

Supplementary Materials

Title: Timescales of call variability in a South American treefrog

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Note feature definitions

Duration: signal length, in seconds

INI: inter-note interval, duration of time between offset of signal to onset of next signal, in seconds

INO: inter-note onset, duration of time between onset of signal to onset of next signal, in seconds

Mean dom: average of the dominant frequency measured through the signal, in kHz

Max dom: maximum of the dominant frequency measured through the signal, in kHz

Mean peakF: mean peak frequency, frequency with the highest energy from the mean frequency spectrum

Df range: dominant frequency range measured through the signal, in kHz

Modindx: modulation index, calculated as the cumulative absolute difference between adjacent measurements of dominant frequencies divided by the dominant frequency range. 1 means that the signal is not frequency modulated

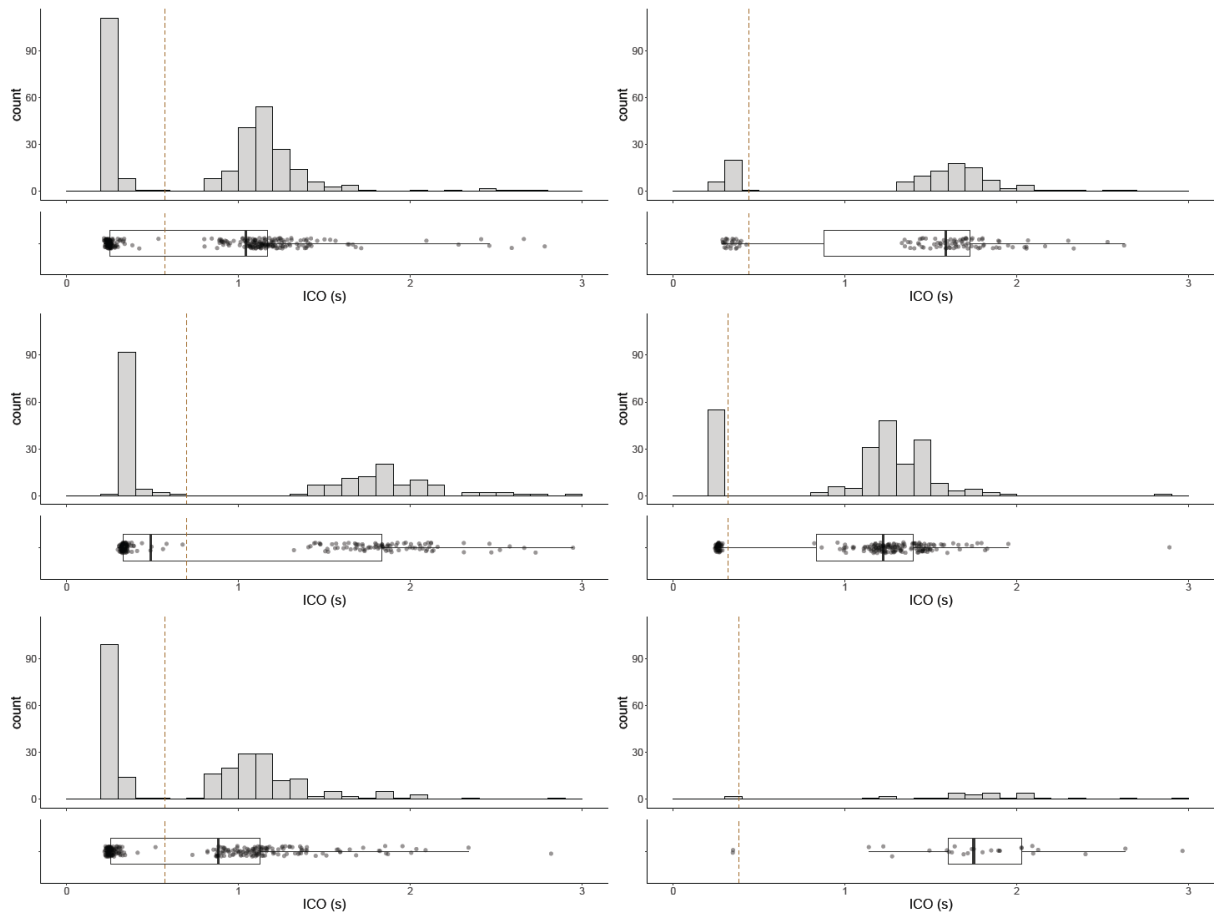
Sfm: spectral flatness, pure tone ~ 0, loud ~1

Skew: skewness, asymmetry of the amplitude distribution

Entropy: product of the spectral and temporal entropy

Time median: average time, the time at which the signal is divided into two time intervals of equal energy, in seconds

Time IQR: interquartile time range, in seconds



Supp. Fig. 1 Examples of within-male inter-call onset (ICO) distributions. Vertical lines denote cut-offs for left-most peak distributions per male. Exact ICO cutoffs vary by individual males, all males had two unique ICO distributions with varying ranges.

<i>Model: call dur ~ series length * seq + (1 frogID)</i>				
Response variable	Fixed Effect	estimate	std. error	p-val (LRT)
duration	Intercept	0.113	0.004	-
	Series4	-0.0003	0.003	0.918
	Series5	-0.016	0.004	< 0.001 ***
	SeqMid	-0.016	0.001	< 0.001 ***
	Series4*SeqMid	-0.001	0.004	0.745
	Series5*SeqMid	0.012	0.005	0.02 *
Marginal R ² :	0.2			
Conditional R ² :	0.76			
<i>Model: ICI ~ series length * seq + (1 frogID)</i>				
Response variable	Fixed Effect	estimate	std. error	p-val (LRT)
ICI	Intercept	0.18	0.016	-
	Series4	0.073	0.021	< 0.001 ***
	Series5	0.022	0.031	0.471
	SeqMid	0.042	0.009	< 0.001 ***
	Series4*SeqMid	0.001	0.025	0.963
	Series5*SeqMid	0.011	0.035	0.748
Marginal R ² :	0.16			
Conditional R ² :	0.48			
<i>Model: ICO ~ series length * seq + (1 frogID)</i>				
Response variable	Fixed Effect	estimate	std. error	p-val (LRT)
ICO	Intercept	0.293	0.018	-
	Series4	0.073	0.021	< 0.001 ***
	Series5	0.006	0.032	0.842
	SeqMid	0.026	0.009	0.001 **
	Series4*SeqMid	-0.00001	0.003	0.1
	Series5*SeqMid	0.023	0.036	0.522
Marginal R ² :	0.098			
Conditional R ² :	0.508			

Supp. Table 1 Results of linear mixed model to examine how call features vary depending on series length and within-series sequence order. Coefficients from three linear mixed models are presented in the table organized by response variable (call duration, ICI, ICO). For all models, series type (containing three, four, five calls) and sequence order (first and mid) are included as fixed effects and individual frog (frogID, n=18) as a random effect. The reference levels were series length “three” and sequence “first”.

<i>Model: note dur ~ series length * seq + (1 frogID)</i>				
Response variable	Fixed Effect	estimate	std. error	p-val (LRT)
Note 1 duration	Intercept	0.016	0.0004	-
	Series4	0.0004	0.0005	0.353
	Series5	-0.0005	0.0008	0.535
	SeqMid	-0.002	0.0002	< 0.001 ***
	Series4*SeqMid	-0.0002	0.0006	0.788
	Series5*SeqMid	0.0007	0.0009	0.428
Marginal R ² :	0.374			
Conditional R ² :	-			
Response variable	Fixed Effect	estimate	std. error	p-val (LRT)
Note 2 duration	Intercept	0.04	0.002	-
	Series4	0.0009	0.001	0.482
	Series5	0.0006	0.002	0.754
	SeqMid	-0.008	0.0001	< 0.001 ***
	Series4*SeqMid	-0.001	0.002	0.454
	Series5*SeqMid	-0.003	0.002	0.224
Marginal R ² :	0.254			
Conditional R ² :	0.775			
<i>Model: INI ~ series length * seq + (1 frogID)</i>				
Response variable	Fixed Effect	estimate	std. error	p-val (LRT)
INI	Intercept	0.058	0.003	-
	Series4	-0.002	0.001	0.253
	Series5	-0.003	0.002	0.216
	SeqMid	-0.006	0.001	< 0.001 ***
	Series4*SeqMid	0.003	0.002	0.123
	Series5*SeqMid	0.006	0.003	0.04 *
Marginal R ² :	0.061			
Conditional R ² :	0.8			
<i>Model: INO ~ series length * seq + (1 frogID)</i>				
Response variable	Fixed Effect	estimate	std. error	p-val (LRT)
INO	Intercept	0.073	0.003	-
	Series4	-0.001	0.001	0.44
	Series5	-0.003	0.002	0.154
	SeqMid	-0.008	0.001	< 0.001 ***
	Series4*SeqMid	0.003	0.002	0.151
	Series5*SeqMid	0.006	0.003	0.02
Marginal R ² :	0.118			
Conditional R ² :	0.853			
<i>Model: note DF ~ series length * seq + (1 frogID)</i>				
Response variable	Fixed Effect	estimate	std. error	p-val (LRT)
Note 1 DF	Intercept	2.512	0.047	-
	Series4	0.005	0.048	0.915
	Series5	-0.039	0.081	0.628
	SeqMid	0.022	0.021	0.279
	Series4*SeqMid	-0.003	0.062	0.955
	Series5*SeqMid	0.003	0.094	0.974
Response variable	Fixed Effect	estimate	std. error	p-val (LRT)
Note 2 DF	Intercept	2.574	0.056	-
	Series4	-0.091	0.085	0.281
	Series5	0.03	0.141	0.833
	SeqMid	0.042	0.037	0.249
	Series4*SeqMid	-0.136	0.109	0.213
	Series5*SeqMid	-0.063	0.165	0.704

Supp. Table 2 Results of linear mixed model to examine how note features vary depending on series length and within-series position. Coefficients from six linear mixed models are presented in the table organized by response variable (duration, INI, INO, and DF). For all models, series type (containing three, four, five calls) and sequence order (first, mid) are included as fixed effects and individual frog (frogID, n=18) as a random effect. The reference levels were series length “three” and sequence “first”.

Variation in Temporal Features Across Timescales

		feature	N	mean (s)	sd (s)	mean CV _w (%)	CV _b (%)	CV _b / CV _w
within bouts	series	duration	18	0.25	0.08	68.80	33.22	0.48
		interval	18	1.65	0.24	42.70	14.69	0.34
		ISO	18	1.90	0.25	36.60	13.39	0.37
	calls	duration	18	0.11	0.01	11.12	11.81	1.06
		interval	18	1.23	0.31	73.89	25.04	0.34
		ICO	18	1.34	0.32	67.25	23.69	0.35
	notes	NI duration	18	0.01	0.00	11.59	9.83	0.85
		N2 duration	18	0.04	0.01	13.91	15.39	1.11
		interval	18	0.06	0.01	9.47	16.87	1.78
		INO	18	0.07	0.01	8.04	12.75	1.59
		N1 DF (kHz)	18	2.56	0.15	4.03	5.68	1.41
		N2 DF (kHz)	18	2.63	0.17	6.44	6.59	1.02
within series	calls	duration	13	0.10	0.01	11.74	14.14	1.21
		<i>seq position</i> (1 st mid)		0.11 0.1	0.02 0.01	5.92 7.86	15.04 13.47	2.54 1.71
		interval	13	0.21	0.05	26.91	25.96	0.96
		<i>seq position</i> (1 st mid)		0.18 0.24	0.03 0.08	13.48 27.76	16.90 34.56	1.25 1.24

notes	ICO	13	0.32	0.06	17.62	20.28	1.15
	<i>seq position</i> (1 st mid)		0.29 0.34	0.04 0.09	9.04 20.59	14.69 26.98	1.62 1.31
	N1 duration	13	0.01	0.00	11.71	11.89	1.02
	<i>seq position</i> (1 st mid)		0.02 0.01	0 0	7.28 7.32	9.9 13.02	1.36 1.78
	N2 duration	13	0.03	0.01	16.76	18.06	1.08
	<i>seq position</i> (1 st mid)		0.04 0.03	0.01 0.01	5.68 10.43	16.39 18.07	2.88 1.73
	interval	13	0.05	0.01	10.45	18.56	1.78
	<i>seq position</i> (1 st mid)		0.06 0.05	0.01 0.01	7.06 4.61	20.03 20.08	2.84 4.36
	INO	13	0.07	0.01	8.55	13.85	1.62
	<i>seq position</i> (1 st mid)		0.07 0.06	0.01 0.01	5.36 3.42	15.58 15.17	2.91 4.43
	N1 DF (kHz)	13	2.51	0.17	6.14	6.89	1.12
	<i>seq position</i> (1 st mid)		2.53 2.53	0.15 0.19	1.8 5.37	5.88 7.53	3.26 1.4
	N2 DF (kHz)	13	2.59	0.19	6.63	7.5	1.13
	<i>seq position</i> (1 st mid)		2.61 2.58	0.21 0.2	3.57 6.51	8.15 7.8	2.28 1.2

Supp. Table 3 Summary of mean, standard deviation, mean of the coefficient of variation within males (CV_w), coefficient of variation between males (CV_b), and the CV_b/CV_w ratio for temporal features across timescales of calling. Mean CV_w is the average CV of within-male calculated CV. CV_b is the between-male calculated average. CV_b/CV_w ratio represents the degree to which there is more between-male variation per temporal feature. Ratio values > 1 indicate greater between-male variation than within-male variation for that temporal feature per timescale.

Variation in Spectral Note Features Across Timescales

	feature	N	mean	sd	mean CV _w	CV _b (%)	CV _b /CV _w Ratio
within bouts	N1 dfrange	18	0.00	0.00	675.15	145.93	0.22
	N2 dfrange	18	0.23	0.23	214.09	99.63	0.47
	N1 entropy	18	0.37	0.06	20.26	15.19	0.75
	N2 entropy	18	0.33	0.05	10.60	15.16	1.43
	N1 maxdom	18	2.56	0.14	4.05	5.63	1.39
	N2 maxdom	18	2.70	0.15	2.75	5.67	2.06
	N1 meandom	18	2.56	0.15	4.03	5.68	1.41
	N2 meandom	18	2.63	0.17	6.44	6.59	1.02
	N1 meanpeakf	18	2.58	0.15	4.23	5.79	1.37
	N2 meanpeakf	18	2.68	0.15	2.58	5.55	2.15
	N1 modindx	18	1.00	0.00	0.00	0.00	
	N2 modindx	18	1.12	0.14	24.78	12.36	0.50
	N1 sfm	18	0.10	0.04	36.50	39.31	1.08
	N2 sfm	18	0.05	0.03	43.86	74.68	1.70
	N1 skew	18	6.64	0.70	12.02	10.61	0.88
	N2 skew	18	11.25	1.32	10.13	11.76	1.16
	N1 time.IQR	18	0.00	0.00	227.66	140.56	0.62
	N2 time.IQR	18	0.02	0.01	23.20	21.47	0.93

within series	N1 time.median	18	0.00	0.00	34.25	15.51	0.45
	N2 time.median	18	0.01	0.00	55.23	37.08	0.67
	N1 dfrange	13	0.00	0.00	403.52	165.17	0.41
	<i>seq position</i> (1 st mid)		0 0	0.01 0	291.9 245	196.2 360.6	0.67 1.47
	N2 dfrange	13	0.21	0.23	204.33	113.51	0.56
	<i>seq position</i> (1 st mid)		0.19 0.23	0.37 0.38	92.5 149.7	194 165.2	2.1 1.1
	N1 entropy	13	0.41	0.09	18.76	21.52	1.15
	<i>seq position</i> (1 st mid)		0.35 0.44	0.1 0.1	12.2 9.2	20.8 22.5	1.7 2.5
	N2 entropy	13	0.33	0.04	13.11	13.31	1.01
	<i>seq position</i> (1 st mid)		0.3 0.3	0 0.1	5.4 10.6	10.8 16.5	2 1.6
N1 maxdom	13	2.51	0.17	6.18	6.85	1.11	
<i>seq position</i> (1 st mid)		2.5 2.5	0.15 0.19	2 5.4	5.8 7.5	3 1.4	
N2 maxdom	13	2.67	0.16	1.97	6.15	3.12	
<i>seq position</i> (1 st mid)		2.68 2.66	0.16 0.15	1.3 1.9	6.1 5.7	4.8 3	
N1 meandom	13	2.51	0.17	6.14	6.89	1.12	
<i>seq position</i> (1 st mid)		2.53 2.53	0.15 0.19	1.8 5.4	5.9 7.5	3.3 1.4	

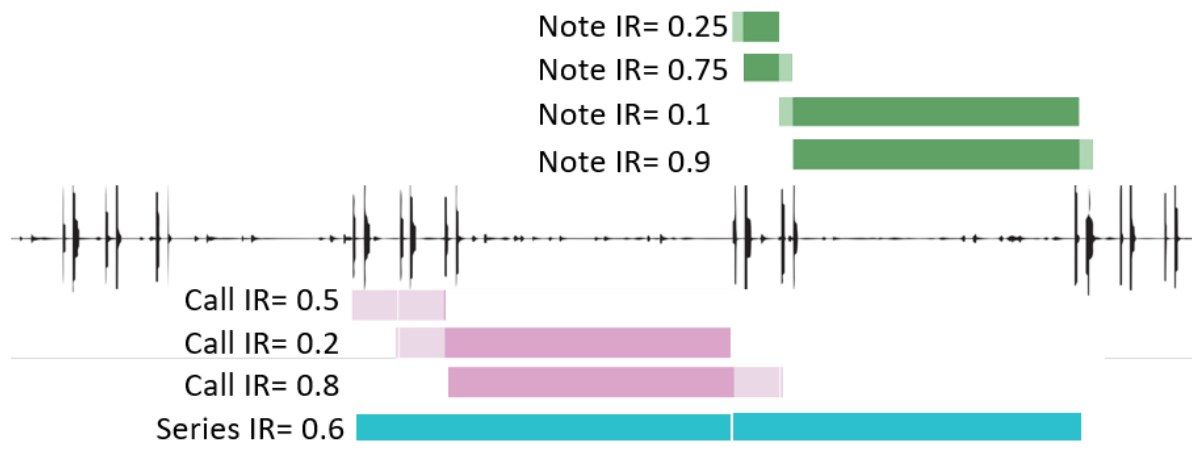
N2 meandom	13	2.59	0.19	6.63	7.50	1.13
<i>seq position</i> (1 st mid)		2.61 2.58	0.21 0.2	3.6 6.5	8.2 7.8	2.3 1.2
N1 meanpeakf	13	2.53	0.19	6.52	7.61	1.17
<i>seq position</i> (1 st mid)		2.54 2.56	0.15 0.17	1.63 6.32	6.1 6.5	3.7 1.02
N2 meanpeakf	13	2.65	0.16	1.84	6.21	3.38
<i>seq position</i> (1 st mid)		2.65 2.65	0.16 0.15	1.2 1.5	6.1 5.7	5.1 3.8
N1 modindx	13	1.00	0.00	0.00	0.00	
<i>seq position</i> (1 st mid)		1 1	0 0	0 0	0 0	
N2 modindx	13	1.13	0.17	15.75	14.81	0.94
<i>seq position</i> (1 st mid)		1.26 1.08	0.35 0.14	14.12 10.44	27.8 13.2	2 1.3
N1 sfm	13	0.11	0.05	28.01	42.39	1.51
<i>seq position</i> (1 st mid)		0.09 0.13	0.05 0.06	6.4 18.9	52.3 44.8	3.2 2.4
N2 sfm	13	0.05	0.03	38.42	65.20	1.70
<i>seq position</i> (1 st mid)		0.03 0.06	0.01 0.05	20 25	45 78	2.3 3.1
N1 skew	13	6.21	1.18	14.82	19.00	1.28
<i>seq position</i>		6.94 5.84	0.55 1.48	5.22 9.8	7.97 25.4	1.5 2.6

N2 skew	13	10.75	1.27	13.25	11.84	0.89
<i>seq position</i> (1 st mid)		11.69 10.32	0.94 1.66	4 13.2	8.1 16.1	2 1.2
N1 time.IQR	13	0.00	0.00	143.98	113.78	0.79
<i>seq position</i> (1 st mid)		0 0	0 0	84.4 42	156.7 94.5	1.9 2.3
N2 time.IQR	13	0.02	0.01	28.85	24.23	0.84
<i>seq position</i> (1 st mid)		0.02 0.02	0.01 0.01	13.2 33.7	21.1 27.1	1.6 0.8
N1 time.median	13	0.00	0.00	32.45	13.68	0.42
<i>seq position</i> (1 st mid)		0 0	0 0	33.1 11.1	25.9 11.2	0.8 1
N2 time.median	13	0.01	0.00	68.12	45.22	0.66
<i>seq position</i> (1 st mid)		0.01 0.01	0 0	41.5 120.3	35 59.5	0.8 0.5

Supp. Table 4 Summary of mean, standard deviation, mean of the coefficient of variation within males (CV_w), coefficient of variation between males (CV_b), and the CV_b / CV_w ratio for spectral features of notes 1 and 2 across timescales. Mean CV_w is the average within-male CV. CV_b is the between-male calculated average. CV_b / CV_w ratio represents the degree to which there is more between-male variation than within such that ratio values > 1 indicate more between-male variation.

Note Feature	Note 1		Note 2		Note 3	
	<i>mean ± sd</i>	<i>range (min - max)</i>	<i>mean ± sd</i>	<i>range (min - max)</i>	<i>mean ± sd</i>	<i>range (min - max)</i>
duration (s)	0.015 ± 0.002	(0.007 - 0.036)	0.037 ± 0.008	(0.009 - 0.062)	0.099 ± 0.015	(0.043 - 0.130)
INI (s)	0.056 ± 0.012	(0.033 - 0.085)	1.119 ± 0.939	(0.121 - 9.364)	1.162 ± 1.252	(0.234 - 6.741)
INO (s)	0.071 ± 0.012	(0.043 - 0.104)	1.156 ± 0.940	(0.159 - 9.418)	1.261 ± 1.253	(0.330 - 6.849)
meanfreq (kHz)	2.768 ± 0.216	(2.258 - 3.828)	2.856 ± 0.217	(2.457 - 4.027)	2.810 ± 0.266	(2.310 - 3.444)
freq.IQR (kHz)	0.227 ± 0.301	(0.048 - 1.857)	0.105 ± 0.217	(0.018 - 2.919)	0.665 ± 0.745	(0.052 - 2.030)
time.median (s)	0.003 ± 0.001	(0.000 - 0.014)	0.008 ± 0.005	(0.000 - 0.024)	0.047 ± 0.013	(0.017 - 0.080)
time.IQR (s)	0.002 ± 0.005	(0.000 - 0.023)	0.022 ± 0.007	(0.000 - 0.041)	0.045 ± 0.010	(0.026 - 0.067)
skew	6.691 ± 1.145	(2.224 - 9.057)	11.084 ± 1.741	(2.721 - 14.494)	6.576 ± 1.499	(3.044 - 11.003)
entropy	0.364 ± 0.104	(0.152 - 0.642)	0.324 ± 0.062	(0.200 - 0.661)	0.619 ± 0.095	(0.453 - 0.780)
Sfm	0.098 ± 0.053	(0.023 - 0.288)	0.046 ± 0.042	(0.013 - 0.291)	0.074 ± 0.052	(0.012 - 0.242)
meandom (kHz)	2.530 ± 0.201	(1.421 - 3.144)	2.603 ± 0.279	(0.876 - 4.235)	2.250 ± 0.347	(1.554 - 2.848)
maxdom (kHz)	2.532 ± 0.201	(1.421 - 3.144)	2.694 ± 0.400	(1.507 - 7.967)	2.645 ± 0.333	(1.938 - 3.747)
dfrange	0.004 ± 0.036	(0.000 - 1.464)	0.245 ± 0.755	(0.000 - 7.838)	0.880 ± 0.875	(0.086 - 3.531)
modindx	1.000 ± 0.000	(1.000 - 1.000)	1.130 ± 0.348	(1.000 - 5.000)	1.395 ± 0.587	(1.000 - 4.000)
enddom (kHz)	2.532 ± 0.201	(1.421 - 3.144)	2.509 ± 0.703	(0.043 - 7.967)	2.332 ± 0.747	(0.043 - 2.972)
meanpeakf (kHz)	2.543 ± 0.213	(1.427 - 3.142)	2.650 ± 0.184	(1.513 - 3.367)	2.348 ± 0.411	(1.513 - 2.897)

Supp. Table 5 Summary of temporal and spectral note features between males by note type.



Supp. Fig. 2 Potential non-0.5 call and note IR within and between series.