

Supplementary Materials: Individual repeatability, species differences, and the influence of socio-ecological factors on neophobia in 10 corvid species

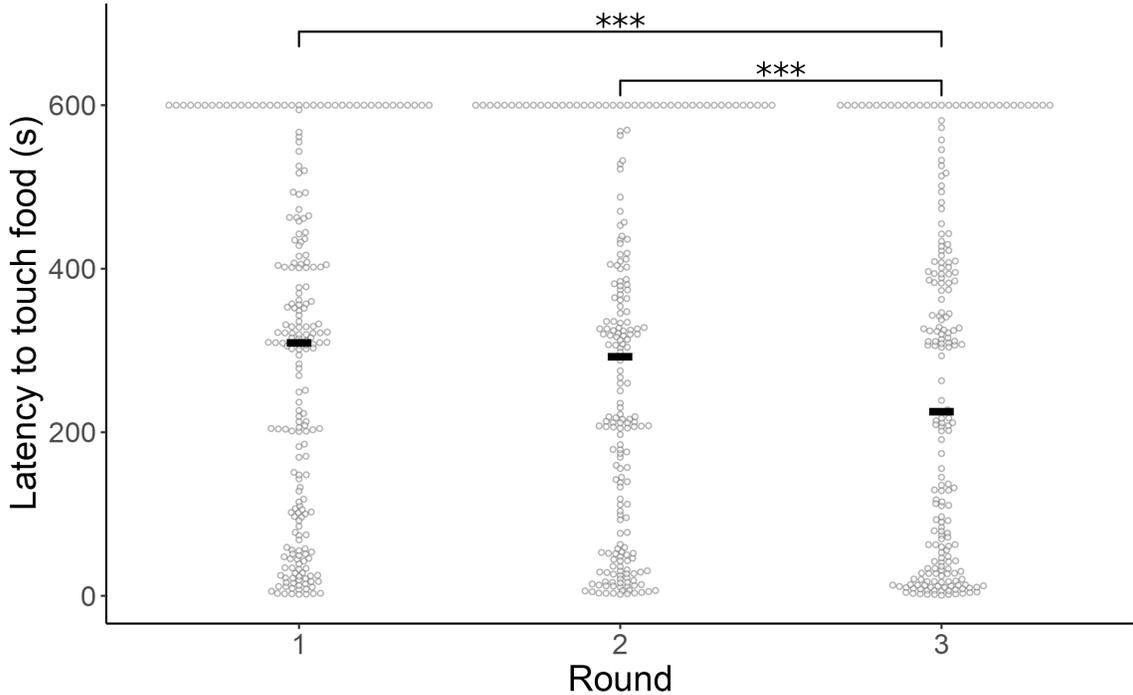


Figure S1. Latency to touch familiar food in each round, across all conditions and species. Round 3 differs from round 1 and 2, while round 1 and 2 do not differ from each other. Points represent individuals, lines represent median.

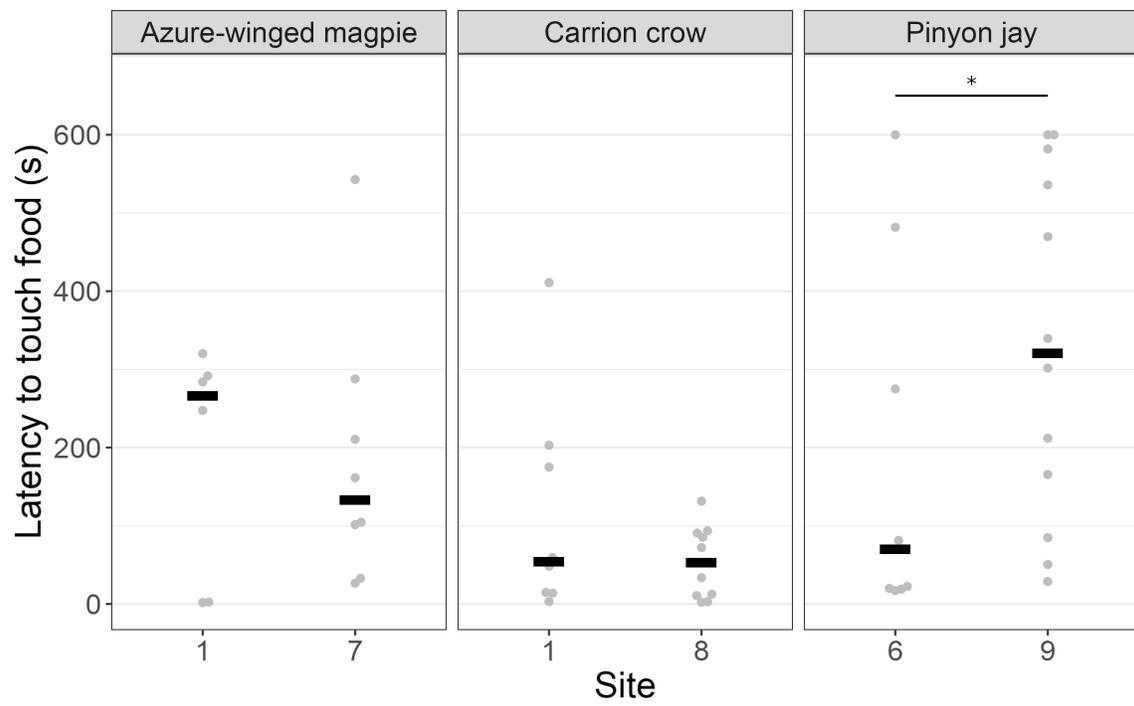


Figure S2. Site effect on latency to touch familiar food in azure-winged magpie, carrion crow and pinyon jay.

Table S1  
*Pairwise comparisons of latency data between species*

	Estimate	Standard error	z	p-value
Blue jay - Azure-winged magpie	0.491	0.209	2.351	0.019
Carrion crow - Azure-winged magpie	-0.496	0.177	-2.811	0.005
Clark's nutcracker - Azure-winged magpie	0.518	0.203	2.558	0.011
Common raven - Azure-winged magpie	-0.437	0.183	-2.392	0.017
Eurasian jay - Azure-winged magpie	0.284	0.166	1.710	0.087
'Alalā - Azure-winged magpie	0.416	0.144	2.891	0.004
Large-billed crow - Azure-winged magpie	0.668	0.189	3.540	0.000
New Caledonian crow - Azure-winged magpie	-0.316	0.209	-1.513	0.130
Pinyon jay - Azure-winged magpie	0.118	0.170	0.693	0.488
Carrion crow - Blue jay	-0.988	0.199	-4.959	0.000
Clark's nutcracker - Blue jay	0.027	0.223	0.122	0.903
Common raven - Blue jay	-0.929	0.205	-4.537	0.000
Eurasian jay - Blue jay	-0.207	0.190	-1.091	0.275
'Alalā - Blue jay	-0.076	0.171	-0.443	0.658
Large-billed crow - Blue jay	0.177	0.210	0.843	0.399
New Caledonian crow - Blue jay	-0.808	0.228	-3.536	0.000
Pinyon jay - Blue jay	-0.374	0.193	-1.937	0.053
Clark's nutcracker - Carrion crow	1.015	0.193	5.271	0.000
Common raven - Carrion crow	0.059	0.172	0.344	0.731
Eurasian jay - Carrion crow	0.780	0.154	5.079	0.000
'Alalā - Carrion crow	0.912	0.129	7.065	0.000
Large-billed crow - Carrion crow	1.165	0.178	6.547	0.000
New Caledonian crow - Carrion crow	0.180	0.199	0.904	0.366
Pinyon jay - Carrion crow	0.614	0.157	3.901	0.000
Common raven - Clark's nutcracker	-0.956	0.198	-4.822	0.000
Eurasian jay - Clark's nutcracker	-0.234	0.183	-1.281	0.200
'Alalā - Clark's nutcracker	-0.103	0.163	-0.631	0.528
Large-billed crow - Clark's nutcracker	0.150	0.204	0.736	0.462
New Caledonian crow - Clark's nutcracker	-0.835	0.223	-3.749	0.000
Pinyon jay - Clark's nutcracker	-0.401	0.186	-2.154	0.031
Eurasian jay - Common raven	0.721	0.161	4.487	0.000
'Alalā - Common raven	0.853	0.137	6.206	0.000
Large-billed crow - Common raven	1.106	0.184	6.007	0.000
New Caledonian crow - Common raven	0.121	0.205	0.591	0.554
Pinyon jay - Common raven	0.555	0.164	3.377	0.001
'Alalā - Eurasian jay	0.132	0.114	1.151	0.250
Large-billed crow - Eurasian jay	0.384	0.168	2.294	0.022
New Caledonian crow - Eurasian jay	-0.600	0.190	-3.159	0.002
Pinyon jay - Eurasian jay	-0.166	0.146	-1.144	0.253
Large-billed crow - 'Alalā	0.253	0.145	1.739	0.082
New Caledonian crow - 'Alalā	-0.732	0.171	-4.286	0.000
Pinyon jay - 'Alalā	-0.298	0.119	-2.499	0.012
New Caledonian crow - Large-billed crow	-0.985	0.210	-4.686	0.000
Pinyon jay - Large-billed crow	-0.551	0.171	-3.222	0.001
Pinyon jay - New Caledonian crow	0.434	0.193	2.247	0.025

Table S2

*Linear mixed models with main effect of site on latency to touch familiar food for the three species that were tested in two sites*

Fixed effect	Azure-winged magpie			Carrion crow			Pinyon jay		
	Chisq	df	p-value	Chisq	df	p-value	Chisq	df	p-value
site	1.024	1	0.312	0.078	1	0.78	4.35	1	0.037

Table S3

*Pairwise comparisons of novel object difference scores between species*

	Estimate	Standard error	z	p-value
Blue jay - Azure-winged magpie	-0.183	0.202	-0.905	0.366
Carrion crow - Azure-winged magpie	0.193	0.175	1.101	0.271
Clark's nutcracker - Azure-winged magpie	-0.307	0.196	-1.566	0.117
Common raven - Azure-winged magpie	0.396	0.178	2.227	0.026
Eurasian jay - Azure-winged magpie	0.191	0.164	1.165	0.244
'Alalā - Azure-winged magpie	0.248	0.140	1.777	0.076
Large-billed crow - Azure-winged magpie	-0.438	0.183	-2.397	0.017
New Caledonian crow - Azure-winged magpie	-0.134	0.203	-0.658	0.510
Pinyon jay - Azure-winged magpie	-0.059	0.165	-0.358	0.720
Carrion crow - Blue jay	0.375	0.193	1.942	0.052
Clark's nutcracker - Blue jay	-0.124	0.212	-0.584	0.559
Common raven - Blue jay	0.579	0.196	2.955	0.003
Eurasian jay - Blue jay	0.373	0.183	2.040	0.041
'Alalā - Blue jay	0.431	0.162	2.660	0.008
Large-billed crow - Blue jay	-0.255	0.200	-1.275	0.202
New Caledonian crow - Blue jay	0.049	0.219	0.224	0.823
Pinyon jay - Blue jay	0.124	0.184	0.671	0.502
Clark's nutcracker - Carrion crow	-0.499	0.187	-2.670	0.008
Common raven - Carrion crow	0.204	0.168	1.210	0.226
Eurasian jay - Carrion crow	-0.002	0.153	-0.014	0.989
'Alalā - Carrion crow	0.056	0.127	0.438	0.661
Large-billed crow - Carrion crow	-0.631	0.173	-3.639	0.000
New Caledonian crow - Carrion crow	-0.326	0.194	-1.678	0.093
Pinyon jay - Carrion crow	-0.252	0.154	-1.632	0.103
Common raven - Clark's nutcracker	0.703	0.190	3.704	0.000
Eurasian jay - Clark's nutcracker	0.497	0.176	2.819	0.005
'Alalā - Clark's nutcracker	0.555	0.155	3.590	0.000
Large-billed crow - Clark's nutcracker	-0.132	0.194	-0.677	0.498
New Caledonian crow - Clark's nutcracker	0.173	0.213	0.811	0.417
Pinyon jay - Clark's nutcracker	0.248	0.178	1.394	0.163
Eurasian jay - Common raven	-0.206	0.156	-1.317	0.188
'Alalā - Common raven	-0.148	0.131	-1.127	0.260
Large-billed crow - Common raven	-0.834	0.176	-4.733	0.000
New Caledonian crow - Common raven	-0.530	0.197	-2.689	0.007
Pinyon jay - Common raven	-0.455	0.158	-2.890	0.004
'Alalā - Eurasian jay	0.058	0.111	0.522	0.602
Large-billed crow - Eurasian jay	-0.629	0.162	-3.886	0.000
New Caledonian crow - Eurasian jay	-0.324	0.184	-1.760	0.078
Pinyon jay - Eurasian jay	-0.250	0.141	-1.768	0.077
Large-billed crow - 'Alalā	-0.687	0.138	-4.985	0.000
New Caledonian crow - 'Alalā	-0.382	0.163	-2.338	0.019
Pinyon jay - 'Alalā	-0.307	0.113	-2.727	0.006
New Caledonian crow - Large-billed crow	0.304	0.201	1.512	0.131
Pinyon jay - Large-billed crow	0.379	0.163	2.325	0.020
Pinyon jay - New Caledonian crow	0.075	0.185	0.402	0.687

Table S4

*Pairwise comparisons of novel food difference scores between species*

	Estimate	Standard error	z	p-value
Blue jay - Azure-winged magpie	-0.005	0.179	-0.031	0.976
Carrion crow - Azure-winged magpie	0.145	0.156	0.932	0.352
Clark's nutcracker - Azure-winged magpie	-0.010	0.173	-0.059	0.953
Common raven - Azure-winged magpie	0.010	0.158	0.066	0.948
Eurasian jay - Azure-winged magpie	0.446	0.146	3.046	0.002
Large-billed crow - Azure-winged magpie	0.012	0.162	0.072	0.942
New Caledonian crow - Azure-winged magpie	-0.186	0.179	-1.040	0.298
Pinyon jay - Azure-winged magpie	0.024	0.146	0.164	0.869
Carrion crow - Blue jay	0.151	0.171	0.879	0.380
Clark's nutcracker - Blue jay	-0.005	0.187	-0.025	0.980
Common raven - Blue jay	0.016	0.173	0.091	0.927
Eurasian jay - Blue jay	0.452	0.163	2.771	0.006
Large-billed crow - Blue jay	0.017	0.177	0.097	0.923
New Caledonian crow - Blue jay	-0.180	0.192	-0.937	0.349
Pinyon jay - Blue jay	0.029	0.163	0.181	0.856
Clark's nutcracker - Carrion crow	-0.155	0.166	-0.936	0.349
Common raven - Carrion crow	-0.135	0.150	-0.900	0.368
Eurasian jay - Carrion crow	0.301	0.138	2.187	0.029
Large-billed crow - Carrion crow	-0.133	0.154	-0.867	0.386
New Caledonian crow - Carrion crow	-0.331	0.171	-1.930	0.054
Pinyon jay - Carrion crow	-0.121	0.137	-0.883	0.377
Common raven - Clark's nutcracker	0.021	0.168	0.122	0.903
Eurasian jay - Clark's nutcracker	0.456	0.157	2.902	0.004
Large-billed crow - Clark's nutcracker	0.022	0.172	0.127	0.899
New Caledonian crow - Clark's nutcracker	-0.175	0.187	-0.936	0.349
Pinyon jay - Clark's nutcracker	0.034	0.157	0.218	0.827
Eurasian jay - Common raven	0.436	0.140	3.113	0.002
Large-billed crow - Common raven	0.001	0.156	0.009	0.993
New Caledonian crow - Common raven	-0.196	0.173	-1.131	0.258
Pinyon jay - Common raven	0.014	0.139	0.098	0.922
Large-billed crow - Eurasian jay	-0.435	0.145	-3.007	0.003
New Caledonian crow - Eurasian jay	-0.632	0.163	-3.876	0.000
Pinyon jay - Eurasian jay	-0.422	0.127	-3.337	0.001
New Caledonian crow - Large-billed crow	-0.197	0.177	-1.116	0.265
Pinyon jay - Large-billed crow	0.012	0.144	0.085	0.932
Pinyon jay - New Caledonian crow	0.210	0.163	1.290	0.197

Table S5  
*Individual temporal repeatability within each species and condition*

Species	Control	Novel object	Novel food
Azure-winged magpie	N=13, ICC=0.309 (0.000, 0.658), p = 0.044	N=13, ICC=0.593 (0.211, 0.827), p = 0.001	N=14, ICC=0.233 (0.000, 0.611), p = 0.121
Blue jay	N=9, ICC=0.962 (0.864, 0.989), p < 0.001	N=9, ICC=0.814 (0.432, 0.939), p < 0.001	N=9, ICC=0.680 (0.252, 0.898), p < 0.001
Carrion crow	N=18, ICC=0.740 (0.477, 0.884), p < 0.001	N=17, ICC=0.755 (0.536, 0.893), p < 0.001	N=17, ICC=0.456 (0.102, 0.731), p = 0.002
Clark's nutcracker	N=10, ICC=0.535 (0.100, 0.818), p = 0.002	N=10, ICC=0.582 (0.134, 0.832), p = 0.001	N=10, ICC=0.492 (0.043, 0.801), p = 0.005
Common raven	N=15, ICC=0.638 (0.306, 0.835), p < 0.001	N=15, ICC=0.707 (0.436, 0.878), p < 0.001	N=15, ICC=0.630 (0.302, 0.828), p < 0.001
Eurasian jay	N=24, ICC=0.557 (0.289, 0.754), p < 0.001	N=24, ICC=0.290 (0.000, 0.568), p = 0.012	N=24, ICC=0.346 (0.039, 0.634), p = 0.003
'Alalā	N=84, ICC=0.542 (0.418, 0.650), p < 0.001	N=84, ICC=0.540 (0.426, 0.653), p < 0.001	NA
Large-billed crow	N=13, ICC=0.496 (0.117, 0.761), p = 0.001	N=13, ICC=0.216 (0.000, 0.571), p = 0.099	N=13, ICC=0.426 (0.048, 0.734), p = 0.006
New Caledonian crow	N=9, ICC=0.177 (0.000, 0.610), p = 0.189	N=9, ICC=0.164 (0.000, 0.625), p = 0.245	N=9, ICC=0.000 (0.000, 0.421), p = 1.000
Pinyon jay	N=21, ICC=0.690 (0.464, 0.842), p < 0.001	N=21, ICC=0.863 (0.733, 0.934), p < 0.001	N=21, ICC=0.738 (0.535, 0.861), p < 0.001

Table S6  
*Individual contextual repeatability within each species*

Species	Repeatability across conditions
Azure-winged magpie	N=14, ICC=0.740 (0.438, 0.892), p < 0.001
Blue jay	N=9, ICC=0.889 (0.646, 0.966), p < 0.001
Carrion crow	N=18, ICC=0.721 (0.486, 0.873), p < 0.001
Clark's nutcracker	N=10, ICC=0.693 (0.292, 0.891), p < 0.001
Common raven	N=15, ICC=0.802 (0.588, 0.910), p < 0.001
Eurasian jay	N=24, ICC=0.583 (0.330, 0.763), p < 0.001
'Alalā	N=84, ICC=0.545 (0.384, 0.679), p < 0.001
Large-billed crow	N=13, ICC=0.651 (0.328, 0.849), p < 0.001
New Caledonian crow	N=9, ICC=0.270 (0.000, 0.687), p = 0.091
Pinyon jay	N=21, ICC=0.800 (0.640, 0.905), p < 0.001

Table S7  
*Individual temporal and contextual repeatability*

Control	Novel food	Novel object	Overall repeatability
N=216, ICC=0.542 (0.467, 0.625), p < 0.001	N=132, ICC=0.477 (0.381, 0.591), p < 0.001	N=215, ICC=0.548 (0.469, 0.625), p < 0.001	N=217, ICC=0.462 (0.402, 0.521), p < 0.001

Table S8  
*Subject information, including sex, source and participation in testing*

Species	Sex (male, female or unknown)	Rearing information	Housing	Completed testing	Lab leader and location
Common raven, <i>Corvus corax</i>	7.8	Hand-reared	Group/ pair	1 missing trial for round 2 & 3 for all conditions (did not participate)	Thomas Bugnyar, Austria
Carrion crow, <i>C. corone</i> ; <i>C. cornix</i>	4.4	Hand-reared	Group/ pair	4 missing trials for control round 2 & 3 and food round 3 and object round 3; 1 missing trial from food round 1; 2 missing trials from food round 2 and object round 2 (did not participate)	Thomas Bugnyar, Austria
Carrion crow, <i>C. corone</i>	10.0	Hand-reared	Group	Yes	Andreas Nieder, Germany
Large-billed crow, <i>C. macrorhynchos</i>	8.5	Wild: parent reared	Group	Yes	Ei-Ichi Izawa, Japan
New Caledonian crow, <i>C. moneduloides</i>	3.6	Wild: parent reared	Group	Yes	Alexander Taylor, New Zealand (subjects in New Caledonia)
Alala, <i>C. hawaiiensis</i>	64.44	Hand-reared and parent-reared	Group/ pair	Control and novel object conditions only (not food condition)	Alison Greggor, USA
Eurasian jay, <i>Garrulus glandarius</i>	14.10	Hand-reared	Group	2 missing trials for control round 2; 5 missing trails for control round 3; 4 missing trials for food round 2 & 3 and object round 2; with 2 missing trials in object round 3 (did not participate)	Nicola Clayton, UK
Pinyon jay, <i>Gymnorhinus cyanocephalus</i>	10.2	Wild: parent reared	Individual cages	Yes	Jeffrey Stevens, USA
Pinyon jay, <i>Gymnorhinus cyanocephalus</i>	4.5	Wild: parent reared	Individual cages	Yes	Debbie Kelly, Canada
Blue jay, <i>Cyanocitta cristata</i>	2.2 (5 unknown)	Hand-reared	Individual cages	Yes	Kristy Gould, USA
Clark's nutcracker, <i>Nucifraga columbiana</i>	7.3	Wild: parent reared	Individual cages	Yes	Debbie Kelly, Canada
Azure-winged magpie, <i>Cyanopica cyanus</i>	6.2	Parent-reared & Hand-reared	Group	Yes	Zhongqiu Li, China
Azure-winged magpie, <i>Cyanopica cyanus</i>	2.4	Parent-reared & Hand-reared	Group	2 missing trials for round 2 and 3 for all rounds (2 birds died due to unrelated causes)	Thomas Bugnyar & Jorg J.M. Massen, Austria