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Mini-Review

Causal reasoning in New Caledonian crows

Ruling out spatial analogies and sampling error

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A large number of studies have failed to find conclusive evidence for causal reasoning in nonhuman animals. For example, when animals are required to avoid a trap while extracting a reward from a tube they appear to learn about the surface-level features of the task, rather than about the task's causal regularities. We recently reported that New Caledonian crows solved a two-trap-tube task and then were able to immediately solve a novel, visually distinct problem, the trap-table task. Such transfer suggests these crows were reasoning causally. However, there are two other possible explanations for the successful transfer: sampling bias and the use of a spatial, rather than a causal, analogy. Here we present data that rule out these explanations.

Introduction

Over the last decade there has been growing interest in the physical cognition of nonhuman animals, particularly those that regularly use tools in the wild. Although both tool using and non-tool using animals can solve complex physical problems, they appear to do so through use of associative learning rather than causal reasoning.[1-14] This has led to assertions that human physical cognition is fundamentally different to that of other animals.[15,16]

However, in a recent experiment we found that New Caledonian crows (*Corvus moneduloides*) solved two physical problems that were visually distinct but shared the same causal relations.[17] Six crows were given a trap-tube problem where they had to extract a reward from a tube while avoiding a trap. Three of these crows learnt to solve this problem. These crows were then presented with a series of transfer tests where the surface-level features of the problem were manipulated. These transfer tests showed that the crows were using the position of the hole in the tube to successfully extract the reward. The crows then solved a visually distinct trap-table problem where they had to choose between two rewards, one of which was behind a trap. These results suggest that New Caledonian crows are able to reason both causally and analogically about proximate causal relations. However, there are two alternative explanations that we did not fully address.

First, we could not completely rule out the possibility that New Caledonian crows possess a predisposition to avoid holes. In the original experiment six crows were tested and only the three that learnt to solve the trap-tube apparatus could then solve the trap-table apparatus. This suggests that New Caledonian crows do not spontaneously avoid holes when presented with novel physical problems. However, the possibility remains that these crows have such a disposition, but that it was not found due to the small sample size. To test this hypothesis we presented a further eight naïve crows with the trap-table apparatus.

The second alternative explanation concerns the relational information being transferred from the trap-tube task to the trap-table task. The three successful crows could have made the transfer by reasoning analogically about a spatial relation, such as 'always avoid pulling food when it is in front of a trap'. Alternatively, the crows could have used a causal relation, which contains an understanding of why this spatial relation is important (i.e., because objects only move along horizontal surfaces). We tested between these two possibilities by presenting the three successful crows from our initial experiment with an inverted trap-tube. If the crows were using a spatial relation they should have continued to avoid the hole when it was on the upper surface of the tube.

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Methods and Results

Sampling bias. We first gave the eight New Caledonian crows experience using stick tools to extract meat from a horizontal Perspex hole. We then gave them the trap-table apparatus as in our original paper. The crows had to avoid the trap while its position (left or right) was randomly alternated across two blocks of ten trials. None of the eight crows performed above chance (Binomial choice, all p-values > 0.05) (Fig. 1). Of the 14 crows that we tested on the trap-table (the eight crows here and six in our original

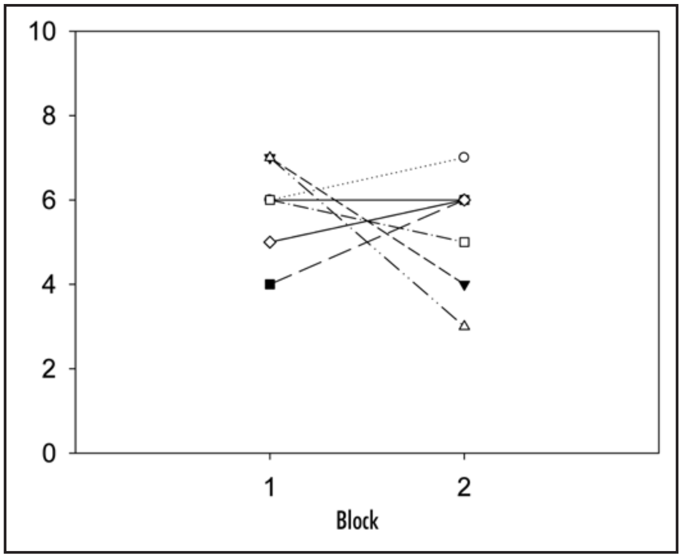

Figure 1. Performance of eight naïve crows with the trap-table apparatus.

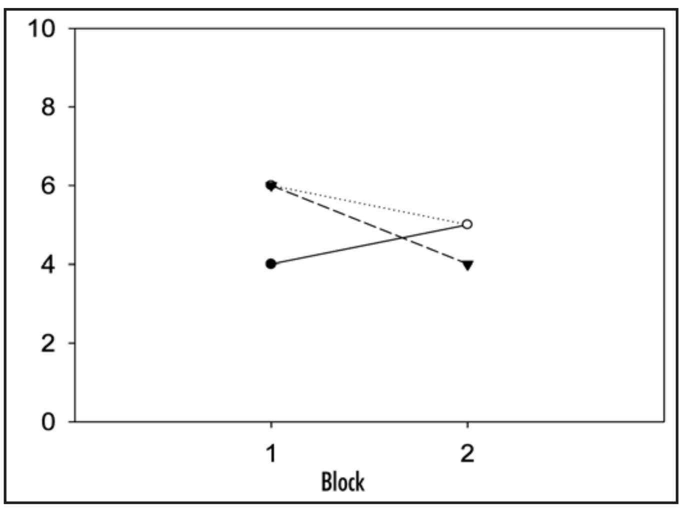

Figure 2. Performance of the three successful crows from the original experiment with the inverted two-trap-tube.

paper), only the three that solved the initial trap-tube problem solved the trap-table problem.

Spatial analogy. As part of the original experiment the three successful crows were presented with an inverted two-trap-tube after transfer three and before the trap-table transfer. One of the inverted traps had a hole that opened onto the tube, while one did not. Subjects could extract the reward from either end of the tube as the hole was on the upper surface of the tube. If the successful crows had learnt a spatial relation based on the position of the food relative to the hole, they should have continued to avoid the inverted trap with the hole when presented with this transfer. However, all three crows had no significant preference to extract the reward from a particular end of the tube (Binomial choice, all p-values > 0.05) (Fig. 2).

Discussion

The supplementary results presented here allow us to discount two alternative explanations for the successful transfer to the trap-table in our original paper. First, New Caledonian crows do not have a predisposition to avoid holes when presented with the trap-table problem. The transfer by the successful crows therefore must be based on what they learnt during their experience with the trap-tube apparatus. Second, the crows' indifference to the inverted hole shows that they had not transferred through use of a spatial analogy based on the relationship between the hole and the food. The crows only avoided the hole when it was in a functional position (i.e., in the bottom of the horizontal tube). This supports our original claim that the three crows had used a causal analogy to solve the trap-table problem.

Our findings highlight the need in experiments with physical problems to control for the possibility that animals may solve these tasks using spatial rather than causal relations. We therefore suggest that the use of visually distinct transfers, in conjunction with tests for sensitivity to causal asymmetries, may be useful in pinpointing the cognitive strategies that animals employ when solving physical problems.

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