

S1. Initial model description

Using the function `buildmer` in the package `buildmer`, we have initially run the tested the fit of the model with the interaction of the main factors and the sound pressure level as an additional random intercept ($\text{mean} \sim 1 + \text{group} + \text{noise} + \text{signal} + \text{group}*\text{noise}*\text{signal} + (1 | \text{subj}) + (1 | \text{sound})$) using `glm`, `gam`, or `(g)lmer` objects. The maximal feasible model was the following: $\text{mean} \sim 1 + \text{group} + \text{noise} + \text{signal} + (1 | \text{subj})$; all higher models failed to converge. This model was then tested with the permutation linear mixed-effects model, so that we could easily obtain robust p-values. The advantage of these permutation p-values is that we could run multiple such models without requiring any Bonferroni correction.

ModelSummary:

Linear mixed model fit by REML ['lmerMod']

Formula: $\text{mean} \sim 1 + \text{group} + \text{noise} + \text{signal} + (1 | \text{subj})$

REML criterion at convergence: -69.2

Scaled residuals:

Min	1Q	Median	3Q	Max
-3.7447	-0.6182	-0.0111	0.6192	3.2935

Random effects:

	Groups	Name	Variance	Std.Dev.
	subj	(Intercept)	0.01525	0.1235
	Residual		0.04298	0.2073

Number of obs: 478, groups: subj, 28

Fixed effects:

	Estimate	Std.Error	t-value	Pr(> t)	
(Intercept)	0.18829	0.04123	4.567	<2e-16	***
groupNH.grou	0.11697	0.05162	2.266	<2e-16	***
p					
noiselow.noise	-0.01831	0.02318	-0.790	0.203	
noisehigh.noise	0.05057	0.02341	2.160	0.003	**
signalspeech	0.04326	0.02369	1.826	0.013	*
signalmusic	0.06362	0.02327	2.734	<2e-16	***

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

Correlation of Fixed Effects:

	(Intr)	grpNH	nsllw.n	nshgh	sgnlsp
groupNH.grp	-0.627				
noiselow.ns	-0.274	0.008			
noisehgh.ns	-0.279	-0.006	0.490		
signalsp	-0.285	0.000	-0.026	0.012	

signalmusic	-0.290	-0.015	-0.008	0.024	0.512
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Type III Analysis of Variance of the model with Satterthwaite's method

	npar	SumSq		MeanSq	F-value	Pr(>F)
group	1	0.2348771	0.2348771	5.464434	0.01940734	
noise	2	0.3684189	0.1842095	4.285647	0.01376471	
signal	2	0.3319152	0.1659576	3.861016	0.02104660	

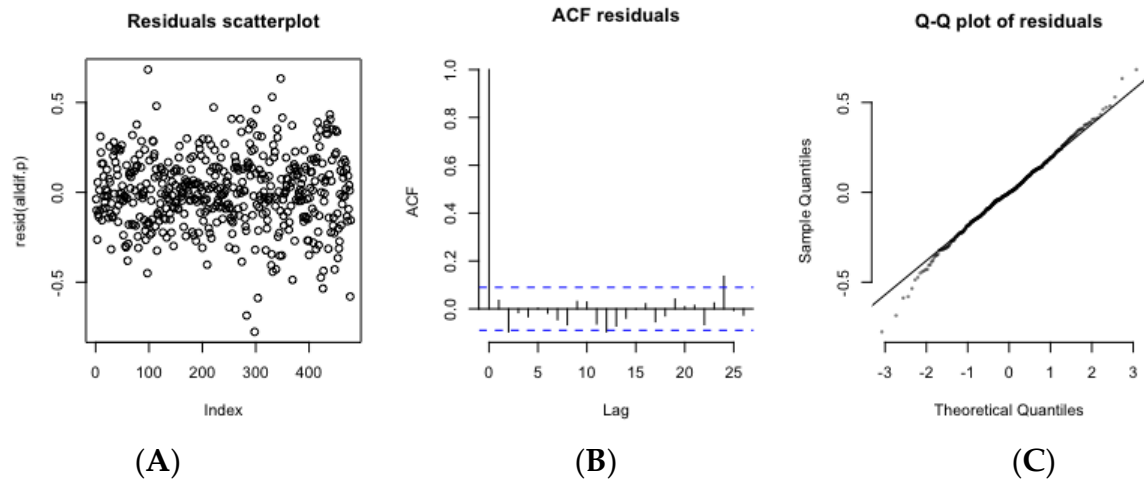


Figure S1. (A) Correlation plot of the residuals of the model initial model. (B) Autocorrelation plot of the residuals of m1. (C) Q-Q plot of the residuals of the initial model.

S2. Permutation-based time-course analysis

The following permutation analyses were conducted separately for each group:

Analysis of the differences between various noise conditions during speech stimuli:

```
Speech.in.noise.CI.group <- clusterperm.lmer(pupil ~ noise + (1 | event),  
      data=subset(group == "CI.group" & signal == "speech"), series.var=~time)  
Speech.in.noise.NH.group <- clusterperm.lmer(pupil ~ noise + (1 | event),  
      data=subset(group == "NH.group" & signal == "speech"), series.var=~time)
```

Analysis of the differences between various noise conditions during music stimuli:

```
Music.in.noise.CI.group <- clusterperm.lmer(pupil ~ noise + (1 | event),  
      data=subset(group == "CI.group" & signal == "music"), series.var=~time)  
Music.in.noise.NH.group <- clusterperm.lmer(pupil ~ noise + (1 | event),  
      data=subset(group == "NH.group" & signal == "music"), series.var=~time)
```

Following Maris & Oostenveld (2007), the p-values corresponding to the cluster-mass test were computed for each time-sample. Although this could already comprise the entirety of the analysis, we used an approach more common fields that use time-course data, which is to use the time samples selected with the cluster-mass test as an input for our actual analysis. Thus, for each analysis, the time-window from the first till the last significant time-sample was selected as an input for our actual analysis, a linear mixed-effects model. We averaged our data along the selected window and then run a permutation linear mixed-effects model to obtain robust p-values.

Speech.in.noise.CI.group:

Linear mixed model fit by REML ['lmerMod']

Formula: spin.ci.mean ~ 1 + noise + (1 | subj)

REML criterion at convergence: 0.4

Scaled residuals:

	Min	1Q	Median	3Q	Max
	-2.72790	-0.54685	0.00106	0.66116	2.13918

Random effects:

Groups	Name	Variance	Std.Dev.
subj	(Intercept)	0.01085	0.1042
Residual		0.04461	0.2112

Number of obs: 74, groups: subj, 14

Fixed effects:

	Estimate	Std.Error	t-value	Pr(> t)	
(Intercept)	0.38443	0.05189	7.409	<2e-16	***
noiselow.noise	-0.07686	0.05958	-1.290	0.070	.

noisehigh.noise	-0.08237	0.06242	-1.320	0.062	.
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Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:

	(Intr)	nslw.n
noiselow.ns	-0.599	
noisehgh.ns	-0.562	0.487

Type III Analysis of Variance of the model with Satterthwaite's method

	npair	SumSq	MeanSq	F-value	Pr(>F)
noise	2	0.1022162	0.05110812	1.145638	0.3180211

Music.in.noise.CI.group:

Linear mixed model fit by REML ['lmerMod']

Formula: muin.ci.mean ~ 1 + noise + (1 | subj)

Data: data

REML criterion at convergence: 28.6

Scaled residuals:

Min	1Q	Median	3Q	Max
-1.80396	-0.62069	-0.07954	0.65678	2.57829

Random effects:

Groups	Name	Variance	Std.Dev.
subj	(Intercept)	0.01973	0.1405
Residual		0.06417	0.2533

Number of obs: 78, groups: subj, 13

Fixed effects:

	Estimate	Std.Error	t-value	Pr(> t)	
(Intercept)	0.21356	0.06392	3.341	<2e-16	***
noiselow.noise	0.06361	0.06886	0.924	0.138	
noisehigh.nois	0.03930	0.07332	0.536	0.366	

e

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

Correlation of Fixed Effects:

	(Intr)	nslw.n
noiselow.ns	-0.566	
noisehgh.ns	-0.523	0.490

Type III Analysis of Variance of the model with Satterthwaite's method

	npars	SumSq	MeanSq	F-value	Pr(>F)
noise	2	0.05534035	0.02767017	0.4312122	0.649721

Music.in.noise.NH.group:

Linear mixed model fit by REML ['lmerMod']

Formula: muin.nh.mean ~ 1 + noise + (1 | subj)

REML criterion at convergence: 10.9

Scaled residuals:

	Min	1Q	Median	3Q	Max
-2.50937	-0.51500	-0.07614	0.61248	2.56408	

Random effects:

	Groups	Name	Variance	Std.Dev.
	subj	(Intercept)	0.01278	0.1130
	Residual		0.05158	0.2271

Number of obs: 91, groups: subj, 14

Fixed effects:

	Estimate	Std.Error	t-value	Pr(> t)	
(Intercept)	0.30312	0.05036	6.020	<2e-16	***
noiselow.noise	0.05736	0.05843	0.982	0.154	
noisehigh.noise	0.24514	0.05810	4.219	<2e-16	***

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

Correlation of Fixed Effects:

	(Intr)	nslnw.n
noiselow.ns	-0.528	
noisehigh.ns	-0.529	0.463

Type III Analysis of Variance of the model with Satterthwaite's method

	npars	SumSq	MeanSq	F-value	Pr(>F)
noise	2	0.9803567	0.4901784	9.504038	7.455015e-05

Figure S2A. Time windows defined by the cluster mass statistic for the permutation-based analysis of speech in noise in the CI group.

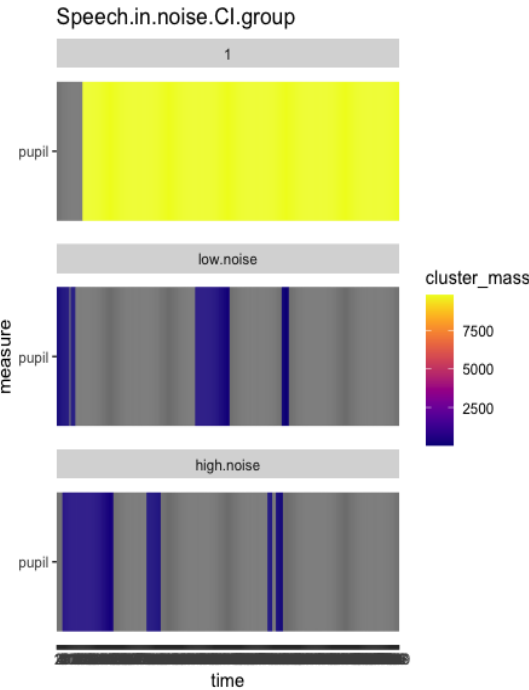


Figure S2B. Time windows defined by the cluster mass statistic for the permutation-based analysis of speech in noise in the NH group.

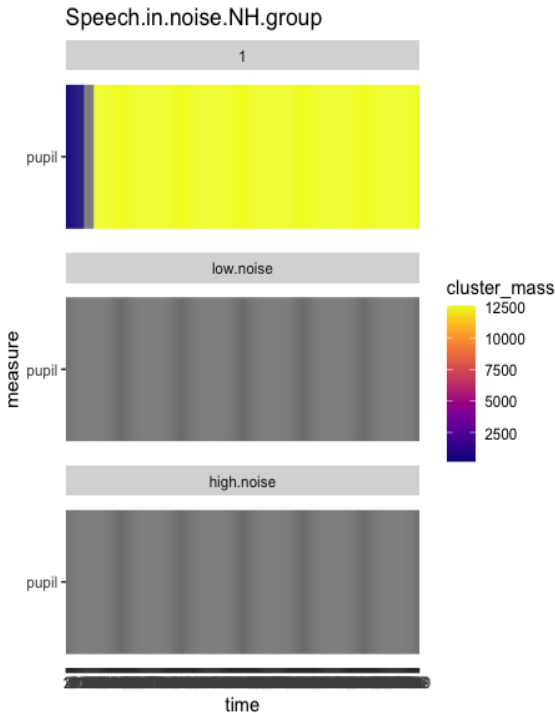


Figure S2C. Time windows defined by the cluster mass statistic for the permutation-based analysis of music in noise in the CI group.

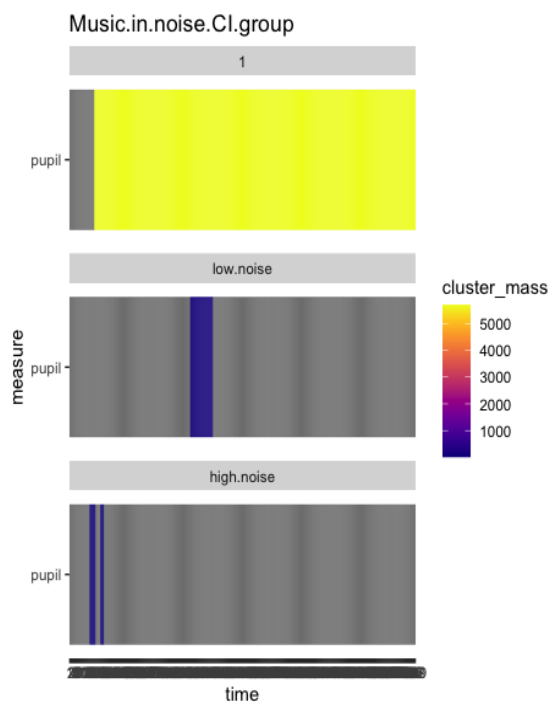


Figure S2D. Time windows defined by the cluster mass statistic for the permutation-based analysis of music in noise in the NH group.

