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The Assessment of Primate Intelligence*

The principal difficulty in the comparative assessment of intellectual or learning skills is that the results of such assessments may be confounded by species differences in sensory, motor, motivational and other capacities. This may be overcome by assessing basic learning and conceptual abilities along the proposed ordinal scale of levels of these abilities. Each level may be assessed for a given species by using tasks which are suited to that species' sensory, motor, motivational and other capacities. A species is tested until its highest level of attainment is determined. The total scale, which is suitable for use with all animals, ranges from the simplest kind of learning (habituation) to three levels of concept learning which are based on the types of logical operations involved (I affirmation; II, conjunction, disjunction, and conditional; III, biconditional). Within these levels, as will be shown, the precision of measurement may be increased via the introduction of logically determined sublevels. The scale may be retroactively applied to existing literature as will be shown. Practical procedures for assessments, such as animals' abilities to use biconditional concepts, which apparently have not been done will be described.

1. Introduction

Interest in the comparative study of intelligence was present from the time when psychology emerged as a discipline separate from philosophy and physiology, and the assessment of intelligence has been controversial since that time (e.g., Romanes, 1882 versus Morgan, 1894). In recent years interest in the comparative assessment of intelligence has continued (e.g., Harlow, 1958; Nissen, 1951, 1958; Razran, 1971; Rensch, 1967) but as yet, no widely accepted approach to assessment has emerged.

A problem which must be considered by anyone who proposes an approach to the comparative assessment of intelligence is that of the potential confounding of relatively intellective with relatively nonintellective aspects of behavior. One species might perform poorly compared to another, because it has less ability to detect and discriminate among the stimuli used in the intelligence test, or the response (motor) requirements might be easier for one species, or the motivating conditions might not be equivalent, etc. Such confounding variables have been enumerated previously (e.g., Bitterman, 1960; Dewsbury, 1978; Hodos, 1970; Nissen, 1951; Warren, 1974), and in this context it has been suggested that measures which reflect *quantitative* differences among species should not be used to argue that one species is more intelligent than another. The view is that quantitative differences might reflect differences in the nonintellective aspects of testing as opposed to intellective differences. Regardless of the number of trials a species representative takes to meet a criterion of successful performance on a task, if it can meet that criterion the intellectual capacity assessed by the task may be said to be among that species' repertoire.

It has been suggested that species comparisons of intelligence should be based on *qualitative* similarities and differences. One should attempt to determine which abilities are

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and which are not within a species repertoire. The sensory, motor, motivational, etc. conditions of testing should be adapted to each species. While it may not be possible to establish *equitable* testing conditions (in terms of sensory, motor, motivational, etc. requirements), it should be possible to render such variables *suitable* for testing any species. The test and comparative results which emerge should reflect the *cognitive* demands of the task and capacities of the species rather than sensory, motor, etc. differences.

If the foregoing arguments are accepted as being reasonable, it would seem to follow that intelligence measures should be able to assess distinguishable degrees of cognitive capacities. Implicit in this view is that the tests should comprise a logically and/or empirically based hierarchy of cognitive requirements. Several contemporary approaches have involved hierarchies of cognitive requirements. However, these have been found lacking or questionable in one or more respects. It will be useful to consider three varieties of these before describing the approach advocated in the present paper.

2. Razran's Approach

Razran (1971; see Epilogue) described "an evolving multiformity of the basics of learning —specifically to an ascending hierarchy of no less than eleven delineated levels . . .". The eleven were combined into four "superlevels" as follows: *reactive* consisting of (1) habituation and (2) sensitization; *connective* consisting of (3) inhibitory or punishing conditioning, (4) classical conditioning, and (5) reinforcing conditioning; *integrative* consisting of (6) sensory-sensory learning, (7) configuring, and (8) eductive learning; and *symboling* consisting of (9) symbosemic, (10) sememic, and (11) logicemic.

One difficulty with Razran's hierarchy is that his definitions (particularly at the integrative and symboling levels) are not always sufficiently clear to suggest how tasks with common cognitive requirements might be constructed which might also be varied to meet the non-intellective requirements of different species. This difficulty is increased by his uncritical acceptance of some studies as being illustrative of certain categories which have been found to be inconclusive on logical grounds by other investigators (for example, compare Razran's discussions at the beginning of chapter 10 with Strong & Hedges, 1966, and Thomas & Boyd, 1973). Furthermore, Razran's linkage of symboling with communication together with his conclusion that symboling is unique to humans runs counter to experiments which suggest that primates can both perceive and respond symbolically (e.g., Czerny & Thomas, 1975; Premack, 1976; Rumbaugh, 1976). Overall, it is suggested that while Razran's approach is well developed in many ways and has considerable promise, it also may require further development and possible revision before its utility may be clearly assessed.

3. Harlow's Approach

Harlow (1958) considered the evolution of learning and described an approach to assessment which is elegant in its simplicity and which has considerable potential for development. The basic strategy is to order a series of tasks in terms of the number of ambiguous cues. It is assumed that the difficulty of the task increases as the number of ambiguous cues increases. Harlow illustrated a one-ambiguous-cue task with a circle versus triangle discrimination; in this case, "object" was relevant and position (the left-right position of the object to which responses were reinforced was randomized) was ambiguous. Actually, a point which will be pertinent below, the shape attribute of "object" appeared to be relevant rather than size and color which appeared to be held constant (i.e., neither relevant or ambiguous).

The principal difficulty with Harlow's approach is with some of the examples that he used. For example, the two-ambiguous-cues task was illustrated with the "two-odd problem" (see French, 1965), and according to Harlow both position and "object" *per se* were ambiguous; the "odd or singly represented object" was said to be relevant. However, another solution to this task is possible; namely, the animal might learn which object was correct in each of the six (only) patterns associated with the two-odd problem (symbolically: AAB, ABA, BAA, BBA, BAB, ABB). That is, the animal might learn the six specific patterns or configurations of stimuli. If so, it would seem that object and position would gain relevance and no longer be ambiguous cues. This objection is minor, however, because good examples of problems with two, three, four, etc. ambiguous cues may be constructed. On the other hand, more than one type of task may be constructed for each number of ambiguous cues, and it becomes an empirical question whether two problems with the same number of ambiguous cues may be performed with equal ease. Harlow's approach awaits further development and implementation before its full merits may be determined, but as noted earlier, the approach has considerable promise.

4. The Piagetian Approach

Several investigators in recent years have attempted to adapt Piaget's theory and methods, which were developed to assess cognitive development in humans, for the assessment of cognitive processes in non-human animals. Much of the impetus for this approach may be attributed to Jolly (1972), and Parker & Gibson (1979) have recently advocated it strongly. However, two major objections may be raised concerning the Piagetian approach.

First, much of the research has involved testing single animals using rather straightforward adaptations of the methods used to test children. Unfortunately, in both cases but particularly with non-human animals, this leaves many questions concerning experimental controls unanswered. This in turn leaves interpretations of the data in terms of the cognitive processes involved unclear. For example, Czerny (1977) examined several of the studies which have claimed to demonstrate "object Permanence" and found them to be inconclusive in that the possibility existed that the animals may have performed correctly by using position cues. Additionally, one of the better controlled studies conducted in the Piagetian framework using animals was Pasnak's (1979). However, even Pasnak's thorough consideration of control procedures, as may be seen (see the Procedure section of Experiment 2), speaking strictly, left some questions as to the adequacy of controls unanswered.

The second objection to the Piagetian approach is more serious. This concerns the role of verbal explanation as part of the evidence necessary to establish a subject's use of certain Piagetian cognitive processes. This issue has been very controversial among those who study humans (e.g., Brainerd, 1973; Miller, 1976; Siegel, 1978), and it has been discussed in the context of animal research (e.g., Czerny & Thomas, 1975; Thomas & Peay, 1976). It will be useful to consider a major example.

Conservation is the term Piaget used to describe the cognitive process whereby a subject recognizes that the quantity of a substance remains unchanged despite physical transformation of its appearance. Typically, a subject is shown two perceptually identical examples of a substance (e.g., two identical beakers of water). Then one or both instances are transformed in appearance (e.g., poured into vessels of different sizes and shapes), and the subject is asked to judge after transformation whether the substances are the same or different. One problem which arises is that two kinds of correct same-different judgments are possible, one based on "equivalence" and one based on "identity" (Elkind, 1968). The identity judgment is critical to establish conservation. Based on equivalence, a subject might judge the transformed substances to be the same, because the subject is a good judge of physical equivalence of quantity despite dissimilarity of appearance; the point is that the subject need not have realized that the substance was actually the same substance both before and after transformation. To distinguish between the equivalence and identity solutions, the child's verbal explanation is used. Such verbal explanations can not be forthcoming with animals. Therefore, the investigator may be unable to determine whether the identity or equivalence judgments were used and, thus, whether the animal has demonstrated conservation. On the other hand, a recent study by Woodruff *et al.* (1978) suggests strongly that their chimpanzee Sarah used conservation, because their study indicates that Sarah's successful performance depended on her use of the information provided by the transformation process. The difficulty with this study, however, is that even if one is willing to accept the *circumstantial* evidence in favor of the identity solution provided by Sarah's use of the information in transformation, it appears that Sarah's performance may be sufficiently unique to suggest that replication may be extremely difficult except with an animal having Sarah's extensive history of training (Premack, 1976).

Briefly (and the reader will have to consider the following points carefully in the context of Woodruff *et al.'s* procedures), it is suggested that: (a) Sarah brought considerable general experience in making sameness-difference judgments to the Piagetian testing situation; had it been necessary to train her to make sameness-difference judgments either in the specific or, merely, temporal context of her Piagetian testing, that might have biased her performance in favor of the equivalence solution discussed above; (b) Sarah's considerable prior experience also enabled her to perform without trial-by-trial reinforcement; the relevance of this may be seen in the following point; (c) It was necessary, but perhaps fortuitous, that she *fail* the critical control test designed to establish her use of the transformation information; had it been necessary to reinforce each of her responses, she might have used equivalence judgments and passed the test.

Although some investigators have used extensive control procedures, it is suggested that controls in the majority of studies in the Piagetian framework have been inadequate. Additionally, the unresolved problem concerning the role of verbal explanation suggests that the use of Piagetian methods to assess cognitive development or comparative intelligence of animals is premature.

5. A Non-concept Learning—Concept Learning Hierarchy

This approach to the comparative assessment of intelligence avoids the difficulties of those described above. It (hereafter abbreviated NL/CLH) has been described in detail elsewhere (Thomas, 1980) and will only be summarized briefly here. The remaining space will be used to emphasized those aspects of the hierarchy which are most relevant to the assessment of primate intelligence and will consider some points not previously discussed.

Basically, the NL/CLH combines some aspects of the general learning hierarchy described by Gagné (1970) and the concept learning hierarchy described, among others, by Haygood & Bourne (1965) and Millward (1971); habituation, a basic kind of learning not included by Gagné, was added to these. The first five levels of the eight level hierarchy involve non-concept learning. Briefly, these are:

(1) Habituation—a learned decrement in responding which is seen upon repeated presentation of a stimulus.
(2) Signal Learning—this is synonymous with Classical or Pavlovian Conditioning.
(3) Stimulus-Response Learning—this is synonymous with simple instrumental conditioning or discriminated operant conditioning.
(4) Chaining—a chain of two or more stimulus-response connections (i.e., stimulus-response learning at level 3) is learned.
(5) Concurrent Discrimination Learning—two or more stimulus-response connections (from level 3) are learned independently (i.e., not chained) and concurrently.

Rensch (1967) provided data which suggest that fish, reptiles, birds, and mammals (apparently amphibians were not tested) are capable of performing at level 5. Assuming that testing conditions are suitable, the *number* of concurrent discriminations which each species can learn might be used to discriminate intellectually among species. However, it would be premature to do so until the presence or absence of conceptual ability in each species has been determined. If an animal can discriminate *conceptually*, the number of concurrent discriminations of which it is capable is practically unlimited (e.g., if an animal has the concept "tree", it may be able to distinguish thousands of trees from objects which are not trees). In any event, intellectual distinctions among primates, several species of which have been shown to perform conceptually, are likely to occur among the three levels of concept learning in the NL/CLH. The remainder of this paper will consider concept learning.

6. Three Levels of Concept Learning

Before specifying the levels, two issues should be considered. The first is that of the definition of conceptual behavior or, alternatively, the basic condition necessary to demonstrate conceptual behavior in a non-human animal. We (Thomas & Kerr, 1976, p. 335) suggested that "Conceptual behavior . . . refers to selective responses to stimuli which are consistently correct in terms of predetermined and discoverable reinforcement contingencies but which do not depend upon prior experience with the specific stimuli presented on a given trial". The principal point here is that to have a demonstration of conceptual behavior one must set the testing conditions to preclude the possibilities of *specific* stimulus or pattern learning. It may be noted that several claims in the literature that conceptual behavior was shown by an animal failed to preclude these possibilities. Such claims must be regarded, at best, as being inconclusive, since they confound conceptual with non-conceptual interpretations of the data.

The second issue concerns the problem of nomenclature. The terms used in the literature are confusing and conflicting. For example, while there is apparently considerable overlap among the meanings of Ellis' (1972) *concrete* concepts, Gagné's *concrete* concepts, Nissen's (1951) *class* concepts, and Premack's (1978) *absolute class* concepts, there are also differences. Gagné's concrete includes "oddity", but for Nissen oddity is an *abstract* concept and for Premack it is a *relational* concept. Whereas "tree" is a concrete concept for Gagné and Ellis, it is an *absolute* concept for Premack and a *thing* concept for Nissen. Nissen's *thing* concepts appear to correspond to *natural categories* as studied by Rosch (1973) or *natural concepts* as studied by Herrnstein *et al.* (1976). Many more examples might be cited. The present paper uses a taxonomy which, if adopted widely, might serve to eliminate such confusion.

The three levels of concepts here (which, as noted earlier, follow Haygood & Bourne, 1965, and Millward, 1971) are defined explicitly in terms of the logical operations or connectives involved. The levels, (continuing from above) are:

(6) Affirmative Concepts—these are based on the definition cited from Thomas & Kerr (1976) above and involve only the logical operation affirmation and its complement, negation. (Actually, the principal operations described at each of these levels of concepts have their complements; see Haygood & Bourne, 1965, or Millward, 1971. However, the complementary operations will not be considered further here.)
(7) Conjunctive, Disjunctive and Conditional Concepts—these determine relationships among elements, at least one of which must be an Affirmative Concept.
(8) Biconditional Concepts—these also determine relationships among elements, at least one of which must be an Affirmative Concept.

In addition to the terms provided by the logical operations and in order to preserve and specify some terms which are used widely in the literature, we (Thomas & Crosby, 1977) suggested that Affirmative Concepts be described synonomously as Class Concepts and that concepts involving the *explicitly* relational logical operations (levels 7 and 8) be defined as Relational Concepts. Further, we made a specific *operational* distinction between two kinds of Class Concepts, namely Absolute and Relative Class Concepts. With the former, it is *not* necessary to compare stimulus choices in order to affirm an instance of the concept. For example, if one has the concept "tree" and sees a tree, it is not necessary to look at other stimuli to affirm the presence of the tree. With Relative Class Concepts, it is necessary to compare stimulus choices in order to affirm an instance of the concept. For example, to choose the "larger" of two stimuli or the "odd" one among three stimuli, it is necessary to examine the other stimulus choices.

This nomenclature, with its bases in the logical operations and the operational distinction related to the necessity to compare, readily clarifies the confusion among the terms cited above from Ellis (1972), Gagné (1970), Nissen (1951) and Premack (1976). There may be utility in preserving such terms as Nissen's *thing* concepts, Rosch's *natural categories*, or Herrnstein *et al.'s natural concepts* above (all of which may be seen as types of Class Concepts).

7. Primate Intelligence

The present approach is appropriate for the assessment of primate intelligence, including that of humans, because it may be argued that *all* conceptual knowledge is structured in terms of Class and Relational Concepts as defined here (see Thomas & Crosby, 1977, and Thomas & Ingram, 1979, for further discussion of this point). Class Concepts provide the elements of knowledge and Relational Concepts refer to the ways that Class Concepts and non-conceptual stimuli may be combined to form complex knowledge. With non-human animals, the tests of the complexity in the ways that they can perform Relational Concepts will presumably involve Class Concepts based on physical stimuli (e.g., "trees", "triangles", "bigger", "fewer", etc.), although, presumably, more abstract concepts might be studied, even in animals, if they are operationally defined in terms of measurable antecedents and consequents (i.e., treated as intervening variables). In any event, according to the present model, intelligence at the higher levels is reflected in the complexity of conceptual relationships which one can use (manifest in behavior).

The initial question is whether it can be demonstrated that a given species performs successfully on tests of absolute and relative class conceptual behavior. Then, one might ask whether it can perform such concepts in conjunctive, disjunctive, conditional, and biconditional relationships. Several species of primates have been shown to perform conceptual conditionals. Apparently, there have been no conclusive demonstrations of a non-human species having performed conjunctive and disjunctive concepts, although some of Premack's work (1976) strongly suggests this possibility with the chimpanzee. Apparently, there has been no attempt to study non-human animals' use of biconditional concepts. It may be noted that practical procedures for assessing conjunctive, disjunctive, and biconditional conceptual behaviors may be found in Thomas (1980).

There have been conclusive demonstrations of level 7 conceptual behavior (viz., conceptual conditionals) with several species of non-human primates, and it is suggested that eventually several species of non-human primates may be shown to be capable of biconditional concepts. Thus, it is of interest to be able to improve the precision of measurement in order to be able to distinguish among species which achieve the same general levels of performance. It has been shown (Thomas, 1980) that the precision of measurement can be increased systematically at levels 7 and 8, thereby permitting sublevel measurement such as 7·1, 7·2, . . . 8·1, 8·2, . . . etc. Precision can also be increased systematically at levels 4 and 5, permitting distinctions to be made among species which achieve only those general levels; as suggested here earlier, this involves the *number* of chained or concurrent stimulus-response units an animal can learn. Precision of measurement may also be increased at level 6, for example, by varying the number of ambiguous, relevant, and constant cues which determine the correct concept (an adaptation of Harlow's, 1958, approach described in an earlier section). Since such cues might be varied along more than one dimension and in more than one paradigm (e.g., conceptual matching-to-sample, oddity, and sameness–difference pardigms), it will be necessary that one who compares species do so with comparable procedures.

8. Concluding Remarks

It is not, of course, suggested that the intellectual capacities assessed by the NL/CLH described here reflect, necessarily, capacities which an animal might use in its natural environment. Certainly, it is not suggested that even if an animal can use Relational Concepts under laboratory conditions that it is aware of or that it understands the basis of its performance. Yet, it is not unreasonable to suggest that some animals, particularly primates, might make choices in their natural environments which involve conjunctions, conditionals, etc. even though they may not understand the role of the operations in these choices. By way of analogy, it is obviously within human capacity to use conjunctions, biconditionals, etc., both singly and in complex combinations, but relatively few humans could explain the role of the logical operations in their judgment processes (of course, it might help to have studied symbolic logic).

It is not unreasonable to suggest that non-human animals, like humans, might have acquired these capacities despite the probable absence of direct selection pressures to do so. There were obviously no selection pressures for prehistoric humans or even humans until recent centuries to develop the capacities to build microcomputers. On the other hand, it is worth noting that the basic operations of computers involve no more than the logical operations and their complements as summarized here in levels 6–8 of the NL/CLH (actually, no more than a subset of these). It is also worth noting that, according to Turner (1967), Whitehead & Russell's *Principia Mathematica* attempted to base all mathematics on only four of the operations: negation, conjunction, disjunction, and implication (conditional). In sum, as suggested earlier, all knowledge is reducible to conceptual and nonconceptual elements which are related in terms of the logical operations. From an evolutionary standpoint, it is of interest to know where in the animal kingdom such processes as those which involve Class and Relational Concepts are represented.

Although the present scale (i.e., the numerical values associated with the levels and sublevels of the NL/CLH) reflects only ordinal measurement, it provides a significant step towards the quantification of comparative intellectual capacities. Such an index should be extemely valuable in conjunction with comparative brain indices to determine whether there is a correlation between the evolution of the brain and the evolution of intelligence. Another possible use of the quantification of intelligence suggested here might be in the assessment of the roles of genetics and environmental experiences to intelligence. Experimental controls which may be used with animals may help to eliminate the unavoidable confounding which occurs when the data are derived from studies with human subjects.

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