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Chimpanzees infer the location of a reward based on the effect of its weight

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The extent to which animals in general, and non-human primates in particular, understand physical causality is currently unclear [1,2]. One way to assess an animal's causal understanding is to test its ability to analyze a causal chain backwards — to infer cause from an effect [3]. In the study reported here, chimpanzees saw a given outcome (effect) of an action and had to infer the preceding event (cause) in order to solve the problem. More specifically, subjects saw a banana being hidden inside one of two opaque cups mounted on opposite sides of a balanced beam but they were kept ignorant about the banana's exact location. Subsequently, the subjects witnessed the balance beam tilting to one side after the experimenter released it from its equilibrium position (Balance condition). The chimpanzees preferentially (and from trial one) selected the lower, compared to the upper, cup. Two control conditions demonstrated that chimpanzees lacked an intrinsic preference for the lower cup when there was no movement involved (Wedge condition) or the balanced was tilted by the experimenter's action (Non-causal balance condition). We conclude that chimpanzees demonstrated evidence of causal inference based on an object's weight.

Chimpanzees selected the baited cup significantly above chance in the Balance condition (see the Supplemental data available online for details). We compared the Balance condition to two control conditions. In the Wedge condition, the cups were mounted on opposite sides of a fixed ramp so that they simulated the position of the cups in the titled balance position. This

condition allowed us to assess whether subjects simply showed an intrinsic preference for the bottom cup. Subjects performed significantly better in the Balance than in the Wedge condition. Analyzing the first trial performance confirmed this result. All eight subjects in the Balance condition selected the bottom cup, but only four out of eight subjects did so in the Wedge condition. It is remarkable that for subjects that began with the Balance condition (group 1), a comparison between the last Balance-block with the first Wedge-block revealed that they significantly decreased their performance by 30% (Figure 1). In contrast, subjects that began with the Wedge condition (group 2) significantly improved their performance by 18% when comparing the last Wedge-block to the first Balance-block. We tested the Non-causal balance control condition on a new group of subjects. In this condition subjects witnessed the same beam movement as in the Balance condition, except

that the movement was caused by the experimenter, not by the weight of the reward. This condition allowed us to assess whether subjects simply preferred the cup that followed a downward trajectory independently of its cause. Subjects performed significantly better in the Balance than in the Non-causal balance condition (Figure 2).

Our results suggest that chimpanzees inferred the location of the reward based on the movement and the resultant final position of the balance. This result was not due to an intrinsic preference for the bottom cup, because subjects lacked such a preference in the first trial of the Wedge condition. Arguably, subjects may have been particularly attracted by falling (rather than raising) trajectories, as shown for cotton-top tamarins and human infants younger than 2.5 years of age [4,5]. We can rule out that explanation, however, because subjects did not show such preference in the Non-causal balance condition. Therefore, it is conceivable that subjects

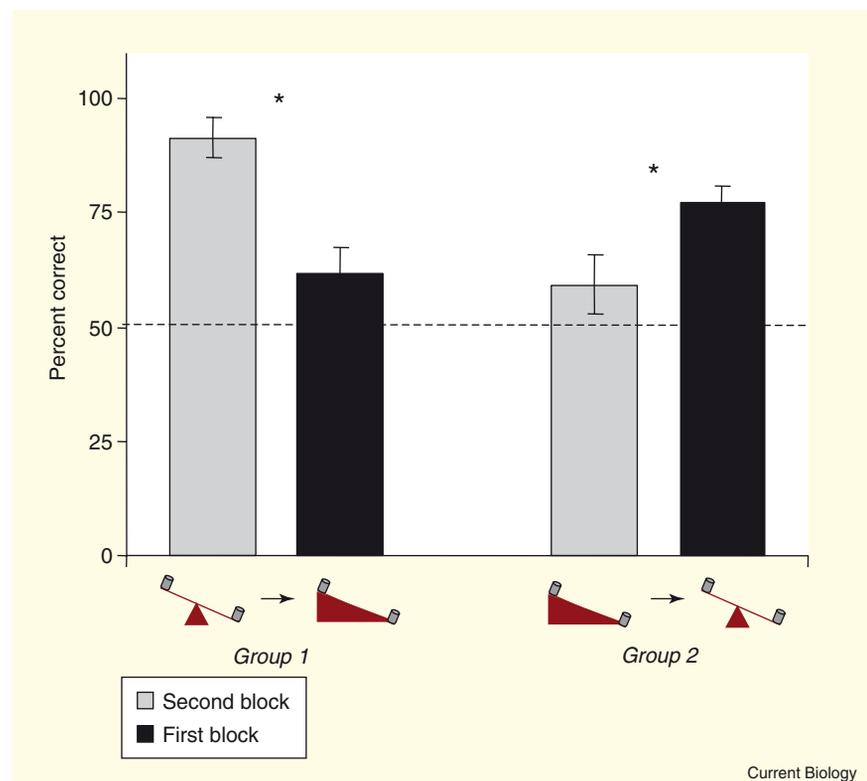


Figure 1. Mean percent of trials (+SEM) in which subjects selected the lower cup for subsequent testing blocks of different conditions.

For group 1, performance of the last balance-block (trial 17–32) is compared with the first wedge-block (trial 33–48). For group 2, the performance of the last wedge-block (trial 17–32) is compared with the first balance-block (trial 33–48). Asterisk: $p < 0.05$.

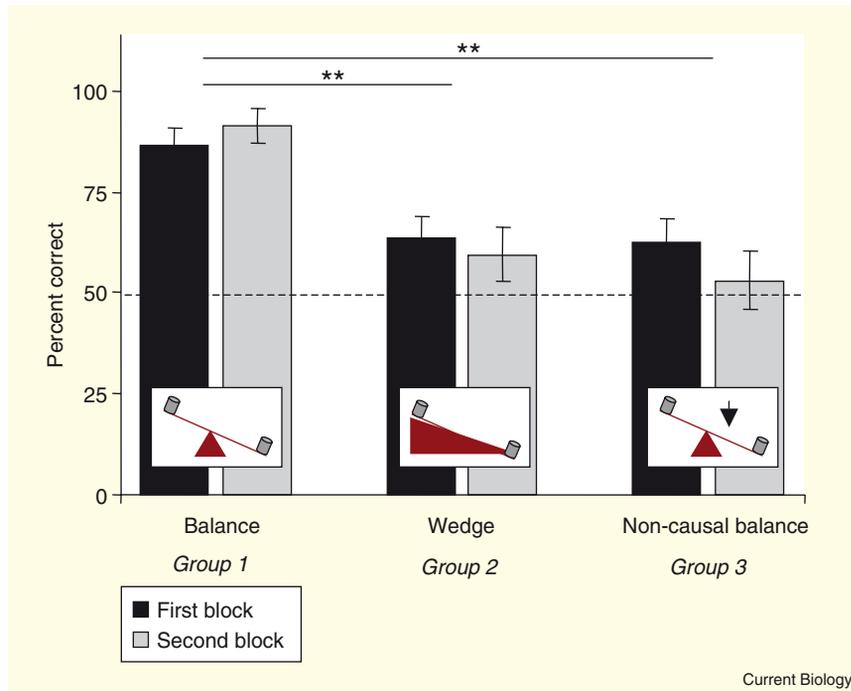


Figure 2. Mean percent of trials (+SEM) in which subjects selected the lower cup as a function of condition.

Only the first 32 trials for each group are included, with the first block containing trial number 1–16 and the second block containing trial number 17–32. Double asterisk: $p < 0.001$.

selected the bottom cup because they inferred that the presence of the reward, and its weight in particular, caused the balance to tilt. These data support the notion that chimpanzees more easily solve tasks whose elements hold a causal rather than an arbitrary relation [2,7]. Subjects' flawless performance in the first trial ruled out the possibility that they learned to respond in this way during the course of the experiment.

Furthermore, subjects that received the Wedge condition first increased their performance when confronted with the Balance condition whereas subjects that were tested with the Balance condition first decreased their subsequent performance upon encountering the Wedge condition. More importantly, these results make a 'choosing the lower cup' heuristic untenable, because once subjects were already choosing the bottom cup in the Balance condition, it is unclear why they would decrease their preference for the bottom cup drastically in the following Wedge condition.

A typical approach to investigating causal understanding in non-human

animals is to test their ability to anticipate the effect that their own action will have on certain elements of the physical world. If they understand the underlying causal principle then they are expected to act accordingly towards a wanted outcome – mostly access to food [3,6]. In general, tool-using behavior is a typical example for the 'productive' aspect in causal reasoning. According to the definition of Visalberghi and Tomasello [6], 'comprehensive' or 'postdictive' abilities can be postulated when subjects solve a problem by inferring the preceding event (cause), based on a given outcome (effect). We argue that the current study revealed evidence that chimpanzees can engage in the 'comprehensive' aspect of causal reasoning with regard to object weight. Further research is needed to clarify whether such basic comprehensive aspect of causal reasoning represents a precursor of more sophisticated forms of physical reasoning found in adults involving abstract concepts such as gravity.

Supplemental data

Supplemental data are available at <http://www.current-biology.com/cgi/content/full/18/8/Rxxx/DC1>

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