis's (1982), Piaget (1967e, pp. 279–280) used to say that the results would be far more convincing had the experimenter confronted the child with problems in which the use of a matching strategy would yield incorrect inferences. That happens in the logical argument known as *affirmation of consequent* (see Footnote 3): for example, "If John is at school, then Mary is also at school. Mary is at school. What can we say about John?" When confronted with this problem, children do conclude that "John is also at school" when, obviously, nothing follows logically from the premises.

Recent studies (e.g., Overton, Byrnes, & O'Brien, 1985; Overton, Ward, Noveck, Black, & O'Brien, 1987) support Piaget's observation because they show that although 7- to 8-year-old children readily solve *modus ponens* problems, they are less successful in the *modus tollens* problems (where a matching strategy also guarantees success), and they completely fail both the negation of antecedent and the affirmation of consequent (see Footnote 3), that is, problems in which a matching strategy can only lead to failure (see Braine & Romain, 1983). More-

over, studies have also shown that 6 year olds give similar responses to, and use similar types of justifications for, logical and illogical syllogisms. For example, when children are confronted with two matched sets of syllogisms, one with a logical link between its premises (i.e., in the form $A \rightarrow B, B \rightarrow C$, as in "Every Zobole is yellow. All yellow things have a nose. Do Zoboles have a nose?") and the other without such link (i.e., in the form $A \rightarrow B, C \rightarrow D$, as in "Every Zobole is yellow. All red things have a nose. Do Zoboles have a nose?"), children respond in the same way—"Yes, it's true that Zoboles have a nose"—to both logical and illogical sets of problems (Markovits, Schleifer, & Fortier, 1989). This result indicates that correct performance on logical syllogisms may be explained by a low-level matching strategy and not necessarily by deductive reasoning.⁴

Conceptually, we identify two flaws in the reasoning of critics who claim that Piaget was wrong about age norms. First, they often assume that Piaget considered age a criterion of developmental level, whereas for Piaget the key element was the sequence, not the age, of cognitive transformations—from sensory-motor to preoperational, to operational, and to formal thinking (see Beilin, 1990; Chapman, 1988a; Montangero, 1991; Smith, 1991; Strauss, 1989). In Piagetian theory, age is at best an indicator, not a criterion, of developmental stage:

It is possible to characterize stages in a given population in terms of chronology, but this chronology is extremely variable. It depends on the previous experience of the individuals . . . and it depends above all on the social milieu which can speed up, slow down, or even prevent its manifestation . . . I consider the ages only relative to the populations with which we have worked; they are thus essentially relative. (Piaget in Osterrieth et al., 1956, p. 34; see also Piaget, 1924, 1972c)

Second, the critics presuppose that if the data invalidate the ages stated in Piagetian protocols, then Piaget's theory must be wrong. But if the sequence of transformations, not the age of acquisitions, is the key in Piaget's theory, then if a child solves a task earlier than reported by the protocol, no serious conceptual damage is inflicted on the theory (see P. Miller, 1989; Strauss, 1989). Furthermore, from within Piaget's theory it does not

³ The *modus ponens* rule says that if we are given as true a conditional statement and its antecedent then its consequent may be validly inferred. For example, given as true that "If it's sunny then John is at the beach" and "It is sunny" we can validly conclude that "John is at the beach." However, if we are given as true the conditional statement and its consequent—*affirmation of consequent*—then we cannot validly infer anything about the antecedent. From "If it's sunny then John is at the beach" and "John is at the beach" we cannot infer validly whether it is sunny or not. The *modus tollens* rule asserts that if we are given as true a conditional statement and the negation of its consequent then the negation of its antecedent may be validly inferred. Given "If it's sunny then John is at the beach" and "John is not at the beach," we may validly conclude that "It is not sunny." However, if we are given as true the conditional statement and the negation of its antecedent—*negation of antecedent*—then we cannot validly infer anything about the consequent. From "If it's sunny, then John is at the beach" and "It is not sunny," we cannot infer logically whether or not John is at the beach.

⁴ Curiously enough, some authors have argued that "when assessed using techniques similar to Piaget's, cognitive skills appear at about the ages he reported" (Bidell & Fischer, 1989, p. 364).

make sense to expect a precise age for the emergence of a specific competence because nothing in development begins *ex abrupto* (Piaget, 1936, 1950/1973b, 1967a).

In summary, the criticism discussed in this section views Piaget in terms of age of acquisitions even though he was primarily interested in sequence of transformations. Piaget, a dialectical, developmental, and constructivist psychologist, was treated by his critics as a differential psychologist, concerned more with the question of how children perform at specific ages on isolated cognitive tasks than with the problem of how they develop new types of competencies.

3. Piaget Characterizes Development Negatively

In his early books, Piaget (1923, 1924) characterized the thinking of young children as prelogical and egocentric, and he emphasized the role of social interaction in cognitive development. Later, during the structuralist phase of his career, Piaget embraced the idea that cognitive structures emerge from the self-regulation of the individual's actions, and he replaced the concepts of prelogical and egocentric thought with the concept of preoperational thinking (Beilin, 1992a; Bidell & Fischer, 1992; Montangero, 1985). Yet Piaget continued to characterize preoperational thought as not capable of seriation (Piaget & Inhelder, 1959), class inclusion (Piaget & Szeminska, 1941/1980), and conservation (Piaget & Inhelder, 1961/1968a), that is, in terms of what the child lacks with respect to the next stage.

Perhaps on the basis of these historical facts, many psychologists have claimed that Piaget portrays development negatively. Preschool children in particular seem to be described as illogical and incompetent (Donaldson, 1987; Donaldson, Grieve, & Pratt, 1983; Siegal, 1991). Development from one stage to the next is depicted poorly as a transition from a state of absence (negative stage) to a state of presence (positive stage). Flavell and Wohlwill (1969), for example, have characterized stage transitions as transitions "from not-in-competence to first-in-competence" (p. 80). The impoverished conception of development issued from these descriptions is for some authors a serious shortcoming of Piaget's theory (e.g., Bruner, 1966; Flavell, 1963; Gelman, 1978; Siegel, 1978).

The present criticism relies on another set of objectionable interpretations of Piagetian theory. First, in Piaget's account, development does not occur as a movement from absence to presence but as a process of progressive transformation, differentiation, and integration (Smith, 1993). Piaget always maintained a fundamental continuity not only between biological and psychological functioning (Piaget, 1967a) but also within psychological functioning itself (Piaget, 1975). Thus, for Piaget there is no absolute beginning in development or any noncompetence phase preceding the emergence of a given competence; development never ends, and nothing in it begins *ex-abrupto*: "At the behavioral level, a scheme never has an absolute beginning because it derives from previous knowledge through a process of successive differentiation the source of which has to be sought in the very early sensorimotor coordinations" (Piaget, 1967a, p. 26; see also Piaget, 1936, 1950/1973b).

Second, when psychologists say that Piaget equated development with a transition from absence-to-presence of a given competence, they fail to recognize that Piaget did not argue for

evidence of cognitive incompetence in children but for the lack of evidence for a cognitive competence (Montangero, 1991; Smith, 1991). Thus, when Piaget and Inhelder (1961/1968a) referred to the "absence of conservation of quantity," they were thinking of young children's lack of one logical competence (i.e., conservation), not of children devoid of any logical abilities. The question raised by Piaget was not whether thinking was logical or not, for thinking always involves logic, but what kind of logic children manifest over development.

Third, to say that Piaget gives a negative picture of development because he defined a particular stage in terms of absence of certain cognitive abilities is only half true. Piaget also defined each stage positively with respect to its predecessor. For example, when compared with older children, preschool children are incapable of seriation, conservation, and reversibility; when compared with younger ones, however, they exhibit several manifestations of representational intelligence, such as deferred imitation and symbolic play (see Davidson, 1992a). Hence, to characterize Piagetian theory as a prospective theory (i.e., a theory in which progress is measured by the distance already covered in moving away from an initial state of reference; Chapman, 1988b) is as legitimate as to characterize it retrospectively or teleologically, as a theory that defines developmental progress in terms of the decreasing distance toward a predetermined end state (Geert, 1987).

Even if it were true that Piaget characterized development negatively, this criticism would disregard the fact that after 1960 Piaget returned to the study of preoperational thinking and ascribed to it three fundamental positive characteristics: preoperational structural competencies, such as morphisms (Piaget, Henriques, & Ascher, 1990), functions (Piaget, 1968a), identities (Piaget, 1968b), and correspondences (Piaget, 1980c); an emerging capacity to distinguish reality, possibility, and necessity (Piaget, 1981, 1983a) without which there are few chances of forming new cognitive structures; and an ability to attribute meanings to objects and actions by using signifying implications (Piaget & Garcia, 1987; see also Beilin, 1992a, 1992b; Chapman, 1988a; 1992; Davidson, 1988, 1992a; Ricco, 1990, 1993). In this category-theoretical formulation of cognitive development (further extended during the 1970s; see MacLane, 1971), Piaget stressed the systematic nature of children's competencies rather than the inadequacies that appear by comparison with operational thought. To illustrate, preoperational children were then viewed as capable of understanding that (a) when the water contained in a beaker is poured into another beaker, the water remains qualitatively the same (qualitative identities); (b) when playing with a ball, the harder the child throws, the further the ball gets (functions); (c) when playing with a collection of five dolls of increasing size and five dresses of increasing size, every element in the first collection maps onto an element in the second (morphisms or structural correspondences), which constitute an epistemologically distinct system that is as necessary as transformations and operations (see Davidson, 1988).

In summary, the criticism discussed in this section is based on a widespread conception of development as a transition from absence to presence (i.e., from not-in-competence to first-in-competence) that is completely at odds with the constructivist

and developmental nature of Piaget's approach to human development.

4. Piaget's Theory Is an Extreme Competence Theory

Many investigators have criticized Piaget because, in their view, he ignored the role played by performance factors in the solution of operational tasks. Two well-known critics summarized the issue thus:

When a child fails a certain Piagetian test that is supposed to tap some given underlying concept, what does this mean? Of course, it could mean that the child does not possess the concept. This interpretation is known as a "competence explanation," and is the sort of interpretation favored by Piaget . . . A Piagetian test invariably measures many other things than what it actually is supposed to measure. Therefore, it is always possible that failure on a Piagetian test results from these other things rather than from absence of the underlying concept. This second interpretation is known as a "performance explanation." (Siegel & Brainerd, 1978b, p. xii)

Critics have contended that because Piaget overemphasized the psychological meaning of logical structures on the one hand and underemphasized the effects of content and context on the other, his theory is an "example of an extreme competence theory" (Fischer, Bullock, Rotenberg, & Raya, 1993, p. 94; see also Broughton, 1981; Bruner, 1982; Hofmann, 1982).

The criticism just described is shared by investigators who otherwise have little in common. Authors in the best empiricist tradition have accused Piaget of downplaying the importance of learning in the formation of cognitive structures (Brainerd, 1977a; Gelman, 1969); authors associated with the sociocultural approach have blamed him for neglecting the cultural context in general, and language in particular (Vygostky, 1934/1981; Wertsch & Kanner, 1992); information-processing theorists have criticized Piaget for having studied the development of very global competencies instead of more local and specific ones (Kail & Bisanz, 1992; Siegler, 1978); and neo-Piagetians have accused Piaget of failing to address the process of transition across stages and the issue of individual differences (Case, 1992b; Rieben, Ribapierre, & Lautrey, 1983). As we shall see, although reasonable at first sight, these criticisms illustrate the misunderstandings that are likely to occur when researchers analyze the theory of Piaget from without before considering it from within (see Chapman, 1988a).

What is a competence theory? If it is a theory that (a) focuses on the pattern of organization of the individual's cognitions rather than on problems of content and specific knowledge; (b) stresses formal causes of behavior and its organization rather than functional antecedents; and (c) establishes an analogical relationship between the thinking individual and some formal system, such as logic, for instance, then Piaget's theory is indeed a competence theory (see Ricco, 1993). Does it follow then, as some of his critics have claimed (e.g., Fischer et al., 1993), that Piaget's is an extreme or pure competence theory? If by theory of pure competence the critics mean a theory that conceives the cognitive structures as completely independent of the situations to which they apply, then Piaget's theory is immune to such criticism:

It is clear that in each task there intervenes a multitude of *heterogeneous factors* such as the words we use, the length of our instructions . . . the number of objects considered, etc., etc. Therefore . . . we never attain a measure of comprehension in a pure state, but always a measure of comprehension relative to a given problem and a given material. (Piaget & Szeminska, 1941/1980, p. 193; emphasis added)

Piaget never believed that performance on his tasks depended exclusively on cognitive competencies. As Chapman (1988a) observed,

The "logical structure" of a task in operatory terms . . . refers to the manner in which the subject actually goes about solving the task, not to any abstract feature of the task that remains invariant regardless of how it is administered. (p. 350)

If Piaget did not deny the importance of performance factors, then why did he not study them in greater detail? Piaget believed that science begins with description, not explanation. Therefore, it would be strategically premature and tactically unproductive to study the effect of performance factors on cognitive competencies when psychologists have not identified, let alone described or classified, the new forms of thinking, knowing, and reasoning that emerge in the course of development. Piaget's biological training also supported this viewpoint. As biologists had done before, genetic epistemologists should begin with a taxonomy of the most general forms of thinking before attempting to explain them. Hence, even if Piaget had wanted to make functional analyses and study the role of performance factors in cognitive assessment and development, he would have to have been a structuralist first and identify general forms of knowing and thinking.⁵ This observation, frequently overlooked by the critics, is likely to explain why Piaget moved from an initial, somewhat functionalist phase (1920–1940; Piaget, 1923, 1932, 1936, 1937) to an intermediate and strongly structuralist phase (1940–1960; Piaget & Inhelder, 1961/1968a; Piaget & Szeminska, 1941/1980), before reaching, after 1970, a functionalist–structuralist phase with distinctive emphasis on dialectical processes such as equilibration (Piaget, 1975), contradiction (Piaget, 1974a), reflective abstraction (Piaget, 1977), and opening to new possibilities (Piaget, 1981, 1983a).

Piaget also realized that to oppose competence and performance is to create a false dichotomy given that "logical form and physical content are inseparable" (Piaget & Inhelder, 1961/1968a, p. 217). It is as illogical to think of pure competence as it is to think of pure performance, because performance factors are always mediated by the operational level of the individual (see Inhelder, Sinclair, & Bovet, 1974). From this viewpoint, it hardly surprises us that the more Piaget advanced in his career, the more he acknowledged the roles of content and context and the more sensitive he became to questions of meaning in development (Piaget & Garcia, 1987; see also Beilin, 1992b). For example, regarding formal thought, Piaget (1972a) acknowledged explicitly that an individual may attain the stage of formal

⁵ "I have no interest whatsoever in the individual. I am very interested in general mechanisms, intelligence and cognitive functions, but what makes one individual different from another seems to me . . . far less instructive" (Piaget, 1971, p. 211).

operations in one area but not in another; also, in his book with Garcia on the logic of meanings (Piaget & Garcia, 1987), Piaget explicitly avoided reducing issues of meaning to issues of formal truth. We address this point in finer detail in Criticism 10.

From the foregoing analysis it is clear that Piaget's theory is far from being an extreme competence theory; that Piaget's relative lack of interest in performance factors stems from his pyramid of epistemological concerns, at the top of which, and requiring maximum priority, was the first great mystery of knowledge, the identification of new types of thinking as they emerge in development; and that Piaget's lack of interest in performance variables can be overcome from within (i.e., without changing the theory's basic foundations—its developmental, constructivist, structuralist, and dialectical assumptions).

5. Piaget's Theory Neglects the Role of Social Factors in Development

Piaget was more interested in the emergence and sequence of cognitive stages than in the factors that can accelerate, retard, or even prevent their appearance. When Piaget tried to explain the construction of necessary knowledge, which he described as "the central problem of the psychogenesis of operational structures" (Piaget, 1967d, p. 391), he appealed to the process of equilibration, not to the traditional factors of development, maturation, physical experience, and social factors. In addition, Piaget (1952, 1967e) always tried to formalize in logicomathematical terms the cognitive activities of the human subject.

It has probably been on the basis of these three facts that many researchers have faulted Piaget for neglecting the role of social factors in development (Winegar & Valsiner, 1992), for falling prey to genetic individualism (Forman, 1992), for conceiving development in a social vacuum (Broughton, 1981), and for extending to all domains, subjects, and cultures the forms of thinking he found in his studies (Buck-Morss, 1982). Murray (1983) has summarized the criticism well: "the [Piagetian] epistemic subject has no social class, sex, nationality, culture, or personality" (p. 231). In a similar vein, Broughton (1981) has claimed that the structuralist theory of Piaget refers to "knowledge without history and self" (p. 320). The criticism is pervasive (e.g., Baltes, 1987; Bidell, 1992; Bruner, 1966; Cohen, 1983; Dasen, 1972; Light, 1986; Sigel, 1981; Suarez, 1980; Wertsch & Tulviste, 1992) and, according to some psychologists, it highlights an intrinsic limitation of the Piagetian approach (e.g., Broughton, 1981; Forman, 1992; M. Miller, 1987; Cole, 1992; Vygotsky, 1981; Wallon, 1947).

Reasonable as it may seem, the current criticism is at odds with several statements made by Piaget: "The individual would not come to organize his operations in a coherent whole if he did not engage in thought exchanges and cooperation with others" (Piaget, 1947/1967b, p. 174). "Society is the supreme unit and the individual can achieve his inventions and intellectual constructions only to the extent that he is the seat of collective interactions whose level and value depend obviously on society as a whole" (Piaget, 1967a, p. 508; see also Piaget, 1947/1967b). Piaget also stressed repeatedly that although not sufficient, social factors are necessary for cognitive development (Piaget & Inhelder, 1966/1973).

To understand the opposite viewpoints of Piaget and his crit-

ics on the role of social factors, a brief historical digression is appropriate. During the initial and functionalist phase of his studies, Piaget (1923, 1932) considered social interaction the main factor responsible for the transition from egocentric to socialized thinking and gave a purely social explanation of cognitive structures. Later, when he found a sensorimotor intelligence and logic before the emergence of verbal language (Piaget, 1936, 1937), Piaget (1976a) confessed that in his initial phase he had overestimated the role of language and social interaction in the construction of knowledge. He then moved to a strongly structuralist phase and pursued the idea that cognitive structures and operations come from the subject's own coordination and self-regulation of his or her actions (see also Beilin, 1992a; Bidell & Fischer, 1992; Chapman, 1988a). But even when Piaget moved from the communicative component of interaction (i.e., subject-subjects relation) to its operative component (i.e., subject-objects relation), he still stressed the role of social factors in the development of knowledge, as when he said that "by himself, the individual would never achieve complete conservation and reversibility" (Piaget, 1950/1973a, p. 271). Piaget's work on sociological issues (Piaget, 1965) and the moral development of children (Piaget, 1932) also contradicts the putative individualism of his theory (cf. Bidell, 1992; Glassman, 1994).

The preceding historical digression clearly identifies a social dimension in Piagetian theory, but it does not explain why Piaget never converted that social dimension into an empirical research program. We suggest two reasons. First, Piaget strongly opposed the functionalist interpretation that complacently reduces social factors to mere independent variables capable of speeding up or slowing down development, or that equates social interaction with mere exposure to others and acquisition of knowledge with mere knowledge transmission. "The social fact is a fact to be explained, not a fact to be invoked only as an explanatory factor" (Piaget, 1946/1976b, p. 10).

Second, as we mentioned before, Piaget was interested not only in the sequence of cognitive stages but also in the construction of necessary knowledge. But to look for social factors in the origins of necessary knowledge was for Piaget an epistemologically lost battle because necessary knowledge, in contrast with simply true knowledge, goes beyond empirical generalizations and social regularities (see Ricco, 1993; Smith, 1993). This observation also explains why Piaget in his late functionalist-structuralist phase overstressed the role of equilibration and reflective abstraction in development. Trying to identify the processes responsible for human knowledge, Piaget proposed physical abstraction and reflective abstraction as the main sources of physical and logicomathematical knowledge, respectively. Contrary to physical knowledge, which comes directly from actions on, or experience with, objects, logicomathematical knowledge derives from the coordination of the actions themselves. During the last years of Piaget's career (e.g., Piaget, 1977), reflective abstraction became one of the cornerstones of his theory, as it accounted for the transitions in cognitive development and for the construction of new knowledge structures. Similarly, the equilibration process—the activities of the subject directed to assimilate, integrate, and regulate all cognitive perturbations due to either external contradictions or internal limitations—was considered by Piaget (1975) to be a key element in the construction of knowledge because its main function is to coordi-

nate in a coherent whole the traditional factors of development, maturation, physical experience, and the social factors.

Being a developmentalist, not a socialization theorist, Piaget conceived social interaction as integral to human development; in a sense, social interaction was embodied in the cognitive structures themselves. This idea was elaborated explicitly in later writings where, sensitive to his critics, Piaget admitted that his epistemic subject was not so universal and context free as he had assumed hitherto (cf. Piaget, 1972a). Specifically, Piaget admitted not only that formal thinking could exist in some domains but not in others but also that development could follow psychogenetic paths different from the one he had identified. The following paragraph is revealing:

I got interested in Chinese science because of the book we're doing with Garcia [Piaget & Garcia, 1983]. The problem was whether there is only one possible line of evolution in the development of knowledge or whether there may be different routes . . . Garcia, who is quite familiar with Chinese science, thinks they have traveled a route very different from our own. So I decided to see whether it is possible to imagine a psychogenesis different from our own . . . and I think that it is possible. (Piaget in Bringuier, 1977/1980, p. 100)

The foregoing arguments show that the neglect of social factors in Piaget's theory (a) is more apparent than real (see also Chapman, 1988a; Davidson, 1992b; Furth, 1986; Parrat-Dayan, 1993; Smith, 1993); (b) does not lead to a genetic individualism; and (c) happened because Piaget rejected social empiricism, and more important, because he was concerned with epistemological questions not addressed generally by his critics. Chapman (1988a), for instance, asserted that "the effects of social factors can be studied within the theory without requiring essential modifications" (p. 373). For that matter, it would suffice to integrate in a single model the communicative and operative components Piaget used on different occasions. Such integration, Chapman's (1991) epistemic triangle, would change the dual structure of knowledge (subject-objects) and social interaction (subject-other subjects) into a triadic structure, that is, a structure "consisting of an active subject, the object of knowledge, and a (real or implicit) interlocutor, together with their mutual relations" (p. 211). Subjects in this model would interact operatively with the object and communicatively among themselves.

6. Piaget's Theory Predicts Developmental Synchronies Not Corroborated by the Data

As we mentioned earlier, very often Piagetian protocols associate specific ages with developmental levels. Furthermore, when Piaget characterized his cognitive stages, he said they conform to a structure of the whole (*structures d'ensemble*; e.g., Piaget, 1960, pp. 12-13; 1972c, pp. 26-27). On some occasions, Piaget referred to his structures of the whole as "causally active" in the mind of the subject (Piaget, 1941, p. 217). He also stated that "each stage is characterized by a given structure-of-the-whole as a function of which it is possible to explain the typical [cognitive] behaviors of the respective stage" (Piaget & Inhelder, 1966/1973, p. 121).

Some researchers have inferred from the preceding remarks

that Piaget's theory predicts strongly homogeneous and synchronous performance across operational tasks. Thus, when children enter the concrete operational stage, for example, their developmental level in various tasks such as class inclusion, seriation, classification, and conservation should be highly correlated (e.g., Bruner, 1983; Case, 1992a; Demetriou, Efklides, Papadaki, Papantoniou, & Economou, 1993; Fischer, 1983; Flavell, 1982a, 1982b). In Corrigan's (1979) words, "the structuralist position taken by Piaget and his followers is that synchrony between task domains is a fundamental developmental principle because overall structures explain functioning in many different areas" (p. 620). Similarly, Braine (1959) argued "that Piaget's notion that reasoning processes develop in groups clearly implies the postulate that where operations, inferences, etc., are mutually interdependent . . . the corresponding reasoning processes develop in association in children's thinking" (p. 29).

The studies designed to test the developmental synchrony "predicted" by Piaget's theory generally have found asynchrony and heterogeneity both in concrete operational and in formal tasks (Brainerd, 1973b; Hooper et al., 1978; Tomlinson-Keasey, Eisert, Kahle, Hardy-Brown, & Keasey, 1979; Wason, 1977). Developmental *décalages* have been found among different contents or domains (e.g., conservation of quantity and weight; Piaget & Inhelder, 1961/1968a), among different same-stage structures within a given area of content (e.g., classification and seriation; Piaget & Inhelder, 1959), and among different versions of nominally the same task (e.g., transitivity length task in the original and alternate versions; Chapman & Lindenberger, 1988). Other forms of developmental *décalages* have also been documented (see Chapman, 1988a; Hofmann, 1982).

Décalages, their meaning, and their theoretical implications are a subject of debate among Piagetian critics (Brainerd, 1978b; Bullinger & Chatillon, 1983; Fischer, 1983; Flavell, 1963; Gelman & Baillargeon, 1983). Some authors see them as a serious "anomaly of Piagetian theory" (Demetriou et al., 1993, p. 481); others characterize them as a nuisance because they refute one of the most permissible predictions of Piaget's theory (Fischer, 1978); for still others they jeopardize the structuralist underpinnings of the theory (Siegel & Brainerd, 1978b); finally, for some researchers they indicate that the Piagetian concepts of stage and structures of the whole are clearly doomed and should be abandoned in the developmental research of the future (Flavell, 1977, 1982b).

Despite their empirical support, the foregoing conclusions must be taken with caution because underlying them is a functionalist interpretation of Piagetian structures of the whole. That is, structures of the whole, or logicomathematical structures such as the eight groupings of concrete logical operations (Piaget, 1952), are conceived by the critics as higher order functional entities that, in ways similar to independent variables, determine the behavior typical of a given stage. Performance, in other words, is caused by these functional antecedents (e.g., Braine, 1959; Corrigan, 1979; Fischer, 1983). In what follows, we show that although widely taken for the theory itself, this functionalist interpretation is in complete variance with it (Chapman, 1988a, may be consulted for a more detailed analysis of this issue).

Why is it commonplace to confuse the functionalist reading

of Piaget's theory for the theory itself? At the beginning of this section we identified four facts internal to Piagetian theory that may have led critics to assimilate structures of the whole with functional entities responsible for all cognitive manifestations of a given stage. The penchant for functional or antecedent-consequent analyses in U.S. and Canadian psychology, however, is also an external factor responsible for such confusion. As Chapman (1988a) put it, "Inevitably, perhaps, developmental psychologists assimilated Piaget's structural-stage theory to their own functionalist approach" (p. 363).

When Piaget says that performances such as classification or seriation involve the same structure of the whole, he is not saying that the groupings determine such performances (i.e., functional explanation) but rather that these performances can be described by a common set of formal properties, the groupings. That is, in terms of level of formal organization (i.e., formal or structural explanation), the two types of performance are equivalent. It does not follow necessarily that such formal properties are all acquired at the same time and at the same rate, or that they are displayed equally often in every conceivable task (see, e.g., Piaget & Inhelder, 1959, Chapter 5). More to the point, Piagetian structures of the whole are morphological or formal criteria used to classify the types of thinking or knowing that emerge during psychogenesis. Had Piaget conceived structures of the whole as a sort of superfunctional totalities that regulate performance, he would certainly have suggested a single task to assess concrete operational thinking and a single task to assess formal thinking. He never did.

A second misunderstanding that also supports the idea that Piaget's theory is inconsistent with asynchronous manifestations in development is to conceive Piagetian stages as chronological and global phases of development (Braine, 1959; Brainerd, 1978b). But, as we mentioned before, to interpret Piagetian theory in terms of age of acquisitions instead of sequence of transformations is at variance with Piaget's developmental, dialectical, and constructivist interests (see Montangero, 1991; Smith, 1991). As Piaget put it, "Genetic psychology takes mental processes in their construction and the [developmental] stages are preliminary tools to analyze those processes; they are not ends in themselves" (Piaget in Osterrieth et al., 1956, pp. 56-57). Concerning the presumed global character of developmental stages, Piaget had this to say:

There are no general stages . . . We see an intermingling of processes of development which are evidently interrelated, but to different degrees or according to multiple temporal rhythms; there is no reason why these processes should constitute a unique structural whole at each level." (Piaget, 1960, pp. 14-15; emphasis added)

The foregoing analyses indicate that it is only when we interpret structures of the whole functionally that we see inconsistency between the structuralist nature of Piaget's theory and developmental asynchrony. If instead we see structures of the whole as levels of organization or formal causes and take into account, as Piaget claimed (e.g., Piaget & Szeminska, 1941/1980, p. 193), that there is always a multitude of heterogeneous factors intervening in each task, then the contradiction disappears.⁶ As Chapman (1988a) observed, "the idea that the concept of *structures d'ensemble* implies developmental synchrony

across content areas is based on a confusion between formal analogies and functional totalities" (p. 346). Although issues of homogeneity-heterogeneity and synchrony-asynchrony are important in their own right, they are irrelevant for testing the empirical implications of Piaget's theory because the theory itself allowed for developmental asynchrony.

7. Piaget's Theory Describes but Does Not Explain

Another criticism of Piaget's theory says, in its mild version, that the theory provides vague explanations of cognitive development, and in its strong version, that the theory describes much but explains little (Boden, 1979; Campbell & Bickhard, 1986; Cohen, 1983; Flanagan, 1992; Halford, 1989). Critics have said, for example, that Piagetian stages describe age-related cognitive changes well but have no explanatory power (Brainerd, 1978b), or that equilibration, considered by Piaget the most fundamental principle of cognitive development, is a metaphor at best (Ferreira da Silva, 1982), a superfluous concept at worst (Bruner, 1959; Zazzo, 1962).

When psychologists criticize Piaget for being only descriptive, they often point to an important article by Brainerd (1978b) on the concept of stage in developmental theory. Briefly, Brainerd argued that in order to explain a fact, one needs to (a) describe the fact, (b) identify its antecedents, and (c) measure the antecedents independently of the fact to be explained. Brainerd claimed that the concept of stage in Piaget's theory satisfies requirement (a) because a stage describes modifications associated with age; it poorly meets requirement (b), although equilibration could be seen as a possible candidate; and it fails totally with respect to requirement (c) because performance typical of a given stage is defined by the properties of the corresponding stage when in fact these properties were initially (and circularly) inferred from performance itself. Brainerd summarized, "whereas Piaget's stages are perfectly acceptable as descriptions of behavior, they have no status as explanatory constructs" (p. 173).

Whether Piaget's theory explains or simply describes is more complex than Brainerd's (1978b) conclusions lead us to believe. To address the issue we analyze the following points (see also Chapman, 1988a; Ricco, 1993): What does Piaget's theory attempt to explain? Why does equilibration take a preponderant role as an explanatory construct in the theory? What levels of explanation did the critics seek and how do these compare with Piaget's goals?

When critics state that Piagetian theory is primarily descriptive, they are not saying anything Piaget did not acknowledge. As we argued before, Piaget considered his major task to identify and characterize the new forms of thinking that emerge, develop, and attain full equilibrium and reversibility in the course of ontogenesis. He believed that only when this purely

⁶ Some horizontal, that is, within-stage, *décalages* identified by Piaget's critics (e.g., Brainerd, 1974; McGarrigle et al., 1978) are most likely vertical or between-stages *décalages*. As we argued in Criticism 1, authors who have used different versions of the "same" Piagetian task have assessed not the same operational structure at an earlier point in development (horizontal *décalages*), but different competencies (vertical *décalages*).

descriptive phase of research is achieved can we profitably try to explain the transitions from one form of thinking to the next (see Piaget, 1947/1967b; Sugarman, 1987). Furthermore, Piaget struggled with the logicomathematical properties and the level of organization of the stages (i.e., with their structural or formal content); he was not directly interested in the tempo of development, its accelerations, decelerations, or even arrests (i.e., its functional properties). It is true that Piaget was initially concerned with functional accounts—hence the concepts of assimilation, accommodation, and organization both as biological and as psychological functions—and that, later in his career, he returned to functionalism—hence his concern with procedures (Inhelder & Piaget, 1979), learning and development (Inhelder, Sinclair, & Bovet, 1974), contradiction (Piaget, 1974a), dialectics (Piaget, 1980a), cognizance of one's actions (Piaget, 1974b, 1974c), and opening to new possibilities (Piaget, 1981, 1983a). But the fact remains that Piaget's functionalist concerns were always conceptualized in a structuralist framework. For example, according to Piaget, the learning of a new operational concept depends heavily on the child's previous level of cognitive development (see Inhelder et al., 1974). Finally, it was the sequence of the stages, not their dependency on age, physical experience, or social condition, that intrigued Piaget. Hence, although Brainerd (1978b) is right when he says that Piagetian stages have no explanatory (functional) power, his conclusion loses much of its strength when we realize that the issues that concerned Piaget the most are somewhat secondary to Brainerd, and reciprocally, central issues for Brainerd were only marginally important for Piaget.

Piaget was also interested in the development of necessary knowledge: For a 7-year-old child it is not only true that a given amount of water remains the same when poured into a different container, but it must also be the case. That is, a sense of necessity permeates the child's operational judgments. Piaget therefore distinguished necessary from simply-true knowledge. Whereas the latter, as exemplified by a scientific law, appeals to induction, observable facts, probability, and contingent relations among events, necessary knowledge, as exemplified by the conservation of number, appeals to deduction, universality, certainty, and necessary relations between states of affairs.⁷

Necessary knowledge poses a difficult problem to functional accounts because it cannot be derived solely from observable facts in the social and physical worlds. The mere fact that something is the case (i.e., true) does not imply that it must be the case (i.e., necessary). Hence, an account based exclusively on maturation, physical experience, and social environment will certainly identify the necessary conditions for the development of necessary knowledge, but with the same certainty it will miss its sufficient ones (see Ricco, 1993; Smith, 1993).

Piaget explained necessary knowledge in terms of the subject's coordination and regulation of his or her actions according to the principle of equilibration (Piaget, 1967c, 1973c, 1975). Herein then lies the origin of the principle of equilibration (not to be confused with the principle of equilibrium; Maurice & Montangero, 1992) and the justification of its important role in Piaget's theory (see also Piaget 1918, 1960, 1975). Commenting on the principle of equilibration and what it meant to developmental psychology, Piaget said:

We cannot rejoice with a finished deductive theory, or with an agreement with the data beyond a few intersections among the results of various investigations. I believe, however, that we have moved beyond the descriptive level in a variety of domains where it is now possible to invoke "reasons," some functional . . . , others structural. (Piaget, 1975, pp. 179–180)

With respect to the discrepancies between the levels of explanation sought by Piaget, on one side, and his critics on the other side, we note that the paradigmatic type of explanation advocated by Brainerd (1978b; i.e., the discovery of antecedent–consequent relationships), was ranked by Piaget (1950/1973b, 1967c, 1973c) as the weakest level of explanation. This is so because antecedent–consequent relations assert only the generality of a factual relation, the temporal succession, or the correlation between the elements involved, but do not entail any element of necessity. Hence, according to Piaget (1967c), antecedent–consequent relations are only the first level of a true explanation. At the second level of explanation, two or more laws are coordinated in a deductive system that adds the element of necessity not present before. However, an explanation becomes a true causal explanation (Piaget's third level) only when the deductive system of laws is "inserted into a model that provides its real, empirical foundation, and allows the reconstruction of the phenomena [being explained]" (Piaget, 1967c, p. 160).

Ironically, as Chapman (1988a, p. 339) remarked, given his three levels of scientific explanation, Piaget could have said of Brainerd's functional explanation what Brainerd said of Piaget's theory, namely, that it falls "somewhere between pure description and true explanation" (Brainerd, 1978b, p. 175).

In summary, the criticism that Piaget's theory is merely descriptive is clearly an oversimplification. Once again, researchers criticized Piaget from without before understanding him from within. In the process, some of Piaget's deepest concerns and insights were forgotten instead of being explored systematically (see Murray, 1990). We believe that psychologists in general and Piagetian critics in particular have yet to rise to the challenge posed by Piaget's (1978) claim that the two great mysteries of knowledge—how new forms of thinking emerge in development and how they become psychologically necessary—cannot be solved solely within a functionalist framework.

8. Piaget's Theory Is Paradoxical Because It Assesses Thinking Through Language

Grounded on the very theory it questions, this criticism is possibly one of the most pertinent ever directed against Piaget. Critics say specifically that in order to assess cognitive development, Piaget (e.g., 1926) relied heavily on the clinical method and related verbal techniques, but, and herein lies the paradox, he did not include language in his theoretical definition of operational thinking. For if thinking comes mainly from the coordination and progressive interiorization of actions (Piaget, 1947/

⁷ Smith (1993) also characterized necessary knowledge as universal and self-identical; universal because in principle any person can acquire it; self-identical because all people who have acquired it possess the same knowledge.

1967b, 1954, 1964; Sinclair, 1969), then, as Larsen (1977, p. 1164) keenly remarked, to use language to explain and infer cognition is equivalent to using the effect of a cause to explain the cause itself.

Trying to resolve the paradox, some authors have suggested that when researchers assess children's operational competencies they should use nonverbal methods (e.g., Braine, 1959; Siegel, 1978; Siegel & Hodkin, 1982) or simply ignore the child's justifications of her or his own actions and judgments (e.g., Brainerd, 1973b, 1977b). They have argued that when children are asked to justify their judgments on Piagetian tasks, their "true" operational competence is not revealed because the procedure appeals to an additional linguistic competence that may lower the child's operational competence (e.g., Kalil, Youssef, & Lerner, 1974; Siegel et al., 1978). When verbal justifications are removed, the cognitive competence appears in a "purer" state, and consequently the researcher is less likely to underestimate the child's cognitive abilities.

In an often-cited example of the negative effects of linguistic factors, McGarrigle et al. (1978) compared performance of 5- to 6-year-old children on two class-inclusion tasks. In the standard task, the superordinate class was defined generically: "In this set, with four cows, three being black and one white, are there more black cows or more cows?"; in the modified task, the superordinate class was linguistically marked: "In this set, with four standing-up cows, three being black and one white, are there more black cows or more standing-up cows?" Consistent with the hypothesis that children's "operational" competence would be enhanced by the salience of the linguistic cues defining the superordinate class, the authors found that correct judgments were significantly more frequent on the modified task. They concluded that when researchers peel the husk of verbal performance from the kernel of cognitive competence, they are more likely to grasp children's "true" competence.

This conclusion, however, runs the risk of being premature. That is, rather than peeling the husk of verbal performance from the kernel of cognitive competence, the strategy of eliminating children's justifications as criteria for concrete operations or the strategy of introducing facilitating linguistic cues in Piagetian tasks may leave us not with a purer form of cognitive competence but simply with a smaller piece (see also, Chapman, 1991). For example, when Chapman and McBride (1992) replicated the McGarrigle et al. (1978) study, they also found a significantly higher rate of "correct" judgments on the linguistically marked task, but they found no significant differences when the cognitive competence was assessed according to judgments and justifications (i.e., correct judgments justified with operational explanations, i.e., in terms of inclusion logic). This finding indicates that a judgments-only criterion is likely to mistake preoperational or nonlogical figurative competencies for truly operational ones. As Flavell (1963) remarked, "there is a point beyond which stripping a concept of its verbal-symbolic accouterments makes of it a different, lower-order concept" (p. 436). Hence, rather than assessing cognitive competencies with less error, as many critics have claimed (e.g., Braine, 1962; Brainerd, 1973a), the new methods simply assess different and lower level competencies (see Chandler & Chapman, 1991).

If verbal explanations are essential to operational assessment, the presumed independence in Piagetian theory of thought

from language is not so clearcut as most critics assume. But, then, why didn't Piaget include language in his theoretical definition of operational thinking? To understand the scope of the "paradox" as well the adequacy of the methodological suggestions advanced by some researchers, we need some historical perspective. As already stated, Piaget moved from an initial phase during which he believed communicative interaction was the main factor responsible for cognitive development to a phase where the operative component of interactions played that role. This theoretical turn happened because Piaget found a "logic of action" in the sensorimotor stage when language is virtually nonexistent (Piaget, 1936, 1937). In one of his autobiographies Piaget (1976a) commented, "In order to grasp the development of intellectual operations I needed to study the actions of the subject upon the objects. But this I realized only when I began to study intelligent behavior in the first years of life" (p. 12). More important for our present concerns, from then on in most of his tasks Piaget moved from the clinical to the clinical-critical method wherein "problems of action" supplement verbal problems. The 10-sticks seriation task (Piaget & Szeminska, 1941/1980) and the vehicles classification task (Piaget & Inhelder, 1959), for example, appeal strongly to the child's nonverbal performance. These and similar studies, together with the analysis of sensorimotor intelligence, reinforced Piaget's belief that thinking is indeed genetically prior to language, and show that, contrary to critics' claims, operational assessment does not rely exclusively on language.

However, to be "genetically prior to" does not mean "to be independent from." In fact, Piaget said explicitly that language is not only integral to the definition of formal thinking (Inhelder & Piaget, 1955) but important in the development of concrete operational thought as well: "Without this system of symbolic expression we call language, operations would never be more than successive, disconnected actions, that is, actions not integrated in systems of coordinated and simultaneous transformations" (Piaget, 1964, p. 113). Thus, although language had no explicit place in Piaget's theoretical definition of operational competencies, it was nonetheless considered a necessary factor of development.

The foregoing analysis already identifies some of the reasons why Piaget considered justifications quintessential to operational assessment. Operational tasks assess not only the true-false value of children's judgments and knowledge, but also their sense of logical necessity. Piaget assessed necessary knowledge by a variety of means—the child's justifications, her or his resistance to a variety of perturbing countersuggestions or to cues of perceptual seduction are cases in point. If critics simply disregard justifications and do not advance alternative but equivalent methods to assess necessary knowledge, they will either overestimate the cognitive competence under investigation or assess an altogether different competence (see the Chapman & McBride, 1992, study described earlier and Chapman & Lindenberger, 1992b).

In summary, the criticism that Piaget's theory is paradoxical because it assesses thinking through language, although incorrect when examined in detail, is both pertinent and opportune: pertinent because it comes from within Piaget's theory; opportune because Piaget failed to integrate the communicative component of interaction, investigated early in his career, with the

operative component of that same interaction, investigated later during his structuralist years. Justifications, however, far from being a nuisance in operational tasks are their most critical ingredient, one that calls for deeper exploration rather than elimination.

9. Piaget's Theory Ignores Postadolescence Development

Until 1970 Piaget used to mention that the stage of formal thinking begins sometime between 11 to 12 and 14 to 15 years of age, and that in this stage human cognition reaches a final form of equilibrium (see Inhelder & Piaget, 1955). These two statements underlie one of the most recent criticisms directed against Piaget's theory, namely, that it ignores cognitive development after adolescence, when all available evidence indicates otherwise (Alexander & Langer, 1990; Basseches, 1984; Commons, Richards, & Armon, 1984; Commons, Sinnott, Richards, & Armon, 1989).

Riegel (1975) was one of the first authors to state clearly the present criticism and to suggest an alternative, a fifth, postformal stage of development. The "dialectical stage," as he labeled it, is characterized by the fact that the individual "is able to accept contradictions as the basis of all thought and to tolerate conflicting operations without equilibrating them under all circumstances" (p. 61). Following Riegel's work, many other developmentalists have proposed a postformal stage identified by a variety of names: epistemological stage (Broughton, 1978), dialectical stage (Basseches, 1984), relativistic stage (Sinnott, 1984), stage of unitary operations (Koplowitz, 1990), and stage of discovery, not solution, of problems (Arlin, 1977). A few authors have gone further and suggested not one but three stages of postformal thinking (i.e., systematic, metasytematic, and cross-paradigmatic; Commons, Richards, & Kuhn, 1982).

According to its proponents, a postformal stage eliminates the shortcomings of Piaget's formal stage, namely, the fact that it ignores development after adolescence and that it stresses excessively cognitive features and structural aspects of development to the detriment of its constructivist and dialectical dimensions (Basseches, 1984). In contrast, a postformal stage allows us to handle the relativistic nature of knowledge, the acceptance of contradiction, and the integration of contradiction into an overriding whole (Kramer, 1983). To assess the adequacy, novelty, and implication of this criticism, consider the following three questions: (a) In what sense is Piaget's formal stage final? (b) How did Piaget revise over time his conception of formal operations? (c) What is the nature of the new postformal stages? We will answer each of these questions in turn.

His critics notwithstanding, Piaget never said that cognitive development stops after adolescence. What he did say was that the structure of formal operations is a final form of equilibrium, and this in two complementary senses:

Formal operations integrate in a single system the groupings that until then were not coordinated with one another, [and] the structure of formal operations is not modified during the life span of the individual, although it may be integrated into larger systems [such as polyvalent logics]. (Inhelder & Piaget, 1955, pp. 294-295)

In other words, *final* in Piaget's formal stage refers to the

structure, not the content, of the stage; it characterizes the operative way of solving physical, logical, and mathematical problems, and does not preclude, nor is incompatible with, a widening knowledge base in any domain of human experience, be it affective, emotional, or artistic (see also Kohlberg & Ryncarz, 1990). As Piaget (1972a) put it:

Certain behavior patterns characteristically form stages with very general properties. This occurs until a certain level in development is reached; from this point onwards, however, individual aptitudes become more important than these general characteristics and create greater and greater differences between subjects. (p. 8)

We also note that the proponents of a postformal stage do not characterize the new stage operatively because, in Linn and Siegel's (1984) words, "if stages are conceived, following Piaget, as logical structures, then formal operational reasoning is the zenith of stages" (p. 244). Furthermore, the existence of two distinct forms of cognition with different developmental paths—one more operative (e.g., mechanics of intelligence) and the other more content-based (e.g., pragmatics of intelligence)—has also been defended by students of adult cognition (e.g., Dittmann-Kohli & Baltes, 1990). Finally, although critics always refer to a single formal stage, Piaget himself reported the existence of different levels of formal thought in his formal stage (e.g., early formal thinking and full operational formal reasoning).

Concerning the question of how Piaget revised his conception of the formal stage, we observe that he changed the period for the stage's onset from 11 or 12-14 or 15 to 15-20 years of age (Piaget, 1972a); he stressed the stage context dependency and hence made it less epistemic; and in his writings on possibility and necessity (Piaget, 1981, 1983a, 1986), he characterized development as a permanent opening to new possibilities and as a never-ending process (see also Beilin, 1992a). The fact that these ideas were expressed late in Piaget's career partly explains why critics still claim that Piaget's theory ignores development after adolescence.

With respect to the nature of the various postformal stages, the whole issue remains controversial because these stages have not been defined with sufficient clarity as to yield a consensus among developmental psychologists (see Commons et al., 1990; Kohlberg, 1990). However, there is some evidence that such a stage is not structurally superior to the formal stage: "[If] postformal reasoning constitutes a stage at all, it is not logically superior to formal-operational reasoning" (Linn & Siegel, 1984, p. 244). Rather, the postformal stage may constitute a form of cognition parallel to formal thought, albeit with a practical, contextual, and meta-reflexive character (see Chandler & Boutilier, 1992). For instance, after assessing college students in a variety of formal and postformal tasks, the authors of a recent study concluded that "subjects showing full formal operational reasoning were not more likely than those showing early formal operations to be scored postformal" (Kallio & Helkama, 1991, p. 20). Similarly, a study designed to analyze how formal thinking relates to Kitchener and King's (1981) level of reflective judgment, nominally an indicator of postformal competencies, found that "formal operations do not account for differences in epistemic assumptions [reflective judgments]" (Kitchener & Brenner, 1990, p. 225).

Taken together, these results indicate that the postformal "stage" may not be stronger than the formal stage.

Additional evidence questions whether we need a postformal stage in order to explain adult achievements such as wisdom (Sternberg, 1990), expertise (Baltes, 1987), and especially the stage's most distinctive features—the acceptance of the relativistic nature of knowledge, the acceptance of contradiction, and the integration of contradiction into a new whole. Fakouri (1976) and Kramer (1983), for example, have argued that these features may be derived from, and hence explained on the basis of, formal operations. Kohlberg's (1984) extensive research on postconventional moral development also supports this conclusion because, in terms of cognitive development, only the formal stage is required to attain Kohlberg's postconventional stages.

In summary, Piaget did not ignore postadolescent development, as his critics have frequently claimed, and empirical studies have not shown unambiguously that from an operational viewpoint the postformal stage is more advanced than its predecessor. Ironically, most of the proponents of the new stage confess that the very target of their criticism, Piaget's formal stage, provides a good model to conceptualize their own postformal "stage."

10. Piaget's Theory Appeals to Inappropriate Models of Logic

It is well known that Piaget (1952, 1953, 1967d) used logic to characterize the several kinds of intelligence that emerge in development and their structural organization, and also to explore the formal analogies that exist between cognitive activities that at first glance appear to have nothing in common. It suffices here to recall the eight Piagetian groupings of concrete operations (Piaget, 1952), the 16 binary operations, and the INRC group of formal operations (identity, negation or inversion, reciprocal, and correlative; Inhelder & Piaget, 1955).

This recourse to logic has not been without its critics, however. According to some psychologists, by using logic and truth tables excessively, Piaget distanced himself from natural thinking, his major subject of inquiry (Basseches, 1984; Broughton, 1984; Bruner, 1992; Bynum, Thomas, & Weitz, 1972; Halford, 1990, 1992; Wason, 1977). According to some logicians (Ennis, 1978; Osherson, 1975; Parsons, 1960), Piaget violated norms of logic and advanced a propositional logic that yields "very odd results" (Ennis, 1982, p. 128). In a word, Piaget used too much logic for psychologists and too much psychology for logicians. In what follows we consider these criticisms in greater detail.

Logicians contend that Piaget proposed logical structures foreign to logic itself. For example, the unconventional Piagetian groupings are a mixture of the algebraic group structure and the lattice. Like the standard group, the Piagetian grouping has the properties of closure with respect to the operation involved (composition), associativity, general identity, and reversibility. Unlike the standard group, the Piagetian grouping has special identities, such as tautology and resorption. In common with the lattice structure, a Piagetian grouping has a *supremum*, that is, a least upper bound, but unlike a lattice, it has no *infimum*, or greatest lower bound (see Piaget, 1967d, and also Flavell, 1963).

Criticisms have also been based on empirical grounds. Psychological studies on the development of propositional logic have yielded results apparently at odds with Piaget's theory. Two such results, with opposite signs, have been used so frequently that they deserve special mention: The solution of the *modus ponens* logical argument by children as young as 5 to 6 years of age, and the generalized failure, even of intelligent adults, to solve Wason's (1968) classic four-card problem. Piaget's theory predicts incorrectly the child's failure in the former task and the adult's success in the latter. Thus, Piaget's theory of formal operations is wrong because it is too optimistic in some cases and too pessimistic in other cases (see Braine & Rumain, 1983).

To assess how relevant these findings and interpretations are, we will analyze three issues. First, what was Piaget trying to accomplish when he formalized the operatory activity of young children and adolescents? Second, what did it mean for Piaget to have formal thinking? Third, how did Piaget change his initial models of logic?

Piaget used models of logic because, according to him, psychological explanations should go beyond Aristotelian "efficient causes." They should describe, coordinate, and eventually integrate psychological phenomena into a coherent theory. Piaget believed that logic provided a language that could help psychologists achieve these goals, particularly when they decide to address the same sorts of issues that informed all his life: the formal organization of the distinct modes of thinking that emerge during ontogenesis, the level of modal understanding (e.g., contingency vs. necessity) underlying children's different epistemic states, and the universalizability of these ways of thinking and epistemic states. Thus, unlike logicians, Piaget was not interested in purely formal issues, or issues internal to logic, such as its axiomatic foundations. He wanted to develop an operational logic, a logic of action, a logic that in some sense would be a "*tertium*" between psychology and axiomatic logic"; as he liked to say, a logic that would be truly a "psycho logic" (Piaget, 1953, pp. 23–26). When we overlook Piaget's major interests and goals, his groupings look strange indeed.

Recent studies have now seriously questioned the surprising results obtained with the *modus ponens* logical argument (Ennis, 1975) and syllogistic reasoning in children (Hawkins et al., 1984), results hitherto thought to violate and even refute Piaget's theory. As discussed earlier in this article, the Markovits et al. (1989) study, for example, suggests that the reasoning problems at stake can also be solved through preoperational competencies such as transductive reasoning or other figurative nonlogical methods, as Piaget originally claimed (1967a). We also reiterate that for Piaget the distinctive feature of formal thinking is not the isolated solution of a particular problem but its combinatorial power (i.e., the subject's ability to envisage all possibilities). As Papert (1961) used to say, the main misunderstanding comes from the fact that Piaget looked for the algebra in the thought processes of the subject, not in the situation or the problem (see also Monnier & Wells, 1980).

Researchers also believe that the poor results in Wason's (1968) original selection task have to do more with a lack of understanding than with an absence of formal thinking. Two pieces of evidence substantiate this conclusion: Performance in this task improves remarkably when its content is made familiar

to the subject (Johnson-Laird, Legrenzi, & Legrenzi, 1972) or when initial practice is given to subjects (Ward, Byrnes, & Overton, 1990): "Over multiple studies, we have found that some initial practice in the mechanics of the selection task is necessary to maximize performance" (p. 834).

During the last years of his life, Piaget revised his models of logic substantially (Piaget, 1986; Piaget & Garcia, 1987). He considered the common criticism that his "psycho-logic" hinged excessively on Aristotelian truth-value tables and failed to solve the well-known paradoxes of material implication, that is, statements logically or formally correct but without meaning: "If Piaget is Swiss, Geneva is the capital of Switzerland. Piaget is Swiss. Therefore Geneva is the capital of Switzerland" (see Piérait-Le Bonniec, 1990; Ricco, 1990). Having realized that his initial model of formal operations had relied too much on extensional or truth-functional logic ("*logique extensionnelle*"), Piaget and Garcia (1987), in their book *Toward a Logic of Meanings*, tried to develop an alternative account, an intensional logic that did not reduce issues of meaning to issues of truth and that posited a strong interdependence of form and content (see also Ricco, 1993). In this new intensional logic the "central operation is what we call a meaning or signifying implication" (Piaget & Garcia, 1987, p. 11), not a material implication.

A meaning implication is an implication in which " p implies q if and only if a meaning of q is incorporated in that of p and this meaning is transitive" (Piaget, 1980b, p. 5). In modal logics (Anderson & Belnap, 1975) a meaning implication is also known as a *logic of entailment*. Piaget realized that an implication involving entailment is more meaningful and better organized than an implication not involving entailment. Compare "If I am a man, then I am mortal" with "If I am mortal, then I am a man." Whereas in the former case the negation of the consequent—"I am not mortal"—would be false and impossible, in the latter—"I am not a man"—it would be false but possible. Signifying (or meaning) and material implications are, therefore, two distinct modes of inference that map onto two different forms of organizing the possible and the necessary. In those cases in which there is a necessary rather than a contingent relation between the antecedent and the consequent, an entailment or meaning implication exists. In contrast, a material implication asserts only a conditionality between two events. In this vein one may think that truth-functional logic and material implication are to hypothesis testing as entailment logic and meaning implication are to constructivist accounts of causal explanations in science (see Piaget & Garcia, 1974, 1983; Ricco, 1993).

Some researchers have argued that Piaget's new logic constitutes a qualitatively new theory of formal operations (e.g., Beilin, 1992b; Byrnes, 1992; Garcia, 1992; Inhelder & Caprona, 1990; Matalon, 1990; Ricco, 1990, 1993). Some also believe that this theory will have major effects once psychologists take it seriously as a model of adolescent and adult thinking. Lourenço (1995), for example, studied how adolescents and adults handle conditional reasoning problems that vary in terms of type of implication (meaning vs. material), as illustrated earlier, and in terms of familiarity (compare "If I am a man, then I am mortal" with "If this is an archeopterix, then this is a bird"). The specific items included the four classic logical arguments *modus*

tollens, *modus ponens*, affirmation of consequent, and negation of antecedent (see Footnote 3). In agreement with the logic of entailment and the Piagetian logic of meanings, experiment participants performed significantly better on entailment problems than on corresponding nonentailment problems, a result found for both familiar and unfamiliar items. Surprisingly, when no meaning implication was involved, participants performed better with unfamiliar contents. According to the author, when entailment relations do not exist, the more unfamiliar the items are, the less disorganized and illogical they appear. These results suggest that Piaget may have been right when he argued that factual knowledge alone does not lead to correct performance and that, to an extent, to understand is to invent. They also hint at the heuristic potential of Piaget's new logic of meanings for both basic and educational psychology.

In summary, the criticism that Piaget used inadequate models of logic ignores the fact that he was primarily concerned with an operational, not an axiomatic, logic; that in his later writings he revised his model of formal operations considerably; and that he moved toward a logic of significations that stresses that from its very beginning knowledge always involves organization, inference, and meaning. So much for someone who is criticized for being too formal and abstract.

Conclusion

In 1983 the English psychologist David Cohen stated that "it was time psychologists ceased to be quite so obsessed with Piaget. . . . He deserves to be honored and remembered as one of the great psychologists, but as a psychologist of the past" (Cohen, 1983, p. 152). He also predicted that his book would be the last to assess Piaget as a contemporary psychologist. Twelve years have passed, and it is clear that as a material implication of empirical findings, Cohen's pronouncements are clearly overstated; as a meaningful implication of recent conceptual breakthroughs or the development of stronger theoretical approaches, his statements are at best of questionable validity. The time to move beyond Piaget is yet to come.

On further reflection, Cohen's suggestions had little chance of becoming true, and for one major reason: Piaget took very seriously the statement Plato wrote at the entrance of his Academy at Athens: "Let no one ignorant of Geometry enter here." Deeply interested in what he called "the two great mysteries of knowledge"—how new modes of thinking develop during ontogenesis and how they become psychologically necessary—Piaget exposed developmental psychology to new and profound issues. By his permanent concern with the relationship between knowledge and values, and between logical necessity and moral obligation, Piaget (1918, 1932, 1965) brought to the forefront of developmental psychology two dimensions, the good and the true, that help us enter the Platonic Academy and make sense of our everyday life (Habermas, 1979; Kohlberg, 1984; Rawls, 1971).⁸

Although we have not discussed explicitly some other criti-

⁸ Paraphrasing Einstein on Euclid, "if Piaget failed to kindle your youthful enthusiasm, then you were not born to be a developmental psychologist."

cisms directed against Piagetian theory (e.g., the learning of operational competencies), we believe the preceding analyses amply document how the majority of the current criticisms misrepresent the central themes and goals of Piaget's work; how they ignore the multiple refinements and revisions, some of them quite substantial, of his theory; how they rely on tabular asterisks at the expense of theoretical risks; and how they fail to grasp the full power of Piaget's dialectical, constructivist, and, of course, developmental assumptions.

Why is Piaget's theory so often misrepresented and unjustly criticized? Although tentative and speculative, the following reasons may shed some light on this issue. First, because Piaget wrote an enormous number of books, articles, and chapters, gathered a huge quantity of empirical data, and changed some of his core assumptions over time, the appearance of partial, diverse, disparate, and even contradictory readings of his theory and research was almost inevitable. In addition, too excited with the discovery of the unexpected, Piaget often disregarded accurate communication of his findings (many readers justifiably complain about Piaget's writing style). Second, the nonexperimental, "clinical" nature of his research, his nonstatistical style of data analysis, his concern with abstract constructs, his interest in scientific progress by means of integrative work, all of which run counter to predominant trends in psychology, also help to explain why his theory is frequently distorted and misunderstood. In his foreword to Flavell's (1963) well-known book, Piaget observed that "the differences between us stem from the fact that his [Flavell's] approach is perhaps too exclusively psychological and insufficiently epistemological while the converse is true for me" (p. viii). Needless to say that postmodernism in general (Kvale, 1992), and some information-processing approaches to cognitive development in particular (e.g., Kail & Bisanz, 1992), are more attracted by fragmentation and local knowledge than by grand theories or universal cognitive structures. Third, the contemporary tendency to see babies' minds in adult terms (Kaye, 1982), or the corresponding idea of infancy as paradise (Bradley, 1991), both at odds with Piaget's claim that children are logically different from adults, are also sources of dissatisfaction with, and distortion of, Piaget's theory. At a more specific level, we think that the ever-growing divorce between action and cognition, a divorce that pervades some dominant approaches to intellectual development (see Sternberg & Berg, 1992), also contributes to widespread misunderstandings of Piaget's thinking.

But it is our conviction that Piaget's theory has been misunderstood mainly because developmentalists have forgotten Piaget's major goals, to investigate the ontogenetic emergence of new forms of thinking and the construction of necessary knowledge. They persist in thinking that developmental psychology is concerned with children, adolescents, and adults at specific ages rather than with how they develop over time; they persist in studying cognitive truth, not logical necessity.

We can certainly analyze Piaget's contributions from without his theory, as the majority of his critics have done. But it is also important to understand those contributions from within, while we keep in mind the purposes, issues, and concepts that informed Piaget's scientific work. We hope students of psychology in general and development in particular will continue to

discuss Piaget's theory in the years ahead. That is, after all, a necessary condition for truly moving beyond it.

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