

Electronic Supplementary Material

Trial-and-error copying of demonstrated actions reveals how fledglings learn to “imitate” their mothers

Noa Truskanov and Arnon Lotem

Figure S1: The distribution of actions performed by each individual during test and training phases (aggregated group data are described in Figures 2 and 3 of the main text)

The number of successful pecking actions (in white), successful pushing actions (in grey) and grabbing of leaves' tips (in black) performed by each of the fledglings of both experimental groups in: (a) the test phase; and (b) the training phase. Pushing demonstration group: n = 10, pecking demonstration group: n = 8. Fledglings of the first and second cohorts are denoted by numbers a1-11 and b1-b7 respectively

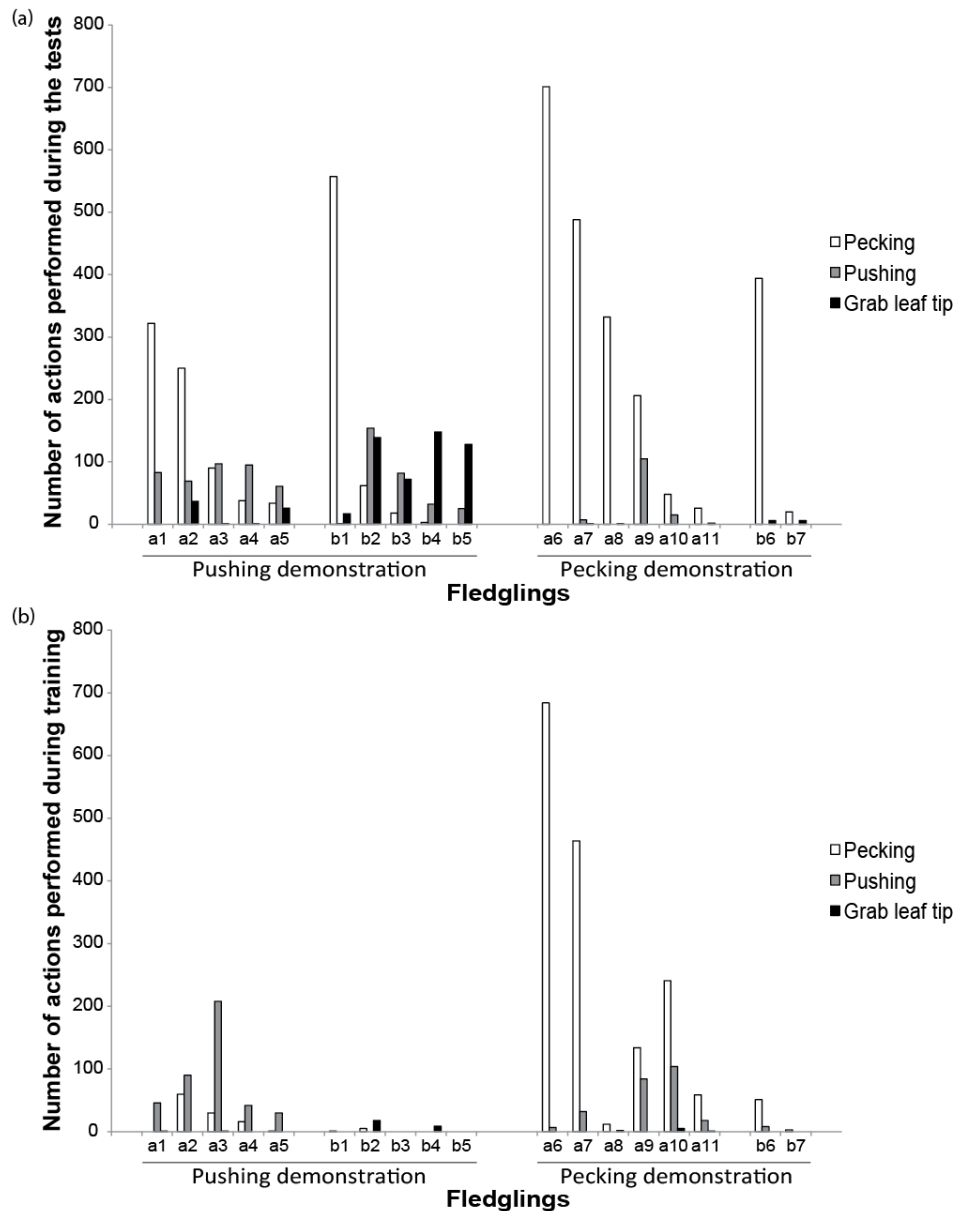


Figure S2: Performance of independent actions during training

The average numbers of different successful actions performed by fledglings of both experimental groups in each training session: pushing demonstration group: n=10, successful pecking denoted by (●), successful pushing by (▲). Pecking demonstration group: n=8, successful pecking denoted by (○), successful pushing by (△).

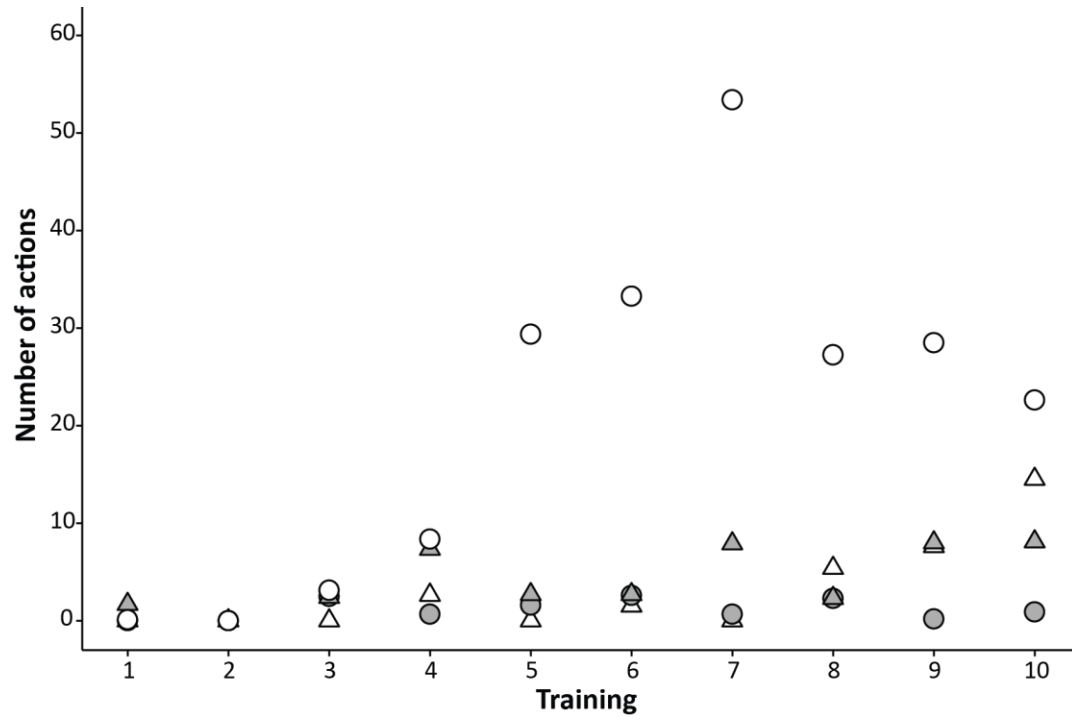


Table S1: Action performance during the training phase

Linear models exploring differences between treatment groups in the amounts of the different actions performed during the training phase. All models included intercept (not shown) and were based on N=18 birds. Due to technical problems, for three of the fledglings (two from the pushing mother group and one from the pecking mother group) one of the training videos was missing. For analysis involving data from the training period, we repeated the analysis while excluding these fledglings and found no differences in the effect sizes.

Model	Response	Effects	Df	Likelihood ratio χ^2	P
SA	Joining events	Group	1	0.134	0.714
		Cohort	1	5.435	0.019
		Interaction	1	0.298	0.585
SB	Independent successful actions	Group	1	3.525	0.06
		Cohort	1	10.749	0.001
		Interaction	1	0.164	0.686
SC	Successful pushing	Group	1	0.41	0.522
		Cohort	1	13.372	0.0003
		Interaction	1	2.555	0.11
SD	Successful pecking	Group	1	6.871	0.009
		Cohort	1	5.648	0.017
		Interaction	1	1.803	0.179
SE	Unproductive attempts	Group	1	0.019	0.889
		Cohort	1	0.27	0.603
		Interaction	1	0.417	0.519

*All analyses performed on transformed data

Table S2: Effect of treatment and cohort on pushing and pecking actions performed during the test (see also Table 1 and Figure 2 in the main text)

Linear models exploring differences between treatment groups in the amounts of pushing and pecking actions performed during the test phase. All models included intercept (not shown) and were based on N=18 birds.

Model	Response	Effects	Df	Likelihood ratio χ^2	P
SF	Successful pushing	Group	1	12.221	0.0005
		Cohort	1	2.617	0.106
		Interaction	1	0.022	0.882
SG	Successful pecking	Group	1	1.421	0.233
		Cohort	1	0.827	0.363
		Interaction	1	0.0006	0.98

*All analyses performed on transformed data

Table S3: Analysis of action performance using permutation-based factorial Anova models

Analysis of action performance in both training and test phases using permutation-based factorial Anova models with 10,000 unrestricted permutations. This analysis corresponds to the linear models provided in the main text (table 1) and above (tables S1 and S2). All models explored the effect of experimental group and cohort on the fledglings' performance of different action types during either training or test phases. The models are based on a sample size of N=18 birds.

Model	Response	Effects	Df	F	P
Test phase					
SH	Pushing proportion (out of successful action performances)	Group	1	13.393	0.003
		Cohort	1	3.255	0.091
		Interaction	1	1.454	0.240
SI	Unproductive attempts (total)	Group	1	8.150	0.013
		Cohort	1	28.286	0.0002
		Interaction	1	4.423	0.051
SJ	Grabbing leaf tip	Group	1	7.141	0.015
		Cohort	1	20.201	0.001
		Interaction	1	6.620	0.023
SK	Successful pushing	Group	1	8.431	0.012
		Cohort	1	0.099	0.765
		Interaction	1	0.001	0.980
SL	Successful Pecking	Group	1	1.327	0.265
		Cohort	1	0.534	0.489
		Interaction	1	0.101	0.764
Training phase					
SM	Joining events	Group	1	0.013	0.914
		Cohort	1	6.594	0.021
		Interaction	1	0.114	0.743
SN	Independent successful actions	Group	1	3.248	0.090
		Cohort	1	6.898	0.018
		Interaction	1	1.065	0.334
SO	Successful pushing	Group	1	1.318	0.291
		Cohort	1	6.750	0.013
		Interaction	1	0.915	0.374
SP	Successful pecking	Group	1	4.855	0.024
		Cohort	1	3.725	0.052
		Interaction	1	1.826	0.190
SQ	Unproductive attempts	Group	1	0.001	0.973
		Cohort	1	0.032	0.868
		Interaction	1	0.024	0.887

Hand-rearing of sparrow nestlings

Two cohorts of 12 nestlings were taken from nests in the captive house sparrow colony of I. Meier Segal's Garden of Zoological Research, Tel-Aviv University. In each cohort, no more than three nestlings were taken from the same nest, with two nestlings from each nest being the common procedure. Our final sample size of 18 fledglings originated from 12 different nests and nestmates were assigned to separate experimental treatments where possible.

Nestlings were raised in three incubators, containing separate rearing boxes (10×10 cm and 8 cm high) lined with cotton wool and dry straw, weighed every morning before feeding started, and fed from syringes containing a mixture of commercial hand-rearing blend, vitamins, calcium and minced fly larvae (supplemented by mashed boiled eggs from the age of 7-8 days). Feeding sessions during which nestlings were fed to satiation were carried out at 5–30 min intervals throughout the day (0700–1900 hours). To imprint the nestlings on the mother model, they were fed adjacent to its beak, while the mother model itself was oriented towards the nestling. All individuals were ringed with a numbered aluminium ring and plastic colour rings to ensure individual recognition at later stages.

Towards fledging, at the age of 14 days, all individuals were transferred to separate cages that were located in the outdoor premises of the Zoological Garden. The cages (75×45 cm and 45 cm high) were visually isolated from each other and contained a rearing box (the old 'nest' from which the young had fledged), wooden branches and artificial foliage at the rear, and a wooden board at the front. A water bowl and a food bowl containing an ad libitum supply of commercial seed mixture and grated boiled eggs were placed on top of the board. Feeding was gradually shifted from hand rearing to joint pecking with the mother model, which continued to be introduced to the fledglings throughout this stage (the mother model's body was connected to a pole, enabling the experimenter to move it around freely and mimic a foraging sparrow. See Figure 1a in the main text). The experiment began only after all the individuals were capable of feeding independently and pecking at millet seeds. It is important to note that the fledglings were still highly attached to the mother model at this stage, running or flying towards it when it arrived at the cage, begging and following it around.