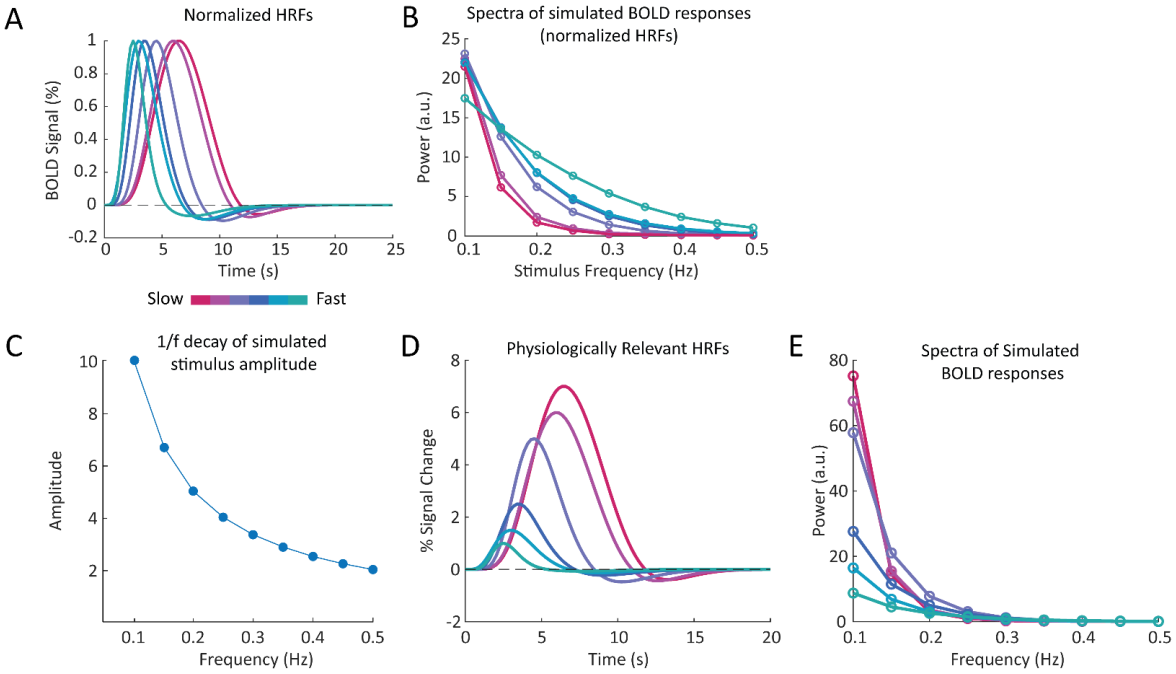
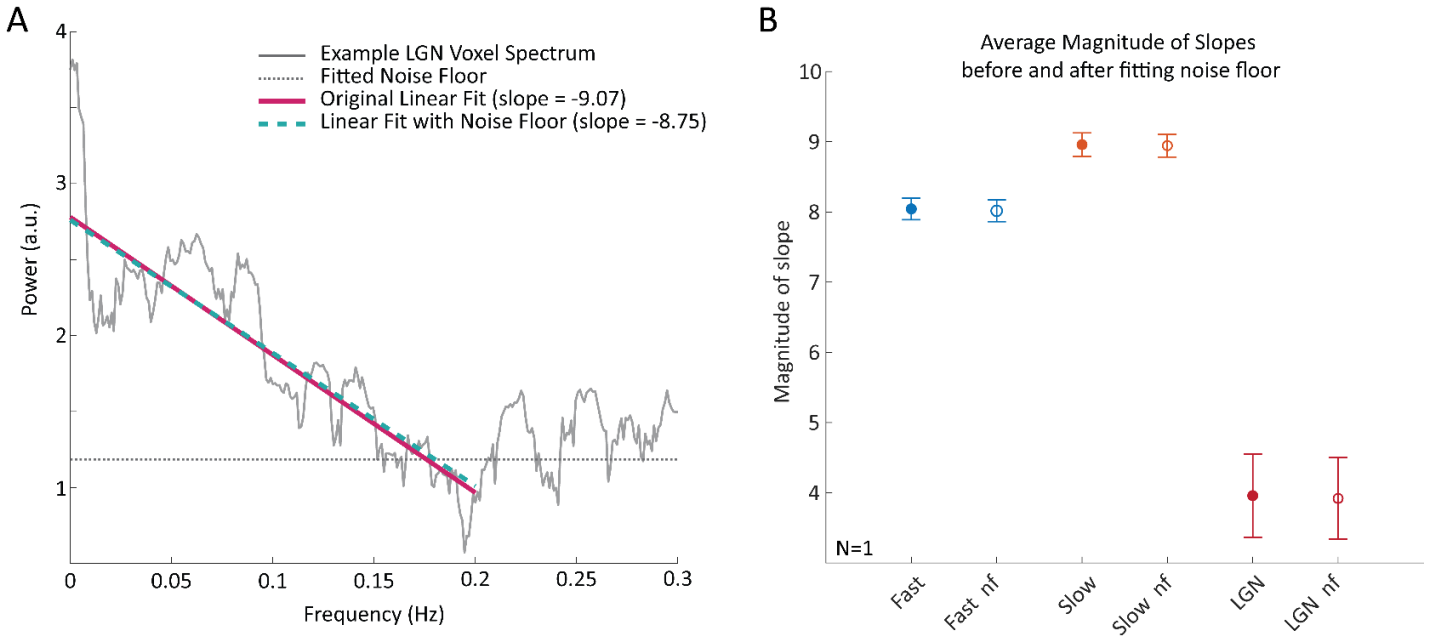
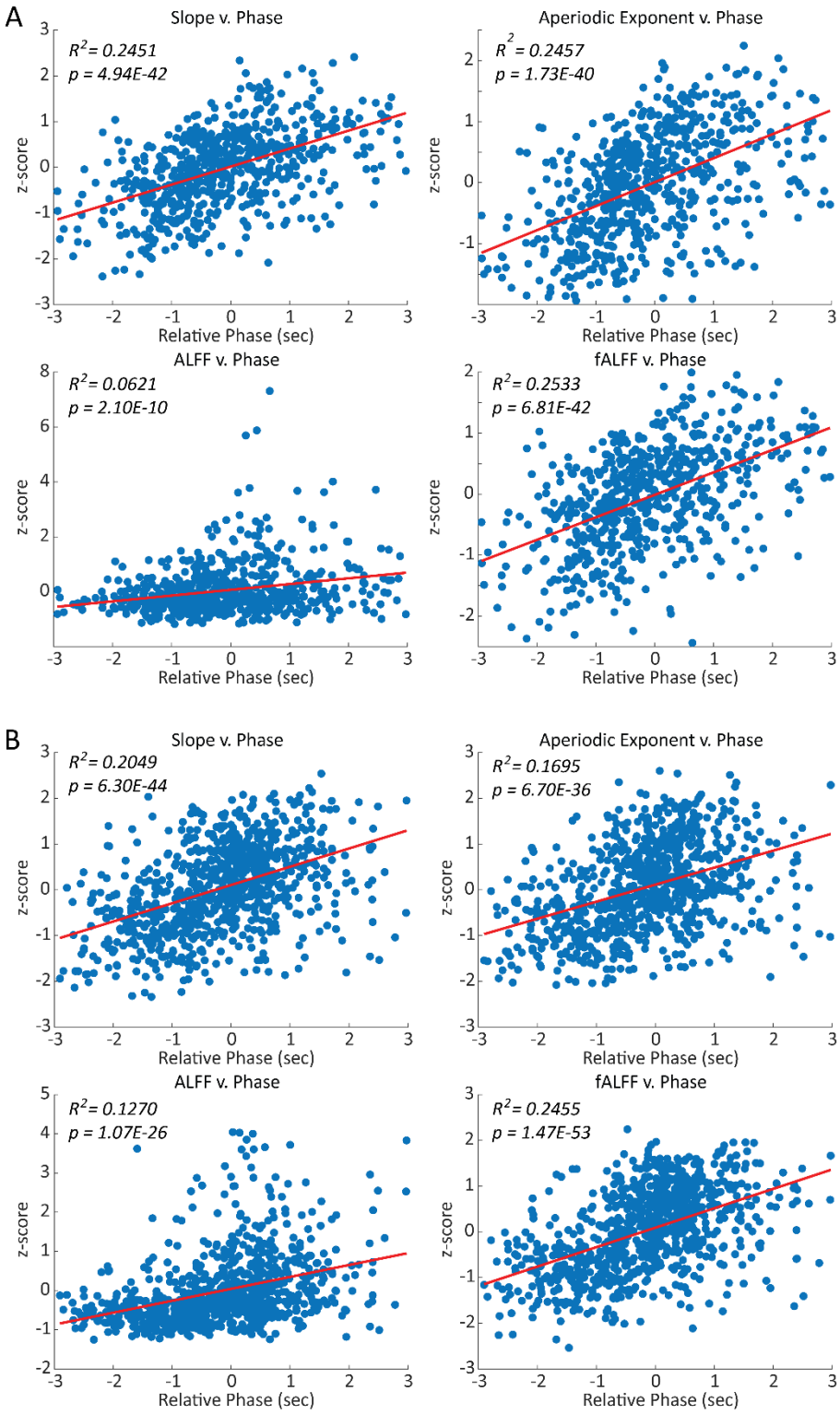
Supplementary Material



Supplementary Figure S1 – Simulation results are robust to changes in HRF amplitude and 1/f decay of stimulus amplitude. ***A)*** *We normalized each HRF to its respective peak amplitude to examine effect on frequency spectra.* ***B)*** *The differences in spectral content of the BOLD signal are not simply due to the amplitude of each HRF but rather a signature of the temporal dynamics of the HRF, as the slope differences persist when normalizing for amplitude, with slower HRFs generating steeper frequency responses.* ***C)*** *Plot showing the magnitudes of the neural waveform at each frequency and their 1/f decay.* ***D)*** *Physiologically relevant HRFs used in simulations.* ***E)*** *Temporal properties of HRF noticeably affect the slope of the simulated spectra even when oscillation amplitudes decay with 1/f pattern, demonstrating that distinct slopes are expected for distinct HRFs regardless of the specific neural signal amplitude.*



Supplementary Figure S2 – Accounting for thermal noise does not significantly change the estimated slope of the frequency spectrum under 0.2 Hz in V1 or LGN voxels. **A)** Spectra of example LGN voxel demonstrating the method for accounting for the noise floor in the slope of the linear fit. The original linear fit and the linear fit with the noise floor produce similar results. **B)** Average magnitude of slopes before and after fitting the noise floor in fast and slow cortical voxels as well as LGN voxels with error bars showing SEM. The within group averages did not significantly change when fitting for the noise floor versus not.



Supplementary Figure S3 – Example subjects showing significant (p<0.05) correlations between each spectral feature and phase on a voxel-wise basis. Each point represents a single voxel, red-line shows linear fit. p-values are from a linear hypothesis test on the model coefficients. **A)** Example subject showing significant, positive correlations between each spectral feature and the magnitude of the phase. **B)** A second example subject also showing a significant, positive correlation between each spectral feature (except ALFF) and the magnitude of the phase.

Table S1: p-values for all subjects and all resting-state spectral features between fast, slow, and LGN voxels, within individual subjects. Significant differences based on Wilcoxon rank-sum test (p<0.05) are bolded.

	Slope < 0.2 Hz			*Aperiodic Exponent*			*ALFF*			*fALFF*		
	Fast-Slow	Fast-LGN	Slow-LGN	Fast-Slow	Fast-LGN	Slow-LGN	Fast-Slow	Fast-LGN	Slow-LGN	Fast-Slow	Fast-LGN	Slow-LGN
S1	**1.13E-14**	**6.51E-09**	**7.15E-17**	**1.13E-12**	**3.26E-09**	**1.71E-16**	**6.98E-14**	0.7237	**7.52E-09**	**1.64E-14**	**7.88E-10**	**7.38E-17**
S2	**1.29E-21**	**3.93E-10**	**6.16E-14**	**6.21E-22**	**6.12E-11**	**9.59E-14**	**2.33E-10**	**0.0021**	0.4402	**2.59E-20**	**3.26E-05**	**1.14E-10**
S3	**5.06E-16**	**3.08E-06**	**1.13E-10**	**7.46E-17**	**4.79E-06**	**5.69E-11**	**4.89E-05**	0.8869	**0.0159**	**3.34E-15**	**7.78E-07**	**6.76E-11**
S4	**3.51E-03**	**4.42E-06**	**2.06E-08**	**3.95E-03**	**3.82E-07**	**2.59E-09**	**3.20E-03**	0.2091	**0.0079**	0.0643	**2.09E-05**	**2.05E-07**
S5	**6.67E-08**	**2.88E-09**	**6.29E-10**	**3.91E-12**	**1.17E-09**	**3.45E-10**	**1.15E-05**	**2.98E-05**	**0.0446**	**2.02E-06**	**6.62E-09**	**8.86E-10**
S6	**3.61E-25**	**1.01E-10**	**1.85E-12**	**4.20E-22**	**1.12E-10**	**1.34E-12**	**3.59E-20**	0.9969	**6.20E-06**	**3.72E-30**	**9.55E-07**	**1.27E-11**
S7	**9.71E-04**	**2.51E-04**	**7.79E-05**	0.1432	**2.51E-04**	**9.19E-05**	0.5493	**0.0498**	0.0867	**0.0322**	**3.76E-04**	**1.75E-04**
S8	**6.89E-14**	**1.39E-09**	**4.15E-14**	**1.20E-20**	**1.74E-09**	**1.41E-14**	**3.14E-03**	0.4995	0.2247	**4.56E-11**	**1.48E-09**	**9.87E-14**
S9	**1.72E-24**	**9.55E-15**	**7.08E-21**	**6.84E-18**	**1.64E-14**	**6.48E-21**	**0.5928**	0.6579	0.2915	**1.27E-24**	**5.91E-11**	**8.89E-20**
S10	**4.47E-10**	**1.75E-13**	**9.63E-19**	**9.19E-04**	**9.38E-18**	**9.81E-22**	0.1464	0.3322	0.8048	**9.32E-10**	**5.00E-13**	**5.58E-18**
S11	**6.65E-04**	**2.19E-11**	**6.32E-12**	**4.96E-04**	**1.39E-11**	**4.80E-12**	**6.78E-04**	0.0585	0.1637	0.0533	**1.05E-09**	**4.39E-10**
S12	**4.08E-13**	**1.41E-10**	**3.68E-13**	**1.77E-15**	**4.72E-09**	**1.01E-12**	**1.83E-09**	**5.88E-08**	**1.15E-10**	**1.83E-07**	**1.03E-09**	**2.38E-12**
S13	**8.83E-10**	**7.77E-08**	**1.79E-11**	**5.32E-09**	**4.31E-04**	**8.21E-09**	0.3715	**4.92E-10**	**5.66E-07**	**8.67E-08**	**9.20E-10**	**2.47E-12**
S14	**5.76E-04**	**4.19E-06**	**1.54E-08**	**2.70E-03**	**5.63E-06**	**8.22E-09**	0.3232	0.1669	0.3733	**0.0233**	**5.27E-06**	**9.18E-08**
S15	**1.92E-12**	**1.06E-07**	**9.38E-11**	**6.07E-14**	**1.44E-08**	**2.79E-11**	**1.81E-07**	**8.08E-04**	0.8278	**8.47E-13**	**8.46E-05**	**2.32E-09**

Table S2: Average Classification Accuracies per subject. Results are average of over 1000 bootstraps with 95% confidence intervals for each subject on each model trained. For each subject the model with the highest accuracy is bolded. Chance is 33%.

	Subsampled Spectra	**Spectral Features**	**Breath Hold Latencies**
S1	**71.43 % (0.31)**	65.21 % (0.37)	58.46 % (0.36)
S2	68.91 % (0.31)	**71.63 % (0.31)**	50.08 % (0.34)
S3	**70.46 % (0.44)**	69.25 % (0.46)	49.06 % (0.50)
S4	**58.63 % (0.49)**	53.88 % (0.47)	38.39 % (0.45)
S5	**62.48 % (0.30)**	62.19 % (0.31)	52.94 % (0.35)
S6	**80.56 % (0.25)**	77.37 % (0.29)	60.19 % (0.34)
S7	**72.69 % (0.48)**	59.31 % (0.54)	64.01 % (0.53)
S8	**73.18 % (0.35)**	72.12 % (0.37)	42.57 % (0.38)
S9	72.87 % (0.29)	**74.38 % (0.29)**	53.93 % (0.34)
S10	**73.54 % (0.24)**	61.90 % (0.26)	49.16 % (0.26)
S11	50.09 % (0.44)	**59.49 % (0.43)**	46.74 % (0.45)
S12	63.63 % (0.33)	**64.98 % (0.34)**	51.65 % (0.37)
S13	**67.50 % (0.32)**	67.14 % (0.35)	46.58 % (0.35)
S14	**57.92 % (0.37)**	57.34 % (0.38)	50.83 % (0.36)
S15	**67.99 % (0.35)**	61.94 % (0.36)	63.08 % (0.39)
COMBINED	**66.68 % (0.08)**	65.70 % (0.08)	52.02 % (0.11)

Table S3. Subject-wise results from fit of linear model relating each spectral feature with phase. p-values are from a linear hypothesis test on the model coefficients.

	Slope < 0.2 Hz			*Aperiodic Exponent*			*ALFF*			*fALFF*		
	x1	**R^2**	**p-value**	**x1**	**R^2**	**p-value**	**x1**	**R^2**	**p-value**	**x1**	**R^2**	**p-value**
S1	0.3865	0.1058	1.51E-16	0.3391	0.0781	1.93E-12	0.3998	0.1063	1.28E-16	0.3868	0.1080	7.14E-17
S2	0.3657	0.1204	1.46E-20	0.4044	0.1251	2.40E-21	0.2475	0.0500	4.24E-09	0.3239	0.1017	1.93E-17
S3	0.3935	0.2451	4.94E-42	0.3940	0.2457	1.73E-40	0.2096	0.0621	2.10E-10	0.3691	0.2533	6.81E-42
S4	0.2592	0.1153	5.87E-17	0.2692	0.1208	9.75E-18	0.1670	0.0351	6.14E-06	0.2188	0.0922	1.04E-13
S5	0.1836	0.0413	1.93E-09	0.2591	0.0718	1.49E-15	0.1394	0.0227	9.65E-06	0.1727	0.0364	1.81E-08
S6	0.3990	0.2049	6.30E-44	0.3721	0.1695	6.70E-36	0.3041	0.1270	1.07E-26	0.4249	0.2455	1.47E-53
S7	0.2918	0.1363	1.09E-27	0.2558	0.0911	1.34E-18	0.1839	0.0710	1.09E-14	0.3188	0.1625	3.73E-33
S8	0.2714	0.1870	8.47E-37	0.2969	0.2009	1.00E-39	0.1327	0.0593	5.78E-12	0.2725	0.1868	9.43E-37
S9	0.3289	0.2446	5.36E-43	0.2775	0.1641	1.31E-27	-0.0130	3.28E-4	6.38E-01	0.3258	0.2519	2.01E-44
S10	0.2136	0.0618	2.87E-16	0.1492	0.0277	5.86E-08	-0.0320	0.0013	2.41E-01	0.2145	0.0648	5.10E-17
S11	0.2033	0.0509	6.62E-13	0.1769	0.0328	9.44E-09	0.0555	0.0032	7.59E-02	0.1810	0.0424	5.78E-11
S12	0.2287	0.0797	2.62E-18	0.2434	0.0855	1.42E-19	0.1593	0.0351	1.06E-08	0.1814	0.0527	1.85E-12
S13	0.2697	0.0905	6.89E-20	0.2490	0.0735	2.60E-16	0.1060	0.0127	8.16E-04	0.2467	0.0793	1.60E-17
S14	0.1062	0.0153	3.11E-04	0.0883	0.0103	3.08E-03	0.0462	0.0030	1.13E-01	0.0592	0.0049	4.19E-02
S15	0.2537	0.0818	6.84E-17	0.2710	0.0892	2.40E-18	0.1104	0.0159	2.99E-04	0.2268	0.0668	5.75E-14

Table S4: Average regression coefficient of determination (R^2) and Root Mean Squared Error (RMSE). Results are averaged over 1000 bootstraps with 95% confidence intervals for each subject on each model trained. All RMSE values are smaller than the RMSE from a model trained on shuffled labels.

	R^2		*RMSE*	
	Subsampled Spectra	**Spectral Features**	**Subsampled Spectra**	**Spectral Features**
S1	0.203 (0.006)	0.057 (0.005)	0.724 (0.003)	0.780 (0.003)
S2	-0.012 (0.006)	0.052 (0.005)	0.822 (0.004)	0.793 (0.004)
S3	0.422 (0.006)	0.237 (0.005)	0.961 (0.005)	0.971 (0.004)
S4	0.173 (0.008)	0.067 (0.005)	1.217 (0.006)	1.095 (0.004)
S5	-0.041 (0.005)	-0.036 (0.004)	0.914 (0.003)	0.880 (0.003)
S6	0.278 (0.005)	0.242 (0.004)	0.896 (0.004)	0.924 (0.004)
S7	0.326 (0.008)	0.167 (0.005)	0.913 (0.005)	1.015 (0.004)
S8	0.266 (0.006)	0.173 (0.004)	1.112 (0.004)	1.151 (0.004)
S9	0.389 (0.004)	0.342 (0.005)	1.065 (0.004)	1.106 (0.004)
S10	0.253 (0.004)	0.060 (0.004)	0.909 (0.003)	1.022 (0.003)
S11	-0.078 (0.008)	0.002 (0.003)	0.787 (0.004)	0.914 (0.003)
S12	0.120 (0.006)	0.049 (0.004)	0.999 (0.004)	1.033 (0.003)
S13	0.147 (0.005)	0.104 (0.004)	0.903 (0.003)	0.928 (0.003)
S14	0.149 (0.007)	-0.023 (0.003)	0.790 (0.004)	0.947 (0.003)
S15	0.197 (0.005)	0.044 (0.004)	0.803 (0.003)	0.927 (0.003)
COMBINED	0.171 (0.001)	0.123 (0.001)	0.949 (0.002)	0.976 (0.001)

Table S5. Simulated HRF parameters.

	TTP (s)	**FWHM (s)**	**Peak PSC (BOLD % Signal Change)**
HRF #1	6.0	5	6.0
HRF #2	4.5	3.5	5.0
HRF #3	3.5	3.0	2.5
HRF #4	3.0	3.0	2.0
HRF #5	2.5	2.0	1.5
HRF #6	6.5	5.5	1.0