schema-specific tool-using skills. This should be possible even for human infants because, contrary to what Chevalier-Skolnikoff suggested, the range of tertiary-circular reactions reported for human babies appears limited.

Preoperational and higher levels of intelligence require the construction of hierarchical manipulative and conceptual schemes from simpler units (Case 1985; see also Gibson 1983a; 1988; in press). Thus, a second task also lies ahead – the analysis of species-typical levels of mental constructional ability. This will be a quantitative task. It involves counting the number of objects and relationships used together simultaneously or in succession to meet a single end as well as determining the levels of hierarchical integration possible. I urge other investigators interested in comparative intelligence to read Case's neo-Piagetian perspectives and to follow his quantitative analytical methodology rather than the one presented by Chevalier-Skolnikoff, which I find confusing and subjective. The pioneering analysis presented by Parker (1977) is also adaptable to this perspective.

Cebus uses tools, but what about representation? Comparative evidence for generalized cognitive structures

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Ontogenetically, tool use *is* the byproduct of Stage 5 sensorimotor development. If the human species' capacity to use tools depends on this cognitive development then it makes sense that this would also be the case in other related species. More important, the evolutionary history of tool use would depend on the evolution of the requisite cognitive abilities. In other words, Chevalier-Skolnikoff's thesis concerning the origin of tool use has evolutionary logic as well as detailed comparative data to support it.

The main alternative view seems to be that tool use is conditioned as an operant response. If we consider the structure of an operant, we find that it is defined as a response that has been emitted and then reinforced, increasing its probability of future repetition. If we translate an operant into Piagetian terms, we find that it is, by definition, Stage 3 sensorimotor behavior. At Stage 3, a response produces an unintentional effect (the reinforcer, in operant terms), which leads to a repetition of the response, this time with an intentional effect. However, as Chevalier-Skolnikoff has demonstrated, Stage 3 behavior does *not* constitute full-fledged tool use, which has an intentional quality from its very initiation. In other words, operant conditioning cannot explain tool use because it is *by definition* at a lower cognitive level than tool use itself. It also cannot explain the evolution of tool use or species differences in the tool-using capacities: All species can be operantly conditioned; only a few species can use tools.

A second point I would like to raise vis-à-vis Piaget is the relation between insight and representation. Chevalier-Skolnikoff takes *insight* to be the hallmark of sensorimotor Stage 6. However, for Piaget the hallmark is *representation*. These are not the same. Based on Koehler (1927) and other classic sources, Chevalier-Skolnikoff defines insight as "behavior that involves sudden solutions to problems and shows that what is learned during previous experiences is reorganized to suit the requirements of new situations." Representation, in contrast, involves the use of some sort of mental model.

Chevalier-Skolnikoff agrees with critics of insight that insightful tool use is difficult to verify empirically. I would maintain that this is not a problem for representation. There exist behavioral indices which can show that an animal has a model in mind, as when an animal *searches* for a tool to carry out a particular task. (This seems to have been done by chimpanzees, according to examples in Table 14.) In such a case we can infer that a model of the requisite tool guided the search.

However, my careful reading of the examples given in the tables did not turn up one instance indicative of representation in the *Cebus* monkeys' tool use. In all cases where Chevalier-Skolnikoff has classified *Cebus* tool use as Stage 5 or 6, I would put it at 5. Her one Stage 6 classification appears to me to be ambiguous between 5 and 6: In Table 7, a *Cebus* is reported to pick up a nut, then a stick, carry both up onto a rock, put the nut down in an indentation in the rock (from which it will not roll) and hit it with the stick to crack it. I do not believe that we have enough information to know whether the critical feature of Stage 6 – mental representation – is involved.

If the monkey *remembered* the indentation and went to the rock *in order* (i.e., with prior intentionality) to utilize the indentation, mental representation is involved and this would be an example of Stage 6. Or if the monkey looked around *with the prior intention* of finding a rock to serve as a substrate, mental representation would be involved and this would be Stage 6 behavior.

However, if the monkey had the rock in his view at the same time as the nut and the stick and merely recognized the indentation as useful after finding it by chance, no mental representation would necessarily be involved, and this example could not be classed as Stage 6. With the information given, the example provided is ambiguous between Stages 5 or 6. My view, based on these data, is that *Cebus* has stopped at sensorimotor Stage 5 in the area of tool use (although there were two clear examples of Stage 6 *imitation:* imitation of an absent – i.e., represented – model).

As far as I can tell from reading Chevalier-Skolnikoff's target article, the reason for the discrepancy between her classifications and mine lies in the fact that she has put too much emphasis on the *immediate* solution of problems, that is, *insight,* and not enough on *representation* in her definitions of Stage 6. The primatologists' interest in insightful learning has been superimposed on Piaget's definition of Stage 6 capabilities, changing the criterion in the process. I feel that it is important to maintain the Piagetian criterion because representation is central to language and the issue of primate linguistic capacities is of course an important and controversial one. If *Cebus* does not develop full-blown Stage 6 behavior across various sensorimotor domains, we would not expect *Cebus* to develop human-like language, which so far it has not.

A final point relates to the challenges to Piagetian theory referred to by Chevalier-Skolnikoff: the claims that evidence of abstract underlying structures – Piaget's generalized stages – is lacking in studies of human development. Chevalier-Skolnikoff herself has provided comparative evidence on just this point. A major type of evidence for underlying structures is correlated structural development across domains. Chevalier-Skolnikoff finds that species that reach sensorimotor Stage 5 in the domain of tool use also reach it in the domain of imitation and intelligent (cause-effect) behavior more generally. In contrast, species who do not use tools do not reach Stage 5 in imitation or general cause-effect behavior. Hence there is a cross-species correlation between stage development in different domains.

Stage 6 correlations are less clear, but that is because the evidence for Stage 6 behaviors is sparse in any domain for any species considered by Chevalier-Skolnikoff. If we therefore consider only the dividing line between Stages 4 and 5, there *is* a correlation between a species' ability to reach stage 5 in a variety of sensorimotor domains; a species reaches Stage 5 in all domains or in none at all. This is empirical support for the unity of underlying sensorimotor stages that could not be obtained with human data alone; it relies on comparative methodology. In conclusion, Chevalier-Skolnikoff has perhaps the strongest evidence available so far to counter the Piagetian critics who claim

that there is no evidence for generalized sensorimotor structures.

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The right tools for the job?

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The idea of extending theories of ontogenetic mental development to phylogenetic differences can be traced back at least as far as Hobhouse (1902; see Langer 1988). However, even if one were able to find a universally accepted theory of mental development, its extension to cross-species comparisons cannot be taken for granted. This is simply because the questions and issues deemed to be interesting in ontogeny are not always those deemed to be of relevance in phylogeny. In the case of Piagetian theory, this problem is compounded by the existence of a growing body of counterevidence regarding human development.

Some ten years of subtle research and theorizing about infancy have challenged Piaget's view of the neonate and young infant (Anderson 1988; Baillargeon 1986; Diamond & Gilbert, in press; Leslie & Keeble 1987; Mehler & Bertoncini 1988; Rutkowska 1987; Slater et al. 1983; Spelke 1982; Starkey & Cooper 1980). For example, elaborate imitative ability is already within the competence of newborns (Meltzoff 1981). Furthermore, infants at around 12 months have now been shown to have complex problem-solving and planning capacities (Willats & Rosie 1988). Indeed, the very notion of a purely sensorimotor period of intelligence, for example the lack of symbolic representations in infancy, has been convincingly called into question (Mandler 1983a; 1988). Thus, although we were impressed with Chevalier-Skolnikoff's careful observations of *Cebus* behaviour and her subtle distinctions between inclination to manipulate objects, attention span, and spontaneous tool use, we were surprised to note that the target article totally ignores most of the important new work on infancy, despite its obvious consequences for the sensorimotor bases of Piagetian theory. This problem with the Piagetian account of human mental development aside, we continue to have reservations about the applicability of the theory to development in other species.

Chevalier-Skolnikoff supports the use of the Piagetian framework for mental development in *Cebus* by virtue of the fact that both the early environment (reared in the wild) and age are important factors for the development of tool use in any individual. However, the Piagetian framework is not the only one to take both environment and developmental stage into account and not the only contrast with the "trial-and-error" learning that Chevalier-Skolnikoff rightly rules out (see for example, Karmiloff-Smith 1986; 1989). Moreover, environmental deprivation does not always result in impoverished human cognition. Cerebral palsied teenagers, although having never held pen to paper, can demonstrate elaborate geometric knowledge when provided with appropriate computer aids (Papert, personal communication). Similarly, deaf children of hearing parents invent a rudimentary form of syntactically structured sign language without any environmental model (Goldin-Meadow 1982).

Even if one were to accept that sensorimotor capacities of *Cebus* are analogous to those of human infants, the next question becomes: What's so special about human intelligence then? [See Macphail: "The Comparative Psychology of Intelligence" *BBS* 10(4) 1987.] For example, why does *Cebus* not go on to acquire the rudiments of language, since an integral part of the Piagetian argument is that the sixth stage of sensorimotor intelligence culminates in the semiotic function, of which language, drawing, deferred imitation, and so on, are, according to the theory, the manifestations. Chevalier-Skolnikoff argues that she has demonstrated a causal link between Stage 5 and 6 functioning and tool use, but it is just such a causal link that Piagetians put forward between Stage 5 and 6 functioning and language (Sinclair 1971). Without going outside the theory and invoking a maturational (i.e. biologically prespecified) component, it is difficult to see why there should be a strong causal relationship in the one case and none in the other. There are alternative theories which suggest that sensorimotor intelligence develops in a modular fashion, totally independent of other capacities such as language (Chomsky 1975; Fodor 1983; Marshall 1984), but this entails the adoption of a very different view from the Piagetian one. Although we believe that the Piagetian account of early mental development in both species is flawed, it is still conceivable that the theory would be useful for the specific purpose of comparing between species. Leaving aside the difficulty of trying to use a theory specifically developed for one species to compare of several species (Johnson 1988), the vagueness of the conclusion reached by Chevalier-Skolnikoff that "new genotypes for more complex brains . . . mediated more complex cognitive functioning" is indicative of the inappropriate level of abstraction at which the Piagetian framework is pitched for addressing questions about the subtle interactions between the environment of a species, its social structure, infant rearing practices, and genotype which would give rise to the ability for tool use. For example, according to Jolly (1972), *Cebus* monkeys in the wild systematically take apart dead branches and rolled up leaves with their fingers while probing and poking for concealed larvae to eat. Spider monkeys, in contrast, confine themselves to fruit. Similarly, *Cebus* locomote by climbing, springing, and running along branches leaving their arms free, while spider monkeys mainly swing with their arms (Napier & Napier 1967). Either or both of these differences may contribute to the development of tool use.

These considerations, together with the recent comprehensive review of the application of the Piagetian framework to comparative issues by Dore and Dumas (1987), suggest that an alternative approach to comparative cognitive development might now be timely. There may well be subtle differences in the generally similar sensorimotor development between human infants and *Cebus*. For example, imitation in human infants is very precocious (Melzoff 1981), yet seems to follow a U-shaped curve (Maratos 1982; Vinter et al. 1982). These so-called regressions at the level of behaviour in a number of areas of human development are frequently indicative of progression at the level of internal representations (Karmiloff-Smith 1987; 1988). To our knowledge there is no evidence for such a developmental pattern in other primates. Sensorimotor intelligence per se cannot explain this. It is our belief that if cross-species comparisons are to break new ground descriptions of external behaviour, however subtle and detailed, must give way to models of internal processes.

Piagetian stages and the anagenetic study of cognitive evolution

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Two issues have historically posed problems for comparative psychologists. The first concerns whether animals can be said