

## Comment

**On the flexibility of lizards' cognition: a comment on Leal & Powell (2011)**

Leal & Powell [1] (L&P) report experiments on the tropical lizard *Anolis evermanni* which, in their view, 'show that *A. evermanni* exhibits behavioural flexibility across multiple cognitive tasks, including solving a novel motor task using multiple strategies and reversal learning, plus rapid associative learning'. Given the standards that the authors themselves establish ('a robust demonstration of behavioural flexibility should show that individuals are capable of solving multiple cognitive tasks'), their findings and conclusions deserve careful scrutiny, especially because the issue of interpretive parsimony is at the heart of progress in comparative cognition [2].

L&P exposed six lizards to an apparatus with two wells, of which a randomly chosen one contained food. The baited well was partly covered by a blue disc that was progressively moved until it fully blocked food access. Four subjects became proficient at removing the disc on an average of 28 trials after full obstruction ('motor task', L&P's table 1). The movements differed among individuals, including using the snout as a lever, and lifting the disc with the mouth. Once they learned to systematically remove the blue disc, a second (yellow) disc was added, occluding the empty well. All four lizards continued to remove the blue disc ('discrimination, first experiment', L&P's table 1; one lizard tackled the alternative once). After six such trials, the yellow disc was replaced by another coloured with yellow and blue concentric rings. The lizards continued to respond to the blue disc ('discrimination, second experiment', L&P's table 1). After six further trials, the bait was placed in the well under the concentric rings disc. The lizards continued to respond to the (now unrewarded) blue disc, two of them until losing interest through response extinction. The remaining two eventually explored the other well, and after about 58 trials ('choice reversal', L&P's table 1), switched to remove consistently the concentric rings disc.

We do not think this demonstrates problem-solving flexibility of individuals across multiple tasks, reversal learning or rapid associative learning. The animals learned a discrimination gradually during the pre-training and motor task phases: food was under the blue disc, not elsewhere. Since pre-training length is not reported, the time to acquisition is unknown. The next two phases (discrimination experiments 1 and 2) involved no new learning (they showed persistent

responses to the rewarded blue disc), hence they also do not yield estimates of rate of learning.

New learning took place for the two lizards that eventually switched to the concentric rings disc. L&P correctly describe this as choice reversal, rather than reversal learning, but they conclude elsewhere that they studied reversal learning. In reversal learning, contingencies of two stimuli are learnt and then reversed, repeatedly in the case of serial reversal learning. By contrast, the lizards had not previously demonstrably learned anything about the concentric rings disc (see [3,4] for demonstrations of reversal learning in ectothermic tetrapods).

Thus, rather than multiple problem-solving tasks, two lizards learned the same thing (a colour signal for food location) twice. Their speed of learning cannot be assessed because they learned during the pre-training period, for which quantitative measures are not given. The only measure given for speed of behavioural change is the number of trials to choice reversal, but these data cannot be compared with typical reversal learning studies.

What is the evidence of cognitive and behavioural flexibility? As L&P explained, individual flexibility across multiple tasks would be informative with respect to cognitive flexibility, but this was not investigated in their study. Inter-individual variation in the disc-removal techniques is interesting, but differences in the form of the final response nearly always emerge by chance during instrumental conditioning, and do not indicate cognitive flexibility [5,6]. In summary, we agree that it should be interesting to conduct a comparative analysis of cognitive flexibility as a function of diversity in species' ecology using multiple tasks, measuring speed of associative learning, and including reversal learning, but this is yet to be done. L&P's experiments do not 'strongly suggest a re-thinking of our understanding of the cognitive abilities of ectothermic tetrapods'. They certainly do not show that lizards possess cognitive abilities 'comparable with those of some endothermic species including species recognized as having highly flexible behaviours', since they offer no metric for such comparison. The study is valuable because it broadens the taxonomic range of experimental models [7], and because there are those who, ignoring the existing literature on learning across many different taxa (see [4,7] and references therein), continue to hold an unjustified scepticism about cognitive complexity outside birds and mammals.

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