Science Advances
AAAS

Supplementary Materials for

Cross-modal perception of identity by sound and taste in bottlenose dolphins

Jason N. Bruck*, Sam F. Walmsley, Vincent M. Janik*

*Corresponding author. Email: jason.bruck@sfasu.edu (J.N.B.); vj@st-andrews.ac.uk (V.M.J.)

Published 18 May 2022, *Sci. Adv.* **8**, eabm7684 (2022)
DOI: 10.1126/sciadv.abm7684

This PDF file includes:

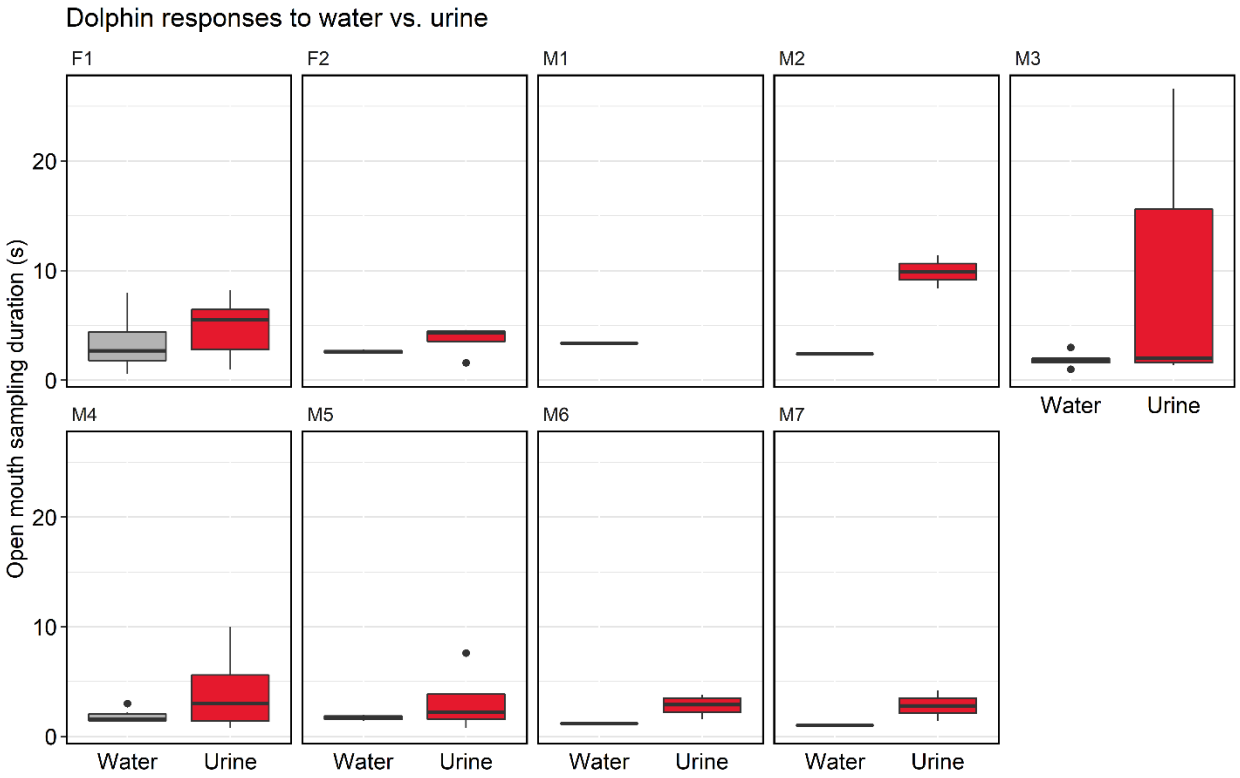

Fig. S1.

Variation in the duration of *T. truncatus* open-mouth sampling of water (n = 33) or a conspecific's urine (*n* = 33). Each facet shows results from a single animal. One individual (M1) was only presented with water. M= male, F = female

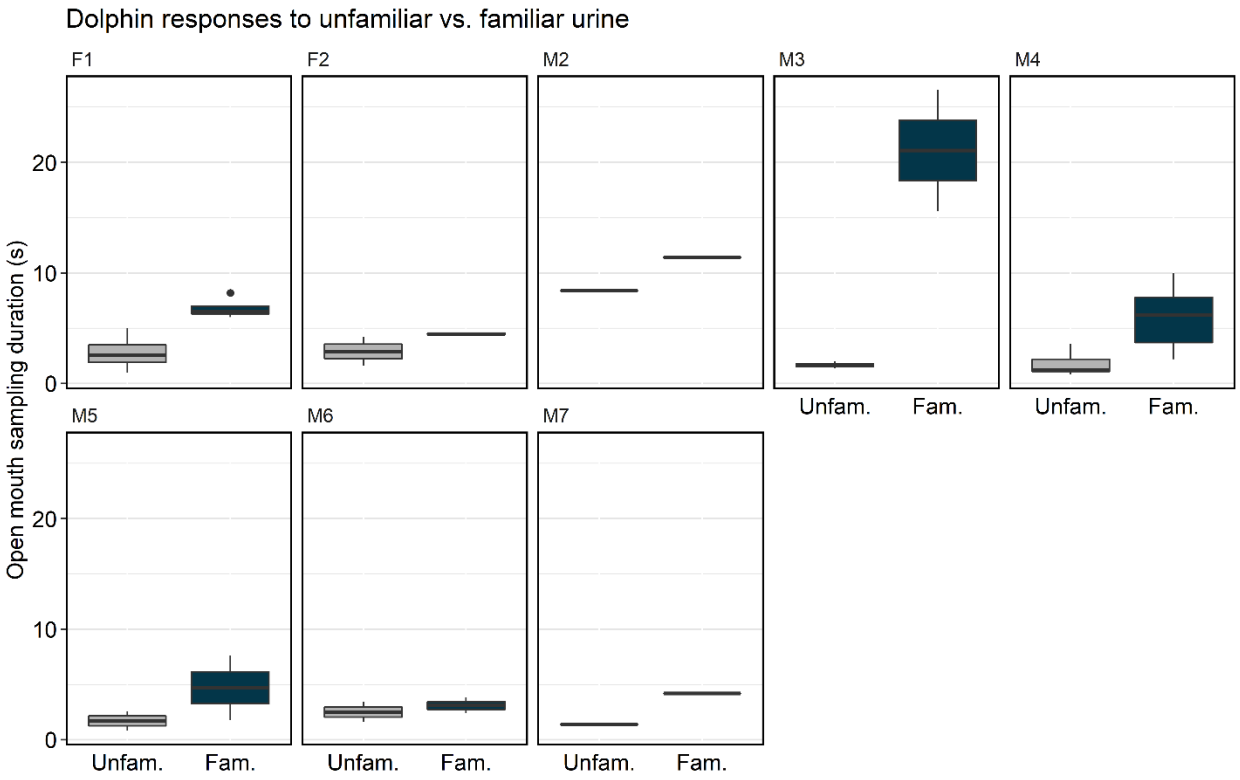

Fig. S2.

Variation in the duration of *T. truncatus* open-mouth sampling of urine from an unfamiliar (n = 22) conspecific, or a familiar one (*n* = 21). Each facet shows results from a single animal. M= male, F = female

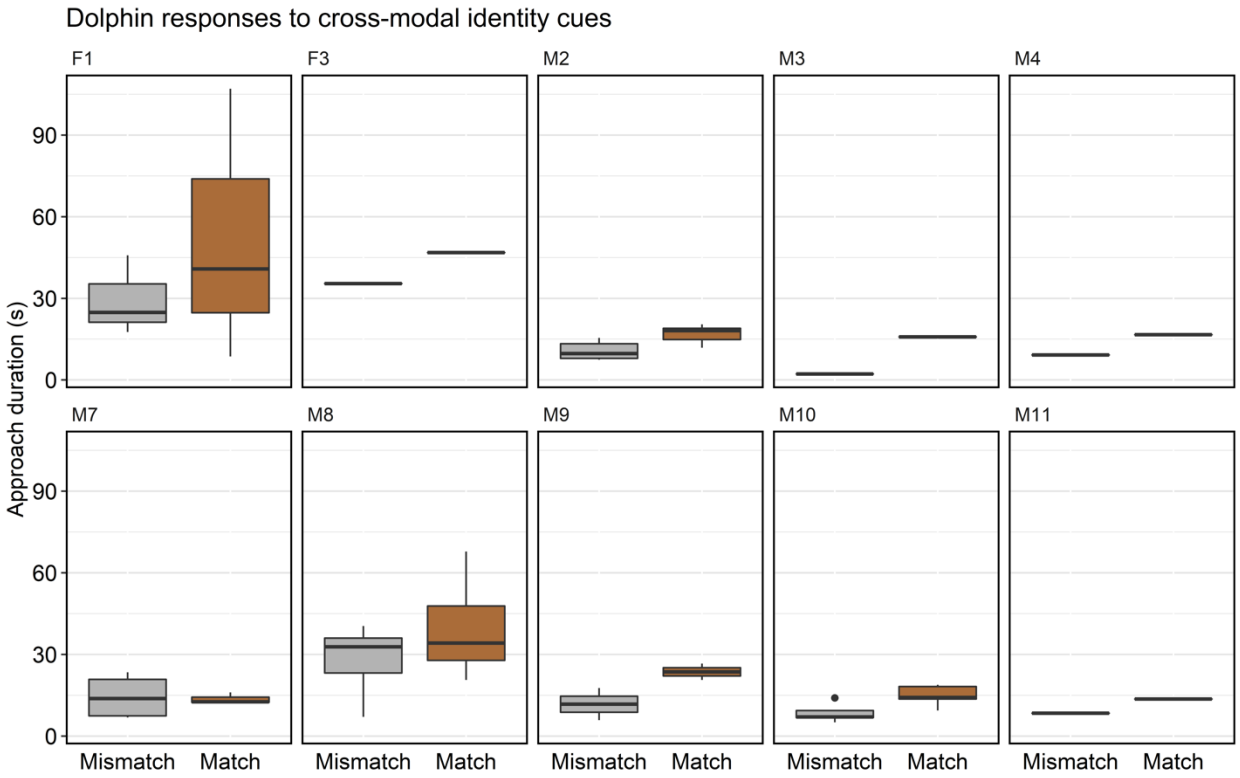

Fig. S3.

Variation in the amount of time that *T. truncatus* approaches and explores a speaker following a mismatched (n = 37) or matched presentation (n = 36) of cross-modal identity cues. Acoustic cues consisted of signature whistles and chemical cues consisted of urine. Each facet shows results from a single animal. M= male, F = female.

Table S1.

Complete details of individual dolphins involved in study, both as subjects and donors of urine and acoustic samples. DQB = Dolphin Quest Bermuda, DQH = Dolphin Quest Hawaii, DQO = Dolphin Quest Oahu

Dolphin identity	Facility	Sex	Age	Subject	Urine Donor (familiarity)	Urine Donor (cross-modal)	Acoustics Donor	Urine received in familiarity tests: Dolphin ID (number of tests)	Urine received in cross-modal tests: Dolphin ID (number of tests)	Acoustics received in cross-modal tests: Dolphin ID (number of tests)
F1	DQH	F	9	Yes	Yes	Yes	Yes	M2 (2), M10 (1), M11 (2), M7 (2), M4 (1)	F2 (3), F12 (2), M5 (1)	F14 (1), F12 (2), F2 (2), M5 (1)
F2	DQH	F	6	Yes	Yes	Yes	Yes	M7 (1), M11 (2), M6 (1)		
F3	DQB	F	4	Yes	No	No	No		F7 (1), F4 (1)	F9 (1), F4 (1)
M1	DQH	M	17		Yes	No	No			
M2	DQO	M	32	Yes	Yes	Yes	Yes	F13 (1), F2 (1)	M7 (4), M6 (1), M10 (3), M11 (2), M4 (2)	M7 (5), M4 (3), M6 (3), M11 (2), M5 (1)
M3	DQH	M	5	Yes	No	Yes	No	M11 (3), M4 (2), M10 (1)	F12 (1), F2 (1)	F12 (1), F1 (1)
M4	DQO	M	25	Yes	Yes	Yes	Yes	F12 (1), F2 (1), M12 (1), F1 (2), M7 (2), F13 (2), M5 (1), M6 (1), F11 (1), M10 (1), M2 (1)	M7 (1), M10 (1)	M7 (1), M2 (1)
M5	DQH/DQO	M	8	Yes	Yes	Yes	Yes	M11 (1), M7 (1), M2 (1), M4 (1)		
M6	DQO	M	21	Yes	Yes	Yes	Yes	F12 (1), F2 (1), M4 (1), M1 (1)		

M7	DQO	M	19	Yes	Yes	Yes	Yes	M10 (1), M1 (1)	M2 (3), M7 (1), M11 (2), M10 (1), M6 (1)	M6 (2), M7 (1), M2 (2), M5 (1), M4 (2)
M8	DQB	M	6	Yes	No	No	No		F4 (5), F7 (6), F9 (2), F5 (4), F8 (4), F6 (4),	F4 (5), F5 (5), F10 (5), F6 (7), F8 (2), F9 (2)
M9	DQH	M	4	Yes	No	No	No		F1 (1), F11 (1), F12 (1), F13 (1)	F1 (2), M5 (1), F13 (1)
M10	DQO	M	22	Yes	Yes	Yes	Yes		M7 (4), M6 (2), M2 (2), M11 (2)	M7 (4), M4 (2), M6 (2), M2 (1), M5 (1)
M11	DQO	M	16	Yes	Yes	Yes	Yes		F2 (1), F13 (1)	F1 (1), F13 (1)
F4	DQB	F	27	No	No	Yes	Yes			
F5	DQB	F	23	No	No	Yes	Yes			
F6	DQB	F	6	No	No	Yes	Yes			
F7	DQB	F	6	No	No	Yes	No			
F8	DQB	F	13	No	No	Yes	Yes			
F9	DQB	F	42	No	No	Yes	Yes			
F10	DQB	F	2	No	No	Yes	Yes			
F11	DQH	F	31	No	Yes	Yes	No			
F12	DQH	F	45	No	Yes	Yes	Yes			
F13	DQH	F	16	No	Yes	Yes	Yes			
M12	DQH	M	20	No	Yes	No	No			
F14	DQH	F	4	No	No	No	Yes			

Table S2.

Parameter estimates of generalized linear mixed effects models (GLMMs) testing whether *T. truncatus* produce different behavioural responses to water vs. urine. Sample sizes differ by model and are reported in the formal model descriptions.

Dolphin responses to water vs. urine				
	Estimate	SE	$statistic$	p
Model 1. Open mouth sampling				
Intercept	0.757	0.180	4.206	< 0.001
Treatment: urine	0.764	0.177	4.323	< 0.001
Individual (Variance)	0.067			
$R^{2\ marginal}$	0.127			
$R^{2\ conditional}$	0.190			
Model 2. Whistling				
Intercept	2.374	1.397	1.700	0.089
Treatment: urine	-0.880	0.961	-0.916	0.360
Individual (Variance)	7.28			
$R^{2\ marginal}$	0.015			
$R^{2\ conditional}$	0.623			
Model 3. Number of whistles				
Intercept	0.459	0.626	0.734	0.463
Treatment: urine	0.826	0.149	5.557	< 0.001
Individual (Variance)	2.301			
$R^{2\ marginal,\ non\text{-}truncated\ model}$	0.106			
$R^{2\ conditional,\ non\text{-}truncated\ model}$	0.884			
Model 4. Echolocation				
Intercept	1.452	0.883	1.646	0.100
Treatment: urine	0.306	0.685	0.447	0.655
Individual (Variance)	2.594			
$R^{2\ marginal}$	0.003			

$R^{2\ conditional}$	0.326			
Model 5. Duration of echolocation				
Intercept	0.981	0.242	4.059	< 0.001
Treatment: urine	0.541	0.218	2.485	0.013
Individual (Variance)	0.136			
$R^{2\ marginal}$	0.063			
$R^{2\ conditional}$	0.190			

Table S3.

Parameter estimates of generalized linear mixed effects models (GLMMs) testing whether *T. truncatus* produce different behavioural responses to urine from familiar vs. unfamiliar individuals. Sample sizes differ by model and are reported in the formal model descriptions.

Dolphin responses to familiar vs. unfamiliar urine				
	Estimate	SE	*statistic*	*p*
Model 6. Open mouth sampling				
Intercept	0.960	0.267	3.593	< 0.001
Familiarity	1.119	0.179	6.237	< 0.001
Urine sample age	0.007	0.013	0.527	0.598
Urine donor sex: male	-0.319	0.276	-1.153	0.249
Individual (Variance)	5.6			
$R^{2\ marginal}$	0.385			
$R^{2\ conditional}$	0.494			
Model 6-CB. Open mouth sampling *(counter-balanced dataset)*				
Intercept	0.831	0.431	1.929	0.068
Familiarity	1.282	0.296	4.329	< 0.001
Urine sample age	-0.031	0.024	-1.272	0.218
Urine donor sex: male	0.655	0.410	1.597	0.126
R^2	0.617			
Model 7. Whistling				
Intercept	8.612	4.752	1.812	0.070
Familiarity	-1.420	1.833	-0.775	0.439
Individual (Variance)	150.1			
$R^{2\ marginal}$	0.001			
$R^{2\ conditional}$	0.342			
Model 8. Number of whistles				
Intercept	0.885	0.612	1.446	0.148
Familiarity	0.932	0.141	6.605	< 0.001

Individual (Variance)	1.784			
R^{2} marginal, non-truncated model	0.136			
R^{2} conditional, non-truncated model	0.928			
Model 9. Echolocation				
Intercept	2.211	1.105	2.001	0.045
Familiarity	-0.702	0.835	-0.840	0.401
Individual (Variance)	2.633			
R^{2} marginal	0.015			
R^{2} conditional	0.321			
Model 10. Duration of echolocation				
Intercept	1.292	0.258	5.009	< 0.001
Familiarity	0.460	0.254	1.811	0.070
Individual (Variance)	0.182			
R^{2} marginal	0.046			
R^{2} conditional	0.200			

Table S4.

Parameter estimates of generalized linear mixed effects models (GLMMs) testing whether *T. truncatus* produce different behavioural responses to matched and mismatched cross-modal identity cues. Sample sizes differ by model and are reported in the formal model descriptions.

Dolphin responses to cross-modal identity cues				
	Estimate	SE	*statistic*	*p*
Model 11. Approach duration				
Intercept	2.706	0.240	11.293	< 0.001
Treatment: matched	0.424	0.100	4.229	< 0.001
Urine sample age	9.054×10^{-5}	3.912×10^{-3}	0.023	0.982
Urine donor sex	-0.286	0.303	-0.945	0.345
Individual (Variance)	0.117			
$R^{2\ marginal}$	0.168			
$R^{2\ conditional}$	0.468			
Model 11-CB. Approach duration *(counter-balanced dataset)*				
Intercept	2.587	0.295	8.758	< 0.001
Treatment: matched	0.391	0.101	3.874	< 0.001
Urine sample age	0.008	0.005	1.617	0.106
Urine donor sex	-0.389	0.497	-0.783	0.433
Individual (Variance)	0.112			
$R^{2\ marginal}$	0.233			
$R^{2\ conditional}$	0.599			
Model 12. Whistling				
Intercept	0.566	0.863	0.656	0.512
Treatment: matched	-0.284	0.547	-0.518	0.604
Individual (Variance)	4.547			
$R^{2\ marginal}$	0.002			
$R^{2\ conditional}$	0.530			
Model 13. Number of whistles				

Intercept	1.197	0.585	2.047	0.041
Treatment: matched	-0.036	0.113	-0.319	0.750
Individual (Variance)	2.198			
R^{2} marginal, non-truncated model	< 0.001			
R^{2} conditional, non-truncated model	0.914			
Model 14. Echolocation				
Intercept	0.546	0.746	0.731	0.465
Treatment: matched	1.034	0.638	1.621	0.105
Individual (Variance)	2.707			
R^{2} marginal	0.036			
R^{2} conditional	0.399			
Model 15. Duration of echolocation				
Intercept	1.457	0.319	4.564	< 0.001
Treatment: matched	0.061	0.182	0.335	0.738
Individual (Variance)	0.364			
R^{2} marginal	0.001			
R^{2} conditional	0.394			