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Supplemental information

Social network centrality predicts dietary decisions in a wild bird population

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Supplementary Information: Social network centrality shapes dietary decisions in a wild bird population

Keith McMahon[1]*, Nicola M. Marples[2], Lewis G. Spurgin[3], Hannah M. Rowland[4,5], Ben C. Sheldon[1] & Josh A. Firth[1,6]*

[1]Department of Biology, Oxford University, Oxford, UK

[2]Department of Zoology, School of Natural Sciences, Trinity College Dublin, Eire

[3]School of Biological Sciences, University of East Anglia, Norwich, UK

[4]Max Planck Institute for Chemical Ecology, Jena, Germany

[5]Department of Zoology, University of Cambridge, Cambridge, UK

[6]School of Biology, University of Leeds, Leeds, UK

*Correspondence: Keith.McMahon@biology.ox.ac.uk & Joshua.Firth@biology.ox.ac.uk

SUPPLEMENTARY INFORMATION CONTENT:

The green dye for the food was prepared by mixing O'Brien's (Citywest, Dublin 24, Ireland) liquid green 90 food colouring in the ratio of 5 ml dye to 500 ml water. This solution was then mixed with 500 g of kibbled peanut. The mixture was placed in an oven at 50°C for 20–30 min until dry. This was repeated with O'Brien's Christmas Red for the red dyed peanut.

SUPPLEMENTARY FIGURES

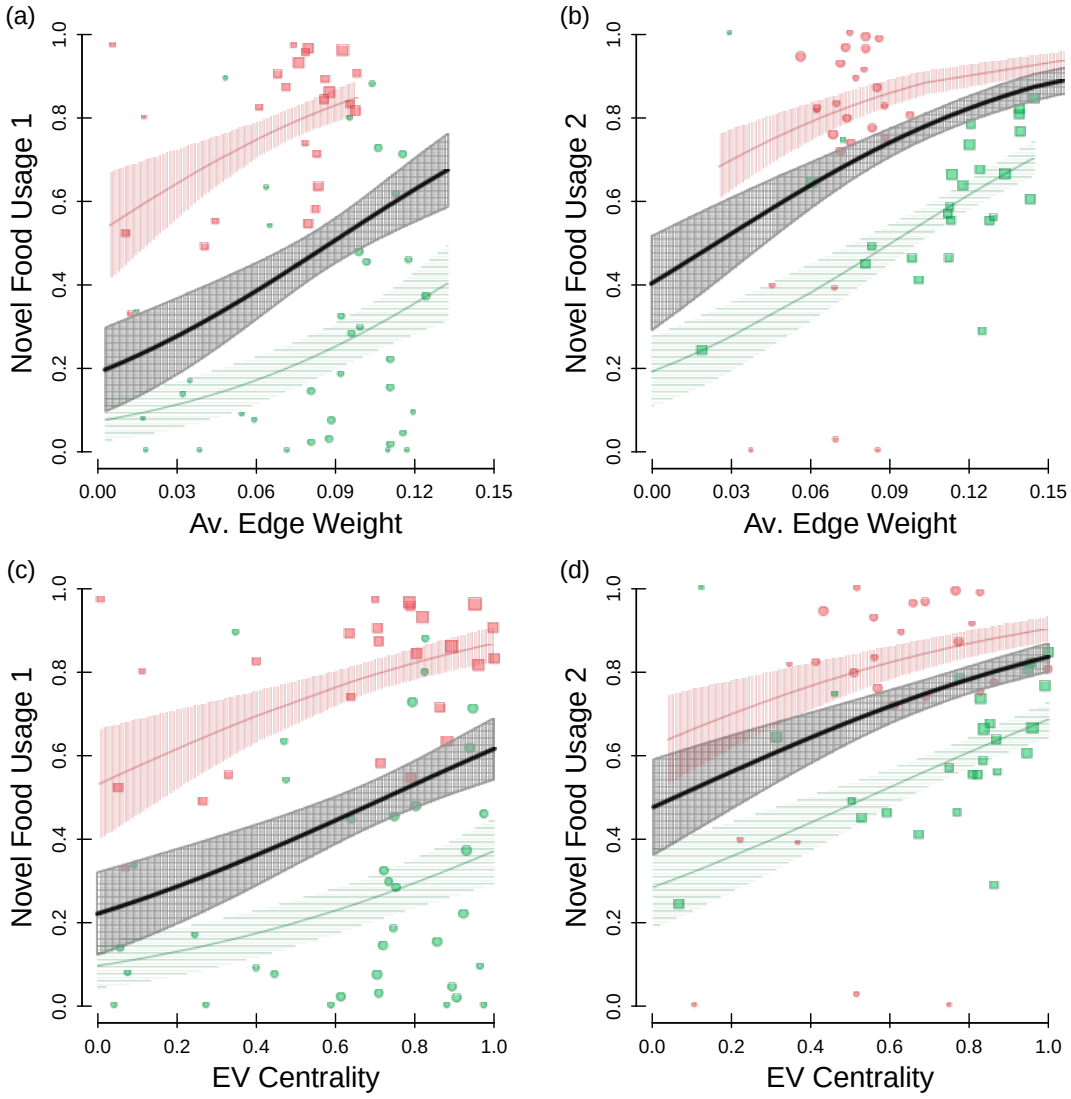

Figure S1: Social centrality metrics and novel food usage, related to Figure 2. Prior social centrality (x axis), as measured as (a-b) Average edge weight and (c-d) eigenvector centrality, and subsequent novel food usage (proportion of novel food usage – y axis) for the (a,c) first trial, and (b,d) second trial. The point positions show the individual data points, point colour shows the colour of the novel food (red or green dyed peanut), point shape shows which experimental site the individual was at (site 1 or site 2), and point size indicates weight of the data point i.e. the total number of detections (at both the novel, and familiar food feeder). The lines show the GLM fit, and the surrounding polygons show the associated standard error around this estimate, with the red lines showing the fit for the red novel food site, the green line showing the fit for the green novel food site, and the black line denoting the overall fit. See Table S3 & S4 for full model details.

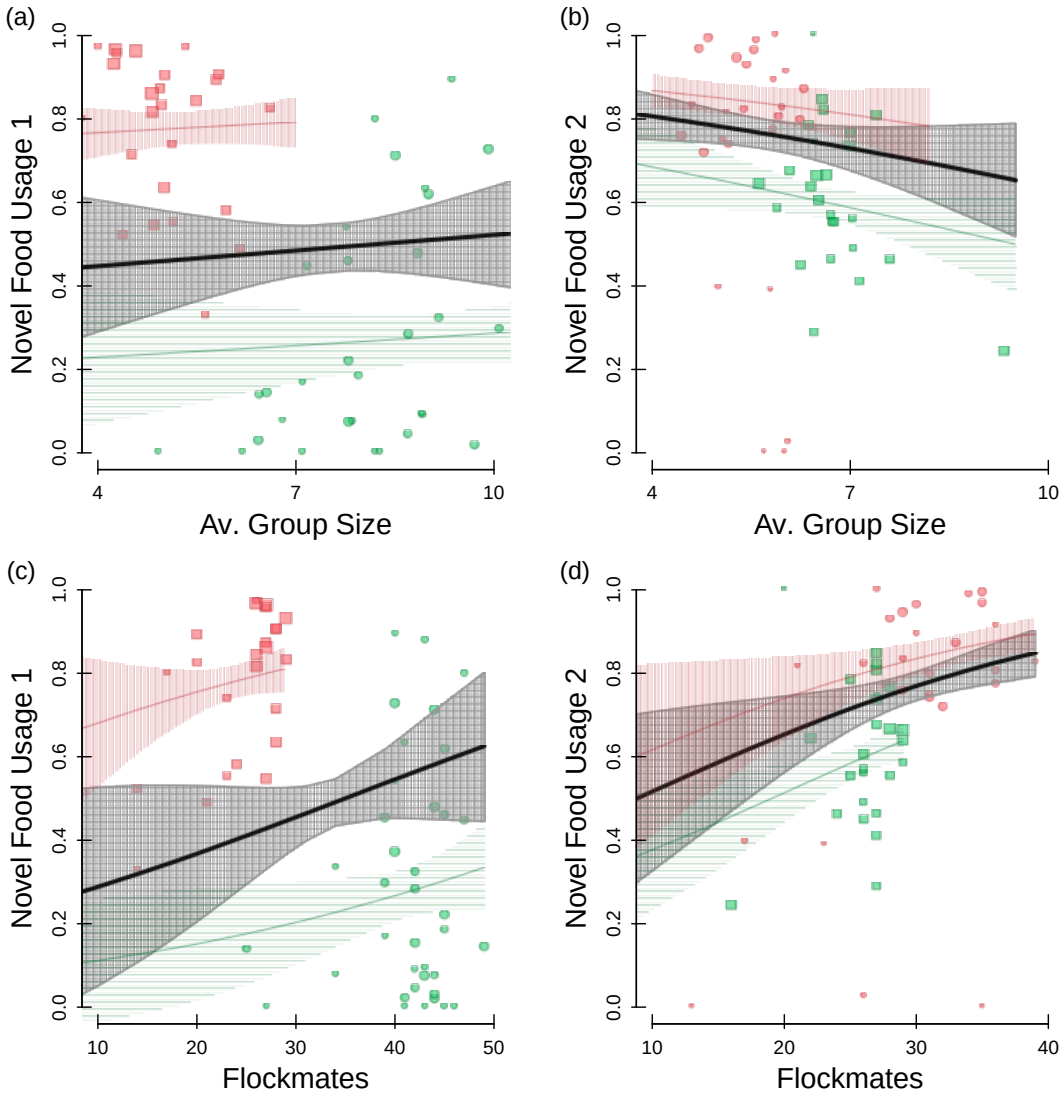

Figure S2: Basic social measures and novel food usage, related to Figure 2. Average group size is the average size of the flocking event that the individual was observed in, and flockmates is the total number of unique individuals the individual was observed occurring with in at least one flocking event. Prior basic measures (x axis), as measured as (a-b) Average group size and (c-d) number of flockmates, and subsequent novel food usage (proportion of novel food usage – y axis) for the (a,c) first trial, and (b,d) second trial. The point positions show the individual data points, point colour shows the colour of the novel food (red or green dyed peanut), point shape shows which experimental site the individual was at (site 1 or site 2), and point size indicates weight of the data point i.e. the total number of detections (at both the novel, and familiar food feeder). The lines show the GLM fit, and the surrounding polygons show the associated standard error around this estimate, with the red lines showing the fit for the red novel food site, the green line showing the fit for the green novel food site, and the black line denoting the overall fit. See Table S5 & S6 for full model details.

SUPPLEMENTARY TABLES

Table S1: Summary of experimental procedure, related to Figure 1. The study protocol at each of the sites, showing the phase of the study and food-types used over the data-collection days and the fine-scaling positioning of the feeders within the feeding sites.

Site	Phase	Day	Food Type	Position
1	Baseline	1-12	Familiar	Mid
	Trial 1	13-14	Familiar	Side 1
			Green	Side 2
		15-16	Familiar	Side 2
			Green	Side 1
	Trial 2	16-17	Familiar	Side 2
			Red	Side 1
		18-19	Familiar	Side 1
			Red	Side 2
2	Baseline	1-12	Familiar	Mid
	Trial 1	13-14	Familiar	Side 2
			Red	Side 1
		15-16	Familiar	Side 1
			Red	Side 2
	Trial 2	16-17	Familiar	Side 2
			Green	Side 1
		18-19	Familiar	Side 1
			Green	Side 2

Table S2: Social network strength and novel food usage model outputs, related to Figure 2. Output of GLMs assessing the relationship between individuals' propensity to use novel food (response variable) and individuals' prior network strength (Figure 2 - Main Text), along with the other fitted explanatory variables. Each column holds the test statistics for (A) experimental trial 1 and (B) experimental trial 2. Each row gives the result for each explanatory variable, with 'Sex' in relation to female birds, Age in relation to adult birds, Immigrant status in relation to residents, and the 'Strength' as weighted network degree directly prior to each experimental trial (see Methods) and 'Observations' as the number of records.

	(A) Experimental Trial 1					(B) Experimental Trial 2				
	Coeff.	SE	T	P	P_{rand}	Coeff.	SE	T	P	P_{rand}
Intercept	-3.4250	0.9927	-3.4502	0.0011	0.001	0.3557	0.4499	0.7908	0.4333	0.001
Sex (Male)	0.2716	0.2789	0.9736	0.3346	0.530	0.2671	0.2011	1.3281	0.191	0.396
Sex (Unk)	-0.2357	1.0475	-0.225	0.8228	0.752	-0.1956	0.3889	-0.503	0.6175	0.772
Age (Juv)	0.4943	0.2612	1.8928	0.0637	0.242	0.2943	0.1902	1.5469	0.1291	0.366
Immigrant	0.2481	0.3388	0.7322	0.4672	0.656	0.2103	0.2233	0.9418	0.3514	0.546
Site	3.4020	0.7086	4.801	0.0001	0.016	-1.592	0.2672	-5.9592	0.0001	0.150
Strength	0.5285	0.2347	2.2517	0.0284	0.010	0.4668	0.1500	3.1114	0.0033	0.012
Observations	0.0000	0.0001	-0.091	0.9278	0.972	0.0001	0.0001	-0.087	0.9310	0.968

Table S3: Average edge weight and novel food usage model outputs, related to Figure 2 and Figure S1. Output of GLMs assessing the relationship between individuals' propensity to use novel food (response variable) and individuals' average edge weight (Figure S1a;S1b), along with the other fitted explanatory variables. Each column holds the test statistics for (A) experimental trial 1 and (B) experimental trial 2. Each row gives the result for each explanatory variable, with 'Sex' in relation to female birds, Age in relation to adult birds, Immigrant status in relation to residents, and the 'Edge' as average non-zero edge weight directly prior to each experimental trial (see Methods) and 'Observations' as the number of records.

	(A) Experimental Trial 1					(B) Experimental Trial 2				
	Coeff.	SE	T	P	P_{rand}	Coeff.	SE	T	P	P_{rand}
Intercept	-2.8021	0.7216	-3.8833	0.0001	0.0001	0.2123	0.4475	0.4745	0.6375	0.002
Sex (Male)	0.2257	0.2763	0.817	0.4175	0.642	0.2974	0.1978	1.5033	0.1399	0.348
Sex (Unk)	-0.446	1.0028	-0.4447	0.6583	0.532	-0.0812	0.3914	-0.2074	0.8367	0.922
Age (Juv)	0.4891	0.261	1.8738	0.0664	0.25	0.3282	0.1876	1.7499	0.0871	0.302
Immigrant	0.1774	0.3361	0.5279	0.5997	0.754	0.2717	0.2216	1.2261	0.2267	0.436
Site	2.55	0.3977	6.4116	0.0001	0.236	-1.8735	0.2753	-6.8054	0.0001	0.006
Edge	16.4625	7.2095	2.2835	0.0264	0.022	15.9091	4.5385	3.5053	0.0011	0.004
Observations	0.0001	0.0001	0.18	0.8578	0.91	0.0001	1E-04	-0.2065	0.8374	0.928

Table S4: Eigenvector centrality and novel food usage model outputs, related to Figure 2 and Figure S1. Output of GLMs assessing the relationship between individuals' propensity to use novel food (response variable) and individuals' eigenvector centrality (Figure S1c;S1d), along with the other fitted explanatory variables. Each column holds the test statistics for (A) experimental trial 1 and (B) experimental trial 2. Each row gives the result for each explanatory variable, with 'Sex' in relation to female birds, Age in relation to adult birds, Immigrant status in relation to residents, and the 'Eigenvector' as weighted eigenvector centrality directly prior to each experimental trial (see Methods) and 'Observations' as the number of records.

	(A) Experimental Trial 1					(B) Experimental Trial 2				
	Coeff.	SE	T	P	P_{rand}	Coeff.	SE	T	P	P_{rand}
Intercept	-2.4432	0.5825	-4.1941	0.0001	0.001	0.3543	0.4713	0.7517	0.4562	0.001
Sex (Male)	0.2578	0.2787	0.9249	0.3591	0.554	0.2684	0.2051	1.3089	0.1973	0.396
Sex (Unk)	-0.3282	1.0023	-0.3274	0.7446	0.652	-0.2009	0.3947	-0.5091	0.6132	0.758
Age (Juv)	0.5059	0.2616	1.934	0.0584	0.226	0.2866	0.1923	1.4901	0.1433	0.384
Immigrant	0.2423	0.3395	0.7138	0.4784	0.656	0.2187	0.2278	0.9598	0.3424	0.538
Site	2.3106	0.3414	6.7671	0.0001	0.718	-1.4989	0.2714	-5.5235	0.0001	0.302
Eigenvector	1.7357	0.7585	2.2881	0.0261	0.05	1.7099	0.5834	2.9307	0.0053	0.012
Observations	0.0000	0.0001	-0.3856	0.7013	0.818	0.0000	1E-04	-0.0523	0.9585	0.988

Table S5: Mean gathering event size and novel food usage model outputs, related to Figure 2 and Figure S2. Output of GLMs assessing the relationship between individuals' propensity to use novel food (response variable) and individuals' average flock size (Figure S2a;S2b), along with the other fitted explanatory variables. Each column holds the test statistics for (A) experimental trial 1 and (B) experimental trial 2. Each row gives the result for each explanatory variable, with 'Sex' in relation to female birds, Age in relation to adult birds, Immigrant status in relation to residents, and the 'Flock size' as mean number of individuals within each flocking event the individual was observed in directly prior to each experimental trial (see Methods) and 'Observations' as the number of records.

	(A) Experimental Trial 1					(B) Experimental Trial 2				
	Coeff.	SE	T	P	P_{rand}	Coeff.	SE	T	P	P_{rand}
Intercept	-1.7901	1.6104	-1.1116	0.2712	0.278	2.2743	0.8448	2.692	0.01	0.422
Sex (Male)	0.1825	0.2921	0.6245	0.5349	0.704	0.0399	0.2023	0.1973	0.8445	0.904
Sex (Unk)	-0.4471	0.9903	-0.4515	0.6535	0.532	-0.476	0.4422	-1.0765	0.2876	0.412
Age (Juv)	0.5458	0.2779	1.9639	0.0547	0.202	0.1677	0.2003	0.8371	0.4071	0.606
Immigrant	0.1904	0.3613	0.527	0.6003	0.732	-0.0225	0.2284	-0.0986	0.9219	0.930
Site	2.1875	0.6794	3.2195	0.0022	0.930	-1.3842	0.3668	-3.7738	0.0001	0.534
Flock Size	0.0487	0.1684	0.2895	0.7733	0.676	-0.1404	0.1526	-0.9199	0.3627	0.232
Observations	0.0001	0.0001	1.1048	0.2741	0.322	0.0000	0.0001	2.3104	0.0256	0.134

Table S6: Unique flockmates and novel food usage model outputs, related to Figure 2 and Figure S2. Output of GLMs assessing the relationship between individuals' propensity to use novel food (response variable) and their number of unique flockmates (Figure S2c;S2d), along with the other fitted explanatory variables. Each column holds the test statistics for (A) experimental trial 1 and (B) experimental trial 2. Each row gives the result for each explanatory variable, with 'Sex' in relation to female birds, Age in relation to adult birds, Immigrant status in relation to residents, and the 'Flockmates' as sum of the number of unique individuals seen in the same flocking events as themselves directly prior to each experimental trial (see Methods) and 'Observations' as the number of records.

	(A) Experimental Trial 1					(B) Experimental Trial 2				
	Coeff.	SE	T	P	P_{rand}	Coeff.	SE	T	P	P_{rand}
Intercept	-2.7682	1.9309	-1.4337	0.1574	0.028	-0.2265	1.2268	-0.1846	0.8544	0.001
Sex (Male)	0.2176	0.2875	0.7568	0.4525	0.628	0.1025	0.2014	0.5089	0.6134	0.732
Sex (Unk)	-0.3795	1.0127	-0.3747	0.7093	0.596	-0.4656	0.4018	-1.1587	0.2528	0.416
Age (Juv)	0.5626	0.2698	2.0855	0.0418	0.184	0.1811	0.1966	0.9212	0.362	0.576
Immigrant	0.3196	0.3807	0.8396	0.4048	0.564	0.0231	0.2252	0.1025	0.9188	0.960
Site	2.6957	0.9638	2.7968	0.0071	0.344	-1.1998	0.3843	-3.1216	0.0032	0.874
Flockmates	0.0361	0.0479	0.7535	0.4544	0.180	0.0565	0.0385	1.4674	0.1494	0.100
Observations	0.0000	0.0001	0.3305	0.7423	0.740	0.0000	0.0001	1.4246	0.1613	0.326

Table S7: Social network strength and first feeder used model outputs, related to Figure 3. Output of GLMs assessing the relationship between whether individuals are first detected on the novel food feeder when they first arrive at the experimental trial and their prior network strength (Figure 3 - Main Text), along with the other fitted explanatory variables. Each column holds the test statistics for (A) experimental trial 1 and (B) experimental trial 2. Each row gives the result for each explanatory variable, with 'Sex' in relation to female birds, Age in relation to adult birds, Immigrant status in relation to residents, and the 'Strength' as weighted network degree directly prior to each experimental trial (see Methods) and 'Observations' as the number of records.

	(A) Experimental Trial 1					(B) Experimental Trial 2				
	Coeff.	SE	T	P	P_{rand}	Coeff.	SE	T	P	P_{rand}
Intercept	-0.667	1.2864	-0.5185	0.6064	0.85	1.1073	1.3439	0.824	0.4146	0.074
Sex (Male)	0.4993	0.8285	0.6026	0.5496	0.51	-0.7047	0.7176	-0.982	0.3317	0.402
Sex (Unk)	1.2155	1.9456	0.6247	0.535	0.378	-19.37	2168.40	-0.0089	0.9929	0.006
Age (Juv)	-0.0508	0.8543	-0.0595	0.9528	0.98	0.6231	0.7775	0.8015	0.4274	0.448
Immigrant	0.892	1.1421	0.781	0.4386	0.386	-1.4231	1.1392	-1.2492	0.2185	0.196
Site	-0.4084	1.1975	-0.341	0.7345	0.164	1.2332	0.9898	1.246	0.2197	0.088
Strength	0.2896	0.413	0.7012	0.4865	0.29	-0.5507	0.5742	-0.9592	0.3429	0.284
Observations	0.0001	0.0001	-1.9471	0.0573	0.012	0.0000	0.0001	-0.6424	0.5241	0.526

Table S8: Social network strength and time delay to use novel food, related to Figure 3. Output of LMs assessing the relationship between the amount of time taken for each individual to first land on the feeding perch of the novel food (quantified as time of day they were first recorded on the novel food), and their prior network strength, along with the other fitted explanatory variables. Each column holds the test statistics for (A) experimental trial 1 and (B) experimental trial 2. Each row gives the result for each explanatory variable, with 'Sex' in relation to female birds, Age in relation to adult birds, Immigrant status in relation to residents, and the 'Strength' as weighted network degree directly prior to each experimental trial (see Methods) and 'Observations' as the number of records.

	(A) Experimental Trial 1					(B) Experimental Trial 2				
	Coeff.	SE	T	P	P_{rand}	Coeff.	SE	T	P	P_{rand}
Intercept	38898	2064	18.84	0.0001	0.334	38958	3802	10.25	0.0001	0.614
Sex (Male)	300	1125	0.2668	0.7908	0.784	1606	2079	0.7727	0.4442	0.468
Sex (Unk)	1439	2871	0.5011	0.6187	0.4	10075	4696	2.1456	0.0379	0.038
Age (Juv)	-2302	1063	-2.1646	0.0356	0.014	-4876	2092	-2.33	0.0248	0.028
Immigrant	519	1452	0.3577	0.7222	0.62	102	2753	0.037	0.9707	0.926
Site	-2875	1696	-1.6956	0.0967	0.276	1929	2575	0.7492	0.458	0.34
Strength	-377	559	-0.6739	0.5038	0.466	-125	1487	-0.084	0.9332	0.944
Observations	0.2099	0.2216	0.9472	0.3485	0.388	-1.5294	1.4881	-1.028	0.3101	0.458

Table S9: Social network strength and overall time delay to use novel food, related to Figure 3. Output of LMs assessing the relationship between the amount of time taken for each individual to first land on the feeding perch of the novel food (quantified as total elapsed foraging time since they were first detected at the site during the trial – log transformed), and their prior network strength, along with the other fitted explanatory variables. Each column holds the test statistics for (A) experimental trial 1 and (B) experimental trial 2. Each row gives the result for each explanatory variable, with 'Sex' in relation to female birds, Age in relation to adult birds, Immigrant status in relation to residents, and the 'Strength' as weighted network degree directly prior to each experimental trial (see Methods) and 'Observations' as the number of records.

	(A) Experimental Trial 1					(B) Experimental Trial 2				
	Coeff.	SE	T	P	P_{rand}	Coeff.	SE	T	P	P_{rand}
Intercept	6.3798	1.8885	3.3782	0.0014	0.216	2.4033	2.3087	1.041	0.3038	0.222
Sex (Male)	-0.7159	1.101	-0.6503	0.5186	0.558	1.9838	1.2731	1.5583	0.1267	0.136
Sex (Unk)	-2.2135	2.9084	-0.7611	0.4503	0.224	4.4115	2.9211	1.5102	0.1385	0.076
Age (Juv)	-0.4054	1.0667	-0.3801	0.7055	0.708	-0.7133	1.3014	-0.5481	0.5865	0.64
Immigrant	-1.1519	1.411	-0.8164	0.4182	0.42	1.3764	1.7166	0.8018	0.4272	0.442
Site	-0.3937	1.5755	-0.2499	0.8037	0.028	0.1215	1.5917	0.0764	0.9395	0.472
Strength	-0.7663	0.5415	-1.4151	0.1634	0.118	0.2549	0.9233	0.276	0.7839	0.778
Observations	0.0001	0.0001	3.05	0.0037	0.002	0.0000	0.0001	0.3954	0.6946	0.73

Table S10: Social network strength and novel food exploitation after first use, related to Figure 4. Output of GLMs assessing the relationship between individuals' propensity to use novel food after they had already first tried the novel food feeder (response variable) and individuals' prior network strength (Figure 4 - Main Text), along with the other fitted explanatory variables. Each column holds the test statistics for (A) experimental trial 1 and (B) experimental trial 2. Each row gives the result for each explanatory variable, with 'Sex' in relation to female birds, Age in relation to adult birds, Immigrant status in relation to residents, and the 'Strength' as weighted network degree directly prior to each experimental trial (see Methods) and 'Observations' as the number of records.

	(A) Experimental Trial 1					(B) Experimental Trial 2				
	Coeff.	SE	T	P	P_{rand}	Coeff.	SE	T	P	P_{rand}
Intercept	-3.5136	1.0769	-3.2627	0.002	0.001	0.4391	0.5057	0.8682	0.3902	0.001
Sex (Male)	0.316	0.3108	1.0167	0.3143	0.508	0.4231	0.2235	1.8928	0.0653	0.210
Sex (Unk)	-0.1159	1.2082	-0.0959	0.924	0.886	-0.0665	0.4319	-0.1539	0.8784	0.948
Age (Juv)	0.5041	0.2892	1.7429	0.0876	0.264	0.3009	0.2112	1.4244	0.1617	0.386
Immigrant	0.2262	0.3783	0.598	0.5526	0.682	0.3363	0.2452	1.3718	0.1774	0.364
Site	3.6381	0.7803	4.6627	0.0001	0.014	-1.8279	0.3112	-5.8741	0.0001	0.158
Strength	0.5483	0.2551	2.1492	0.0366	0.006	0.5324	0.1677	3.1742	0.0028	0.010
Observations	0.0001	0.0001	0.0207	0.9836	0.994	0.0001	1E-04	-0.4635	0.6454	0.802