Title	Naïve biology in pigeons : re-visited
Sub Title	
Author	渡辺, 茂(Watanabe, Shigeru)
Publisher	Centre for Advanced Research on Logic and Sensibility The Global Centers of Excellence Program, Keio University
Publication year	2010
Jtitle	CARLS series of advanced study of logic and sensibility Vol.3, (2009.) ,p.5- 14
JaLC DOI	
Abstract	
Notes	Part 1: Brain and Evolution
Genre	Research Paper
URL	https://koara.lib.keio.ac.jp/xoonips/modules/xoonips/detail.php?koara_id=KO12002001-20100331-0005

1 Naïve Biology in Pigeons: Re-visited

Shigeru Watanabe[1,2]

[1] Department of Psychology, Keio University
[2] Centre for Advanced Research on Logic and Sensibility (CARLS), Keio University

I. Introduction

Recent studies in developmental psychology have demonstrated that children possess a kind of naive theory about various aspects of their surroundings: a "naive physics," "naive biology," and "naive psychology" (Hickling & Gelman, 1995). These are sometimes referred to as "folk theory." A species taxonomy based on folk biology appears to be independent of culture; for example, Maya Indians and students in the United States give the same taxonomic rankings (Atran, 1998). This suggests that there is a developmental change in folk biology in the human species: at first, children consider plants to be nonliving because they cannot eat or move; however, by age, they know that both animals and plants are living and understand their cycles of growth, health, and death.

Pigeons have good visual cognition (Herrnstein & Loveland, 1964; Watanabe, 2006a) and are able to learn complex visual categories such as "good" and "bad" paintings (Watanabe, 2009). In various conditions they have been shown to understand the movements of objects hidden by obstacles (Neiworth & Rilling, 1987) and intentional movement of objects (Goto et al., 2002). Male pigeons have been observed to perform courtship displays to video images of female pigeons (Patten et al., 2003), suggesting that they see the video images as representations of living conspecifics. Yamazaki et al. (2006) trained quail to discriminate between moving video images of a quail injected with psychoactive drugs and a normal, undrugged quail. Methamphetamine (a stimulant) or ketamine (an anesthetic) were used to produce drug-induced behaviors; the former induced hyperactive behavior and the latter hypoactive behavior. One group of quail was trained to peck images of a hyperactive quail, but not those of a normal quail. The other group was trained to peck images of a hypoactive quail, but not those of a normal quail. After discriminative training, the subjects received a test with images of hyperactive, normal, and hypoactive quail. The quails showed generalization to novel images of the drug-induced behaviors. They classified different drug-induced behaviors (hypoactive and hyperactive) into a single category ("abnormal") representing behavior that differed from normal behavior. Similar discrimination of drug-induced behavior was seen in pigeons (Yamamoto & Watanabe, 2007). These results suggest that birds can have a visual category whose members appear to be different based on a perception of behavior, not mere appearance. In other words, they perceive a category that cannot be specified solely by appearance-related perceptual cues.

If pigeons understand that animals can move but that plants cannot, a moving plant should be an "impossible" (or at least anomalous) image for them, whereas images of moving animals should be "possible." Using pigeons as subjects, Watanabe and Lea (unpublished data) examined how moving birds and moving trees were perceived. The pigeons showed generalization to the moving birds after training with still images of birds, but they did not show generalization to the moving trees after training with still images of trees. However, in that experiment we artificially moved still images horizontally on a computer screen to make moving images. Hence the movement was artificial and differed from the natural movement of animals.

Later, I replicated this experiment with more natural movements using images of pigeons, goldfish, vegetables, and water plants (Watanabe,2006b). To make moving images of vegetables, I videotaped a corncob or a pumpkin being pulled by a transparent fishing line. I tried to mimic animal movements to produce the non-animal stimuli. First, the movement was not constant; the objects moved and stopped and moved and stopped. Second, the direction of the movement was not fixed; in other words, the objects moved around or wiggled too much. Third, the movement was not random; it looked intentional to human observers.

Although these stimuli were not ideal, experiments using them were suggestive. In the first of two experiments, pigeons were trained in discrimination with still images of pigeons and vegetables, and then received a generalization test with images of moving pigeons and moving vegetables. The latter suppressed subjects' responses, but the moving-pigeon images did not. These results suggested that there are differences in pigeons' perception of moving animals (i.e., "possible" images) and moving plants ("impossible" images). Because the moving pigeons might be familiar stimuli for the pigeons but the moving vegetables presumably were not, a second experiment was conducted in which goldfish and water plants were used as discriminative stimuli. The subjects had not yet had any experience of seeing these stimuli, yet again, moving water plants suppressed responses but moving goldfish did not. Because "naive biology" indicates that animals can move but plants cannot, these results suggested that pigeons possess a type of discrimination resembling naive biology.

In these experiments, however, movement of the non-animal stimuli was not exactly same as that of the animals. Perhaps some difference in movement was perceived, even though the experimenter tried hard to make animal-like movements while manipulating the non-animal objects. In the present experiments, an image of a non-animal object was pasted over moving images of animals. Thus, movements of the non-animal and animal stimuli were exactly the same.

II. Experiment 1: Discrimination with Mouse and Potato

II.1. Methods

Subjects

Five homing pigeons obtained from the Japan Racing Pigeon Association were used. They had experience of operant conditioning (key pecking) but no experience of screen pecking. They lived in cages individually under a 12L: 12D light cycle and their weights were maintained at 80% of their free feeding weight. The temperature of the animal room was maintained at 23 degrees C and water was freely available in the cages. The subjects were treated in accordance with the guidelines of the Japanese Society of Animal Psychology.

Apparatus

Standard operant chambers with a modified pecking window were used (30 x 25 x 30 cm, MED). The birds could see a liquid crystal display monitor (24 x 37cm) of a computer (PowerPC G4, iMac 2.1, 800 MHz) through the rectangular transparent key (10 x 7 cm). The distance between the window and the monitor was 20 cm. There was a liquid crystal shutter (Um glass) between the key and the monitor.

Stimuli

At first I recorded video clips of a walking mouse (male C57/BL) with a digital video camera from overhead. Selecting frames from the clips produced still images. To make moving images of a potato, I took a still image of a potato and then digitally pasted it over the mouse in the moving video. Thus, global movement of the mouse and the potato was exactly the same. (The size of the potato was adjusted to cover the entire body of the mouse, but sometimes part of the tail could be seen.) A negative stimulus—not associated with food reinforcement—was an image of the same visual context, but without the mouse or the potato.

Procedure

All birds received training to peck a rectangular key. They had been trained to peck a regular circular key, and they readily started to peck the rectangular key, through which they saw a red circle stimulus on the computer screen. Then they were trained on a Variable Interval (VI) schedule, whose value of VI was gradually increased to 20 s. During this preliminary training, no training stimuli appeared on the TV monitor. After the subjects showed steady responding on VI 20 s, discriminative training began.

Discriminative training: Four of five birds were trained on mouse discrimination. During discrimination training, 4 different still images of a mouse (S+) and a background stimulus (S-) were presented in accordance with the Gellerman series to avoid three successions of S+ or S-. Four images of the mouse were randomly presented 5 times, and the background was presented 20 times. Pecking at the mouse image (S+) was rewarded by a 4 s period of access to a feeder after a variable interval with a mean of 20 s (VI 20 s schedule), whereas pecking at the background was not rewarded. After the 20 s presentation of a stimulus, the monitor was darkened for 5 s by a liquid crystal shutter and then the next trial began. Any peck on the key during the 5 s period prolonged the darkened period for 5 s: that is, a chained differential reinforcement of zero rate schedule (chain DRO 5 s) was in effect during the darkened period. This training continued until the birds emitted more than 90% of their total responses to the mouse images (the discrimination ratio) for 2 successive sessions. After the discrimination training, the subjects received generalization tests. After completion, the subjects were trained on potato discrimination in which four different still images of the potato were S+, and the background was S-. Discrimination criteria and other procedures were identical to those of the mouse discrimination case.

The one remaining subject received the two discrimination tasks in reverse order: that is, the potato discrimination first, then the mouse discrimination.

Generalization test: Once the criterion was reached, the birds were tested with new images. Two still images of the mouse never shown during the training and two moving images of the mouse were presented (in addition to the two still images of the mouse used for the discriminative training and the image of the background, S-). Each stimulus appeared five times, each time for 20 s. No reward was given for pecking these test stimuli.

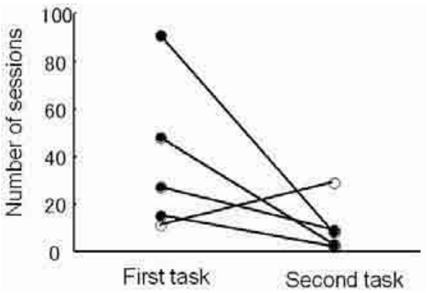

Figure 1. Number of sessions to reach the criterion. Each dot indicates individual subject. The first task and the second task are discrimination with mouse and that with potato for dark dots but the order is reversed for the open dot subject.

II.2. Results and Discussion

Discriminative learning: As presented in Figure 1, the subjects trained on the mouse discrimination first and then on the potato discrimination showed clear transfer of learning. The average number of sessions needed to achieve the criterion was 45.25 and 5.5 sessions for the mouse discrimination and the potato discrimination, respectively. On the other hand, transfer of learning from the potato discrimination to the mouse discrimination was not obtained; this bird required more sessions to learn the mouse discrimination. Discrimination with the mouse seemed to be harder than that with the potato, but two factors might have been involved in this discrepancy. One was stimulus size. To cover the whole body of the mouse, the size of the potato was larger than that of the mouse. Hence, discrimination transfer from the mouse to the potato meant enlargement of the size, whereas the reverse transfer meant reduction of the size. The other factor was stimulus complexity. The mouse had four legs and a tail, whereas the potato had a smooth outline. Hence, transfer from the mouse to the potato involved a reduction of the complexity, while the reverse transfer involved an increase in complexity.

Generalization test: Figure 2 shows the results of the generalization test. The vertical axis indicates the relative response ratio that was obtained by dividing the number of responses to each stimulus item by the total number of responses to all stimuli. After the discriminative training on the mouse task, the subjects responded not only to the new still images but also to the moving images. There was no statistically significant difference in relative response between the old S+ and new still images, and between the old S+ and the moving images (paired t-test, t(4) =1.06 and 2.54, respectively). This result agreed with my previous experiment with pigeon images (Watanabe, 2006b).

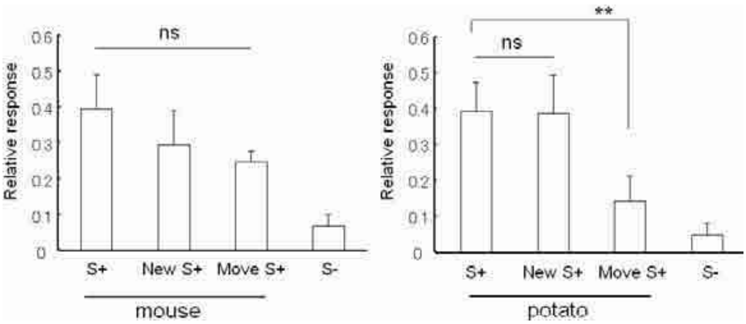

Figure 2. Relative responses to the novel still stimuli and moving stimuli. Left: The generalization test after the discrimination with mouse. Right: The generalization test after the discrimination with potato. The small vertical bars indicate standard error. **P<0.05

After the discriminative training with the potato, the subjects responded often to the novel images of the potato but not to the moving images of the potato. There was no significant difference in response between the old S+ and the novel S+ (t(4)=0.08), but there was a significant difference between the old S+ and the moving images (t(4)=4.02, P<0.05). This result agreed with my previous experiment using vegetable images (Watanabe, 2006b).

Because the bird that trained on the discrimination of the potato first showed a similar generalization to other birds, the order of discriminative training did not affect the results. A paired t-test of the responses to the moving images revealed a significant difference between the mouse group and the potato group (t(5)=3.03, P<0.04).

These results demonstrate that the pigeons perceived moving images of the mouse and those of the potato differently. Because the subjects showed clear generalization to the new still images in both tasks, they acquired a kind of categorical discrimination. The moving mouse should have membership of the category "mouse" but the moving potato should not have any such membership in the category "potato." However, there was a potentially confounding factor in the test stimuli: the tail. The still images of the potato did not have a tail, but the corresponding moving images did have the tail in some frames. Although the difference was slight, the moving potato had something not belonging to the potato, so another experiment was conducted to resolve this issue.

III. Experiment 2: Discrimination with Fish and Stone

Results of Experiment 1 showed a difference in the perception of a moving mouse versus that of a moving potato, suggesting differential cognition of possible image and impossible images. But perhaps a small difference in stimuli, namely a flipping tail attached to the potato, caused the difference. When the image of a potato was sized so as to completely cover the mouse's body including the tail, it was approximately twice as large as the mouse, obviously a noticeable difference. In Experiment 2, I used an image of a fish instead of a mouse. An image of a stone approximately same size of the fish easily covered whole body of the fish.

III.1. Method

Subjects

Four homing pigeons were used. Three of them were the subjects used in Experiment 1, and the fourth had a history of key pecking. They were treated in the same way as Experiment 1.

Apparatus

I used the same apparatus as in Experiment 1.

Stimuli

I recorded video clips of swimming a convict cichlid fish (*Amatitlania nigrofasciata*) from the side view of the aquarium. Selected frames from the clips produced the still images. To make moving images of a stone, I took a still image of a stone and pasted it over the fish in each frame of the video. The size of the stone was adjusted to cover the whole body of the fish. Thus, global movement of the fish and the stone was exactly the same. The negative stimulus—not associated with food reinforcement—was an image of the same visual context, but without the fish or the stone.

Procedure

Discriminative training and testing procedures were identical to those in Experiment 1, except for stimuli. Three of the four birds were trained on the discrimination with fish first, and then with the stone. The remaining bird was trained on the two tasks in reversed order.

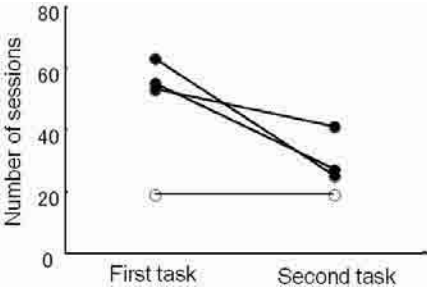

Figure 3. Number of sessions to reach the criterion. Each dot indicates individual subject. The first task and the second task are discrimination with fish and that with stone for dark dots but the order is reversed for the open dot subject.

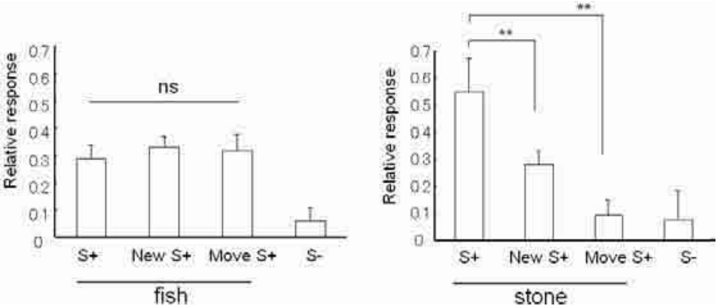

Figure 4. Relative responses to the novel still stimuli and moving stimuli. Left: The generalization test after the discrimination with fish. Right: The generalization test after the discrimination with stone. The small vertical bars indicate standard error. **P<0.05

III.2. Results and Discussion

Discriminative training: Figure 3 shows the number of sessions to reach the criterion. Three birds learned the stone discrimination faster than the fish discrimination, suggesting transfer of learning. The one bird that was trained on the stone discrimination first did not show such transfer. Just as in Experiment 1, the discrimination with images of animals (mouse versus fish) was easier to learn that with the non-animal objects (potato versus stone). Because the stimulus size of the stone was approximately the same as that of the fish, stimulus complexity might have facilitated discriminative learning, but not stimulus size.

Generalization test: Figure 4 shows results of the generalization tests. The birds responded to the still images of the novel fish and the moving image of the fish as much as to the original S+ (paired t-test, t(3)=2.91 and 0.55, respectively). After the training with the stone, they responded less to the new still images (t(3)=3.44, P<0.05) and to the moving images (t(3)=4.87, P<0.05). Thus, the subjects showed generalization to the moving images of the fish. Because the subjects showed a significant decrement in responses to the novel still images of the stone, they might not learn images of stone as a category. There was, however, a significant difference in response between the novel still images of the stone and those of the moving images (t(3)=3.50, P<0.05). Therefore, the moving images of the stone were more distant (psychologically) from the original stone than the novel still images were for the pigeons.

A paired t-test of the responses to the moving images revealed a significant difference between the fish group and the stone group (t(3)=69.80, P<0.000001). These statistical analyses suggested that the moving stone suppressed responding but the moving fish did not. These results were consistent with Experiment 1 and a previous experiment (Watanabe, 2006b).

IV. General Discussion

The present results confirmed the previous experiments (Watanabe, 2006b): that is, moving non-animal objects are impossible images and suppressed responding, but moving animals are possible images and did not suppress responding. Thus, even pigeons may have a kind of naive "theory" of biology. But the present experiments cannot show how or when the birds acquired such a theory. They may have learned through experience, possess a predisposition, or both. However, the fact that young nidifugous birds are readily imprinted by exposure to moving inanimate objects suggests that experience of moving objects may play an important role. Movement may be a special aspect of an object that encourages the perception of them as animals.

Because the global movement of the animal and non-animal objects was exactly the same, the difference between the two categories pertained to local movement of body parts. Although fish do not have limbs, their fins move to produce movement. Global movement without local movement may be criterion of "impossible" movement. Further studies are needed to clarify details of "possible" and "impossible" movement of animals and non-animals.

In our most recent research, we produced a "virtual" pigeon using computer graphics (CG) and made pigeon images with and without impossible movement (Watanabe & Troje,2006). Pigeons were trained to discriminate between movies of a real pigeon and a rat. Then they were tested with movies of the CG pigeon. Subjects did show generalization to the CG pigeon. However, they also responded to modified versions in which the CG pigeon showed impossible movement (namely, hopping and walking without head bobbing). Hence, the pigeons did not attend to these particular details of the movement. But when they were trained to discriminate between the normal and the modified version of the CG pigeon, they could indeed learn the discrimination. Thus, although they could discriminate possible and impossible movement, they needed to learn the discrimination by training. These experiments also suggested that detailed analyses of perception of movement of animals and non-animals are required to clarify the nature of the naive theory of biology in nonhuman animal.

References

Atran, S. (1998). Folk biology and the anthropology of science: Cognitive universals and cultural particulars. Behaviour & Brain Science 21, 546–69.

Goto, K., Lea, S. E. G., & Dittrich, W. H. (2002). Discrimination of intentional and random motion paths by pigeons. Animal Cognition 5, 119–27.

Herrnstein, R. J., & Loveland, D. H. (1964). Complex visual concept in the pigeon. Science, 146, 549–51.

Hickling, A. K., & Gelman, S. A. (1995). How does your garden grow? Early conceptualization of seeds and their place in plant growth cycle. Child Development, 66, 856–76.

Neiworth, J. J., & Rilling, M. E. (1987). A method for studying imagery in animals. Journal of Experimental Psychology: Animal Behavior Processes, 13, 203–14.

Patten, T., Yeida, S., Bushmann, J-U., Troje, N., & Shimizu, T. (2003). Courtship displays of male pigeons can be triggered by video-imaged and computer-animated pigeons. Paper presented at the 10th Annual International Congress of Comparative Cognition.

Watanabe, S. (2001). Van Gogh, Chagall and pigeons: Picture discrimination in pigeons and humans. Animal Cognition, 4, 147–51.

Watanabe, S. (2006a), The neural basis of cognitive flexibility in birds. In Zentall, T. & Wasserman, E. (Eds) Comparative cognition: Experimental exploration of animal intelligence. Oxford Univ. Press, 205–212.

Watanabe, S. (2006b). Do animal have a theory?: Naïve biology in pigeons. In Andler, D., Ogawa, Y., Okada, M., & Watanabe, S. (Eds) Reasoning and cognition Keio University Press, pp. 205–212.

Watanabe, S. (2010). Pigeons condiscriminate “good” and “bad” paintings by children. Animal Cognition, 13, 75–85.

Watanabe, S., & Troje, N. (2006). Towards a “virtual pigeon”?: A new technique for investigating avian social cognition. Animal Cognition, 9, 271–279.

Yamamoto, E., & Watanabe, S. (2007). Dissociation of effects of entopallium lesions upon individual discrimination and behavioral state discrimination in pigeons (*Columba livia*). In Watanabe, S., Tsujii, T., & Keenan, J. P (Eds) Comparative Social Cognition. Keio University Press, Tokyo, pp. 61–70.

Yamazaki, Y., Shinohara, N., & Watanabe, S. (2004). Visual discrimination of normal and drug induced behavior in quails (*Coturnix coturnix, japonica*). Animal Cognition, 7, 128–132.