



Learning from others' mistakes: a paradox revisited

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(Received 22 August 1996; initial acceptance 26 October 1996;

final acceptance 20 March 1997; MS. number: A7689)

Abstract. Some researchers have reported the paradoxical finding of enhanced social learning when naive observers learn from unskilled rather than skilled demonstrators, particularly in discrimination tasks. In two experiments with starlings, *Sturnus vulgaris*, I considered whether this enhanced learning is because the observer (1) sees incorrect responses only, (2) sees both correct and incorrect responses or (3) sees an increase in the proportion of correct responses over trials. In experiment 1, individual starlings observed a demonstrator bird perform multiple simultaneous discrimination tasks. In one group, the demonstrator always picked the correct stimulus; in another group, the demonstrator always picked the incorrect stimulus; in a third group, the demonstrator consistently picked the correct stimulus 50% of the time. Those subjects that observed only incorrect choices performed significantly better than the other two groups, but none of the birds achieved the 90% correct performance criterion. Experiment 2 involved a single discrimination task; thus, a fourth group was added to control for individual learning. Again, subjects that observed only incorrect responses learned the discrimination significantly more quickly than the other three groups. Subjects that observed the demonstrator make both correct and incorrect responses were equally likely to select the same (correct) or opposite (incorrect) stimulus when the demonstrator picked the correct stimulus. When the demonstrator picked the incorrect stimulus, however, these subjects were significantly more likely to pick the opposite (correct) stimulus. These findings suggest that when learning a discrimination problem, observing a foraging companion's lack of success is more informative than observing its success.

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Although most social learning experiments are characterized by naive individuals observing highly skilled demonstrators performing a novel task (e.g. Hogan 1986; Heyes & Dawson 1990; Nicol & Pope 1992), a few studies suggest that learning may be enhanced if observers observe only unskilled demonstrators (e.g. Herbert & Harsh 1944; John et al. 1968; Beauchamp & Kacelnik 1991). This paradoxical finding has been described most frequently for discrimination tasks (e.g. Darby & Riopelle 1959; Vanayan et al. 1985; Biederman & Vanayan 1988), and Vanayan et al. (1985) hypothesized that the paradox is due to the increased 'opportunity to observe crucial stimulus-reinforcement contingencies'. Therefore, seeing a combination of correct and incorrect responses may provide more information to a naive observer than seeing correct responses alone (Myers 1970). No study, however, controlled

the number of correct and incorrect responses produced by the 'proficient' versus 'non-proficient' demonstrators. Thus, it is unclear whether learning is enhanced by the opportunity to observe (1) incorrect responses per se, (2) a combination of correct and incorrect responses or (3) an increase in the proportion of correct responses as the non-proficient demonstrator gradually learns the discrimination problem (Del Russo 1975; Vanayan et al. 1985).

The purpose of this study was to determine what type of social information is most effective for starlings, *Sturnus vulgaris*, learning a simultaneous discrimination task. I conducted two experiments: a multiple simultaneous discrimination task, in which the pairs of stimuli differed from trial to trial, and a single simultaneous discrimination task. In both experiments, I used a technique that allowed complete control over both the stimulus choices of the demonstrator and the payoffs that it received for these choices. Each

experiment had the same three treatment groups: (1) the demonstrator always picked the correct stimulus; (2) the demonstrator always picked the incorrect stimulus; and (3) the demonstrator picked the correct stimulus in 50% of the trials. In all three groups, the performance level of the demonstrator remained consistent over trials.

Different predictions can be made concerning the relative performance of these three groups, depending on what type of social information is most salient to the observer. If learning is enhanced by the opportunity to observe the demonstrator choosing the correct stimulus and obtaining reinforcement, then one would expect the group that observes consistently correct responses to learn the discrimination problem most quickly, followed by the group that observes a combination of correct and incorrect responses, and then by the group that observes consistently incorrect responses. If a combination of correct and incorrect responses increases the information available to a naive observer, then subjects that observe the demonstrator make an equal number of correct and incorrect choices should learn more quickly than subjects in the other two groups. Finally, if learning is enhanced by the opportunity to observe responses to the incorrect stimulus and the accompanying non-reinforcement, then one would expect observers of consistently incorrect responses to learn more quickly than individuals that observe an equal proportion of correct and incorrect responses, which in turn should learn more quickly than observers of consistently correct responses.

EXPERIMENT 1: MULTIPLE SIMULTANEOUS DISCRIMINATION TASKS

Experiment 1 was designed to determine what type of social information would promote the learning of a discrimination task. To ensure that the only information available to the observer would be from the consequences of the demonstrator's stimulus choice, a different pair of stimulus lids were presented for each trial.

Methods

Subjects

I used nine wild-caught adult starlings as naive subjects (observers); a single wild-caught adult

male served as the demonstrator for all individuals in each of the three treatment groups. All birds were maintained on a 12:12 h light:dark cycle in individual cages, provided with water *ad libitum* and maintained 85–90% of their body mass on a diet of bread crumbs, turkey starter crumbs and an insectivorous mix.

Apparatus

During all experimental trials, I placed a single observer in a hardware cloth test cage (30 cm³) facing the demonstrator in a similar cage; both cages had a small opening in front (3.5 cm²) through which the birds could feed. The two cages were separated by a 15-cm wide tray, which was used to slide the discrimination apparatus into place. This apparatus consisted of two inverted petri dish lids (1 cm high, 3.5 cm diameter) which were placed over two food wells (1 cm deep, 2.5 cm diameter) set 5 cm apart in a block of wood (12.5 × 10 × 3 cm). Weights were taped to the inside of the lids, making them heavier (18.5 g) and thus difficult to push completely off the well.

Training

During initial training sessions, I presented the solitary demonstrator bird with two white stimulus lids. The demonstrator was trained to peck off the lid with a small black sticker (4 × 5 mm) on its facing edge to obtain a potential food reward (two mealworm halves). I used a partial reinforcement regime (where 60% of the responses to the correct lid were rewarded) to ensure that the demonstrator would continue to peck off the lid with the black sticker even when it did not conceal food. Observers were trained to peck a single, white lid (no sticker) off a centrally placed hole to obtain a food reward (two mealworm halves). Thus, observers learned both that lids potentially concealed food, and how to remove them prior to the start of the experiment.

Procedure

A trial consisted of two consecutive identical demonstrations and a choice test. During each trial, I presented a different pair of stimulus lids to the demonstrator, selected from a pool of 60

stimulus lids with unique colour patterns. I used a given lid, on average, once every 45 trials (range=31–60 trials), but I never paired it with the same lid for more than one trial. During a demonstration, I pushed the discrimination apparatus in front of the demonstrator, which always pecked off the lid with the sticker (the sticker was not visible to the observer) within 10 s. The position of the lid with the sticker was random over trials, and it concealed either food (two mealworm halves) or nothing, depending on the treatment group of the observer. Because the lid was not completely pecked off, the bottom of the well was concealed from the observer's view; thus, the unambiguous behaviour of the demonstrator (eat or not eat) was the only source of information available to the observer. After remaining in place for 5 s, I removed and re-set the apparatus for the second demonstration, which took place 10 s later. After the second demonstration, I removed the apparatus and there was a delay of 20 s. I then placed a visual barrier between the two birds, pushed the test apparatus in front of the observer, and gave it one opportunity to choose between the same pair of lids used in the previous two demonstrations. The lid pattern that concealed food (two mealworm halves) was either the same or different from that chosen by the demonstrator, depending on the treatment group of the observer. The positions of the lids were also randomized over trials to ensure that the birds did not learn a position rule. No bird took longer than 20 s to make a choice. Each observer completed 12 consecutive trials per day; the inter-trial interval was 2 min. I arbitrarily set the performance criterion at 90% correct choices over 10 consecutive trials, to a maximum of 120 trials.

Treatments

I randomly assigned the nine subjects to one of three observer treatment groups (with the constraint that there were two males and one female in each group). For the 'negative' treatment (group N), the demonstrator always picked the incorrect lid pattern and was never rewarded; thus, the observer had to pick the other lid pattern to obtain food. For the 'positive' treatment (group P), the demonstrator always picked the correct lid pattern and was always rewarded; thus, the observer had to pick the same lid pattern to obtain food. Finally, for the 'positive/negative' treatment

(group P/N), the demonstrator consistently picked the correct lid pattern only 50% of the time; thus, the observer had to pick the same lid pattern if the demonstrator had been correct and pick the other lid pattern if it had been incorrect. I individually tested three birds, one from each of the three treatment conditions, each day. Once all trials for the first set of three birds had been completed, the next set of three birds began their trials. I observed all trials from behind a blind, recording which lid was selected, whether it was correct and on which side it was. I measured the effectiveness of information transmission as the change in per cent correct responses made by the observers over five blocks of 24 trials each.

During experimental trials for group N, I gave a rewarded presentation (six mealworm halves concealed under the lid with the sticker) to the demonstrator prior to every seventh trial while the observer's view was blocked. This was done to avoid possible extinction effects in the demonstrator and to keep its hunger level relatively constant. I carried out a similar procedure in the other two treatments as a control, but the demonstrator received only three mealworms (group P/N) or no mealworms (group P) during these presentations. All observers in all three treatments developed side biases early on, which were dealt with in the following way: when the observer selected the same side for six trials in a row, I gave a series of remedial presentations of the same pair of lids to the observer until it chose the correct lid on the non-preferred side. These remedial presentations were not preceded by demonstrations or included in the data analysis.

Results

Each observer completed the maximum of 120 trials (Fig. 1). There was a significant effect of treatment group (repeated-measures ANOVA, arcsine square-root transformed data; $F_{2,6}=10.44$, $P=0.011$); there was no significant change in performance over blocks of trials, and no significant interaction between group and trial block. This lack of a significant interaction was probably due to an averaging of the effects over blocks. Group N did have a higher mean percentage of correct choices than groups P and P/N in the fourth and fifth blocks of trials; this difference was only significant in the fourth block (contrast

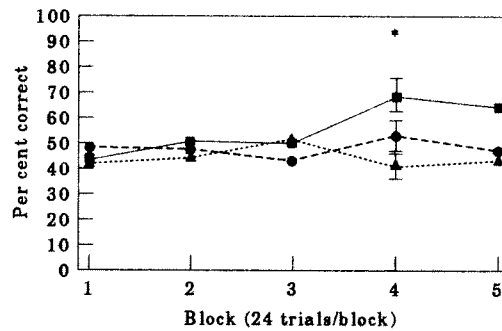


Figure 1. Mean performance over blocks of trials in experiment 1 by: group N observers (—■—, $N=3$) which observed the demonstrator always select the incorrect stimulus, group P observers (---●---, $N=3$) which observed the demonstrator always select the correct stimulus, and group P/N observers (···▲···, $N=3$) which observed the demonstrator select the correct stimulus 50% of the time. *For clarity, standard error bars are shown only for block 4.

subsequent to repeated-measures ANOVA: $F_{1,6} = 9.77$, $P=0.038$). These results suggest that observing errors alone may be more informative than observing correct responses either alone or in combination with errors. The fact that none of the birds in the three groups achieved the 90% correct performance criterion, however, suggests that learning multiple simultaneous discrimination tasks was too difficult; consequently, the specific effects of observing correct and/or incorrect responses may have been masked.

EXPERIMENT 2: SINGLE SIMULTANEOUS DISCRIMINATION TASK

The performance of the birds in experiment 1 suggested that it was too difficult for the birds to have to remember novel patterns on both lids in addition to remembering the payoff that the demonstrator had received from one of these lids. Therefore, in the second experiment, I altered the task to a simpler, single simultaneous discrimination problem. Because the birds would experience the same pair of lids on every trial, individual as well as social learning would be possible. Thus, I added a group that saw no demonstration to control for individual learning.

Methods

Subjects

I used 20 wild-caught adult starlings as naive observers; the demonstrator was the same bird as in experiment 1. All birds were housed, maintained and trained to peck off lids as in experiment 1.

Procedure

The procedure was similar to that of experiment 1 except for the following differences. In this experiment, the same pair of stimulus lids was presented to the demonstrator and observer on every trial. One lid had a black triangle on a white background; the other had a white square on a black background. I determined the correct stimulus lid for each observer by a single presentation of the two unrewarded lids prior to the start of the experiment. I designated the lid not selected by the observer as the correct lid.

In addition to the original three treatment groups, I added a fourth group (group C) to control for individual learning. Individuals in this group observed the stimulus lids being presented to the demonstrator; neither lid had a black sticker, however, and a piece of clear Plexiglas prevented the demonstrator from making a selection. In these trials, the demonstrator looked closely at the lids but made no attempt to peck at them through the Plexiglas. I arbitrarily assigned five observers (three males and two females) to each of the four treatment groups. I measured the effectiveness of information transmission as the number of trials required to learn the discrimination task. Observers were considered to have learned the discrimination when they made nine correct responses in 10 consecutive trials. As in experiment 1, I used remedial presentations to deal with side biases which developed in individual birds; I analysed these remedial data separately from the acquisition data.

Results

There was a significant effect of treatment group that was consistent with the results of experiment 1 ($F_{3,16}=4.96$, $P=0.013$; Fig. 2). Group N birds learned the discrimination significantly sooner than the other three groups (subsequent contrasts: $F_{1,16}=12.71$, $P=0.003$). On average, group P birds learned the task more

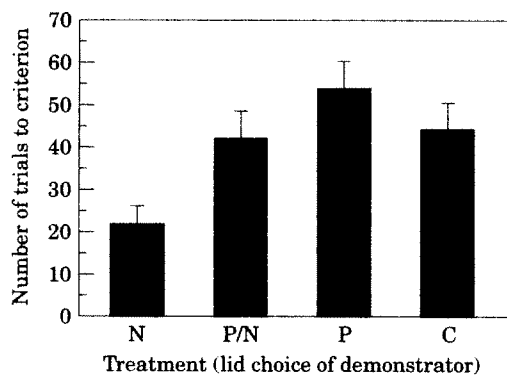


Figure 2. Mean \pm SE number of trials required to learn the discrimination task in experiment 2 by group N observers ($N=5$) which observed the demonstrator always select the incorrect stimulus, group P observers ($N=5$) which observed the demonstrator always select the correct stimulus, group P/N observers ($N=5$) which observed the demonstrator select the correct stimulus 50% of the time, and group C observers ($N=5$) which observed no stimulus choices by the demonstrator.

slowly than the other groups, but the number of trials they required to learn did not differ significantly from those of groups P/N and C (subsequent contrasts: $F_{1,16}=2.11$, $P=0.17$). The number of times that remedial presentations were required to deal with side biases also depended on treatment group ($F_{3,16}=5.52$, $P=0.009$). Group N birds required significantly fewer remedial sessions (1.4 ± 3.1) than the other three groups (group P/N, 6.6 ± 1.5 ; group P, 9.4 ± 4.9 ; group C, 7.2 ± 2.3 ; subsequent contrasts: $F_{1,16}=14.46$, $P=0.002$).

I carried out separate G -tests of independence for each bird in group P/N, whose lid choices were affected by the preceding lid choice of the demonstrator (Fig. 3). Although only two of these tests showed significant differences, the combined probability value from all five P/N birds was significant ($P<0.05$; Sokal & Rohlf 1981). Subsequent paired t -tests showed that whenever the demonstrator picked the correct lid pattern, the P/N observers were not significantly more likely to pick the same (correct) lid pattern over the other (incorrect) pattern ($t_4=1.378$, $P=0.24$). When the demonstrator picked the incorrect lid pattern, however, P/N observers were significantly more likely to pick the other (correct) lid pattern ($t_4=-4.164$, $P=0.014$).

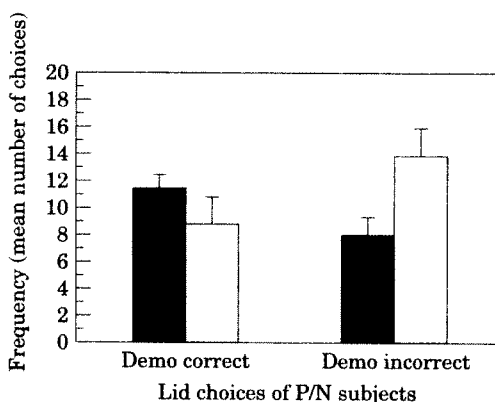


Figure 3. Mean \pm SE number of times that group P/N observers selected the same stimulus lid (■) or the alternative lid (□), after the demonstrator had chosen either the correct lid or the incorrect lid in experiment 2.

DISCUSSION

The results are consistent with the enhanced learning shown by observers of non-proficient demonstrators reported elsewhere (Myers 1970; Vanayan et al. 1985; Biederman & Vanayan 1988). My experiments differed from these previous studies in that I had complete control over the stimulus choices of the demonstrator bird and the payoffs that it received across all trials in all treatment groups. The findings indicate that, for starlings, seeing a conspecific making incorrect foraging decisions is more effective for learning a discrimination task than seeing either a combination of correct and incorrect decisions, or correct decisions alone.

Because the state of a selected food well was concealed from the observers' view by the displaced lid, they could not have used this as a source of non-social information to direct their choice of lid pattern. Nor were they blindly imitating the lid pattern choices of the demonstrator (Palameta & Lefebvre 1985); rather, the observers used the demonstrator's behaviour as a source of social information to direct their own foraging decisions.

There are at least two possible explanations for the enhanced learning shown by the group N birds that observed the demonstrator consistently selecting the unrewarded stimulus. First, some studies have proposed that in individual (solitary) trial and error learning of a simultaneous

discrimination task, attention to the negative or unrewarded stimulus (S⁻) may be even more important than attention to the positive or rewarded stimulus (S⁺) (Biederman et al. 1976). Observers may learn to avoid the S⁻ before they learn to select the S⁺ (Biederman 1967). If so, then the group N birds were probably at an advantage as a result of receiving only social information about the most relevant or salient stimulus for learning the discrimination. In experiment 2, the group P/N birds were significantly more likely to select the correct stimulus on those trials where the demonstrator picked the incorrect stimulus lid, which also supports this hypothesis.

Second, it has been suggested that the sight of food (Darby & Riopelle 1959) or the sight of another individual foraging (Levine & Zentall 1974; Zentall 1988) might distract the observer; thus, when the group P birds saw the demonstrator obtain his food reward, their attention may have been distracted from the crucial stimulus feature (the lid pattern), a problem not experienced by the group N birds. This possibility has some support from the behaviour of the group P/N birds, which were equally likely to select the correct or incorrect lid pattern after observing the demonstrator obtain food from under the correct stimulus lid.

There were several procedural differences between this study and previous research on the social learning of discrimination tasks (Robertson et al. 1985; Vanayan et al. 1985; Hogan 1986; Biederman & Vanayan 1988). Most notably, the typical experimental session in these previous studies consisted of a series of 24–120 demonstration trials, followed by the same number of training trials where the observer had the opportunity to respond to the discriminative stimuli. In contrast, my experimental sessions consisted of only two demonstrations followed by a single opportunity for the observer to respond to the same stimulus pair. It could be argued that this procedure influenced how observers responded to the stimulus choices and payoffs of the demonstrator. For example, when the group P birds observed the demonstrator obtain food from the correct stimulus lid, they may have then considered the well under that lid to be depleted and proceeded to check the (incorrect) alternative lid. There are several arguments against this possibility. First, as I have already mentioned, the contents of the chosen well were hidden from the observers' view

by the displaced lid, so they could not have used this non-social information to decide that the well was now empty. Second, the rewarded lid was always selected for two demonstrations in a row, which should have made the group P birds more likely to learn that the demonstrator was not depleting it. In experiment 2, group P/N birds were also not significantly more likely to pick the incorrect lid after observing the demonstrator select and eat from the rewarded stimulus lid on a P trial, although a depletion effect would predict that.

I cannot rule out a depletion effect entirely, and it might provide an alternative explanation for the results of the P/N group. There could have been a combination of two effects: learning through behavioural cues (if the demonstrator wins, stay; if the demonstrator loses, shift), as well as a depletion effect. These effects should work in opposite directions on P trials (where the demonstrator picked the correct lid), such that the observers should be equally likely to pick the correct or incorrect lid. On N trials (where the demonstrator picked the incorrect lid), however, these effects should work in the same direction and thus facilitate acquisition.

These results extend the findings of Templeton (1993) and Templeton & Giraldeau (1995a, 1996), which showed (1) that group-foraging starlings pay attention to the unsuccessful as well as the successful foraging activities of their companions, and (2) that they use this public sampling information (Valone 1989) in combination with their personal sampling information to help them assess the quality of a resource patch and make more efficient patch departure decisions. The enhanced learning of the group N birds in both experiments 1 and 2, and the higher proportion of correct responses made by the group P/N birds when they observed the demonstrator select the incorrect lid in experiment 2, both suggest that a lack of success may provide more public information about the quality of a resource patch than success. Under natural foraging conditions, this possibility makes intuitive sense. Observing the discovery of a prey item by another individual could tell a potential scrounger one of two things: either that the location is now depleted or that there is more food to be found. Thus, the public information provided by success often could be ambiguous, depending on the environment and an individual's prior foraging experience in that environment. A

lack of success, on the other hand, should provide unambiguous public information, allowing other group members to recognize where not to forage and when not to scrounge (e.g. Benkman 1988; Templeton & Giraldeau 1995b).

ACKNOWLEDGMENTS

This research was carried out while I was supported by NSF grant OSR9255225 and by an FCAR (Québec) post-doctoral fellowship. For helpful discussions at various points during this research, I thank Alan Bond and Al Kamil. I thank Kerri Bestul for her assistance with the experiments and Chris Smith for caring for the starlings. Kari Benson, Jim Mountjoy, Alan Bond and Louis Lefebvre commented on an early version of the manuscript, and I am grateful to them. I also thank Jeff Galef and two anonymous referees for their comments.

REFERENCES

- Beauchamp, G. & Kacelnik, A. 1991. Effects of the knowledge of partners on learning rates in zebra finches, *Taeniopygia guttata*. *Anim. Behav.*, **41**, 247–253.
- Benkman, C. 1988. Flock size, food dispersion, and the feeding behaviour of crossbills. *Behav. Ecol. Sociobiol.*, **23**, 167–175.
- Biederman, G. B. 1967. The overlearning reversal effect: a function of the non-monotonicity of S- during discrimination learning. *Psychon. Sci.*, **7**, 385–386.
- Biederman, G. B. & Vanayan, M. 1988. Observational learning in pigeons: the function of quality of observed performance in simultaneous discrimination. *Learn. Motiv.*, **19**, 31–43.
- Biederman, G. B., Poulos, C. X. & Heighington, G. A. 1976. Paradoxical preference for more frequently occurring negative stimuli and for less-frequently occurring positive stimuli as a function of amount of training in simultaneous discrimination learning. *Learn. Motiv.*, **7**, 603–613.
- Darby, C. L. & Riopelle, A. J. 1959. Observational learning in the rhesus monkey. *J. comp. Physiol. Psychol.*, **52**, 94–98.
- Del Russo, J. E. 1975. Observational learning of discriminative avoidance in hooded rats. *Anim. Learn. Behav.*, **3**, 76–80.
- Herbert, M. J. & Harsh, C. M. 1944. Observational learning by cats. *J. comp. Psychol.*, **37**, 81–95.
- Heyes, C. M. & Dawson, G. R. 1990. A demonstration of observational learning in rats using a bidirectional control. *Q. Jl exp. Psychol.*, **42B**, 59–71.
- Hogan, D. E. 1986. Observational learning of a conditional hue discrimination in pigeons. *Learn. Motiv.*, **17**, 40–58.
- John, E. R., Chesler, P., Bartlett, F. & Victor, I. 1968. Observation learning in cats. *Science*, **159**, 1489–1491.
- Levine, J. M. & Zentall, T. R. 1974. Effect of a conspecific's presence on deprived rats' performance: social facilitation vs. distraction/imitation. *Anim. Learn. Behav.*, **2**, 119–122.
- Myers, W. A. 1970. Observational learning in monkeys. *J. exp. Analysis Behav.*, **14**, 225–235.
- Nicol, C. J. & Pope, S. J. 1992. Effects on the acquisition of discriminatory keypecking in hens. *Bull. Psychon. Soc.*, **30**, 293–296.
- Palameta, B. & Lefebvre, L. 1985. The social transmission of a food-finding technique in pigeons: what is learned? *Anim. Behav.*, **33**, 892–896.
- Robertson, H. A., Vanayan, M. & Biederman, G. B. 1985. Observational learning and the role of confinement in pigeons: suppression of learning as a function of observing the performance of a conspecific. *J. gen. Psychol.*, **112**, 375–382.
- Sokal, R. R. & Rohlf, F. J. 1981. *Biometry: the Principles and Practice of Statistics in Biological Research*. New York: W. H. Freeman
- Templeton, J. J. 1993. The use of personal and public information in foraging flocks of European starlings. Ph.D. thesis, Concordia University, Montréal.
- Templeton, J. J. & Giraldeau, L.-A. 1995a. Patch assessment in foraging flocks of European starlings: evidence for the use of public information. *Behav. Ecol.*, **6**, 65–72.
- Templeton, J. J. & Giraldeau, L.-A. 1995b. Public information cues affect the scrounging decisions of starlings. *Anim. Behav.*, **49**, 1617–1626.
- Templeton, J. J. & Giraldeau, L.-A. 1996. Vicarious sampling: the use of personal and public information by starlings foraging in a simple patchy environment. *Behav. Ecol. Sociobiol.*, **38**, 105–114.
- Valone, T. J. 1989. Group foraging, public information, and patch estimation. *Oikos*, **56**, 357–363.
- Vanayan, M., Robertson, H. A. & Biederman, G. B. 1985. Observational learning in pigeons: the effects of model proficiency on observer performance. *J. gen. Psychol.*, **112**, 349–357.
- Zentall, T. R. 1988. Experimentally manipulated imitative behavior in rats and pigeons. In: *Social Learning: Psychological and Biological Perspectives* (Ed. by T. R. Zentall & B. G. Galef, Jr), pp. 191–206. Hillsdale, New Jersey: Lawrence Erlbaum.