

Failure of a Free-living Northern Mockingbird (*Mimus polyglottos*) to Discriminate Food Rewards on the Basis of Number¹

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ABSTRACT. Spontaneous numerical discrimination has been observed in animals in laboratory and field studies. These studies often rely on subjects choosing the most profitable food items. I designed a feeding apparatus to explore the spontaneous numerical discrimination of a free-living northern mockingbird (*Mimus polyglottos*). The feeder consisted of two tubes containing food rewards. In order to attain the reward from a tube, the subject had to remove one or more obstacles. I tested to see if the subject would choose the tube with greatest profitability first. The subject did not discriminate when given a choice between a tube with two obstacles and a tube with three obstacles. The subject also did not discriminate between a tube with larger number of food items and a tube with fewer food items (each tube with one obstacle). However, the subject did discriminate between a tube with reward and a tube without reward. The failure of the subject to discriminate on the basis of number may reflect the low cost associated with making the sub-optimal choice. With some improvements, the feeding apparatus may provide a way to examine spontaneous numerical competence in free-living birds without having to capture subjects.

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INTRODUCTION

Recent studies have demonstrated remarkable numerical abilities in trained captive birds (Pepperberg 1999; Brannon and others 2001; Xia and others 2001). An African grey parrot (*Psittacus erithacus*) was trained to vocalize the appropriate number label when presented with one to six objects (Pepperberg 1994, 1999). Pigeons (*Columba livia*) were trained to peck the appropriate key (of two possibilities) in response to the difference between two numerical quantities presented as flashes of light (Brannon and others 2001). Brannon and others (2001) interpreted that as evidence of subtraction and a linear number scale in pigeons (but see Dehaene 2001 for an alternative interpretation). Xia and others (2001) trained pigeons to associate visual symbols with numerical quantities from one to five. Those studies and others clearly demonstrated numerical competence in birds in laboratory situations. However, such studies do not allow inferences about numerical competence in wild animals.

Untrained animals can be presented with choice experiments that exploit the tendency of wild animals to make decisions on the basis of optimal foraging theory (Stephens and Krebs 1986). According to that theory, a foraging animal should choose the option that maximizes profitability (the net rate of caloric intake). The optimal choice may be the one providing highest caloric value or the one that can be attained within the least amount of time. Using this approach, spontaneous numerical competence in untrained animals has been demonstrated in a few studies. Hauser and others (2000) presented untrained macaques (*Macaca mulatta*) with a choice of two boxes. Subjects were allowed to witness as researchers placed apple slices into each box. Macaques preferentially approached the box with larger number of apple slices

up to a comparison of three slices in one box and five slices in the other.

The objective of the present study was to determine numerical competence in untrained, wild northern mockingbirds (*Mimus polyglottos*). I designed a feeder consisting of two clear tubes with food rewards held in place by one or more obstacles. After a mockingbird mastered the task of removing one obstacle to attain food, I presented the subject with a choice between a tube with two obstacles and a tube with three obstacles. An increase in number of obstacles represented a decrease in profitability of the reward in that tube. If a mockingbird were capable of recognizing that a tube with a larger number of obstacles holds a reward with lower profitability, then it should choose the tube with fewer obstacles. My hypothesis was that a bird possessing adequate numerical ability would spontaneously prefer the tube with two obstacles. As another way to test numerical competence with the apparatus, I offered the subject a choice between tubes each with one obstacle but with different numbers of food rewards. I predicted a bird possessing numerical competence would choose the tube with larger number of food rewards. My original experimental design was to introduce the feeder to mockingbirds at several locations.

MATERIALS AND METHODS

The subject was a free-living northern mockingbird in Cincinnati, OH. The subject was not captured before or during the experimental tests. The mockingbird was captured and banded after completion of the tests. The banded mockingbird was the only bird seen at the apparatus after being banded. Therefore I believe there was only one subject during the experimental tests. Two other mockingbirds (at different locations) were introduced to the apparatus but failed to master the removal of obstacles, preventing subsequent testing.

The feeder consisted of a wooden board measuring 28.5 × 14 × 2.0 cm with two vertical wooden pegs 20 cm

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apart (see Fig. 1). Each peg suspended an inverted clear plastic test tube (75 mm long \times 11 mm diameter). The test tubes had three pairs of holes approximately 4.0 mm apart allowing up to three wooden matchsticks to be inserted perpendicular to the long axis. Within each test tube was a food reward consisting of roasted mealworms (larvae of *Tenebrio* beetles) and two *Pyracantha* (firethorn) berries. The subject never ate the berries; however, the berries helped hold the mealworms in place. The mealworms and berries were held within the inverted tube by the uppermost inserted matchstick. The plastic tubes were randomly assigned to the pegs before each trial.

The subject was introduced to the apparatus and all testing trials were conducted during January 2004. Introduction of the apparatus began with mealworms placed on the board to attract the subject to visit the feeder. Mealworms were then placed in the tubes and held in place by a single matchstick. A mealworm was tied to the matchstick with dental floss. By pulling the attached mealworm, the subject inadvertently pulled the matchstick and released the food reward within the tube. The subject soon began pulling matchsticks to which no mealworm was attached. All of the pre-testing training involved only one matchstick within each tube.

The first testing condition offered the subject a choice between tubes with equal reward but variable number of obstacles. One tube had six mealworms held in place by two matchsticks, and one tube had six mealworms held in place by three matchsticks (Fig. 1). The tube containing three obstacles was assigned randomly for each trial. The tube with two matchsticks had a matchstick in the uppermost set of holes and one in the lowermost set. The tube with the first matchstick touched by the subject was considered its choice. Test 1 was conducted with 16 trials.

The second testing condition offered the subject a

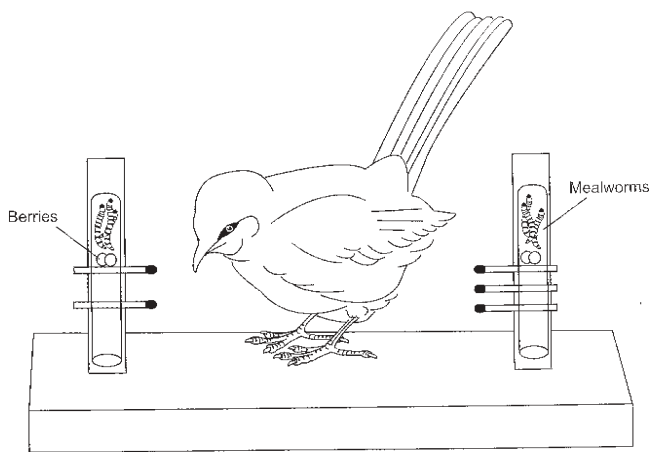


FIGURE 1. Choice feeder used to test numerical competence in a northern mockingbird (*Mimus polyglottos*). Food rewards (roasted mealworms) were held in place by removable obstacles (matchsticks). Berries were used to help keep mealworms above uppermost obstacle. Tubes had differing profitability. The subject's choice was defined as the tube with the matchstick first touched by the subject. The diagram is representative of test 1 (see text for description of test 1, test 2, and test 3). Artwork by Vanessa Sorensen.

choice between tubes with variable reward but equal number of obstacles. One tube had six mealworms held in place by one matchstick, and one tube had one mealworm held in place by one matchstick. The tube containing six mealworms was assigned randomly for each trial. The tube with the first matchstick touched by the subject was considered its choice. Test 2 was conducted with 17 trials.

The third testing condition offered the subject a choice between two tubes, one with a reward and one with no reward. One tube had eight mealworms held in place by one matchstick, and one tube had no mealworms (only two berries) held in place by one matchstick. The tube containing the mealworms was assigned randomly for each trial. The tube with the first matchstick touched by the subject was considered its choice. Test 3 was conducted with 12 trials.

RESULTS

In test 1, the subject did not choose between tubes based on number of matchsticks ($p = 0.60$, one-tailed sign test). The subject chose the tube with two matchsticks 8 times and the tube with three matchsticks 8 times. In trial 6 one of the mealworms fell out of a tube before the subject arrived at the apparatus. In 15 out of 16 trials the subject pulled on matchsticks from both tubes.

In test 2, the subject did not choose between tubes based on number of mealworms ($p = 0.77$, one-tailed sign test). The subject chose the tube with one mealworm 9 times and the tube with six mealworms 7 times. Trial 2 was not included in the analysis; during that trial, the mealworm fell out of the tube with only one mealworm before the subject arrived. Thus in that trial, the subject had a choice between a tube with mealworms and a tube without. In 15 of 16 trials, the subject attempted to remove matchsticks from both tubes.

In test 3, the subject chose the tube with mealworms over the tube without mealworms ($p = 0.02$, one-tailed sign test). The subject chose the tube with eight mealworms 10 times and the tube with no mealworms 2 times. During trial 5 and trial 11 one mealworm fell out of a tube before the subject arrived. The subject left without touching the matchstick in the tube without mealworms during 7 of the 12 trials.

The trials in which a mealworm fell out of a tube before the subject arrived were included in the analyses of test 1 and test 3 because the subject was still presented with a choice similar to that in the normal trials. In trial 2 of test 2 however, the subject was presented with a choice quite different from that of the designed test.

The subject responded differently when one tube had no mealworms compared to when both tubes contained mealworms ($p < 0.001$; G-test of independence). In 30 of the 32 trials with both tubes containing reward (test 1 and test 2) the subject attempted to remove sticks from both tubes. In contrast, the subjects touched sticks from both tubes in only 5 of the 12 trials with a reward in one of the two tubes (test 3).

DISCUSSION

Numerical competence may have an adaptive value for wild animals. For example, American coots (*Fulica americana*) with the ability to respond appropriately to the number of their own eggs within a nest benefited from increased fecundity by laying more eggs than coots unable to appropriately respond to the number of their own eggs (Lyon 2003). Similarly, foraging problems may require numerical competence in order to determine which choice provides maximum profitability. However, in experimental trials of the present study a wild mockingbird did not make the optimal choice between two alternatives when both options yielded some reward. The subject did not discriminate between tubes based on number of matchsticks (test 1) or number of mealworms (test 2). However in the final test, the subject clearly attended to the presence or absence of mealworms in a tube, mostly ignoring tubes with no mealworms. Instead of simply associating matchsticks with mealworms, the mockingbird preferentially pulled on matchsticks when a reward was present.

The results presented here represent only the responses of one subject however, limiting the inferences that may be drawn from this study. After completion of the trials described above, I introduced the apparatus to two additional mockingbirds. In both cases, the birds removed matchsticks from tubes only when a mealworm was attached to a matchstick. These introductions occurred as the weather was warming in late winter. Perhaps other food items were more available at this time, making the new subjects less motivated to learn to perform the task necessary for subsequent testing.

I was surprised the subject did not discriminate between tubes on the basis of amount of mealworms, particularly in light of the fact that the mockingbird attended to whether reward was present in a tube. In a study with wild-caught salamanders, untrained subjects spontaneously preferred tubes with a larger number of flies (Uller and others 2003). In discrimination tests, the greater the difference between numerosities, the more likely a subject will make the appropriate choice (Dehaene 1997). Given the large difference presented to the subject in the present study (one versus six mealworms), I expected the mockingbird to show a consistent preference for the more profitable tube.

Perhaps the subject was capable of discriminating on the basis of number (number of obstacles or number of mealworms) but was not adequately motivated to make the optimal choice. Allowing the subject immediate access to the rewards in both tubes meant the cost of choosing the sub-optimal tube first was paid only if the subject was interrupted before attaining the rewards in both tubes. Indeed, that cost was rarely paid during the trials of test 1 and test 2; the subject retrieved rewards

from both tubes during 23 of the 32 trials. Perhaps increasing the cost associated with making the sub-optimal choice would provide a better test of the numerical competence of mockingbirds.

Future efforts to test the spontaneous numerical competence of free-living birds should also seek to improve on other aspects of the methodology described here. The delivery of the reward was not always reliable. Occasionally a mealworm fell out before the subject arrived. Sometimes one or more mealworms fell out as the subject pulled on a matchstick but before the matchstick was entirely removed. On a few occasions, some or all of the mealworms became stuck temporarily in a tube after the matchsticks were removed. In many of those cases, the mockingbird dislodged mealworms by directly pecking the tube. Such malfunctions of the apparatus probably interfered with the ability of the mockingbird to accurately predict which tube represented the most profitable choice.

Despite the shortcomings of the present study, the results demonstrate a potential way to test foraging decisions in wild birds by using choice feeders. It is encouraging that a free-living mockingbird learned to remove obstacles to attain a food reward from a feeder and regularly returned to that feeder. After mastering the initial task of removing a single obstacle from each tube, the mockingbird extended this behavior to the removal of additional obstacles. More work is needed to adequately test the spontaneous numerical competence in wild birds.

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BOOK REVIEW

Teaching Tips: Innovations in Undergraduate Science Instruction. Edited by Marvin Druger, Eleanor Siebert, and Linda Crow. 2004. NSTA Press, Arlington, VA. 102 p. \$25.95 paper. ISBN 0-87355-245-8

This monograph of the Society for College Science Teaching consists of 51 short (500 to 700 words each) teaching tips, prepared by a variety of authors from different scientific disciplines and different institutions around the country. It was produced for the 25th anniversary of the Society, and strives to continue the Society's mission of enhancing the practice of undergraduate science teaching. It is extremely readable and useful, and is an invaluable resource for college faculty or graduate teaching assistants who desire to better their teaching practices in an effort to enhance the training of the next generation of scientists.

Part I contains articles on Pedagogical Practices (the practice of teaching and learning). These include some general introductory material such as "The Learning Cycle," "Collaboration in the Classroom," and "Thinking Like a Scientist," basic information that all science teachers should understand. A second series of articles contain general pedagogical ideas applicable to a variety of disciplines in science, including "Class Discussion Supported by Preparation," "Promoting Teamwork," "Case Study for Understanding the Scientific Method," "Tips for Managing a Large Active-Learning Classroom," and "Using Constructivist-Based Cooperative Learning to Challenge Students." Many of these ideas are useful whether teaching in a small or large classroom, while others are specific to the large classrooms of our state universities. Finally, a few articles deal with pedagogy specific to one discipline only, such as "Teaching General Chemistry Without a Calculator" and "The Role of Technology in Undergraduate Physics Education." Taken as a whole, with the references listed for each article, these chapters on pedagogy form a body of knowledge about college science teaching that would start a teaching assistant or new faculty member off well on the pathway to becoming a great science teacher. Experienced faculty will also find a variety of useful ideas that can help retool mid-career teaching or turn a good science teacher into a potentially great science teacher.

Part II contains nine articles on that 'hot-button' topic of Assessment Activities. Some articles reiterate tried and true methods such as "Using Pretests and

Post-tests," concentrating on the rationale and practical use of the method. Other articles bring us delightful new ways to look at assessment, such as "Writing Poetry to Assess Creative and Critical Thinking in the Sciences" (thinking outside the box for sure), or "Calibrated Peer Review – a Writing and Critical-Thinking Instructional Tool." Most faculty struggle to deal with the current wave of assessment requirements coming from administrators, accrediting agencies, and other outside reviewers—there are ideas here that most science departments can use to their advantage.

Part III is about Content Challenges (ways that teachers have found to promote learning of traditionally challenging concepts). Many departments and faculty struggle with content and how best to help students learn a growing body of knowledge in the limited time available in the classroom and laboratory. In addition, many departments bemoan the abilities of students coming from high school that do not seem to have been grounded in the basics before arriving at college. The authors of these articles have dealt succinctly with problems such as "Interpreting Graphs," "Conceptualizing Metric Units," and "Teaching Evolution by Analyzing Student Misconceptions." These are topics that can help teachers in all science disciplines improve student understanding. Other articles are once again discipline specific. These include "An Innovative Text and Curricular Design for a Conceptual Physics Course," "Wind Speed and Friction," "Molecules for Non-Majors," and "Jell-O Air Masses."

Throughout the book references are given for the benefit of the reader. Contact information is also given for each author, to help secure additional information or help with classroom issues. Most of the authors are well-known in the field of science education, having authored a variety of peer-reviewed articles in science education journals, and having presented talks and workshops at national conferences such as the National Science Teachers Association/Society for College Science Teachers annual conference, the National Association of Biology Teachers annual conference, the American Chemical Society conferences, and other similar venues.

Only 102 pages in total length, this useful book is a must read for all college science teaching faculty (community college, undergraduate college, and university), and should be a part of the library in every department that trains graduate teaching assistants.

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