
Dopamine-independent effect of rewards on choices through hidden-state inference

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SUPPLEMENTARY TABLES

Supplementary Table 1. Single strategy models.

	Model Category	BIC	Forget	Sym.	Asym.	Bias	Persev.	Multi-Persev.
0	Asym. MB + forget to 0	139831.80						
1	Asym. Bayesian inf.	140036.05						
2	Asym. MB + forget to 0	140086.30						
3	Asym. Bayesian Inf.	140276.03						
4	Asym. MB + forget	141590.81						
5	Asym. hybrid + forget	141805.52						
6	Asym. MB + forget	141867.80						
7	Asym. hybrid + forget	142073.50						
8	Asym. MB + forget to 0	143070.87						
9	Asym. MB + forget to 0	143775.49						
10	Asym. hybrid + forget	144008.16						
11	Asym. Bayesian Inf.	144239.97						
12	Asym. MB + forget	144459.12						
13	Asym. hybrid + forget	144526.49						
14	Asym. hybrid + forget	144544.82						
15	Asym. MB + forget to 0	144862.99						
16	Asym. Bayesian Inf.	144978.67						
17	Asym. hybrid + forget	145051.16						
18	Asym. MB + forget	145149.48						
19	Asym. MB + forget to 0	145728.24						
20	Asym. MB + forget	146579.22						
21	Asym. Bayesian Inf.	146813.37						
22	Asym. MB + forget	147405.69						
23	Asym. Bayesian Inf.	147801.67						
24	Bayesian Inf.	147948.45						
25	Bayesian Inf.	148229.72						
26	MB	149671.55						
27	Hybrid	149682.46						
28	MB	150022.51						
29	Hybrid	150023.82						
30	Asym. MF + forget	153158.95						
31	Asym. MF + forget	153253.21						
32	Asym. MF + forget	153271.91						
33	Asym. MF + forget	153517.90						
34	Hybrid	153970.40						
35	MB	154043.05						
36	MF	154115.34						
37	Bayesian Inf.	154202.23						
38	MF	154273.02						
39	Asym. MF + forget	154621.49						
40	Hybrid	154817.62						
41	Asym. MF + forget	154860.06						
42	Bayesian Inf.	154879.49						
43	MB	154909.12						
44	MF	158491.35						
45	Control	158903.27						
46	Control	159003.42						
47	MF	159080.31						
48	Hybrid	165694.02						
49	MB	165920.96						
50	Hybrid	167002.03						
51	MB	167264.02						
52	Bayesian Inf.	167728.20						
53	Bayesian Inf.	168835.61						
54	Control	168847.38						
55	Control	168878.81						
56	MF	171713.00						
57	MF	172669.69						
58	Control	188360.39						

Abbreviations: Sym. = Symmetric; Asym. = Asymmetric; Inf. = Inference; MB = model based; MF = model free; Persev. = Perseveration; Multi-Persev = Multi-Perseveration.

Supplementary Table 2. Best single strategy model of each class.

Rank	Best models of each class	BIC	parameters	kernels
0	Asymmetric model-based + forget to 0	139831.8	weight: 3.24 ± 1.12 learning rate reward: 0.63 ± 0.14 learning rate non-reward: 0.65 ± 0.14 forget: 0.71 ± 0.18	multi-persev. weight: 2.95 ± 0.59 multi-persev. alpha: 0.21 ± 0.20 bias: 0.01 ± 0.14
1	Asymmetric Bayesian inference	140036.05	weight: 23.24 ± 21.55 prob. reversal: 0.33 ± 0.07	multi-persev. weight: 3.06 ± 0.43 multi-persev. alpha: 0.19 ± 0.10 bias: 0.01 ± 0.14
4	Asymmetric model-based + forget	141590.81	weight: 4.98 ± 1.45 learning rate reward: 0.71 ± 0.14 learning rate non-reward: 0.16 ± 0.08 forget: 0.83 ± 0.13	multi-persev. weight: 2.98 ± 0.61 multi-persev. alpha: 0.23 ± 0.19 bias: 0.01 ± 0.14
5	Asymmetric hybrid + forget	141805.52	weight model-free: 0.37 ± 0.41 weight model-based: 4.81 ± 1.41 learning rate reward: 0.68 ± 0.14 learning rate non-reward: 0.14 ± 0.06 eligibility trace: 0.50 ± 0.42 forget: 0.82 ± 0.16	multi-persev. weight: 2.92 ± 0.65 multi-persev. alpha: 0.20 ± 0.20 bias: 0.01 ± 0.14
24	Bayesian inference	147948.45	weight: 5.36 ± 1.90 prob. reversal: 0.24 ± 0.05	multi-persev. weight: 3.45 ± 0.51 multi-persev. alpha: 0.35 ± 0.16 bias: 0.01 ± 0.14
26	Model-based	149671.55	weight: 1.55 ± 0.49 learning rate: 0.69 ± 0.11	multi-persev. weight: 3.13 ± 0.51 multi-persev. alpha: 0.37 ± 0.19 bias: 0.00 ± 0.16
27	Hybrid	149682.46	weight model-free: 0.25 ± 0.13 weight model-based: 1.32 ± 0.44 learning rate: 0.78 ± 0.11 eligibility trace: 0.17 ± 0.22	multi-persev. weight: 3.13 ± 0.51 multi-persev. alpha: 0.37 ± 0.19 bias: 0.01 ± 0.15
30	Asymmetric model-free + forget	153158.95	weight model-free: 3.06 ± 0.94 learning rate reward: 0.56 ± 0.19 learning rate non-reward: 0.26 ± 0.20 eligibility trace: 0.49 ± 0.15 forget: 0.40 ± 0.14	multi-persev. weight: 2.37 ± 1.06 multi-persev. alpha: 0.49 ± 0.37 bias: 0.01 ± 0.11
36	Model-free	154115.34	weight: 1.26 ± 0.40 learning rate: 0.46 ± 0.08 eligibility trace: 0.53 ± 0.08	multi-persev. weight: 3.06 ± 0.46 multi-persev. alpha: 0.39 ± 0.18 bias: 0.01 ± 0.12
45	Control	158903.27		multi-persev. weight: 3.78 ± 0.45 multi-persev. alpha: 0.32 ± 0.11

Supplementary Table 3. Mixture-of-strategies models.

Mixture-of-strategies model – forget to neutral (0.5)

Second-step value update	Action value update	kernels
<u>Independent</u> learning rate reward: 0.47 ± 0.18 learning rate non-reward: 0.27 ± 0.25 forget: 0.59 ± 0.26	<u>Model-free</u> learning rate reward: 0.52 ± 0.17 learning rate non-reward: 0.46 ± 0.24 eligibility trace: 0.43 ± 0.18 weight: 0.67 ± 0.47	multi-persv. weight: 2.97 ± 0.66 multi-persv. alpha: 0.21 ± 0.18 bias: 0.01 ± 0.15
	<u>Model-based</u> weight: 1.47 ± 1.29	
<u>Bayesian inference</u> prob. reversal: 0.36 ± 0.09	<u>Bayesian inference</u> weight: 22.47 ± 15.03	

Mixture-of-strategies model – forget to 0

Second-step value update	Action value update	kernels
<u>Independent</u> learning rate reward: 0.62 ± 0.15 learning rate non-reward: 0.64 ± 0.19 forget: 0.70 ± 0.26	<u>Model-free</u> learning rate reward: 0.53 ± 0.20 learning rate non-reward: 0.55 ± 0.19 eligibility trace: 0.51 ± 0.18 weight: 0.51 ± 0.54	multi-persv. weight: 2.85 ± 0.73 multi-persv. alpha: 0.17 ± 0.17 bias: 0.01 ± 0.15
	<u>Model-based</u> weight: 2.35 ± 1.18	
<u>Bayesian inference</u> prob. reversal: 0.29 ± 0.20	<u>Bayesian inference</u> weight: 5.05 ± 8.88	

Supplementary Table 4. Description of training stages and task contingencies

Stage	Start poke	Choice pokes	Reward pokes	Task Structure
1.1			X	Reward probability 100%
1.2				Introduce auditory cues Reward probability 100%
2		X	X	Transition probability 80/20% Reward probability 100%
3	X	X	X	Transition probability 80/20% Reward probability 100%
	x	x	x	Start introducing free choice trials and reward probabilities
Substage	Free choice trials	Non-neutral blocks reward probabilities (high / low)	Neutral block reward probability	Block change (independent / dependent on behaviour)
4.1	0%	0.9/0.7	0.8	Independent – 20-30 trials blocks
4.2	25%	0.9/0.5	0.7	Independent – 20-30 trials blocks
4.3	25%	0.9/0.3	0.6	Independent – 20-30 trials blocks
4.4	25%	0.9/0.1	0.5	Independent – 20-30 trials blocks
4.5	50%	0.9/0.1	0.5	Dependent
4.6	75%	0.9/0.1	0.5	Dependent
4.7 – Final	75%	0.8/0.2	0.5	Dependent