Experiments suggest macaques are capable of making decisions based on inference

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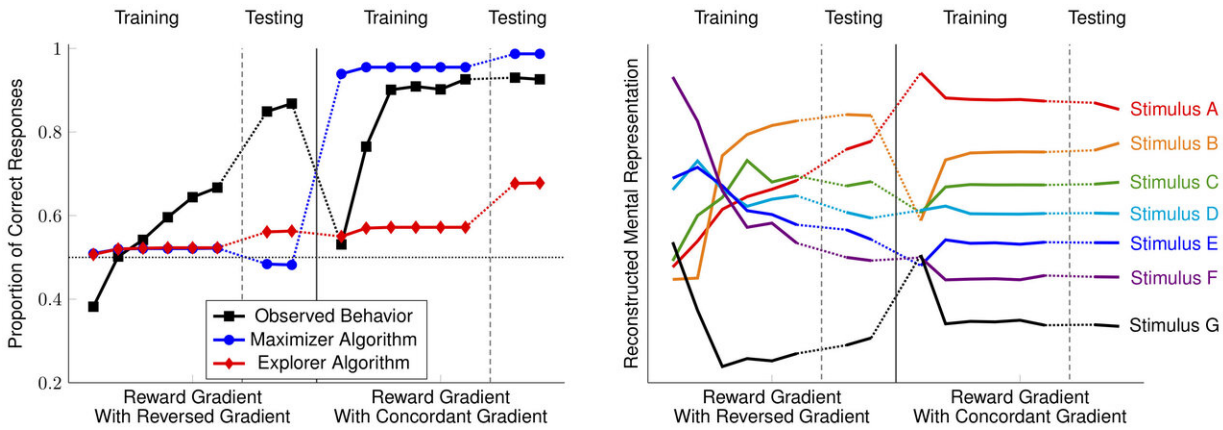

(Left) Performance over time of monkeys performing the transitive inference task, as compared to two algorithms. The "Maximizer" algorithm always chooses the stimulus associated with the highest overall rate of reward. The "Explorer" algorithm favors the better alternative, but often samples the less-rich option in the hopes of discovering something new. All three perform well when the size of the reward is "concordant" with the stimulus rank; that is, when items that are correct more often are also associated with larger rewards. However, when this pattern is reversed (i.e. when items that are often correct yield small rewards, and those that are rarely correct yield large rewards), both algorithms fail at the task, while subjects perform well above chance following training. (Right) Statistical reconstruction of the ranks of the stimuli in the minds of the monkeys, based on their patterns of performance. The items were easily put into the correct order in the concordant case, which is no surprise. What is more surprising is that monkeys were also nearly able to reconstruct the full list in the reversed reward gradient condition. Credit: Jensen, Alkan, Ferrera, & Terrace (2019)

A team of researchers at Columbia University has carried out experiments with macaques and in so doing has found evidence that suggests they are capable of inference-based thinking. In their paper published in the journal *Science Advances*, the group describes the experiments they carried out and what they learned from them.

Most humans are exposed to transitive inference in grade school math classes. It generally comes in the form of being shown that if variable A comes before variable B and variable B comes before variable C, logic suggests that variable A must come before variable C. The human mind is able to "see" all three variables as a sequence and because of that, understand the ideas that are being expressed. Until recently, it was thought that humans were the only creatures capable of such thinking. Some studies have shown that other primates are able to carry out such logic too, as are some birds and even wasps. Now it appears that macaques can be added to the list of animals due to the results of the experiments carried out in this new effort.

The experiments carried out by the researchers consisted of teaching several macaques to learn which of two items in pairs of cards came before the other—by giving them rewards. The researchers then extended the experiments by asking the macaque volunteers which of two in a pair (taken from the pairs they were trained on) came first based on what they knew about the sequence history of the pairs from which they were taken. But the researchers carried out this second part of the experiment in two ways. In the first, the macaques got a bigger reward (a bigger drink of water) for correct answers and smaller drinks for wrong answers. In the second way, things were reversed, the macaques got less reward for correct answers and more reward for wrong answers.

The researchers report that the macaques did only slightly better when given the bigger reward. They suggest this shows the macaques were able to use transitive inference to arrive at the right answer and were not just responding to get a reward.

More information: Greg Jensen et al. Reward associations do not explain transitive inference performance in monkeys, *Science Advances* (2019). DOI: 10.1126/sciadv.aaw2089