

Supplementary Information

Neural Substrates, Dynamics and Thresholds of Galvanic Vestibular Stimulation in the Behaving Primate

Annie Kwan¹, Patrick A. Forbes^{2,3,4}, Diana E. Mitchell⁵, Jean-Sébastien Blouin⁴, and Kathleen E. Cullen^{*5,6}

¹Department of Biomedical Engineering, McGill University, Montreal, QC, H3G 1Y6, Canada

²Department of Neuroscience, Erasmus MC, University Medical Center Rotterdam, Rotterdam, 3000 CA, The Netherlands

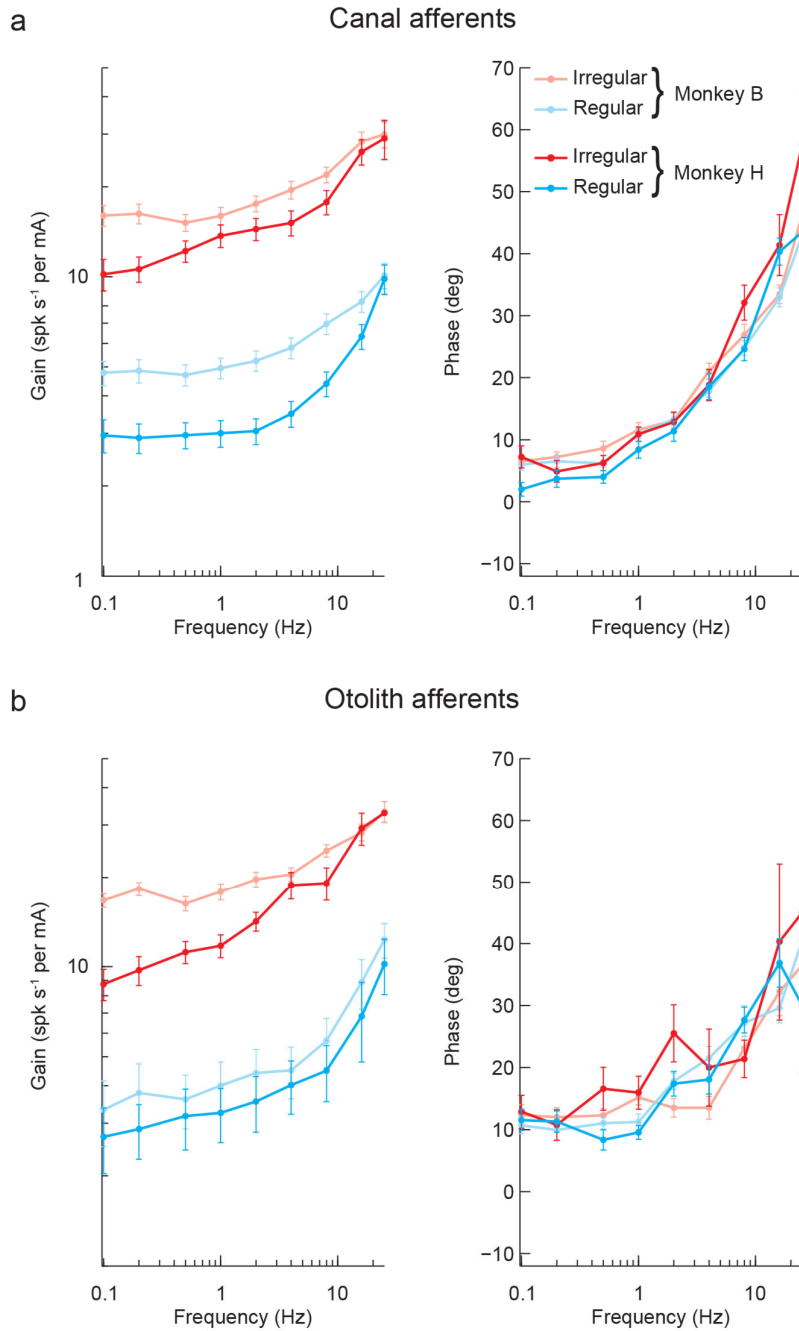
³Department of BioMechanical Engineering, Delft University of Technology, Delft, 2628 CD, The Netherlands

⁴School of Kinesiology, University of British Columbia, Vancouver, BC, V6T 1Z1, Canada

⁵Department of Physiology, McGill University, Montreal, QC, H3G 1Y6, Canada

⁶Department of Biomedical Engineering, Johns Hopkins University, Baltimore, Maryland, USA

Correspondence: kathleen.cullen@jhu.edu



Supplementary Figure 1. Comparison of vestibular afferents recorded from two animals. (a) Population averaged gain and phase of regular (Monkey B: light blue; Monkey H: dark blue) and irregular (Monkey B: light red; Monkey H: dark red) canal afferents to sinusoidal GVS. (b) Population averaged gain and phase of regular (Monkey B: light blue; Monkey H: dark blue) and irregular (Monkey B: light red; Monkey H: dark red) otolith afferents to sinusoidal GVS.

Supplementary Table 1. Statistics summary table. Grey shaded p-values represent effects that were not significant

Figure	Panel	Test used	n		Descriptive statistics shown	P value	Degree of freedom & F/t values
			Exact value	Definition			
1	C left	Repeated measures ANOVA	15	Gain values from 3 monkeys across 5 different frequencies	Error bars are mean $\pm$ s.e.m.	$p = 0.604$ for frequency factor	$F_{4,8} = 0.72$ for frequency factor;
	C right	Repeated measures ANOVA	15	Phase values from 3 monkeys across 5 different frequencies	Error bars are mean $\pm$ s.e.m.	$p < 0.001$ for frequency factor	$F_{4,8} = 59.25$ for frequency factor;
	D left	Repeated measures ANOVA	15	Amplitude values from 3 monkeys across 5 different current amplitudes	Error bars are mean $\pm$ s.e.m.	$p = 0.002$ for amplitude factor	$F_{4,8} = 12.17$ for amplitude factor;
	D right	Repeated measures ANOVA	15	Phase values from 3 monkeys across 5 different current amplitudes	Error bars are mean $\pm$ s.e.m.	$p = 0.714$ for amplitude factor	$F_{4,8} = 0.53$ for amplitude factor;
2	D left	Two-tailed Student's t-tests with Bonferroni correction for multiple comparison at each frequency (threshold $p = 0.0055$)	881	Gain values from 119 canal afferents (56 irregular and 63 regular) across 9 frequencies	Error bars are mean $\pm$ s.e.m.	0.1Hz: $p < 0.001$ 0.2Hz: $p < 0.001$ 0.5Hz: $p < 0.001$ 1Hz: $p < 0.001$ 2Hz: $p < 0.001$ 4Hz: $p < 0.001$ 8Hz: $p < 0.001$ 16Hz: $p < 0.001$ 25Hz: $p < 0.001$	0.1Hz: $t(75) = 9.3$ 0.2Hz: $t(78) = 10.4$ 0.5Hz: $t(114) = 13.0$ 1Hz: $t(116) = 13.1$ 2Hz: $t(116) = 14.3$ 4Hz: $t(116) = 12.8$ 8Hz: $t(108) = 13.3$ 16Hz: $t(87) = 11.9$ 25Hz: $t(53) = 7.6$
		Two-tailed Student's t-test (0.1 vs. 25 Hz)	132	Gain values from 132 canal afferent recordings (66 irregular and 66 regular)	Error bars are mean $\pm$ s.e.m.	Irregular: $p < 0.001$ Regular: $p < 0.001$	Irregular: $t(64) = 6.5$ Regular: $t(64) = 7.9$
	D right	Two-tailed Student's t-tests with Bonferroni correction for multiple comparison at each frequency (threshold $p = 0.0055$)	881	Phase values from 119 canal afferents (56 irregular and 63 regular) across 9 frequencies	Error bars are mean $\pm$ s.e.m.	0.1Hz: $p = 0.010$ 0.2Hz: $p = 0.138$ 0.5Hz: $p = 0.006$ 1Hz: $p = 0.094$ 2Hz: $p = 0.335$ 4Hz: $p = 0.071$ 8Hz: $p = 0.022$ 16Hz: $p = 0.459$ 25Hz: $p = 0.091$	0.1Hz: $t(75) = 2.4$ 0.2Hz: $t(78) = 1.10$ 0.5Hz: $t(114) = 2.6$ 1Hz: $t(116) = 1.3$ 2Hz: $t(116) = 0.43$ 4Hz: $t(116) = 1.5$ 8Hz: $t(108) = 2.0$ 16Hz: $t(87) = 0.1$ 25Hz: $t(53) = 1.4$
		Two-tailed Student's t-test (0.1 vs. 25 Hz)	132	Phase values from 132 canal afferent recordings (66 irregular and 66 regular)	Error bars are mean $\pm$ s.e.m.	Irregular: $p < 0.001$ Regular: $p < 0.001$	Irregular: $t(64) = 14.3$ Regular: $t(64) = 16.0$

4	E left	Two-tailed Student's t-tests with Bonferroni correction for multiple comparison at each frequency (threshold $p = 0.0055$)	588	Gain values from 84 otolith afferents (54 irregular and 30 regular) across 9 frequencies	Error bars are mean $\pm$ s.e.m.	<i>0.1Hz: $p < 0.001$</i> <i>0.2Hz: $p < 0.001$</i> <i>0.5Hz: $p < 0.001$</i> <i>1Hz: $p < 0.001$</i> <i>2Hz: $p < 0.001$</i> <i>4Hz: $p < 0.001$</i> <i>8Hz: $p < 0.001$</i> <i>16Hz: $p < 0.001$</i> <i>25Hz: $p < 0.001$</i>	0.1Hz: $t(49) = 8.7$ 0.2Hz: $t(53) = 9.1$ 0.5Hz: $t(80) = 10.6$ 1Hz: $t(82) = 9.4$ 2Hz: $t(79) = 10.8$ 4Hz: $t(77) = 12.0$ 8Hz: $t(70) = 11.9$ 16Hz: $t(53) = 8.1$ 25Hz: $t(27) = 6.4$
		Two-tailed Student's t-test (0.1 vs. 25 Hz)	80	Gain values from 80 otolith afferent recordings (47 irregular and 33 regular)	Error bars are mean $\pm$ s.e.m.	<i>Irregular: $p < 0.001$</i> <i>Regular: $p < 0.001$</i>	Irregular: $t(45) = 8.4$ Regular: $t(31) = 7.4$
	E right	Two-tailed Student's t-tests with Bonferroni correction for multiple comparison at each frequency (threshold $p = 0.0055$)	588	Phase values from 84 otolith afferents (54 irregular and 30 regular) across 9 frequencies	Error bars are mean $\pm$ s.e.m.	0.1Hz: $p = 0.214$ 0.2Hz: $p = 0.311$ 0.5Hz: $p = 0.026$ <i>1Hz: $p = 0.002$</i> 0.2Hz: $p = 0.254$ 0.4Hz: $p = 0.022$ 0.8Hz: $p = 0.048$ 0.16Hz: $p = 0.383$ 0.25Hz: $p = 0.464$	0.1Hz: $t(49) = 0.8$ 0.2Hz: $t(53) = 0.5$ 0.5Hz: $t(80) = 2.0$ 1Hz: $t(82) = 3.0$ 2Hz: $t(79) = 0.7$ 4Hz: $t(77) = 2.0$ 8Hz: $t(70) = 1.7$ 16Hz: $t(53) = 0.3$ 25Hz: $t(27) = 0.1$
		Two-tailed Student's t-test (0.1 vs. 25 Hz)	80	Phase values from 80 otolith afferent recordings (47 irregular and 33 regular)	Error bars are mean $\pm$ s.e.m.	<i>Irregular: $p < 0.001$</i> <i>Regular: $p < 0.001$</i>	Irregular: $t(45) = 5.9$ Regular: $t(31) = 8.2$
	B left (red)	Two-tailed Student's t-tests with Bonferroni correction for multiple comparison at each frequency (threshold $p = 0.01$)	357	Normalized gain values from irregular canal afferents in response to GVS or motion across different frequencies	Error bars are mean $\pm$ s.e.m.	<i>1Hz: $p = 0.004$</i> <i>2Hz: $p < 0.001$</i> <i>4Hz: $p < 0.001$</i> <i>8Hz: $p < 0.001$</i> <i>16Hz: $p < 0.001$</i>	1Hz: $t(74) = 3.0$ 2Hz: $t(73) = 7.4$ 4Hz: $t(73) = 10.8$ 8Hz: $t(70) = 7.1$ 16Hz: $t(57) = 5.7$
	B left (blue)	Two-tailed Student's t-tests with Bonferroni correction for multiple comparison at each frequency (threshold $p = 0.01$)	411	Normalized gain values from regular canal afferents in response to GVS or motion across different frequencies	Error bars are mean $\pm$ s.e.m.	0.1Hz: $p = 0.926$ 0.2Hz: $p = 0.011$ <i>4Hz: $p < 0.001$</i> <i>8Hz: $p < 0.001$</i> <i>16Hz: $p < 0.001$</i>	1Hz: $t(84) = 0.1$ 2Hz: $t(85) = 2.6$ 4Hz: $t(84) = 5.8$ 8Hz: $t(80) = 5.7$ 16Hz: $t(68) = 5.2$

	B right (red)	Two-tailed Student's t-tests with Bonferroni correction for multiple comparison at each frequency (threshold $p = 0.0083$)	433	Phase values from irregular canal afferents in response to GVS or motion across different frequencies	Error bars are mean $\pm$ s.e.m.	<i>0.5Hz: $p < 0.001$</i> <i>1Hz: $p < 0.001$</i> <i>2Hz: $p < 0.001$</i> <i>4Hz: $p < 0.001$</i> <i>8Hz: $p < 0.001$</i> <i>16Hz: $p < 0.001$</i>	0.5Hz: $t(74) = 7.9$ 1Hz: $t(74) = 9.9$ 2Hz: $t(73) = 9.3$ 4Hz: $t(73) = 8.5$ 8Hz: $t(70) = 8.5$ 16Hz: $t(57) = 7.0$
	B right (blue)	Two-tailed Student's t-tests with Bonferroni correction for multiple comparison at each frequency (threshold $p = 0.0083$)	498	Phase values from regular canal afferents in response to GVS or motion across different frequencies	Error bars are mean $\pm$ s.e.m.	<i>0.5Hz: $p < 0.001$</i> <i>1Hz: $p < 0.001$</i> <i>2Hz: $p < 0.001$</i> <i>4Hz: $p < 0.001$</i> <i>8Hz: $p < 0.001$</i> <i>16Hz: $p < 0.001$</i>	0.5Hz: $t(85) = 4.5$ 1Hz: $t(84) = 2.9$ 2Hz: $t(85) = 3.8$ 4Hz: $t(84) = 5.8$ 8Hz: $t(80) = 9.7$ 16Hz: $t(68) = 9.6$
5	B left (red)	Two-tailed Student's t-tests with Bonferroni correction for multiple comparison at each frequency (threshold $p = 0.01$)	320	Normalized gain values from irregular otolith afferents in response to GVS or motion across different frequencies	Error bars are mean $\pm$ s.e.m.	1Hz: $p = 0.76$ 2Hz: $p = 0.96$ 4Hz: $p = 0.11$ <i>8Hz: $p < 0.001$</i> <i>16Hz: $p < 0.001$</i>	1Hz: $t(68) = 0.3$ 2Hz: $t(66) = 0.1$ 4Hz: $t(64) = 1.6$ 8Hz: $t(61) = 3.6$ 16Hz: $t(51) = 7.8$
	B left (blue)	Two-tailed Student's t-tests with Bonferroni correction for multiple comparison at each frequency (threshold $p = 0.01$)	224	Normalized gain values from regular otolith afferents in response to GVS or motion across different frequencies	Error bars are mean $\pm$ s.e.m.	1Hz: $p = 0.53$ 2Hz: $p = 0.21$ 4Hz: $p = 0.22$ 8Hz: $p = 0.16$ 16Hz: $p = 0.03$	1Hz: $t(46) = 0.6$ 2Hz: $t(46) = 1.3$ 4Hz: $t(45) = 1.2$ 8Hz: $t(42) = 1.5$ 16Hz: $t(35) = 2.2$
	B right (red)	Two-tailed Student's t-tests with Bonferroni correction for multiple comparison at each frequency (threshold $p = 0.0083$)	389	Phase values from irregular otolith afferents in response to GVS or motion across different frequencies	Error bars are mean $\pm$ s.e.m.	0.5Hz: $p = 0.068$ 1Hz: $p = 0.026$ <i>2Hz: $p < 0.001$</i> <i>4Hz: $p < 0.001$</i> <i>8Hz: $p = 0.002$</i> 16Hz: $p = 0.019$	0.5Hz: $t(67) = 1.9$ 1Hz: $t(68) = 2.7$ 2Hz: $t(66) = 4.3$ 4Hz: $t(64) = 4.8$ 8Hz: $t(61) = 3.2$ 16Hz: $t(51) = 2.4$
	B right (blue)	Two-tailed Student's t-tests with Bonferroni correction for multiple comparison at each frequency (threshold $p = 0.0083$)	272	Phase values from regular otolith afferents in response to GVS or motion across different frequencies	Error bars are mean $\pm$ s.e.m.	<i>0.5Hz: $p < 0.001$</i> <i>1Hz: $p = 0.006$</i> <i>2Hz: $p < 0.001$</i> <i>4Hz: $p = 0.001$</i> <i>8Hz: $p < 0.001$</i> 16Hz: $p = 0.151$	0.5Hz: $t(46) = 5.7$ 1Hz: $t(46) = 2.9$ 2Hz: $t(46) = 3.8$ 4Hz: $t(45) = 3.4$ 8Hz: $t(42) = 4.3$ 16Hz: $t(35) = 1.5$

8	E	Two-tailed Student's t-tests with Bonferroni correction for multiple comparison at each frequency (threshold $p = 0.00625$)	781	Log-normal transformed detection threshold values from 119 canal afferents (56 irregular versus 63 regular) across 8 frequencies	Error bars are mean $\pm$ s.e.m. of the non-transformed data	0.1Hz: $p = 0.781$ 0.2Hz: $p = 0.599$ 0.5Hz: $p = 0.212$ 1Hz: $p = 0.504$ 2Hz: $p = 0.257$ 4Hz: $p = 0.011$ 8Hz: $p = 0.0052$ 16Hz: $p = 0.004$	0.1Hz: $t(69) = 0.3$ 0.2Hz: $t(70) = 0.5$ 0.5Hz: $t(108) = 1.3$ 1Hz: $t(111) = 0.7$ 2Hz: $t(110) = 1.1$ 4Hz: $t(106) = 2.6$ 8Hz: $t(103) = 2.9$ 16Hz: $t(88) = 3.0$
	E (red)	Linear mixed model	378	Log-normal transformed detection thresholds from 56 irregular canal afferents across 8 frequencies	Error bars are mean $\pm$ s.e.m. of the non-transformed data	$p < 0.001$ for frequency factor	$F_{7,317.58} = 11.62$ for frequency factor
	E (blue)	Linear mixed model	403	Log-normal transformed detection thresholds from 63 regular canal afferents across 8 frequencies	Error bars are mean $\pm$ s.e.m. of the non-transformed data	$p < 0.001$ for frequency factor	$F_{7,339.18} = 7.01$ for frequency factor
	F	Two-tailed Student's t-tests with Bonferroni correction for multiple comparison at each frequency (threshold $p = 0.00625$)	553	Log-normal transformed detection threshold values from 84 otolith afferents (54 irregular versus 30 regular) across 8 frequencies	Error bars are mean $\pm$ s.e.m. of the non-transformed data	0.1Hz: $p = 0.279$ 0.2Hz: $p = 0.718$ 0.5Hz: $p = 0.493$ 1Hz: $p = 0.931$ 2Hz: $p = 0.405$ 4Hz: $p = 0.349$ 8Hz: $p = 0.040$ 16Hz: $p = 0.197$	0.1Hz: $t(47) = 1.1$ 0.2Hz: $t(48) = 0.4$ 0.5Hz: $t(78) = 0.7$ 1Hz: $t(82) = 0.1$ 2Hz: $t(78) = 0.8$ 4Hz: $t(73) = 0.9$ 8Hz: $t(74) = 2.1$ 16Hz: $t(57) = 1.3$
	F (red)	Linear mixed model	341	Log-normal transformed detection thresholds from 54 irregular otolith afferents across 8 frequencies	Error bars are mean $\pm$ s.e.m. of the non-transformed data	$p < 0.001$ for frequency factor	$F_{7,281.66} = 11.31$ for frequency factor
	F (blue)	Linear mixed model	212	Log-normal transformed detection thresholds from 30 regular otolith afferents across 8 frequencies	Error bars are mean $\pm$ s.e.m. of the non-transformed data	$p < 0.001$ for frequency factor	$F_{7,175.49} = 5.12$ for frequency factor
	E/F (red)	Two-tailed Student's t-tests with Bonferroni correction for multiple comparison at each frequency (threshold $p = 0.00625$)	719	Log-normal transformed detection threshold values from 110 irregular afferents (56 canals versus 54 otoliths) across 8 frequencies	Error bars are mean $\pm$ s.e.m. of the non-transformed data	0.1Hz: $p = 0.413$ 0.2Hz: $p = 0.583$ 0.5Hz: $p = 0.722$ 1Hz: $p = 0.398$ 2Hz: $p = 0.983$ 4Hz: $p = 0.287$ 8Hz: $p = 0.902$ 16Hz: $p = 0.252$	0.1Hz: $t(55) = 0.8$ 0.2Hz: $t(57) = 0.6$ 0.5Hz: $t(85) = 0.4$ 1Hz: $t(86) = 0.9$ 2Hz: $t(84) = 0.0$ 4Hz: $t(84) = 1.1$ 8Hz: $t(81) = 0.1$ 16Hz: $t(67) = 1.2$

	E/F (blue)	Two-tailed Student's t- tests with Bonferroni correction for multiple comparison at each frequency (threshold p = 0.00625)	615	Log-normal transformed detection threshold values from 93 regular afferents (63 canals versus 30 otoliths) across 8 frequencies	Error bars are mean ± s.e.m. of the non- transformed data	0.1Hz: p = 0.777 0.2Hz: p = 0.588 0.5Hz: p = 0.476 1Hz: p = 0.514 2Hz: p = 0.974 4Hz: p = 0.920 8Hz: p = 0.992 16Hz: p = 0.699	0.1Hz: t(61) = 0.3 0.2Hz: t(61) = 0.5 0.5Hz: t(101) = 0.7 1Hz: t(107) = 0.7 2Hz: t(104) = 0.0 4Hz: t(95) = 0.1 8Hz: t(96) = 0.0 16Hz: t(78) = 0.4
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