

1160 **Supplementary Material**

1161 **Supplementary Table 4-1. Statistical results for the level of information integration in**

1162 **GRAB<sub>NE2h</sub> and GRAB<sub>ACh3.0</sub> data**

	<b>NE (Number of ROIs, %)</b>	<b>p-value (Chi-square test)</b>	<b>ACh (Number of ROIs, %)</b>	<b>p-value (Chi-square test)</b>
<b>Choice-outcome (Chance level)</b>	2,917, 10.0% (9.0%)	0	8,357, 22.7% (16.3%)	0
<b>Outcome-reinforcer (Chance level)</b>	2,819, 9.5% (8.4%)	0	3,316, 9.0% (6.0%)	0
<b>Choice-reinforcer (Chance level)</b>	2,153, 7.3% (3.5%)	0	2,252, 6.1% (2.7%)	0

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1164 **Supplementary Table 4-2. Statistical results for the conditional probabilities  $P(v_1|v_2)$**

		<b>NE median (25, 75 percentile) (%)</b>	<b>ACh median (25, 75 percentile) (%)</b>	<b>p-value (median test)</b>
<b>Choice-outcome</b>	$P(r_n c_n)$ (%)	62.3 (28.1, 95.6)	91.2 (82.4, 94.0)	0.044
	$P(c_n r_n)$ (%)	48.8 (29.3, 71.0)	51.9 (31.4, 91.5)	0.864
<b>Outcome-reinforcer</b>	$P(r_n x_n)$ (%)	54.1 (22.3, 95.9)	95.6 (84.3, 97.2)	0.034
	$P(x_n r_n)$ (%)	53.0 (32.2, 60.5)	30.3 (26.7, 36.6)	0.072
<b>Choice-reinforcer</b>	$P(c_n x_n)$ (%)	50.9 (31.6, 72.3)	94.4 (68.3, 98.9)	0.030
	$P(x_n c_n)$ (%)	73.2 (30.2, 88.8)	35.7 (28.3, 41.8)	0.002

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1167 **Supplementary Table 5-1. Statistical results for the temporal parameters of different**  
 1168 **groups**

			<b>NE median (25, 75 percentile)</b>	<b>ACh median (25, 75 percentile)</b>	<b>p-value (rank sum test)</b>
<b>Outcome</b>	Group 1	Median time-to-peak (s)	0.80 (0.75, 0.85)	1.95 (1.35, 2.45)	$1.54 \times 10^{-13}$
		Variance time-to-peak (s <sup>2</sup> )	0.21 (0.08, 1.04)	0.82 (0.28, 1.37)	0.002
		Median peak-value (a.u.)	0.07 (0.05, 0.09)	0.05 (0.04, 0.06)	0.003
	Group 2	Median time-to-peak (s)	0.75 (0.75, 0.85)	0.95 (0.85, 1.15)	$1.43 \times 10^{-4}$
		Variance time-to-peak (s <sup>2</sup> )	0.12 (0.01, 0.60)	0.37 (0.12, 0.58)	0.108
		Median peak-value (a.u.)	-0.04 (-0.06, 0.03)	-0.03 (-0.04, -0.02)	0.002
<b>Choice</b>	Group 1	Median time-to-peak (s)	0.55 (0.35, 0.80)	1.85 (1.25, 2.95)	$1.06 \times 10^{-7}$
		Variance time-to-peak (s <sup>2</sup> )	0.62 (0.02, 1.46)	1.50 (0.33, 3.15)	0.003
		Median peak-value (a.u.)	-0.04 (-0.07, -0.02)	0.03 (0.01, 0.04)	$3.53 \times 10^{-14}$
	Group 2	Median time-to-peak (s)	0.55 (0.38, 0.65)	1.55 (0.80, 2.08)	0.022
		Variance time-to-peak (s <sup>2</sup> )	0.01 (0.00, 0.15)	0.58 (0.21, 1.32)	0.001
		Median time-to-peak (a.u.)	0.02 (0.00, 0.05)	-0.03 (-0.04, -0.02)	$1.88 \times 10^{-7}$

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1172 **Supplementary Table 6-1. Statistical results for the effect of region and power on**  
 1173 **probability to switch, related to Fig. 6F**

1174 **Dbh-cre;Ai32**

Source	Sum Sq.	df	Singular?	Mean Sq.	F	Prob>F
power	0.03526439	2	0	0.01763219	7.56886624	0.00101344
region	0.00098233	4	0	0.00024558	0.10541969	0.98028781
power*region	0.00088444	8	0	0.00011055	0.04745728	0.99994653
Error	0.17471764	75	0	0.00232957		
Total	0.2118488	89	0			

1175 Post-Hoc

Group A	Group B	Lower Limit	A-B	Upper Limit	P-value
power=3mW	power=1.5mw	-0.0095731	0.02022529	0.05002365	0.24236299
power=3mw	power=0mW	0.01847739	0.04827575	0.07807411	0.00065928
power=1.5mW	power=0mW	-0.0017479	0.02805046	0.05784882	0.06931062

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1177 **ChAt-cre;Ai32**

Source	Sum Sq.	df	Singular?	Mean Sq.	F	Prob>F
power	0.02519462	2	0	0.01259731	8.38794621	0.00045669
region	0.00200658	4	0	0.00050165	0.33402191	0.85439824
power*region	0.00156262	8	0	0.00019533	0.13005928	0.99777634
Error	0.13516513	90	0	0.00150183		
Total	0.16392895	104	0			

1178 Post-Hoc

Group A	Group B	Lower Limit	A-B	Upper Limit	P-value
power=3mW	power=1.5mW	0.01586284	0.03793956	0.06001628	0.00026894
power=3mW	power=0mW	-0.0026469	0.01942986	0.04150658	0.0960785
power=1.5mw	power=0mW	-0.0405864	-0.0185097	0.00356702	0.11854034

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1181 **Supplementary Table 6-2. Statistical results for the effect of power on overall session,**  
1182 **related to Fig. 6G**

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1184 **Dbh-Cre;Ai32**

1185 Entropy

Source	SS	df	MS	F	Prob>F
Power	0.06082996	2	0.03041498	0.89538033	0.41628803
Error	1.39272013	41	0.03396878		
Total	1.4535501	43			

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1187 Number of Trials

Source	SS	df	MS	F	Prob>F
Power	43199.4181	2	21599.7091	1.63605203	0.2063718
Error	580902.795	44	13202.3362		
Total	624102.213	46			

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1189 Reward Rate

Source	SS	df	MS	F	Prob>F
Power	0.01813336	2	0.00906668	1.08632669	0.34633196
Error	0.36723201	44	0.00834618		
Total	0.38536537	46			

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1191 **ChAt-Cre;Ai32**

1192 Entropy

Source	SS	df	MS	F	Prob>F
Power	0.00983532	2	0.00491766	0.19571646	0.82297372
Error	1.08043694	43	0.02512644		

Total	1.09027226	45			
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1194 Number of Trials

Source	SS	df	MS	F	Prob>F
Power	15025.9321	2	7512.96603	0.48205245	0.62081147
Error	670170.938	43	15585.3706		
Total	685196.87	45			

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1196 Reward Rate

Source	SS	df	MS	F	Prob>F
Power	5.14E-05	2	2.57E-05	0.00906747	0.99097541
Error	0.12192428	43	0.00283545		
Total	0.1219757	45			

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1199 **Supplementary Table 6-3. Statistical results for the effect of region and stimulation on**  
 1200 **probability to switch, related to Fig. 6I**

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1202 **Dbh-Cre;Ai32**

Source	Sum Sq.	df	Singular?	Mean Sq.	F	Prob>F
Power	0.00287031	1	0	0.00287031	5.61667048	0.02270168
Region	0.00617679	3	0	0.00205893	4.02895583	0.01353153
power*region	0.000573	3	0	0.000191	0.3737537	0.77237318
Error	0.02044133	40	0	0.00051103		
Total	0.03006143	47	0			

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1204 Post-Hoc for region

Group A	Group B	Lower Limit	A-B	Upper Limit	P-value
region=M2-L	region=M2-R	-0.0405306	-0.0157933	0.00894397	0.33137496
region=M2-L	region=V1-L	-0.0490326	-0.0242953	0.00044197	0.05584813
region=M2-L	region=V1-R	-0.0548628	-0.0301256	-0.0053883	0.01160543
region=M2-R	region=V1-L	-0.0332393	-0.008502	0.01623526	0.79367161
region=M2-R	region=V1-R	-0.0390695	-0.0143323	0.01040498	0.41647849
region=V1-L	region=V1-R	-0.0305675	-0.0058303	0.01890699	0.92119217

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1206 Post-Hoc for power

Group A	Group B	Lower Limit	A-B	Upper Limit	P-value
Power=0mW	Power=3mW	-0.0304981	-0.0168194	-0.0031406	0.01723266

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1208 **ChAt-Cre;Ai32**

Source	Sum Sq.	df	Singular?	Mean Sq.	F	Prob>F
stim	4.60E-05	1	0	4.60E-05	0.06706715	0.79676327
region	0.00204866	3	0	0.00068289	0.99466637	0.40338684

stim*region	0.00115308	3	0	0.00038436	0.55984416	0.64411262
Error	0.03295426	48	0	0.00068655		
Total	0.03620204	55	0			

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1211 **Supplementary Table 6-4. Statistical results for the effect of region on overall session,**  
1212 **related to Fig. 6J**

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1214 **Dbh-Cre;Ai32**

1215 Entropy

Source	SS	df	MS	F	Prob>F
Region	0.18972055	3	0.06324018	2.48832741	0.06710368
Error	1.85527574	73	0.02541474		
Total	2.0449963	76			

1216

1217 Number of Trials

Source	SS	df	MS	F	Prob>F
Region	29323.8377	3	9774.61255	0.67280948	0.57131416
Error	1118660.16	77	14528.0541		
Total	1147984	80			

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1219 Reward Rate

Source	SS	df	MS	F	Prob>F
Region	0.04258502	3	0.01419501	2.64214867	0.05522146
Error	0.41368431	77	0.00537252		
Total	0.45626932	80			

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1221 **ChAt-Cre;Ai32**

1222 Entropy

Source	SS	df	MS	F	Prob>F
Region	0.01488469	3	0.00496156	0.32650571	0.80619028
Error	1.77792625	117	0.01519595		

Total	1.79281094	120			
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1224 Number of Trials

Source	SS	df	MS	F	Prob>F
Region	945.888715	3	315.296238	0.02759786	0.99378347
Error	1336685.63	117	11424.6635		
Total	1337631.52	120			

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1226 Reward Rate

Source	SS	df	MS	F	Prob>F
Region	0.00780693	3	0.00260231	1.23293022	0.30096393
Error	0.24694836	117	0.00211067		
Total	0.25475529	120			

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1228 Post-Hoc for Reward Rate

Group A	Group B	Lower Limit	A-B	Upper Limit	P-value
M2-L	M2-R	-0.057629	-0.0180601	0.0215088	0.64422361
M2-L	V1-L	-0.0588981	-0.0193292	0.02023972	0.59174233
M2-L	V1-R	-0.030134	0.0079956	0.04612516	0.94957223
M2-R	V1-L	-0.040838	-0.0012691	0.03829984	0.99979959
M2-R	V1-R	-0.0120738	0.02605572	0.06418528	0.29505019
V1-L	V1-R	-0.0108048	0.0273248	0.06545436	0.25405443

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