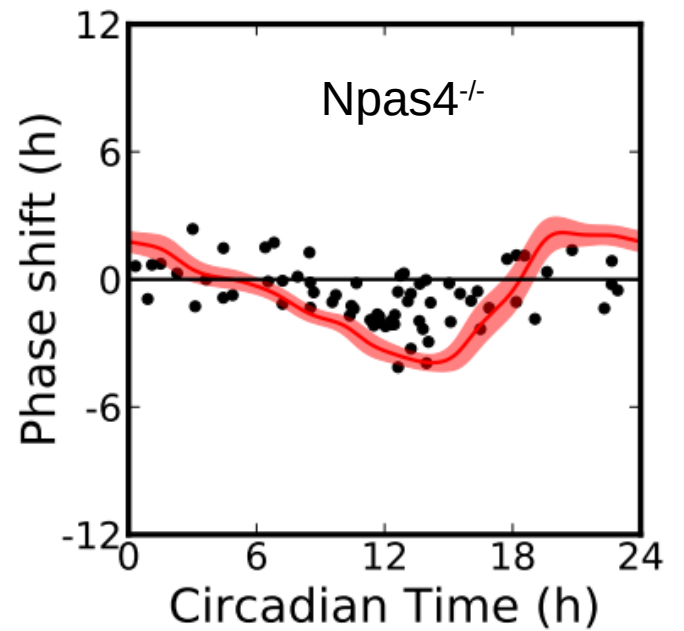
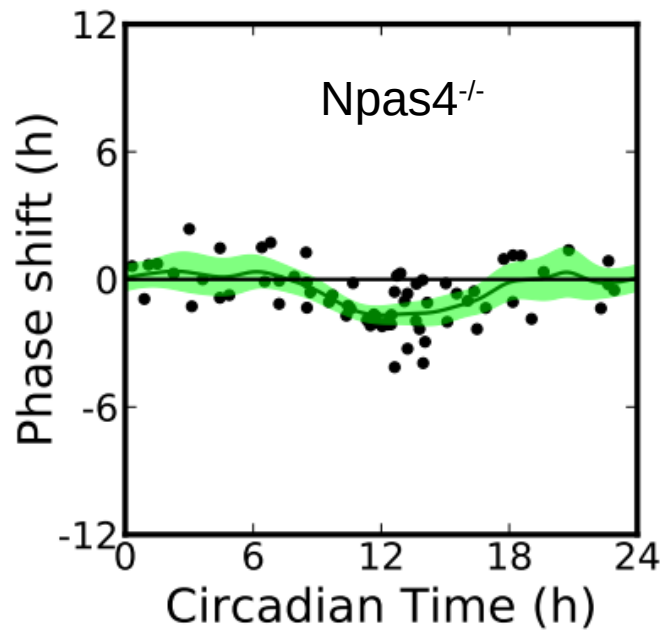
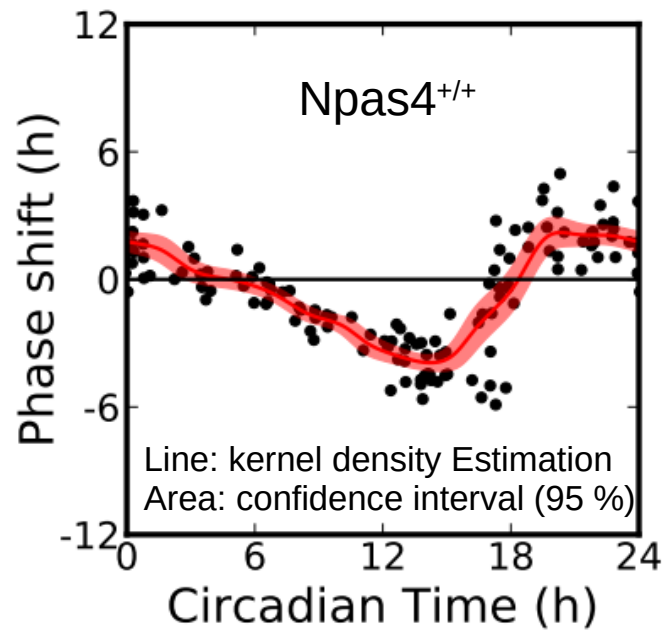


Kernel density estimation and confidence interval



Npas4^{+/+}

CT0 22.5 ~ 1.5	CT3 1.5 ~ 4.5	CT6 4.5 ~ 7.5	CT9 7.5 ~ 10.5	CT12 10.5 ~ 13.5	CT15 13.5 ~ 16.5	CT18 16.5 ~ 19.5	CT21 19.5 ~ 22.5
-0.5873	-0.9556	-1.1584	-2.8490	-5.2221	-5.6299	-5.8917	0.4408
0.0561	-0.5378	-1.1042	-2.4290	-4.8256	-4.9320	-5.5559	0.4713
0.1693	-0.3626	-1.0502	-2.2305	-3.8452	-4.8115	-5.1021	1.0382
0.2896	0.0048	-0.5960	-1.9462	-3.7630	-4.7436	-4.9967	1.0778
0.7644	0.2307	-0.4951	-1.8161	-3.3442	-4.7382	-3.3996	1.3316
1.0224	0.3415	-0.3082	-1.7786	-3.2671	-4.7163	-1.6398	1.5884
1.0409	0.3576	-0.2007	-1.6711	-3.1755	-4.5250	-1.5982	1.7501
1.2434	0.9887	-0.1337	-1.4468	-2.9104	-4.5115	-1.1336	1.7767
1.2889	1.5266	0.1235	-1.4371	-2.9013	-4.4725	-0.8274	2.1696
1.6597	3.2504	0.1629	-1.3069	-2.7561	-4.4625	-0.4067	2.2156
1.6749	nan	0.5377	-0.5393	-2.5953	-4.4400	-0.3922	2.2384
1.7222	nan	1.3936	nan	-2.3157	-3.5715	-0.3053	2.4513
1.7581	nan	nan	nan	-2.1182	-3.5473	-0.1977	2.5818
2.0352	nan	nan	nan	-1.7778	-3.4186	0.4301	3.1440
2.2401	nan	nan	nan	nan	-3.0426	0.9886	3.4850
2.3824	nan	nan	nan	nan	-2.9804	1.3889	4.2608
2.6945	nan	nan	nan	nan	-2.9101	1.5144	4.9670
3.0457	nan	nan	nan	nan	-2.0389	2.3175	nan
3.1535	nan	nan	nan	nan	-1.6230	2.4420	nan
3.6612	nan	nan	nan	nan	nan	2.7539	nan
3.6882	nan	nan	nan	nan	nan	3.7175	nan
4.3652	nan	nan	nan	nan	nan	nan	nan

CT0 22.5 ~ 1.5	CT3 1.5 ~ 4.5	CT6 4.5 ~ 7.5	CT9 7.5 ~ 10.5	CT12 10.5 ~ 13.5	CT15 13.5 ~ 16.5	CT18 16.5 ~ 19.5	CT21 19.5 ~ 22.5
-0.9236	-1.2709	-1.1534	-1.7065	-4.1313	-3.9379	-1.8622	-1.3638
-0.5129	-0.8666	-0.7433	-1.3353	-3.2614	-2.9367	-1.3472	0.3497
-0.2318	-0.0027	-0.1014	-1.2430	-2.2068	-2.3378	-1.0654	1.3771
0.6224	0.2794	-0.0667	-1.0668	-2.1702	-2.3362	0.9555	nan
0.6839	0.7323	1.5028	-0.7373	-2.1283	-1.9976	1.1163	nan
0.8647	1.4679	1.7254	-0.6092	-2.1155	-1.9578	1.1331	nan
nan	2.3681	nan	-0.1467	-2.0391	-1.0963	nan	nan
nan	nan	nan	0.1308	-1.9679	-1.0080	nan	nan
nan	nan	nan	1.2635	-1.9087	-0.6691	nan	nan
nan	nan	nan	nan	-1.7511	-0.5647	nan	nan
nan	nan	nan	nan	-1.6724	-0.2102	nan	nan
nan	nan	nan	nan	-1.6447	-0.1858	nan	nan
nan	nan	nan	nan	-1.3822	-0.0297	nan	nan
nan	nan	nan	nan	-1.0326	nan	nan	nan
nan	nan	nan	nan	-0.6735	nan	nan	nan
nan	nan	nan	nan	-0.5883	nan	nan	nan
nan	nan	nan	nan	-0.1739	nan	nan	nan
nan	nan	nan	nan	0.1729	nan	nan	nan
nan	nan	nan	nan	0.2827	nan	nan	nan
nan	nan	nan	nan	nan	nan	nan	nan
nan	nan	nan	nan	nan	nan	nan	nan
nan	nan	nan	nan	nan	nan	nan	nan

Npas4^{-/-}

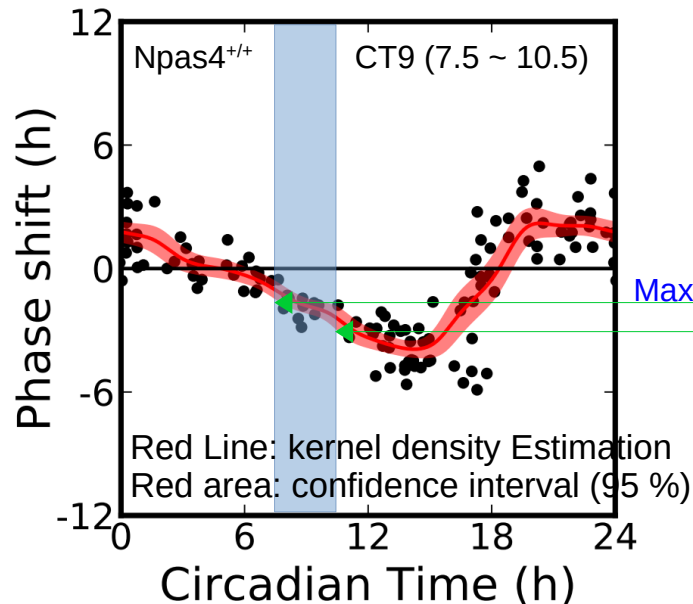
Missing-data (nan) imputation for ART ANOVA analysis

Npas4^{+/+}

Npas4^{+/+} (imputed)

CT0 22.5 ~ 1.5	CT3 1.5 ~ 4.5	CT6 4.5 ~ 7.5	CT9 7.5 ~ 10.5	CT12 10.5 ~ 13.5	CT15 13.5 ~ 16.5	CT18 16.5 ~ 19.5	CT21 19.5 ~ 22.5
-0.5873	-0.9556	-1.1584	-2.8490	-5.2221	-5.6299	-5.8917	0.4408
0.0561	-0.5378	-1.1042	-2.4290	-4.8256	-4.9320	-5.5559	0.4713
0.1693	-0.3626	-1.0502	-2.2305	-3.8452	-4.8115	-5.1021	1.0382
0.2896	0.0048	-0.5960	-1.9462	-3.7630	-4.7436	-4.9967	1.0778
0.7644	0.2307	-0.4951	-1.8161	-3.3442	-4.7382	-3.3996	1.3316
1.0224	0.3415	-0.3082	-1.7786	-3.2671	-4.7163	-1.6398	1.5884
1.0409	0.3576	-0.2007	-1.6711	-3.1755	-4.5250	-1.5982	1.7501
1.2434	0.9887	-0.1337	-1.4468	-2.9104	-4.5115	-1.1336	1.7767
1.2889	1.5266	0.1235	-1.4371	-2.9013	-4.4725	-0.8274	2.1696
1.6597	3.2504	0.1629	-1.3069	-2.7561	-4.4625	-0.4067	2.2156
1.6749	nan	0.5377	-0.5393	-2.5953	-4.4400	-0.3922	2.2384
1.7222	nan	1.3936	nan	-2.3157	-3.5715	-0.3053	2.4513
1.7581	nan	nan	nan	-2.1182	-3.5473	-0.1977	2.5818
2.0352	nan	nan	nan	-1.7778	-3.4186	0.4301	3.1440
2.2401	nan	nan	nan	nan	-3.0426	0.9886	3.4850
2.3824	nan	nan	nan	nan	-2.9804	1.3889	4.2608
2.6945	nan	nan	nan	nan	-2.9101	1.5144	4.9670
3.0457	nan	nan	nan	nan	-2.0389	2.3175	nan
3.1535	nan	nan	nan	nan	-1.6230	2.4420	nan
3.6612	nan	nan	nan	nan	nan	2.7539	nan
3.6882	nan	nan	nan	nan	nan	3.7175	nan
4.3652	nan	nan	nan	nan	nan	nan	nan

CT0 22.5 ~ 1.5	CT3 1.5 ~ 4.5	CT6 4.5 ~ 7.5	CT9 7.5 ~ 10.5	CT12 10.5 ~ 13.5	CT15 13.5 ~ 16.5	CT18 16.5 ~ 19.5	CT21 19.5 ~ 22.5
-0.5873	-0.9556	-1.1584	-2.8490	-5.2221	-5.6299	-5.8917	0.4408
0.0561	-0.5378	-1.1042	-2.4290	-4.8256	-4.9320	-5.5559	0.4713
0.1693	-0.3626	-1.0502	-2.2305	-3.8452	-4.8115	-5.1021	1.0382
0.2896	0.0048	-0.5960	-1.9462	-3.7630	-4.7436	-4.9967	1.0778
0.7644	0.2307	-0.4951	-1.8161	-3.3442	-4.7382	-3.3996	1.3316
1.0224	0.3415	-0.3082	-1.7786	-3.2671	-4.7163	-1.6398	1.5884
1.0409	0.3576	-0.2007	-1.6711	-3.1755	-4.5250	-1.5982	1.7501
1.2434	0.9887	-0.1337	-1.4468	-2.9104	-4.5115	-1.1336	1.7767
1.2889	1.5266	0.1235	-1.4371	-2.9013	-4.4725	-0.8274	2.1696
1.6597	3.2504	0.1629	-1.3069	-2.7561	-4.4625	-0.4067	2.2156
1.6749	1.9520	0.5377	-0.5393	-2.5953	-4.4400	-0.3922	2.2384
1.7222	-0.1667	1.3936	-2.4801	-2.3157	-3.5715	-0.3053	2.4513
1.7581	0.5971	0.3172	-0.5817	-2.1182	-3.5473	-0.1977	2.5818
2.0352	-0.1324	-1.2152	-1.0365	-1.7778	-3.4186	0.4301	3.1440
2.2401	1.6728	-0.3466	-2.8171	-2.1557	-3.0426	0.9886	3.4850
2.3824	0.8395	-1.1780	-2.8944	-3.6021	-2.9804	1.3889	4.2608
2.6945	0.0604	-1.1075	-2.4064	-3.8750	-2.9101	1.5144	4.9670
3.0457	-0.2190	-1.1719	-1.2990	-2.1116	-2.0389	2.3175	2.1309
3.1535	1.4495	-0.4302	-2.1955	-2.2255	-1.6230	2.4420	1.8721
3.6612	-0.3804	-0.9189	-1.6867	-2.7576	-1.2871	2.7539	1.3893
3.6882	-0.5932	0.4270	-2.4901	-3.7676	-4.8906	3.7175	2.4651
4.3652	1.7329	0.4310	-1.9954	-4.0765	-3.0922	-3.1498	1.0185



Data (imputed) = random.uniform(MinEdp + MaxHalfCI, MaxEdp + MaxHalfCI)
: random numbers (uniform distribution) between minimum (MinEdp) and maximum (MaxEdp) estimated phase shift plus maximum half 95 % confidence interval (MaxHalfCI) within a group

MaxHalfCI = $\frac{H}{2}$
MaxEdp = $\frac{H}{2}$
MinEdp = $-\frac{H}{2}$
Range of random imputed data with uniform distribution

kernel density estimation: Gaussian kernel function & bandwidth 1

Reference for kernel density estimation and confidence interval:
Härdle, W. (2013). Applied Nonparametric Regression (Cambridge, Cambridge University Press), pp. 32-42, 123)

Aligned Rank Transform (ART) for nonparametric two-way ANOVA with interaction

- Parametric analysis of variance of raw data (check ANOVA assumptions)

- Shapiro-Wilk residual normality test

data: res1

W = 0.94536, p-value = 4.081e-10

- Levene's Test for Homogeneity of Variance (center = median)

	Df	F value	Pr(>F)
group	15	6.1959	1.524e-11 ***
	336		

> Violate ANOVA assumptions

- Nonparametric analysis of variance of Aligned Rank Transformed data using ARTtool

Table Type: Anova Table (Type III tests)

Model: No Repeated Measures (lm)

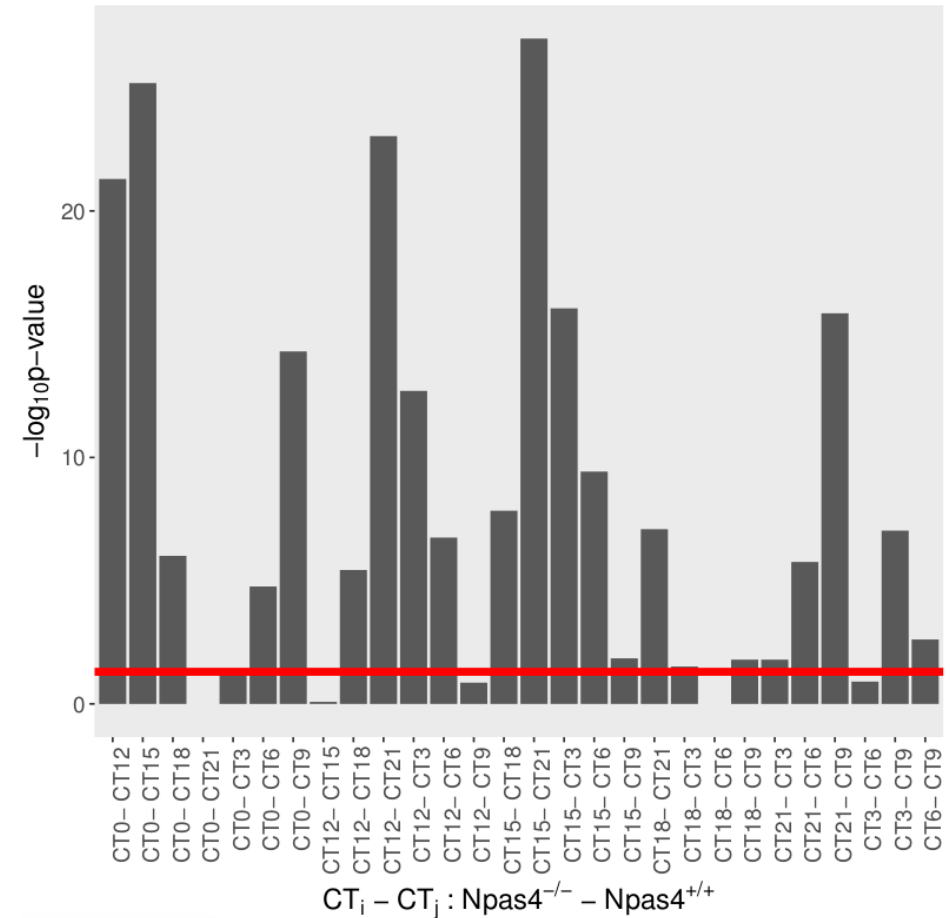
Response: art(Phaseshift)

	Df	Df.res	F value	Pr(>F)
1 CT	7	336	65.363	< 2.22e-16 ***
2 Genotype	1	336	35.825	5.5379e-09 ***
3 CT:Genotype	7	336	43.638	< 2.22e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Aligned Rank Transform (ART) for nonparametric two-way ANOVA with interaction: Pairwise comparison by interaction between two factors

CT-wise & Genotype-wise difference <CT(i)> - <CT(j)> Npas4 ^{-/-} - <CT(i)> - <CT(j)> Npas4 ^{+/+}	Value	Df	Sum.of.Sq	F	Pr..F.
CT0- CT12 : Npas4 ^{-/-} Npas4 ^{+/+}	-345.18	1	655327.68	115.94	<0.0001
CT0- CT15 : Npas4 ^{-/-} Npas4 ^{+/+}	-380.27	1	795340.41	140.71	<0.0001
CT0- CT18 : Npas4 ^{-/-} Npas4 ^{+/+}	-177.18	1	172663.68	30.55	<0.0001
CT0- CT21 : Npas4 ^{-/-} Npas4 ^{+/+}	15.86	1	1384.10	0.24	1
CT0- CT3 : Npas4 ^{-/-} Npas4 ^{+/+}	-85.14	1	39865.10	7.05	0.05
CT0- CT6 : Npas4 ^{-/-} Npas4 ^{+/+}	-157.36	1	136198.23	24.10	<0.0001
CT0- CT9 : Npas4 ^{-/-} Npas4 ^{+/+}	-277.09	1	422286.55	74.71	<0.0001
CT12- CT15 : Npas4 ^{-/-} Npas4 ^{+/+}	-35.09	1	6772.55	1.20	0.82
CT12- CT18 : Npas4 ^{-/-} Npas4 ^{+/+}	168.00	1	155232.00	27.46	<0.0001
CT12- CT21 : Npas4 ^{-/-} Npas4 ^{+/+}	361.05	1	716946.01	126.84	<0.0001
CT12- CT3 : Npas4 ^{-/-} Npas4 ^{+/+}	260.05	1	371930.01	65.80	<0.0001
CT12- CT6 : Npas4 ^{-/-} Npas4 ^{+/+}	187.82	1	194016.18	34.33	<0.0001
CT12- CT9 : Npas4 ^{-/-} Npas4 ^{+/+}	68.09	1	25500.05	4.51	0.14
CT15- CT18 : Npas4 ^{-/-} Npas4 ^{+/+}	203.09	1	226852.55	40.13	<0.0001
CT15- CT21 : Npas4 ^{-/-} Npas4 ^{+/+}	396.14	1	863082.10	152.70	<0.0001
CT15- CT3 : Npas4 ^{-/-} Npas4 ^{+/+}	295.14	1	479080.10	84.76	<0.0001
CT15- CT6 : Npas4 ^{-/-} Npas4 ^{+/+}	222.91	1	273286.55	48.35	<0.0001
CT15- CT9 : Npas4 ^{-/-} Npas4 ^{+/+}	103.18	1	58555.68	10.36	0.01
CT18- CT21 : Npas4 ^{-/-} Npas4 ^{+/+}	193.05	1	204966.01	36.26	<0.0001
CT18- CT3 : Npas4 ^{-/-} Npas4 ^{+/+}	92.05	1	46598.01	8.24	0.03
CT18- CT6 : Npas4 ^{-/-} Npas4 ^{+/+}	19.82	1	2160.18	0.38	1
CT18- CT9 : Npas4 ^{-/-} Npas4 ^{+/+}	-99.91	1	54900.05	9.71	0.02
CT21- CT3 : Npas4 ^{-/-} Npas4 ^{+/+}	-101.00	1	56105.50	9.93	0.02
CT21- CT6 : Npas4 ^{-/-} Npas4 ^{+/+}	-173.23	1	165042.28	29.20	<0.0001
CT21- CT9 : Npas4 ^{-/-} Npas4 ^{+/+}	-292.95	1	472023.01	83.51	<0.0001
CT3- CT6 : Npas4 ^{-/-} Npas4 ^{+/+}	-72.23	1	28692.28	5.08	0.12
CT3- CT9 : Npas4 ^{-/-} Npas4 ^{+/+}	-191.95	1	202656.01	35.85	<0.0001
CT6- CT9 : Npas4 ^{-/-} Npas4 ^{+/+}	-119.73	1	78840.41	13.95	<0.01



R phia testInteractions:

test contrasts of factor interactions

<CT(i)>: mean value of CT(i)

Red line: p-value 0.05

Wobbrock, J.O., Findlater, L., Gergle, D., & Higgins, J.J., (2011) The aligned rank transform for nonparametric factorial analyses using only anova procedures, CHI '11, 143-146

- Parametric analysis of variance of raw data (check ANOVA assumptions): Residual plots

