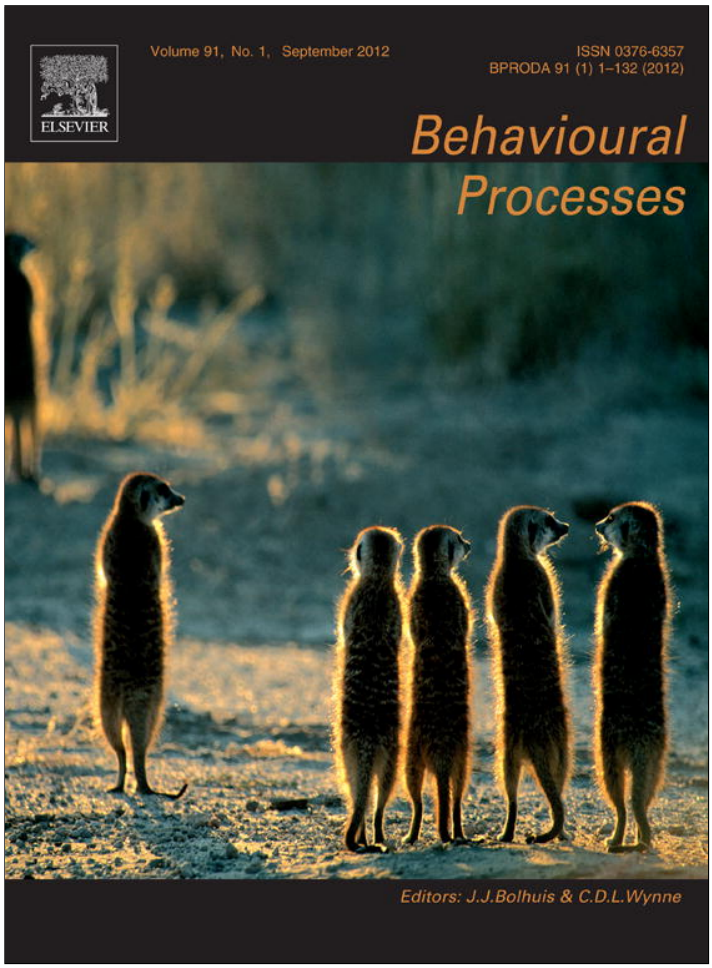

Behavioural Processes 91 (2012) 129–132

Contents lists available at SciVerse ScienceDirect

Behavioural Processes

journal homepage: www.elsevier.com/locate/behavproc

Short report

Food choice in the laboratory pigeon☆

Traci Biedermann, Dennis Garlick, Aaron P. Blaisdell*

University of California, Los Angeles, United States

ARTICLE INFO

Article history:
Received 10 April 2012
Received in revised form 12 June 2012
Accepted 18 June 2012

Keywords:
Pigeon
Food choice
Preference
Reinforcement
Nutrition

ABSTRACT

Although food reward plays a large role in learning and behavioral experiments, there have been few studies examining the most motivating food reward for pigeons. Brown (1969) found that pigeons had a tendency to prefer peas, while Killeen et al. (1993) found pigeons to prefer peas and popcorn in Experiment 1A. We looked to further explore these options as well as expand upon the types of foods examined beyond mainly grains and seeds. Pigeons were presented with six novel foods (granulated peanuts, popping corn, freeze-dried mealworms, bread crumbs, split peas, and sunflower hearts) allocated into two sets of three food items. Once the most consumed food from each food set was determined, they were pooled together with sorghum seeds (a familiar food) to form a third set. Sunflower hearts were the most consumed of all the food items, followed by corn and granulated peanuts. We discuss the potential factors mediating consumption choice, including nutritional profile and food particle size.

Food reward typically plays an integral role in subject performance in pigeon learning and behavioral studies because it provides incentive for a pigeon to learn a new behavior or strengthen control of an established behavior. Currently many behavioral studies involving pigeons utilize mixed grain as a reward; but perhaps there is a better alternative. Although the natural diet of *Columba livia* has been found to consist of mostly seeds (Murton and Westwood, 1966), dietary shifts toward consuming popcorn, peanuts, and bread have been seen in cities as a result of an increased availability of human food waste. Given the seminal role reward plays in motivating the pigeon in behavioral research, our goal was to find those rewards that would be most preferred.

Despite the vast literature of behavioral experiments using pigeons, few studies have investigated food choice or preferences of the pigeon. Killeen et al. (1993) found that pigeons have a preference toward peas and popcorn. Similarly, Brown (1969) found pigeons to have a preference for peas. These studies suggest that there may be some consistency in the appearance of peas and maize among the top food choices for pigeons, a trend to be tested further in this study.

To expand upon previous studies regarding pigeon food preferences, this study broadened the range of food items tested to include sunflower hearts, popping corn, granulated peanuts, freeze-dried mealworms, bread crumbs, and split peas. Prior to the experiment, the pigeons were exposed to a different novel food (from the set above) each day over six consecutive days in their home cages. The pigeons were then presented with groupings of three foods per trial, with the location of each food type randomized across trials. Each pigeon was allowed two minutes to freely consume the available foods. Food preference was determined based on the weight of food consumed. Various factors were assessed to determine the possible relationships between the characteristics of the foods tested and the preferences of the pigeons.

1. Methods

1.1. Subjects

Eight domesticated pigeons (*C. livia*; Double T Farm, Iowa) with prior experience in touchscreen-equipped operant chambers served as the subjects. The pigeons were maintained at 80–85% of their free-feeding weight via a restricted feeding schedule consisting of 15 g of pellets (Royal Feeds) delivered daily following each testing session. The pigeons were individually housed in steel home cages in a vivarium with a 12-h light–dark cycle with free access to grit and water.

1.2. Apparatus

All tests were performed in a 2.3 m × 1.5 m anechoic room covered in white sound insulating tiles. The North wall contained an opening (31.8 cm high and 16.7 cm wide) that led to a white acrylic holding cage (35.6 × 36.8 × 30.5 cm). Illumination was provided by four 25-W incandescent lights. A white noise generator delivered

☆ Support for this research was provided by NIH Grant NS059076 (A. P. Blaisdell). This research was conducted following the relevant ethics guidelines for research with animals and was approved by UCLA's institutional IACUC.

* Corresponding author at: UCLA Department of Psychology, 1285 Franz Hall, Los Angeles, CA 90095-1563, United States.
E-mail address: blaisdell@psych.ucla.edu (A.P. Blaisdell).

0376-6357/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.beproc.2012.06.005

an oscillating 56–63 dB (A) background noise. On the floor was a semicircle of three food holders arranged so that each food was equidistant from the point of entry into the room (61 cm from the entryway with 23 cm between each food holder). Each food holder was a 21.5-cm square plastic bowl, with a 15.9 cm × 15.9 cm round plastic plate glued on the bottom in an inverted position to stabilize the food holder. Food was arranged in each food holder to equate their volume by visual inspection. The specific type of food placed in each holder was counterbalanced across session and by pigeon. There were no physical differences in the bowls to indicate what food each bowl contained. However, all pigeons were tall enough to see over the side of the bowls (7.5 cm in height) to see each food item. The weight of the food was measured before and after the session, with the difference determining the recorded amount of food consumed. The six novel food items were: bread crumbs (Ralphs brand), sunflower hearts (Flanigan Farms), popping corn (Safeway brand), split peas (Ralphs brand), dried mealworms (Fluker's), and granulated peanuts (Garvey Candy and Nut). In the final test, we also used a seventh food item, sorghum seeds (Royal Feeds), that the pigeons had been exposed to in previous experiments in our laboratory for an average of 5 years.

1.3. Acclimation

Prior to testing, each pigeon was individually acclimated to the room and experimental set-up. At the start of each 2-min acclimation session, the bird was manually placed in the holding cage and allowed to enter the room to explore the food holders. Each food holder was filled with approximately 15 g of pellets (Royal Feeds), which made up the daily diet of the pigeons. After two minutes had elapsed, the pigeon was manually retrieved and returned to its home cage. Acclimation was continued for successive days until each bird was reliably eating food from the food holders (defined as a visually detectable portion of food).

1.4. Food exposure

Prior to the start of testing, each pigeon was exposed to the six novel foods. On each exposure day, each pigeon received 15 cm^3 of one of the test food items in its home cage, with a different food item on each day. This continued for six days so that each pigeon had been exposed to each of the six food items once (order of presentation of the novel foods was counterbalanced across the pigeons). The seventh food item (sorghum seeds) was already a familiar food, and thus, not included in this phase.

1.5. Procedure

1.5.1. Phase 1

The six novel foods were randomly allocated into two groups of three foods, Set A and Set B. Set A consisted of granulated peanuts, split peas, and sunflower hearts. Set B consisted of popping corn, bread crumbs, and freeze-dried mealworms. In each daily session, the birds received a single trial consisting of Set A or Set B, alternating between sets across 12 days, with six days for each set. Half the birds received order ABAB, while the remaining birds received order BABA. The position of each food item within a set was varied systematically across each of the six sessions so that each of the six possible arrangements was used. Each session began by placing the pigeon into the holding cage, allowing the pigeon to enter the test area for two minutes. The bird was then manually retrieved and returned to its home cage. A quarter of a cup (59 cm^3) of each food was measured out at the start of each session and the initial weight of the food was obtained. The weight at the end of the session was then again measured to determine how much had been consumed. Any spilled food was returned to the food holder prior to the final weighing.

1.5.2. Phase 2

Pigeons then received sessions involving a new group of three foods as Set C. Set C was composed of (1) the most highly consumed food on average from Set A, (2) the most highly consumed food on average from Set B, and (3) sorghum seeds, a familiar food for these pigeons. Trials were conducted in the same manner as for Sets A and B.

1.6. Results

1.6.1. Food exposure

When presented in the home cages, all the foods were consumed except for bread crumbs and freeze-dried mealworms. Consumption was determined by visual inspection.

1.6.2. Acclimation

The pigeons took a mean of 4 acclimation sessions with a standard deviation of .76 sessions before they were reliably eating from the food holders.

1.6.3. Phase 1

Set A. Subject 2 was removed due to failure to consume any of the Set A foods. Peanuts and sunflower hearts were both consumed considerably more than peas (Fig. 1a). One-tailed Man Whitney U-Tests revealed peanuts ($U = 7$, $p < .05$) and sunflower hearts ($U = 6$, $p = .01$) both to be consumed at significantly greater amounts than peas. In contrast, consumption of peanuts and sunflower hearts did not differ ($U = 24$, $p > .05$), with only a slightly greater overall consumption of sunflower hearts (46.29%) than of peanuts (38.36%). We chose to include sunflower hearts in Set C as they represented the greatest percentage of food consumed as a whole.

Set B. The only food from Set B consumed by the pigeons was the popping corn (Fig. 1b), which was included in Group C.

1.6.4. Phase 2

Set C. Subject 7 was removed due to lack of food consumption during Phase 2. The final test compared sunflower hearts, popping corn, and sorghum. As seen in Fig. 1c, five of the seven birds consumed a greater percentage of sunflower hearts than either of the other two foods presented. Furthermore, a one-tailed Mann Whitney *U*-Test comparing the percentages of sunflower hearts consumed by each bird to those of popping corn and sorghum seeds consumed also demonstrated that sunflower hearts were significantly more consumed than both popping corn ($U = 9.5$, $p < .05$) and sorghum seeds ($U = 7$, $p < .05$).

2. Discussion

We observed that sunflower hearts were the most chosen of the foods we tested, suggesting its preference, although there was some similarity in the choice between sunflower hearts and peanuts in Set A. As shown in Fig. 1a, sunflower hearts and peanuts were each chosen by three birds apiece. Thus, the lack of a significant difference in the overall amount of each food consumed may reflect variability in individual preferences rather than indifference in choice between the two food options. In fact, a similar result of inter-individual variability was also seen in previous studies by Moon and Zeigler (1979) and Shettleworth (1987). Thus, individual preference may be playing an underlying role in the food preferences of the group as a whole when the food options are similar in their macronutrient profiles and other factors.

One possible factor determining food choice in pigeons is nutritional content of the foods. Fig. 2a shows the macronutrient content

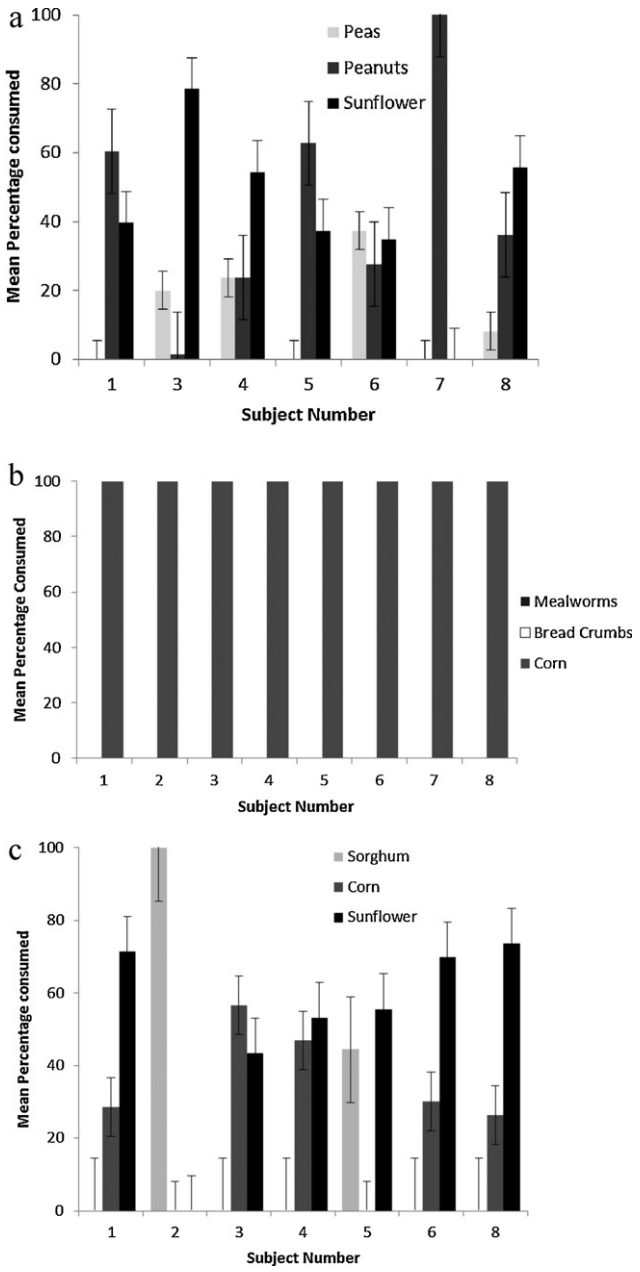

Fig. 1. Mean percentages of total weight of food consumed by each bird across food types for Set A foods (Panel A), Set B foods (Panel B), and Set C foods (Panel C) across all sessions. Percentages were computed individually for each session and then averaged. Error bars represent the standard errors of the mean of the percentages consumed during each session.

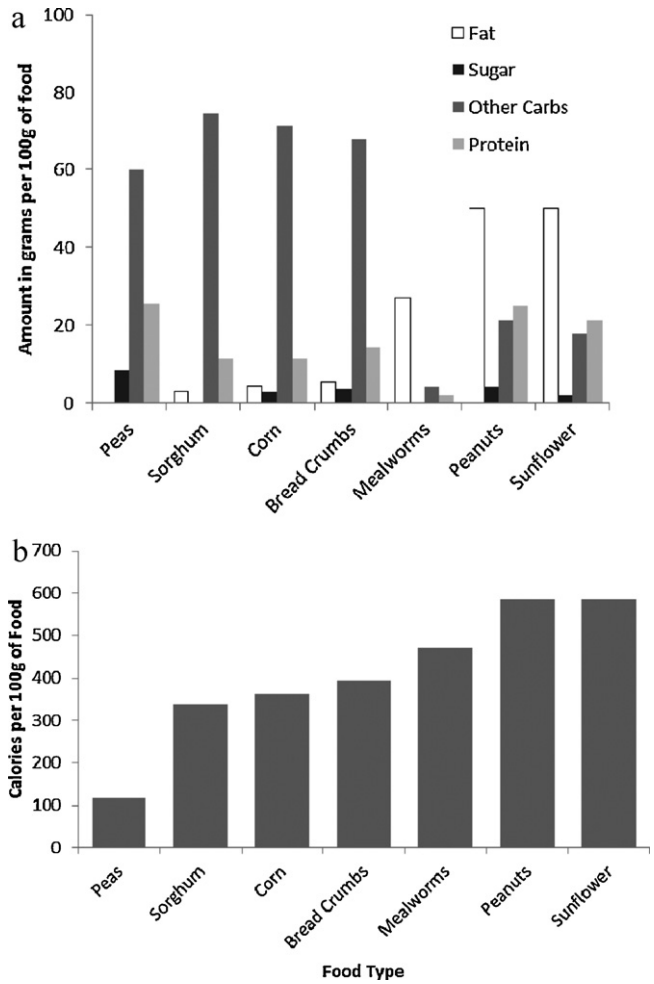

Fig. 2. (a) Nutritional content of each food type per 100 g. Values were derived from the manufacturer or the USDA. Mealworm nutritional information was retrieved from Exotic Nutrition Pet Co. (b) Calorie content per 100 g of each food type. Values were derived from the manufacturer or the USDA. Nutritional information for mealworms was retrieved from Exotic Nutrition Pet Co..

of the different foods tested. Data were derived either from the manufacturer's packaging or the United States Department of Agriculture (USDA) database. Mealworm nutritional information was retrieved from Exotic Nutrition Pet Co. Sunflower hearts and peanuts have very similar nutritional profiles. Both contain the greatest proportion of fat with those fats consisting largely of polyunsaturated (linoleic) fatty acids for sunflower hearts, and monounsaturated (oleic) fatty acids for peanuts. In contrast, the next most selected foods, popping corn and sorghum seeds, were considerably higher in carbohydrates, specifically complex carbohydrates such as starch. Finally, the least consumed food was split peas, which contained the most simple sugars. Long-chain fatty acids are slowest to metabolize, and thus a long-term fuel source, while carbohydrates are the most rapidly metabolized, resulting in rapid energy availability. This suggests a possible relationship between fuel storage and utilization and food choice.

A similar conclusion emerges regarding energy density. Of the foods consumed, sunflower hearts and peanuts rank in the highest number of calories per 100 g. Corn, sorghum, and peas, respectively, follow next (Fig. 2b). Energy density, therefore, may also be a factor determining selection. Fats are much denser and less hydrated than carbohydrates, and thus allow for greater oxidation and energy release per mass quantity than carbohydrates. Perhaps it is the high energy availability of sunflower hearts and peanuts that contributes to selection by pigeons.

Aside from macronutrient profiles, we also looked at the effects of food particle size on choice. Bread crumbs (powder) were the smallest food particle and least consumed food item presented to the pigeons. By contrast, sunflower hearts (9.0 mm), granulated peanuts (6.0 mm), sorghum seeds (4.0 mm), corn (8.5 mm), mealworms (15.0 mm), and peas (6.5 mm) consisted of larger particle sizes. There was no observed correlation among these 5 items between particle size and choice. This suggests that although large size differences may play a role in food selection, macronutrient profile appears to play a more prominent role when size differences are small. While our data are suggestive, further studies directly manipulating nutritional content are needed to determine causality of these factors.

In summary, we sought to identify the foods likely to be most motivating to pigeons for use in behavioral studies. Granulated peanuts and sunflower hearts were most frequently chosen, and therefore may be more motivating as well, though this needs to be empirically assessed. Nutritional profile may be an important (and overlooked) factor that warrants further study. Furthermore, large individual differences in choice suggest a possible benefit to using a mixture of foods, especially when individual preferences are unknown. Examining these factors may increase our understanding of pigeon food selection, guide future investigation of food preference in the pigeon, and improve the reward value and effectiveness in behavioral studies.

References

Brown, R.G.B., 1969. Seed selection by pigeons. Behaviour 34, 115–130.
Exotic Nutrition Pet Co., 2009. Live Mealworm Information. Retrieved from http://www.exoticnutrition.com/limein.html.
Killeen, P.R., Cate, H., Tran, T., 1993. Scaling pigeons' choice of feeds: bigger is better. J. Exp. Anal. Behav. 60, 203–217.
Moon, R.D., Zeigler, H.P., 1979. Food preferences in the pigeon (*Columba livia*). Physiol. Behav. 22 (6), 1171–1182.
Murton, R.K., Westwood, N.J., 1966. The foods of the rock dove and feral pigeon. Bird Study 13, 130–146.
Shettleworth, S.J., 1987. Individual differences in choice of food items by pigeons. Behav. Process. 14, 305–318.
United States Department of Agriculture, 2010. Nutrient Data Laboratory. Retrieved from http://www.nal.usda.gov/fnic/foodcomp/search/.