CONDITIONAL REASONING BY NONHUMAN ANIMALS

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Synonyms

Conditional association, conditional discrimination learning, conditional rule learning, if-then reasoning, if-then rule learning, logical reasoning, relational concept learning

Definition

Conditional reasoning (*conditional association* or *conditional rule-learning* might be better terms) means that, when performing complex tasks, animals should partition discriminanda consistent with the truth-table manifestations for the conditional in symbolic logic (see example below). Conditional reasoning is representative of relational concept learning at the next-to-highest level of intellectual capabilities based on Thomas's approach to assessing animal intelligence (e.g., Thomas, 1980; Bailey, McDaniel & Thomas, 2007).

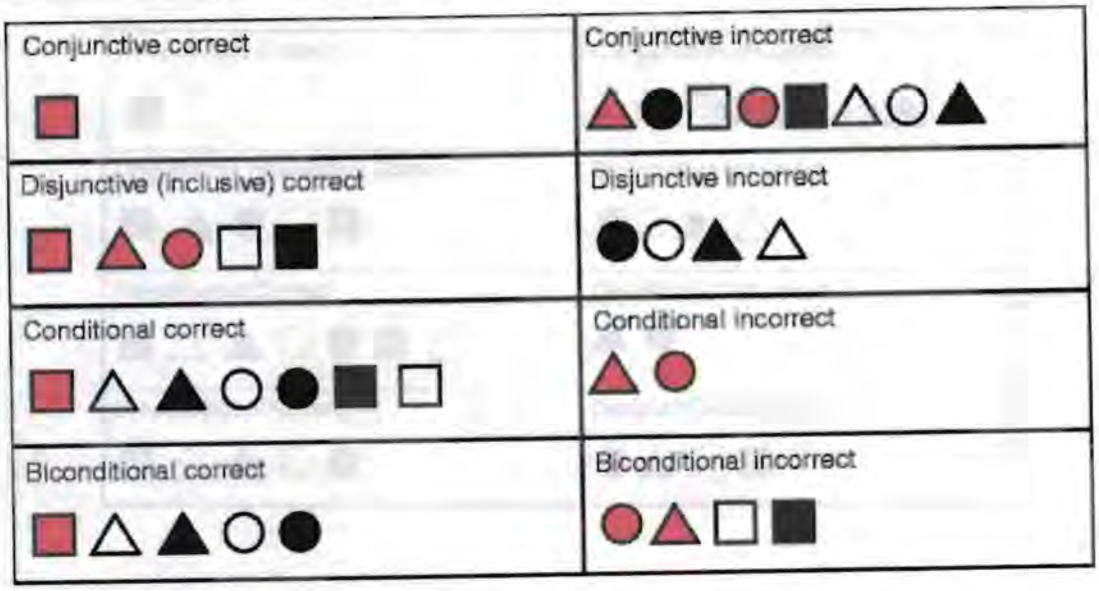
Theoretical Background

It is generally accepted in the human concept learning literature that a nonverbal, experimental demonstration of conditional reasoning must result in the partitioning of discriminanda consistent with the truth-table manifestations specified for those discriminanda by the conditional in symbolic logic (Borne, 1970). Attending first only to the bold print letters and symbols in the truth-tables below, consider both the conditional and the conjunctive, because all known experiments using nonhuman animals have confounded conjunctive and conditional reasoning as potential explanations for successful performances.

Conjunctive				**Conditional**		
p	**q**	**p & q**		**p**	**q**	**p > q**
T red	**T** square	**T** correct		**T** red	**T** square	**T** correct
T red	**F** not-square	**F** incorrect		**T** red	**F** not-square	**F** incorrect
F not-red	**T** square	**F** incorrect		**F** not-red	**T** square	**T** correct
F not-red	**F** not-square	**F** incorrect		**F** not-red	**F** not-square	**T** correct

Truth-tables are abstractions. To adapt them for experimental research, Borne (1970) used discriminanda that varied in color and form. Referring again to the truth-tables and using red and square as focal attributes, substitute red when **p** is **T** and not-red when **p** is **F** and substitute square when **q** is **T** and not-square when **q** is **F**. Regarding partitioning outcomes, beneath **p&q** or beneath **p>q,** read **T** as denoting a "correct" partition and **F** as denoting an "incorrect" partition according to contingencies for each row in the truth-tables. As may be seen in the truth-tables and in the illustration below (adapted from Borne), the only correct partition for the conjunctive is when the object is a red-square. For the conditional, the only incorrect partitions are red objects that are not-square; no conditions are specified for being incorrect when **p** is not-red. In Borne's (1970) research, subjects had to infer which truth-table was applicable based on experimenter feedback, such as, saying "correct" or "incorrect" according to whether the discriminanda were being partitioned consistently with a given truth-table's contingencies. The illustration also shows how discriminanda must be partitioned according to conjunctive, disjunctive, conditional, or biconditional truth-tables when red and square are the focal attributes.

When Red and Square are Focal Attributes, Correct and Incorrect Assignments of Discriminanda according to Truth-Table Requirements for Conjunctive, Disjunctive, Conditional, and Biconditional Relationships



There is an extensive history of investigating "conditional discrimination learning," "conditional rule learning," "if-then rule learning," etc. by nonhuman animals using various procedures, and often it is stated or implied that the animals had demonstrated conditional reasoning corresponding to forms such as, "if p, then q." However, this article questions whether there has ever been a valid demonstration of conditional reasoning by nonhuman animals.

Previous investigators used methods that either (a) confounded conditional reasoning with the possibility of rote-memorization or (b) confounded the possibility of conditional reasoning with conjunctive reasoning. The only nonverbal procedure of which I am aware that might be used to show unequivocal conditional reasoning by an animal was developed for use with humans. However, that experiment appears to be impractically difficult for nonhuman animals, and its author (Bourne, 1970) relied partly on the subjects' verbal explanations to confirm how they had reasoned. It is hoped that one result of the present article will be to prevent future researchers from misinterpreting or misrepresenting, either inadvertently or intentionally, the results of typical conditional-discrimination, rule-learning research using nonhuman animals.

Important Scientific Research and Open Questions

The typical conditional learning task used with nonhuman animals involves two successively-presented discriminanda, represented here as A and B, only one of which is presented on a given trial, and two simultaneously-presented discriminanda, represented here as X and Y, which appear on every trial. A or B serves as an associative cue to select either X or Y. It is tempting to describe and conceptualize such tasks, as many investigators have done, as embodying conditional reasoning such as: "If A, then X and if B, then Y."

Typically, relatively few discriminanda are used and they are presented more than once. Repeated presentations make it likely that the relatively few specific configurations afforded by the discriminanda might be learned by rote-memorization. As others have noted, such configuration learning is confounded with the *possibility* that the animals used conditional reasoning. However, such confounding prevents such studies from providing conclusive evidence for conditional reasoning by animals. Even if specific configuration learning is precluded, there remains a fundamental problem that all known experiments using animals have confounded the possibility of conjunctive with conditional reasoning.

There are three basic ways to avoid specific configuration learning: (a) use exemplars from conceptual categories for the successive discriminanda, (b) use exemplars from conceptual categories for the simultaneous discriminanda, or (c) use exemplars from conceptual categories for both the successive and simultaneous discriminanda. Burdyn and Thomas's (1984) investigation will illustrate both the use of conceptual categories as discriminanda and how conjunctive and conditional reasoning are confounded.

Burdyn and Thomas (1984) used exemplars of the conceptual categories "same" and "different" as the simultaneous discriminanda; an exemplar of "same" was an identical pair of objects and an exemplar of "different" was a non-identical pair of objects. *New* pairs of objects were used on each trial in the conceptual category phases of the testing which precluded the monkeys from memorizing specific discriminanda and reinforcement associations. The successive discriminanda involved the conceptual categories "triangularity" and "heptagonality" which were represented by using 120 discriminable triangles and 120 discriminable heptagons. Such a large number of discriminanda together with trial-unique exemplars of “same” and “different” made it unlikely that the monkeys memorized and associated specific triangles and heptagons with same and different.

An apparatus with three guillotine doors was used. During most of the training, all three doors were raised and lowered concurrently. On a given trial, (a) either a triangle or a heptagon appeared as the center door was raised, (b) a pair of identical objects appeared as a result of raising one of the outer doors, and (c) a pair of non-identical objects appeared as a result of raising the other outer door; the choice of triangle or heptagon and the left-right locations of the same and different pairs were determined quasi-randomly for each trial. When a triangle was presented, the correct response was to displace the object-member of the same-pair that was closest to the center door; doing so revealed a food well with a bit of fruit reinforcement beneath the object. When a heptagon was presented, the correct response, similarly reinforced, was to the object-member of the difference-pair that was closest to the center door.

In the final stage of training, the center door was raised to expose either a triangle or a heptagon; then, it was closed to cover the triangle or heptagon before the outer doors were raised to expose the same and different pairs of objects. Intervals between closing the center door and concurrently raising the outer doors were increased systematically. The best performing monkey met a stringent criterion of correct responding (13 of 15 correct on 15 triangle-same trials and 13 of 15 correct on 15 heptagon-different trials within a 30-trials session) with a 16 sec. interval. Therefore, when the successive cues were visually absent, “triangularity” and “heptagonality” had to be retained symbolically in working memory as cues for “same” and “different,” respectively.

It is tempting to conceptualize the monkeys' successful performances as conditional reasoning which might be expressed as "*if* triangle, *then* same" and "*if* heptagon, *then* different." However, Burdyn and Thomas realized that they could not conclude that unequivocally, because it was also possible that the monkeys were reasoning *conjunctively* such as "triangle *and* same" and "heptagon *and* different." This general interpretational problem appears to have affected all other so-called "conditional rule learning" studies in animals. It should be noted also that most animal studies have *not* used conceptual-category discriminanda which means their subjects might have memorized the specific configurations associated with the discriminanda-reinforcement contingencies.

Bourne (1970) also realized that his subjects might have performed on some basis other than implementing the requirements of the appropriate truth-table, but he was able to determine through a series of transfer experiments that his subjects had learned the rules. Some of the transfer experiments involved the experimenter and the subjects discussing the applicable rule. It is unlikely that such verbal validation will be available to animal researchers, and it remains to be seen whether animals will show the kind of perfect or near-perfect transfer of training that is necessary otherwise to confirm that the subject reasoned conditionally. By "near-perfect," it is meant that there must be so few mistakes that the subject likely could not have memorized specific discriminanda and reinforcement relationships.

A minimum of four trials is necessary merely to present the minimal information to show which rule is operating, namely, one trial each to manifest each row contingency in a given truth-table. After being trained on a succession of problems based on the same logical operation, Bourne's human subjects learned to use the four informational trials to attain thereafter perfect or near-perfect performances on new problems. Presumably, this could be done only if the subjects had inferred correctly and followed the appropriate truth-table.

Future animal research on conditional reasoning can and must be improved by precluding the possibility of rote-memorization of the discriminanda or configurations of the discriminanda. This is best done by using conceptual-category discriminanda. Response contingencies that allow the subject to affirm or negate exemplars might be helpful. If animal experiments are based on Bourne's procedure, they would involve reinforcing an animal's responses that correctly affirmed or negated each discriminandum in accordance with the applicable truth-table. A series of problems should be administered according to a single operation, until, following the administration of the four mandatory, informational trials on *new* problems, the animal continued with perfect or near-perfect performances, or until it seemed unlikely that the animal would be able to attain such performances. If perfect or near-perfect performances were seen on new problems, it should be reasonable to attribute the use of the conditional reasoning to the animal (or conjunctive reasoning, etc., depending upon which truth-table was being applied).

This article would be incomplete without acknowledging that some scholars have tried to reconcile standard logic with what some refer to as "natural" or "mental logic" (e.g., Braine & O'Brien, 1998). Such logic is said to apply to cases of reasoning that reflect genuine, "if-then" conditional reasoning without using procedures that fulfill the requirements of the truth-table for the conditional. However, consideration of natural versus standard logic has not revealed how the methods associated with natural logic will enable us to design experiments to distinguish how animals may have reasoned. Thus, it appears that the most conservative and justifiable approach is to continue to attempt to investigate animals' use of the conditional reasoning based on methods that embody truth-functional logic.

Cross-References

→ Abstract concept learning in animals
→ Animal learning and intelligence
→ Associative learning
→ Categorical learning
→ Complex learning
→ Complex problem solving
→ Concept learning
→ Conditional reasoning
→ Conditions of learning – Robert M. Gagne
→ Discrimination learning model
→ Evolution of learning
→ Human learning
→ Inductive reasoning
→ Judgment of similarity
→ Laboratory learning
→ Logical reasoning and learning
→ Nature of creativity
→ Problem solving
→ Rote memorization

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