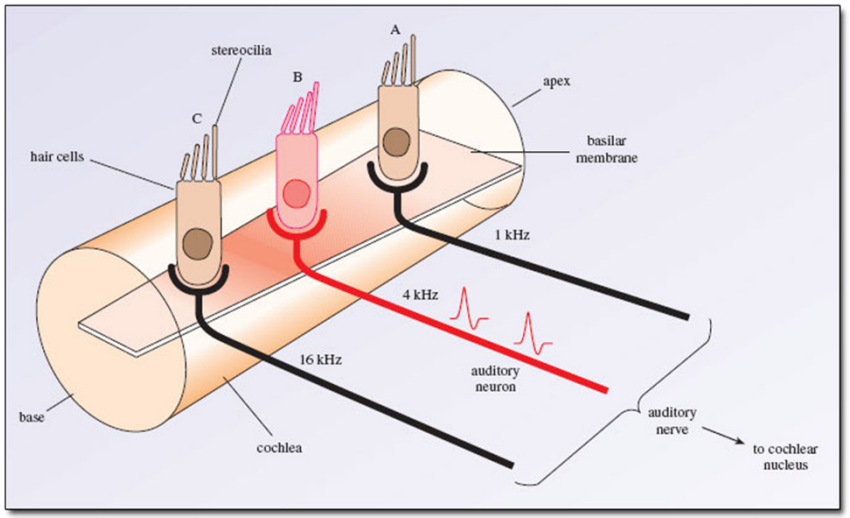
Structural and functional neuroplasticity of tinnitus-related distress and duration

Martin Meyer, Patrick Neff, Martin Schecklmann, Tobias Kleinjung, Steffi Weidt, Berthold Langguth

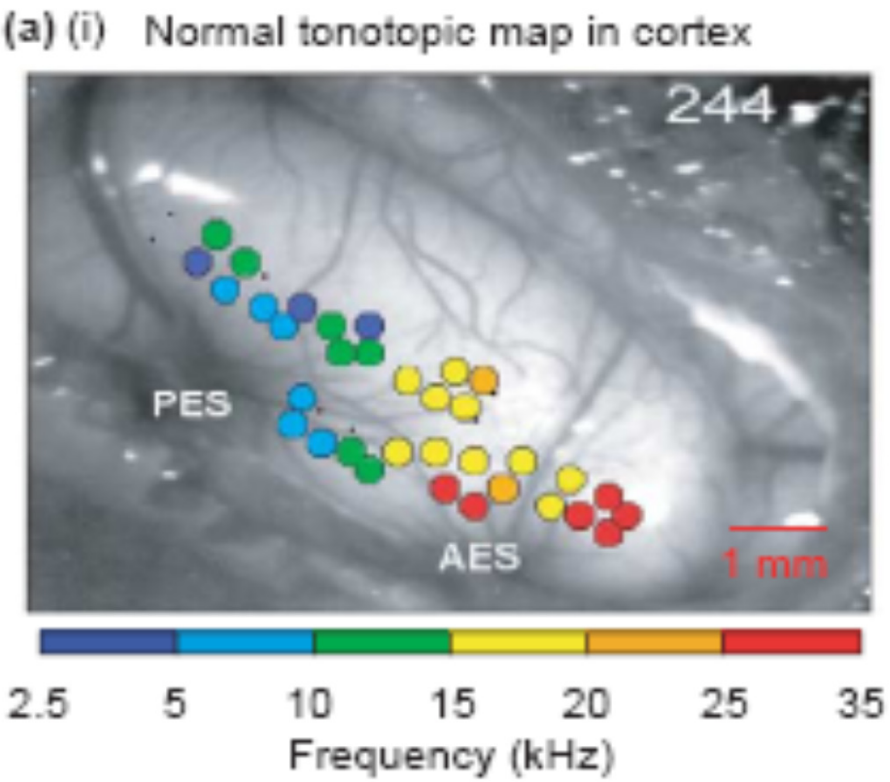
University of Zurich, Switzerland
University of Regensburg, Germany

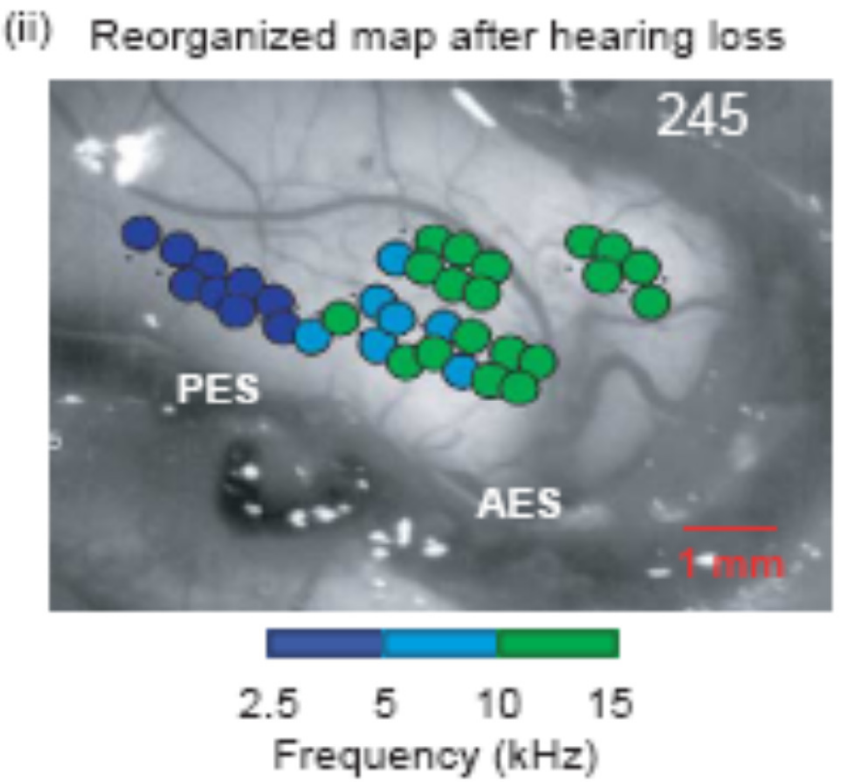
Agenda

- **Background - From the ear to the brain**
- Neuropsychological frameworks
- Tinnitus - distress and duration
- Results of neurophysiological and neuroanatomical studies and discussion



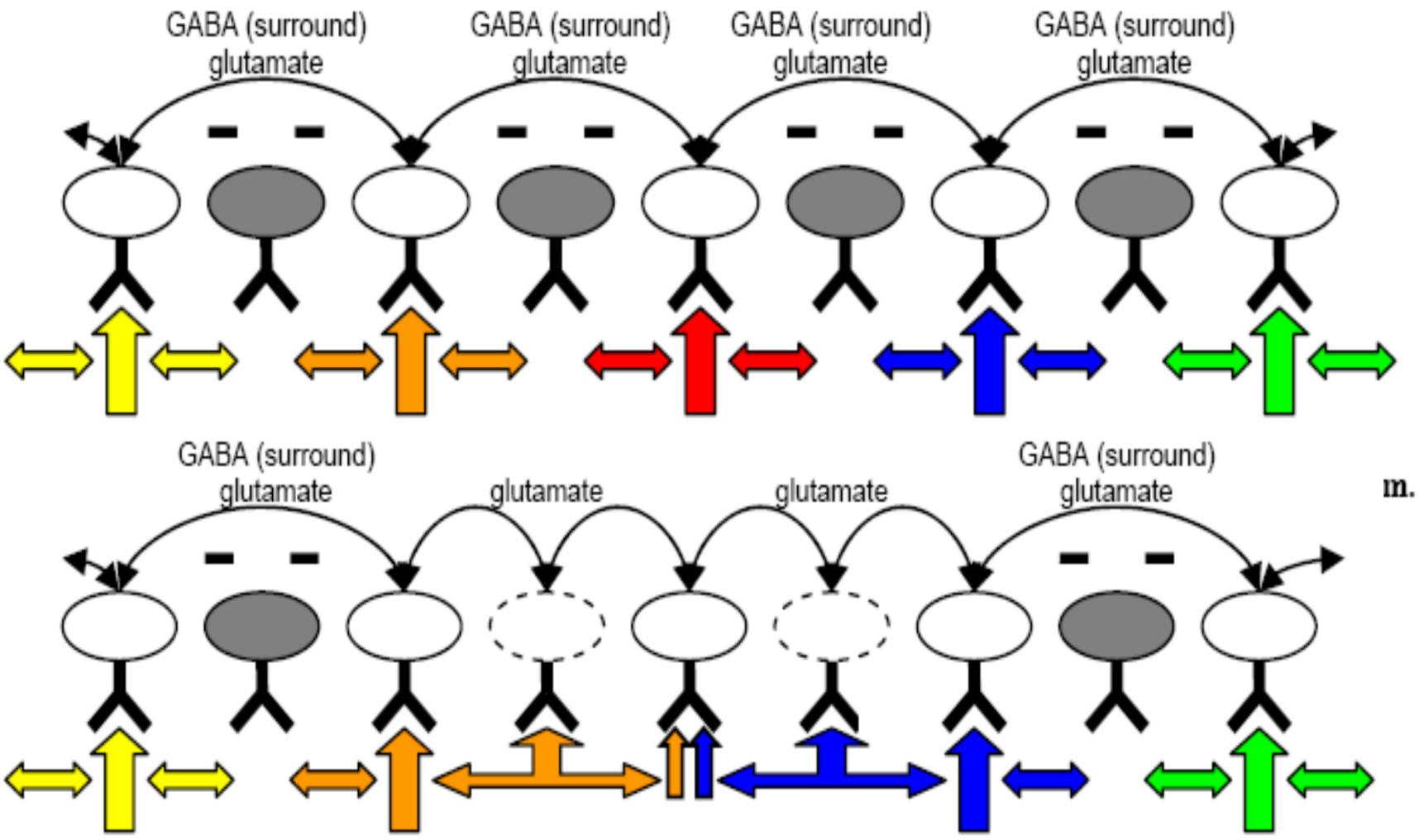
Peripheral hearing loss and reorganization of the auditory cortex





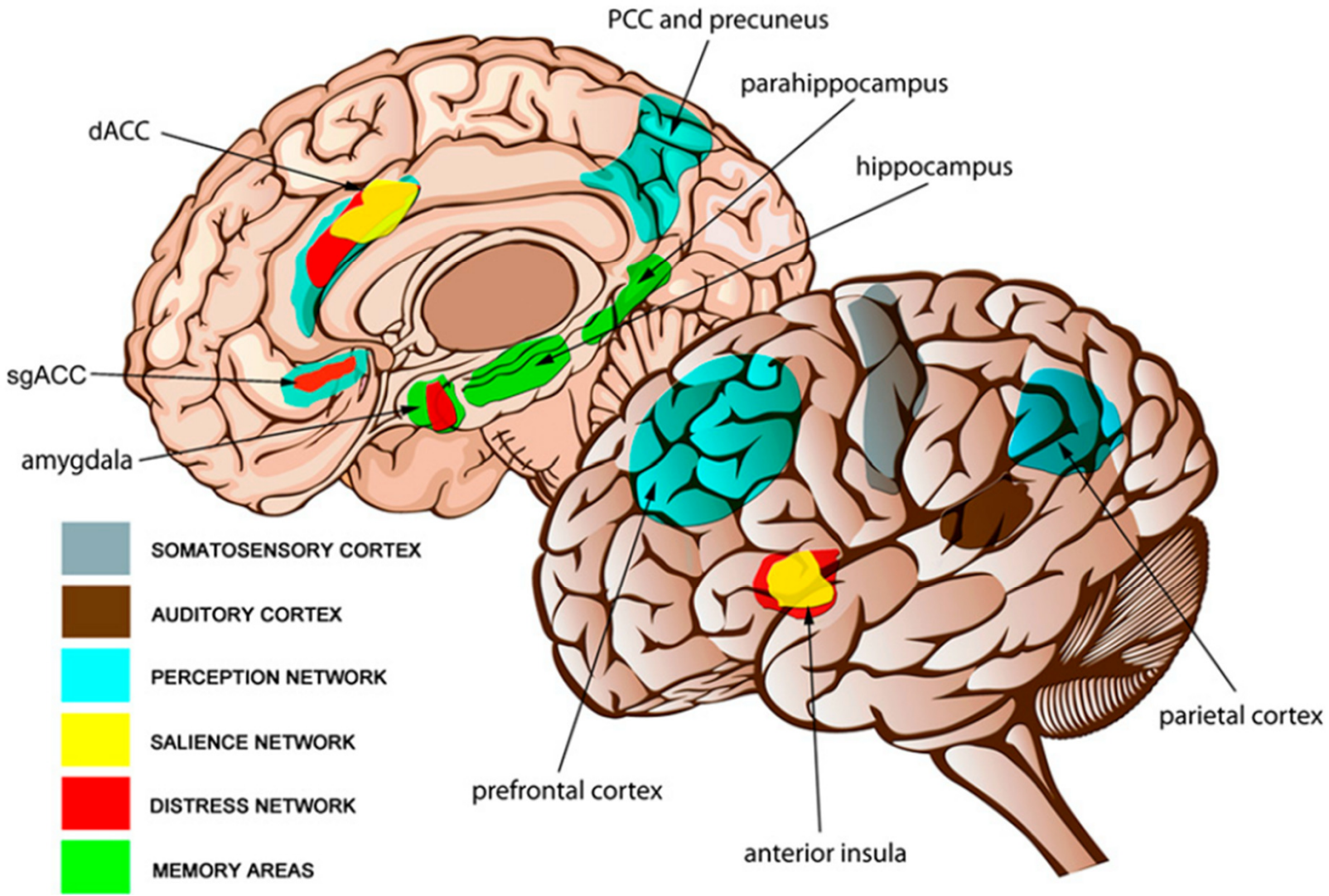
(Eggermont & Roberts 2004)

Plasticity in the auditory cortex



III. late consequences of neural plasticity

The alliance of the tinnitus triad



de Ridder et al. (2011) PNAS

The auditory „phantom pain“

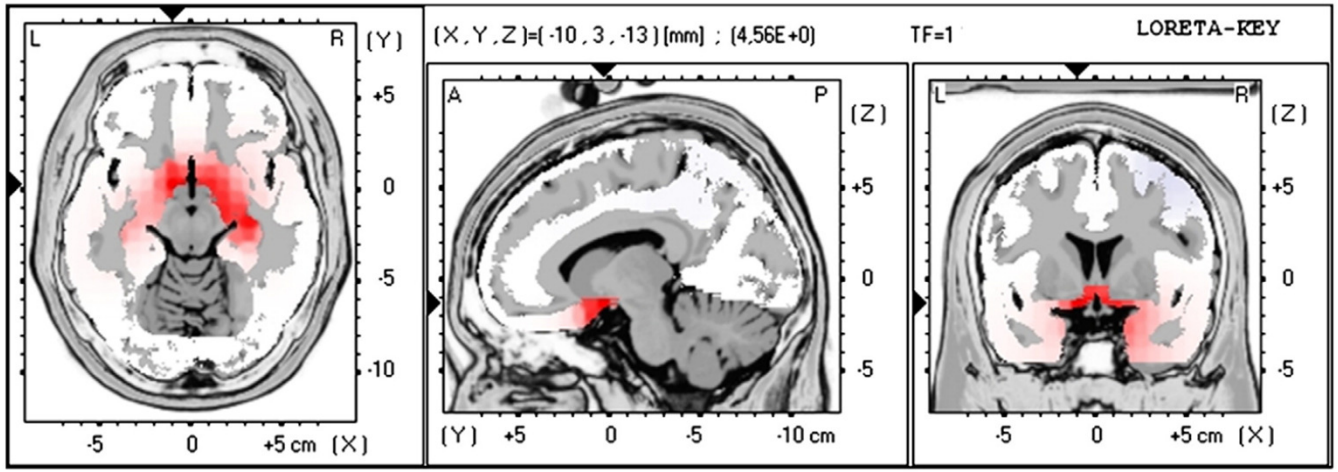
“ .. that phantom perception arises as the consequence of **multiple parallel overlapping dynamic brain networks** ..”

“ .. we hypothesize that both tinnitus and phantom pain are **perceptual states of continuous learning**, where — in the absence of an external input — the **phantom percept is reinforced and the connection with aversive emotional associations is continuously updated**.”

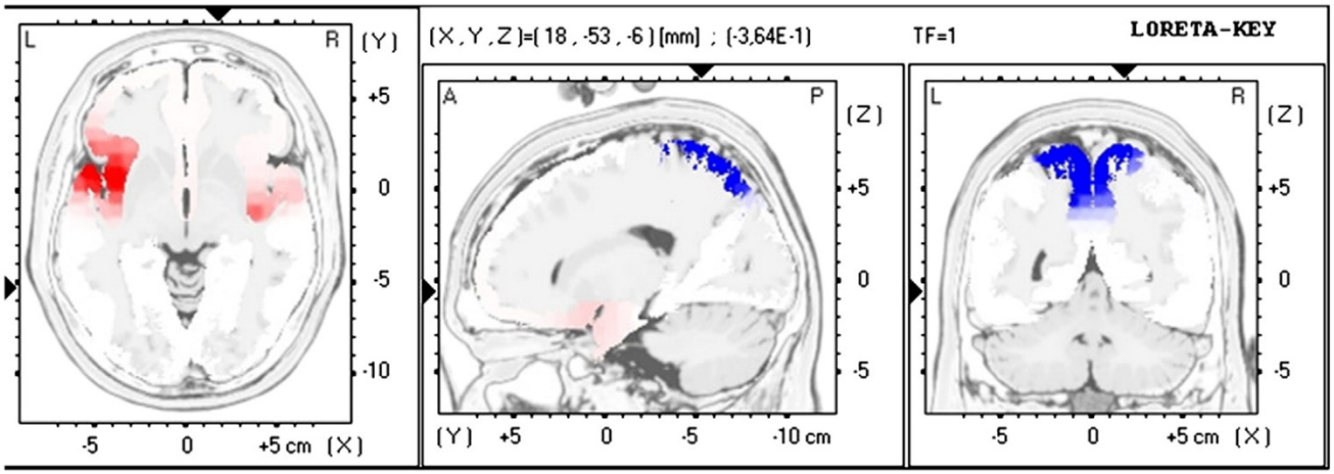
“Through the involvement of learning mechanisms, the phantom percept becomes associated to distress, which in turn is **reflected by a simultaneously coactivated nonspecific distress network** consisting of the parahippocampal area, ACC, anterior insula, and amygdala.

de Ridder et al. (2011), PNAS

Tinnitus and distress



Source density in alpha1 higher for high distress patients



Source density in alpha2 higher for high distress patients

Vanneste et al. (2010)

Subjective aspects of tinnitus

	Component	
	1	2
PRISM	.907	-.247
TQ Total score	.865	-.206
VAS (eyes closed)	.744	.532
Tinnitus duration	-.216	.917

Meyer et al. (2014) Neural Plasticity

Data driven PCA identifies two main factors:

1. Tinnitus distress
2. Tinnitus duration/presence

Subjective aspects of tinnitus

Correlations between Components and Other Variables

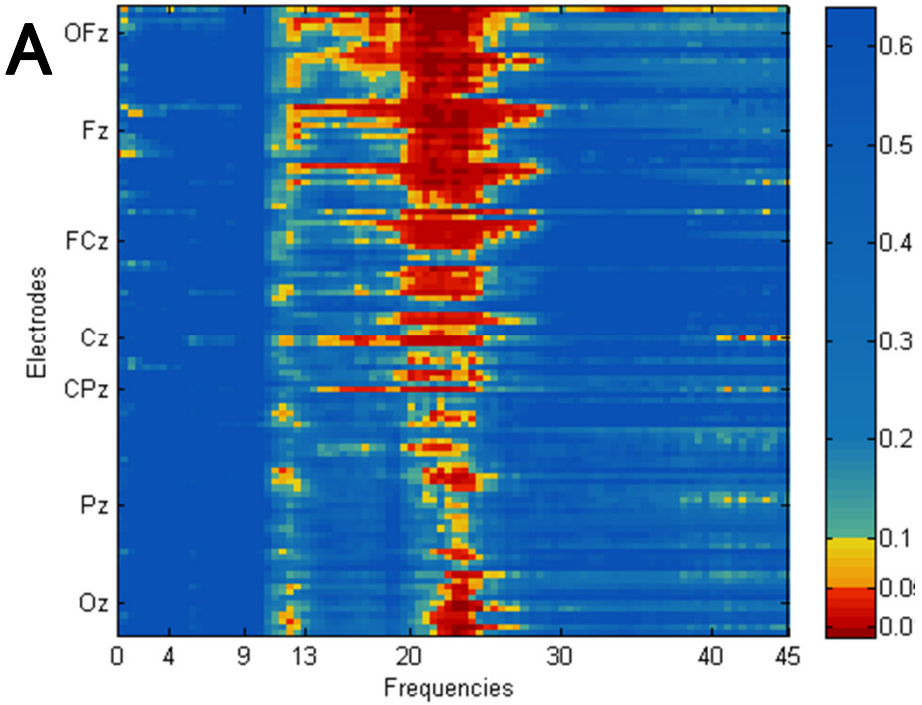
		Tinnitus Presence	Hearing threshold	Time of day	Age	Tinnitus disturbance	BDI
Tinnitus Distress	*r*	.000	-.024	.159	.056	,527*	,627**
(first component)	*p*	1.000	.911	.457	.795	.030	.001
Tinnitus Presence	*r*		.151	.289	,380	-.074	-.033
(second component)	*p*		.481	.170	.067	.779	.877
Hearing treshold	*r*			.031	,594**	.160	.123
	p			.886	.002	.541	.567
Time of day	*r*				.120	-.098	-.080
	p				.576	.708	.710
Age	*r*					.315	.208
	p					.219	.329
Tinnitus severity	*r*						,480
	p						.051

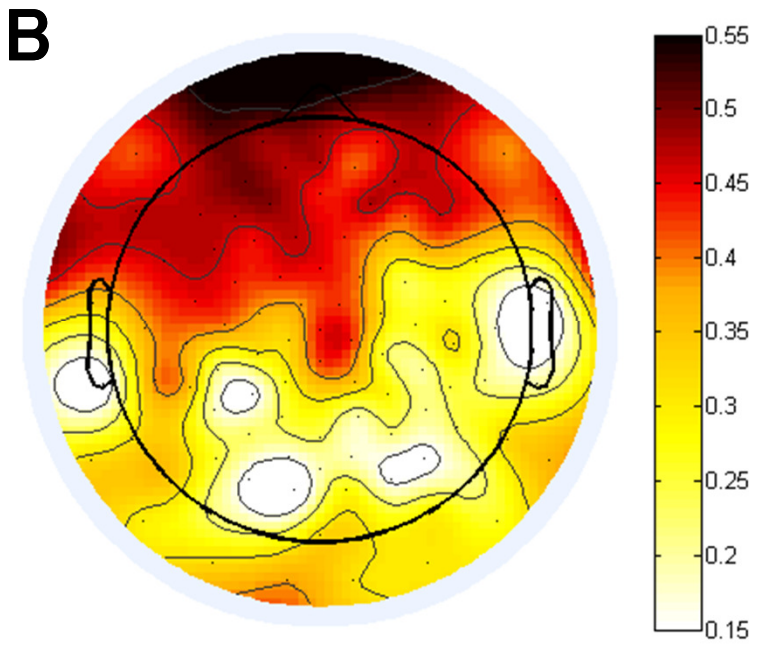
Note. Correlations are Pearson Product-Moment Correlations. *N* = 24; except for Tinnitus disturbance, *N* = 17. */** Significanct correlation with p < .05 / .001 (two-sided testing).

Meyer et al. (2014), Neural Plasticity

Correlation with psychopathological data

Distress

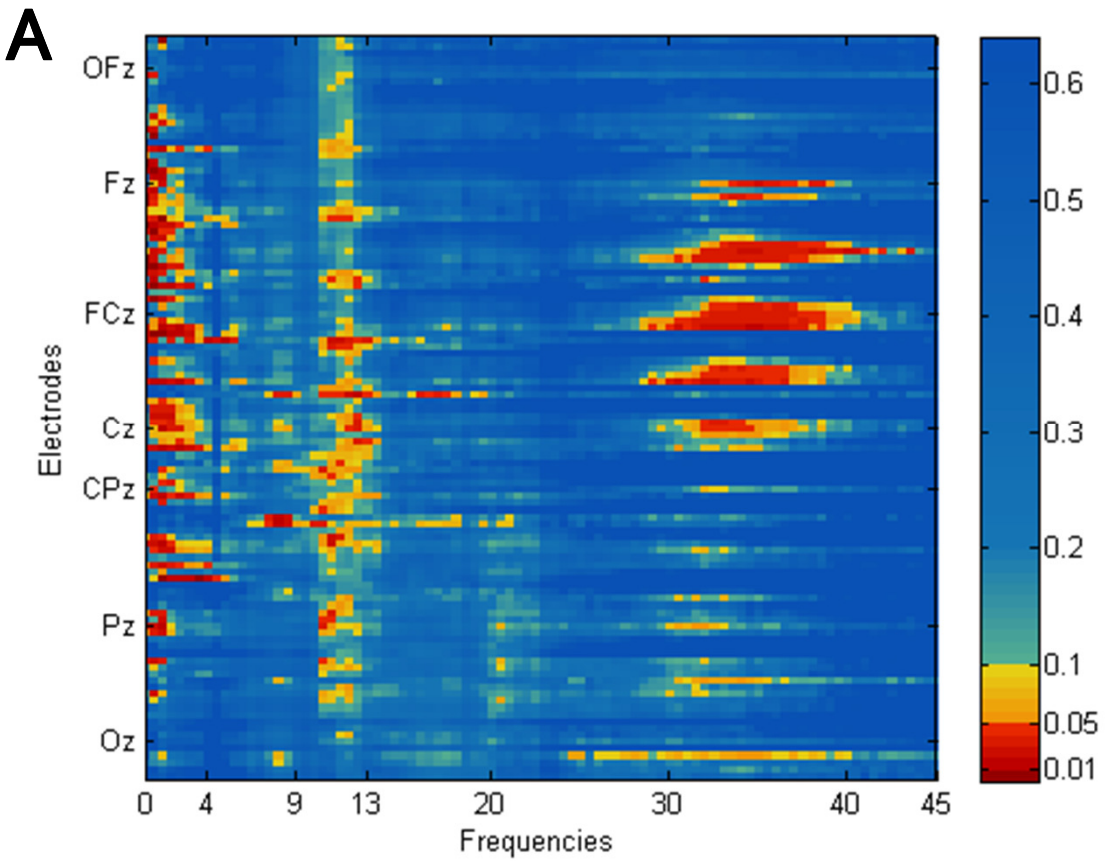


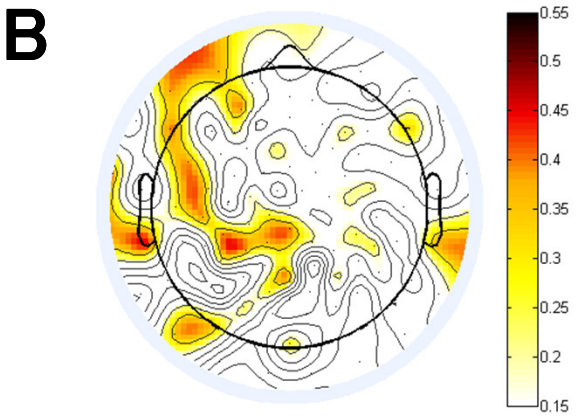


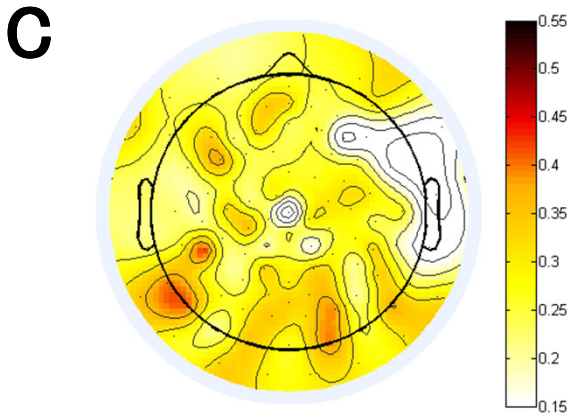
Meyer et al. (2014), Neural Plasticity

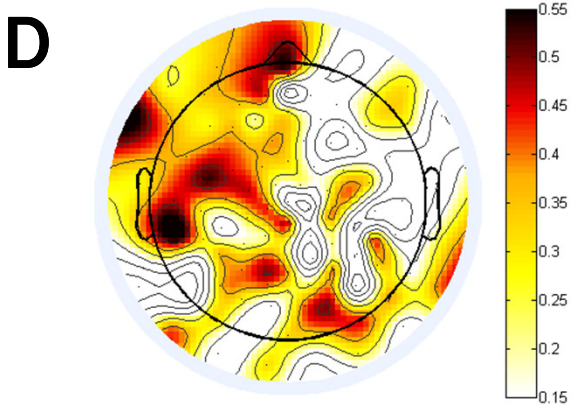
Correlation with psychopathological data

Duration



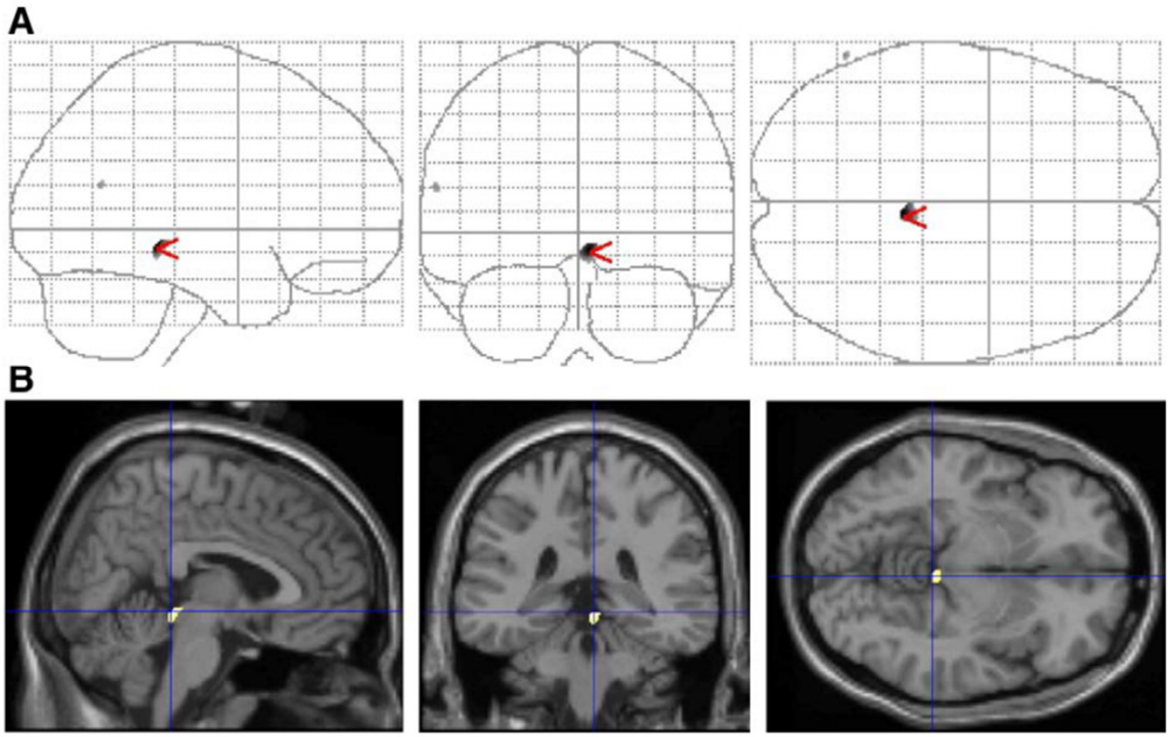






Meyer et al. (2014), Neural Plasticity

Structural Neuroimaging of Tinnitus



Landgrebe et al. (2009)

Cerebral Cortex Advance Access published May 3, 2013

Cerebral Cortex
doi:10.1093/cercor/bht094

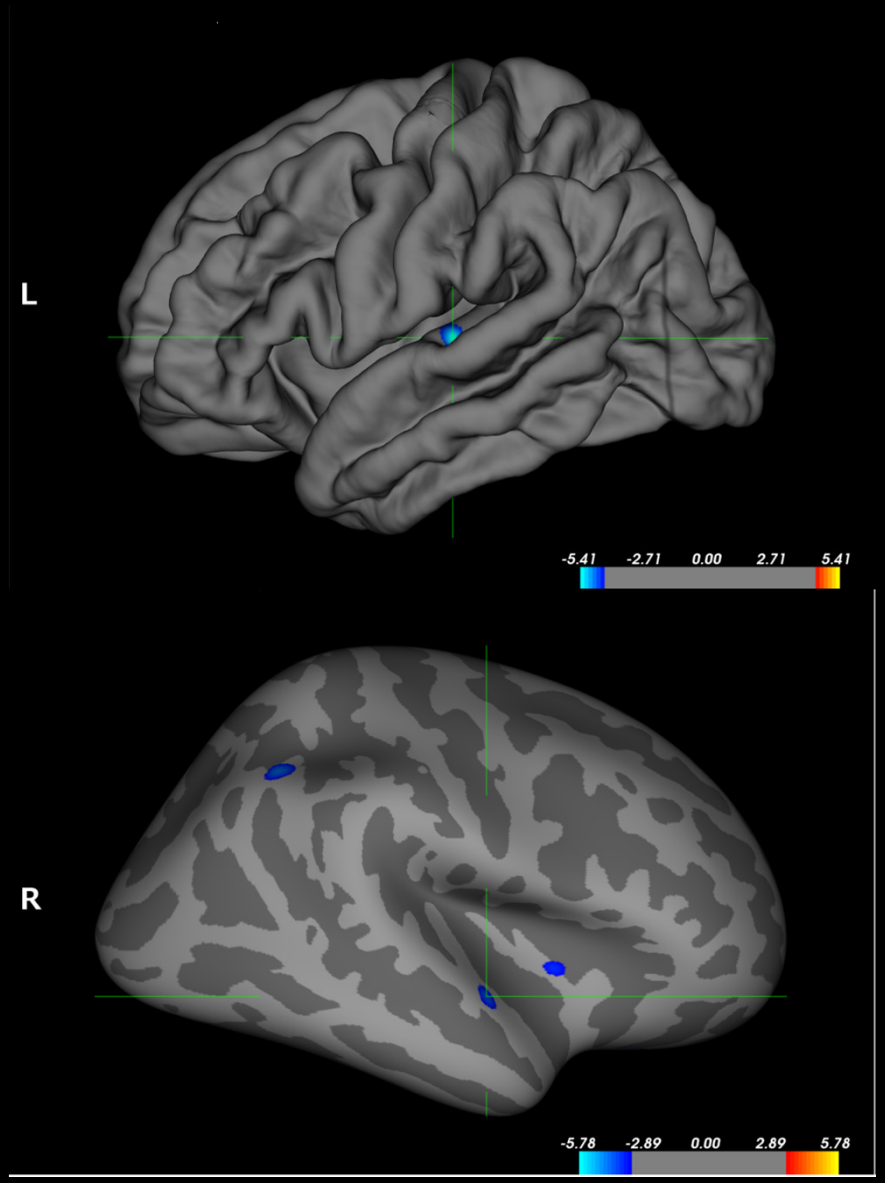
Cortical Surface Area and Cortical Thickness Demonstrate Differential Structural Asymmetry in Auditory-Related Areas of the Human Cortex

Martin Meyer[1,2], Franziskus Liem[1,3], Sarah Hirsiger[2], Lutz Jäncke[2,3] and Jürgen Hänggi[3]

[1]Neuroplasticity and Learning in the Healthy Aging Brain (HAB LAB), Institute of Psychology, [2]International Normal Aging and Plasticity Imaging Center and [3]Division of Neuropsychology, Institute of Psychology, University of Zurich, Zurich, Switzerland

Negative Correlation „Distress - Volume“

(n=256, corrected for multiple comparisons)

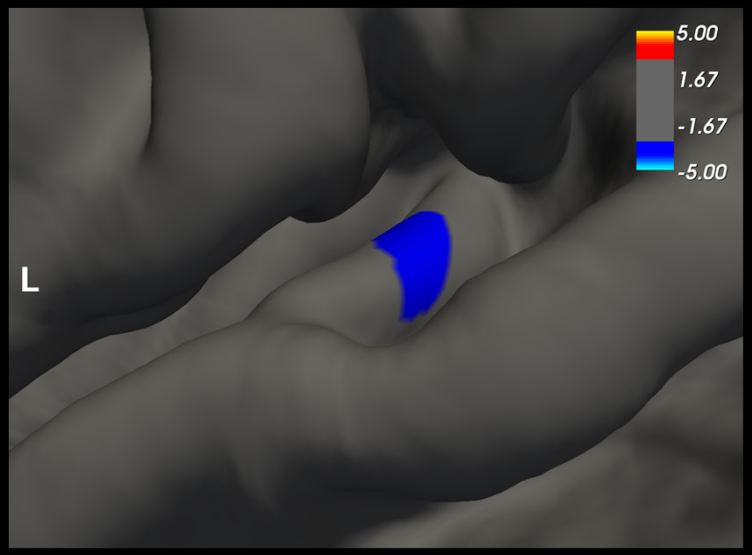


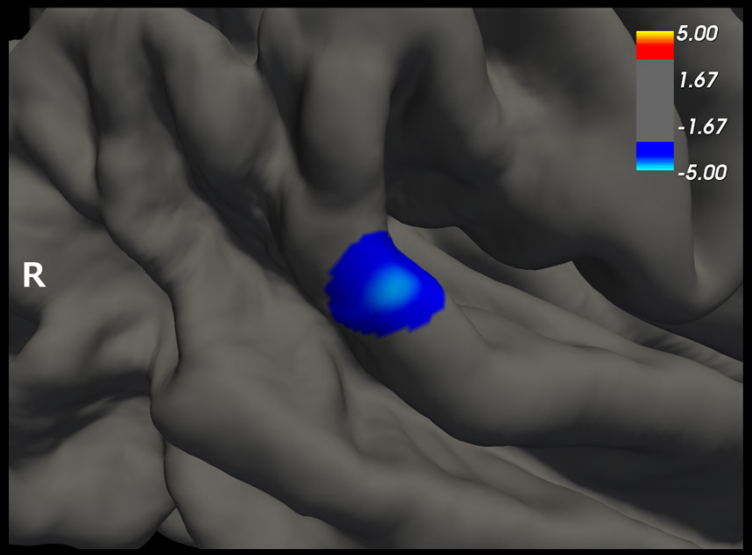
Reduced cortical volume in the bilateral auditory cortex and the right anterior insula

Meyer, Neff, Liem, Kleinjung, Weidt, Langguth, Schecklmann (in prep.)

Negative Correlation „Distress - Area“

(n=256, corrected for multiple comparisons)

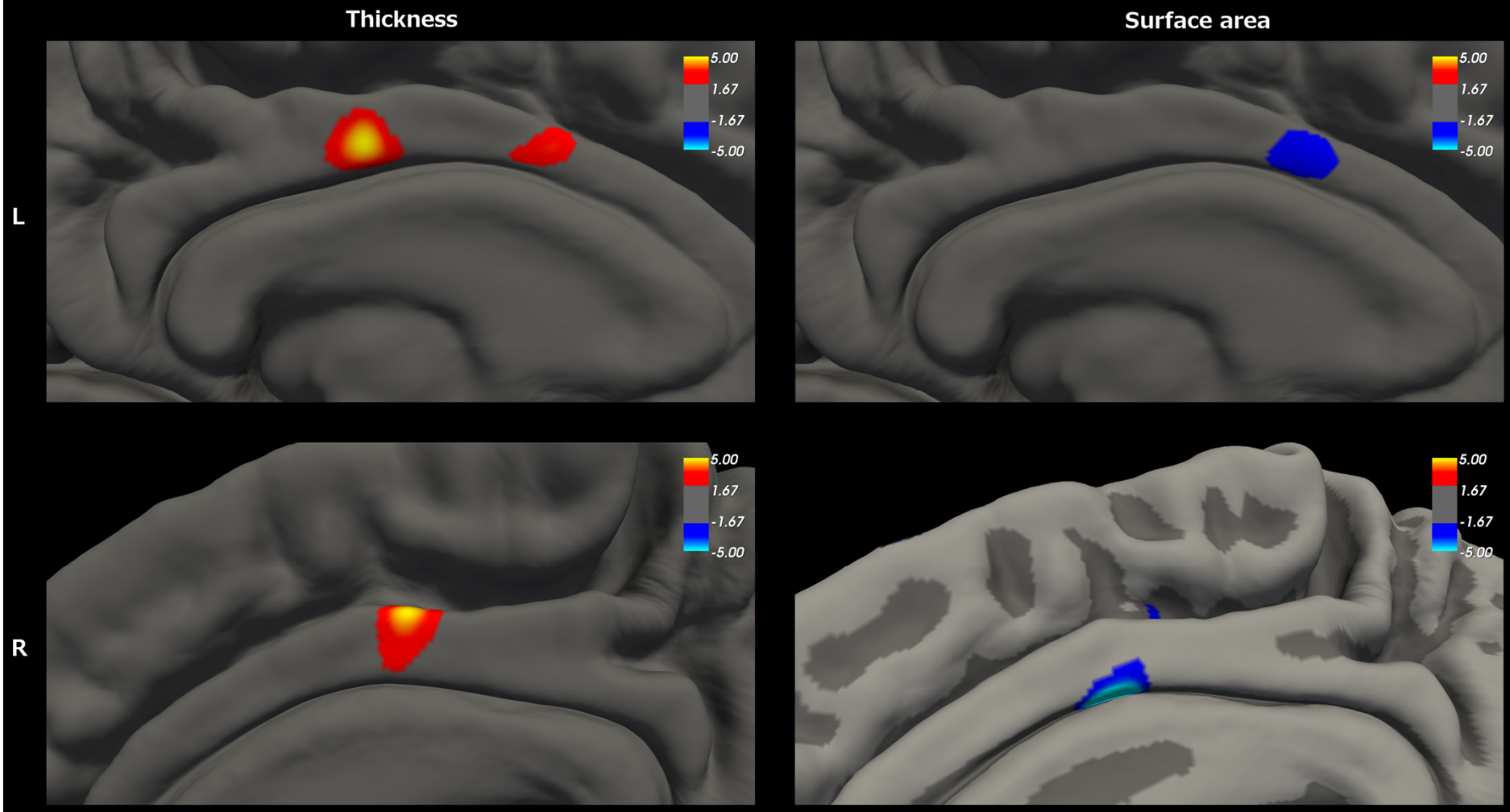




Area contributes (not thickness) contributes to the finding of structural plasticity in bilateral auditory cortex

Meyer, Neff, Liem, Kleinjung, Weidt, Langguth, Schecklmann (in prep.)

Correlation „Distress – Thickness“



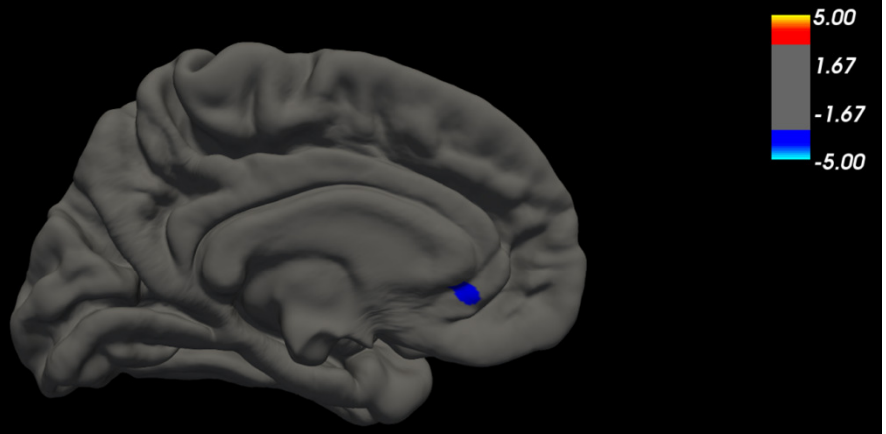
Meyer, Neff, Liem, Kleinjung, Weidt, Langguth, Schecklmann (in prep.)

Correlation „Duration – Thickness“

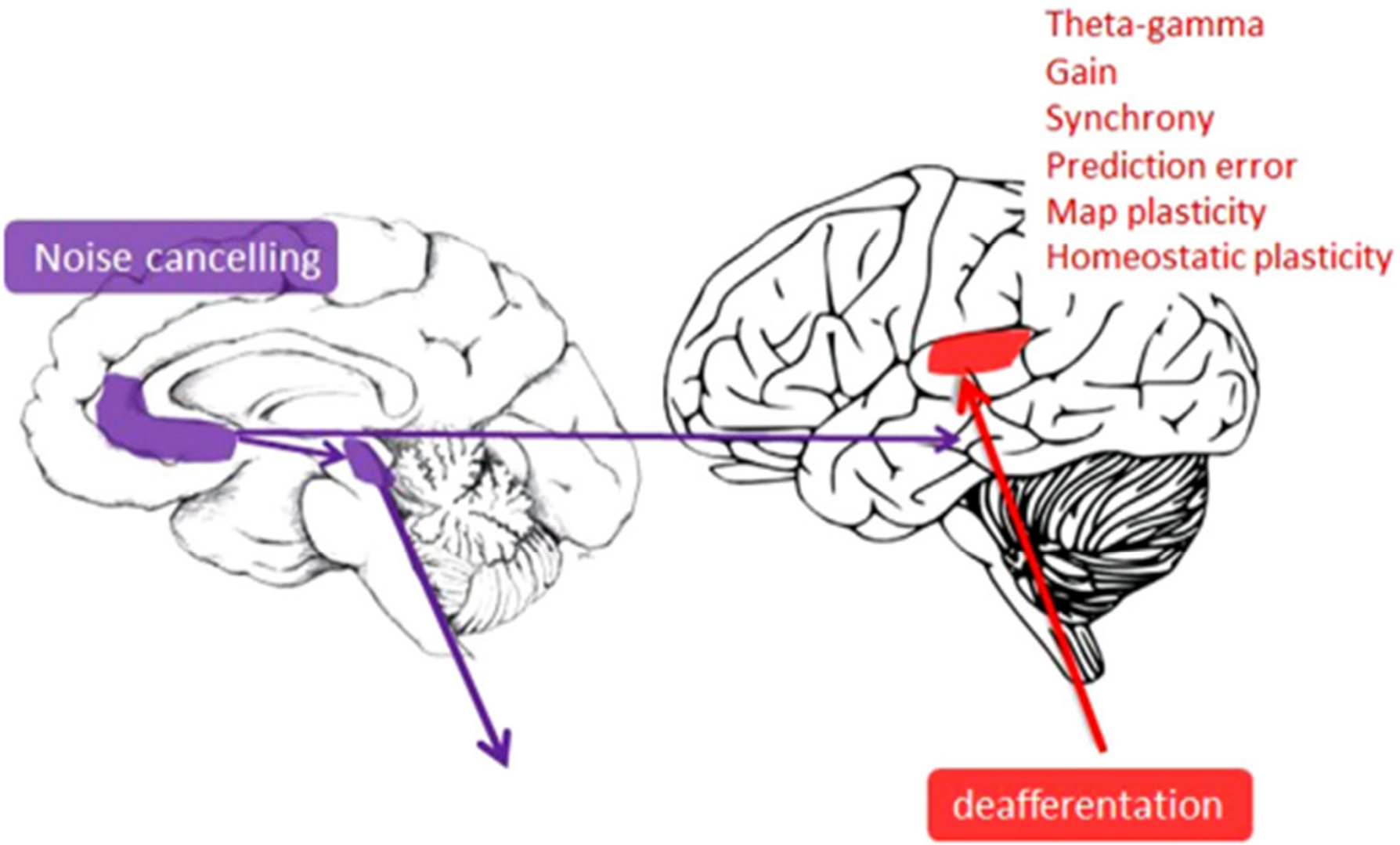
Anterior ACC/subcallosal area =>

Gateway in the serotonergic limbo-thalamocortical circuit

(Rauschecker et al. 2010, Neuron)



Meyer, Neff, Liem, Kleinjung, Weidt, Langguth, Schecklmann (in prep.)



De Ridder et al. (2013)

Summary

- Evidence that TI must not be considered a homogeneous group.
- Long duration since onset of tinnitus does not necessarily result in emotional distress
- Non-distressed TI may have better noise cancelling system or top-down coping strategies
- Cortical surface area and cortical surface may change specifically as function of tinnitus-related distress and duration
- EEG- and MRI based brainprints may help to classify distinct tinnitus subtypes and may further development of neuromodulatory treatment.

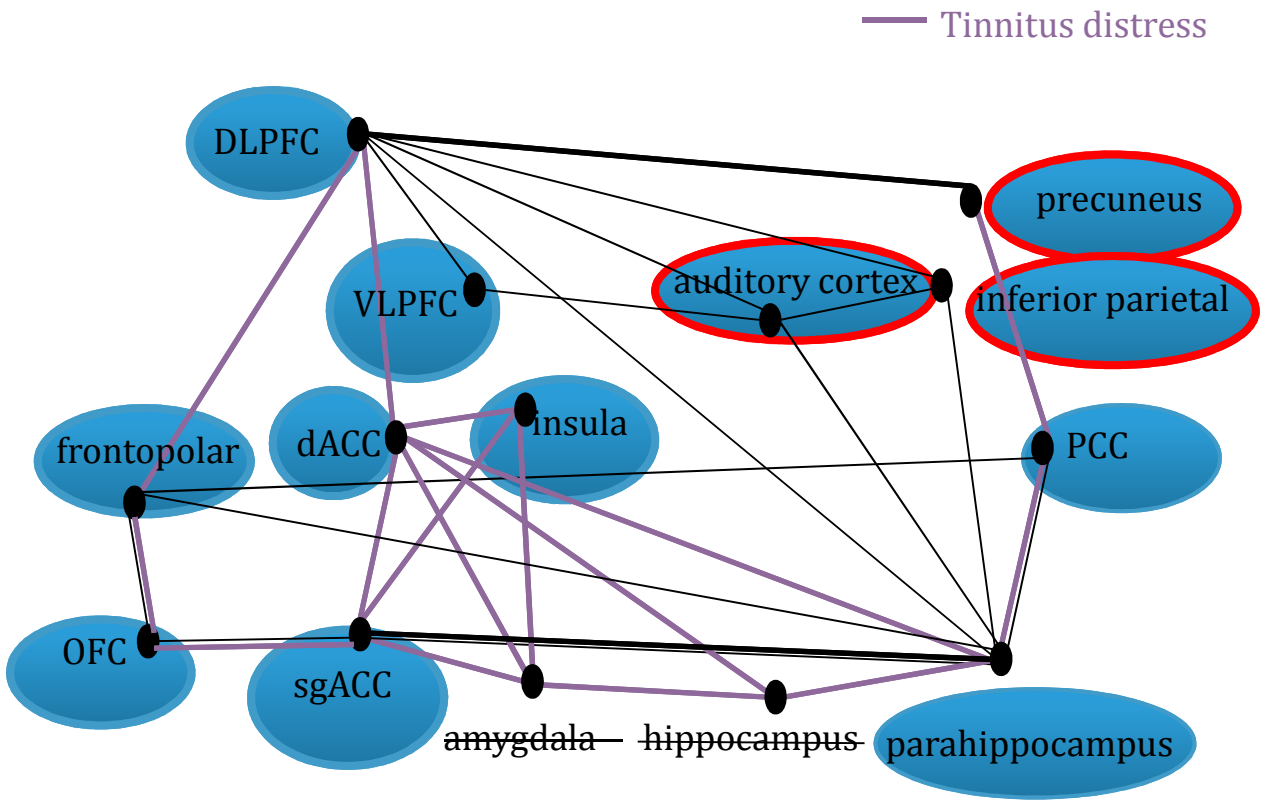
Thanks for your attention !!



Before brain imaging always think of

Functional-structural Network Model of Tinnitus Pathophysiology

(modified after De Ridder et al. (2013))



Red circles: results corrected for multiple comparisons
Blue circles: uncorrected results

Neuronal synchronicity

Cochlear damage results in partial deafferentiation and breakdown of lateral inhibition of frequency gradients in the auditory cortex.

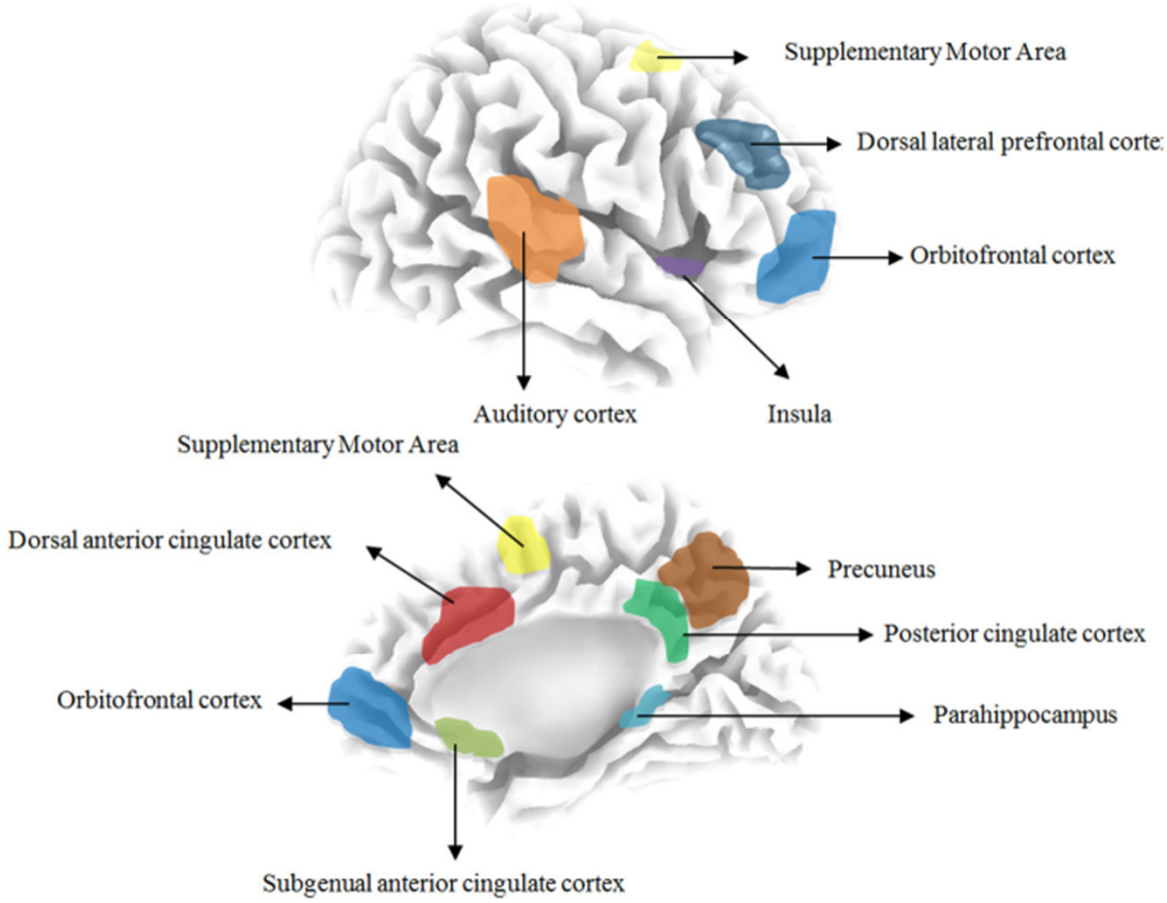
When local inhibition is reduced the neighbouring modules "take over" the recent representation due to increased excitation.

Eventually, this leads to subjective abnormal sound sensations.

Thalamocortical (TRN) dysrhythmia contributes to the generation of this vicious circle.

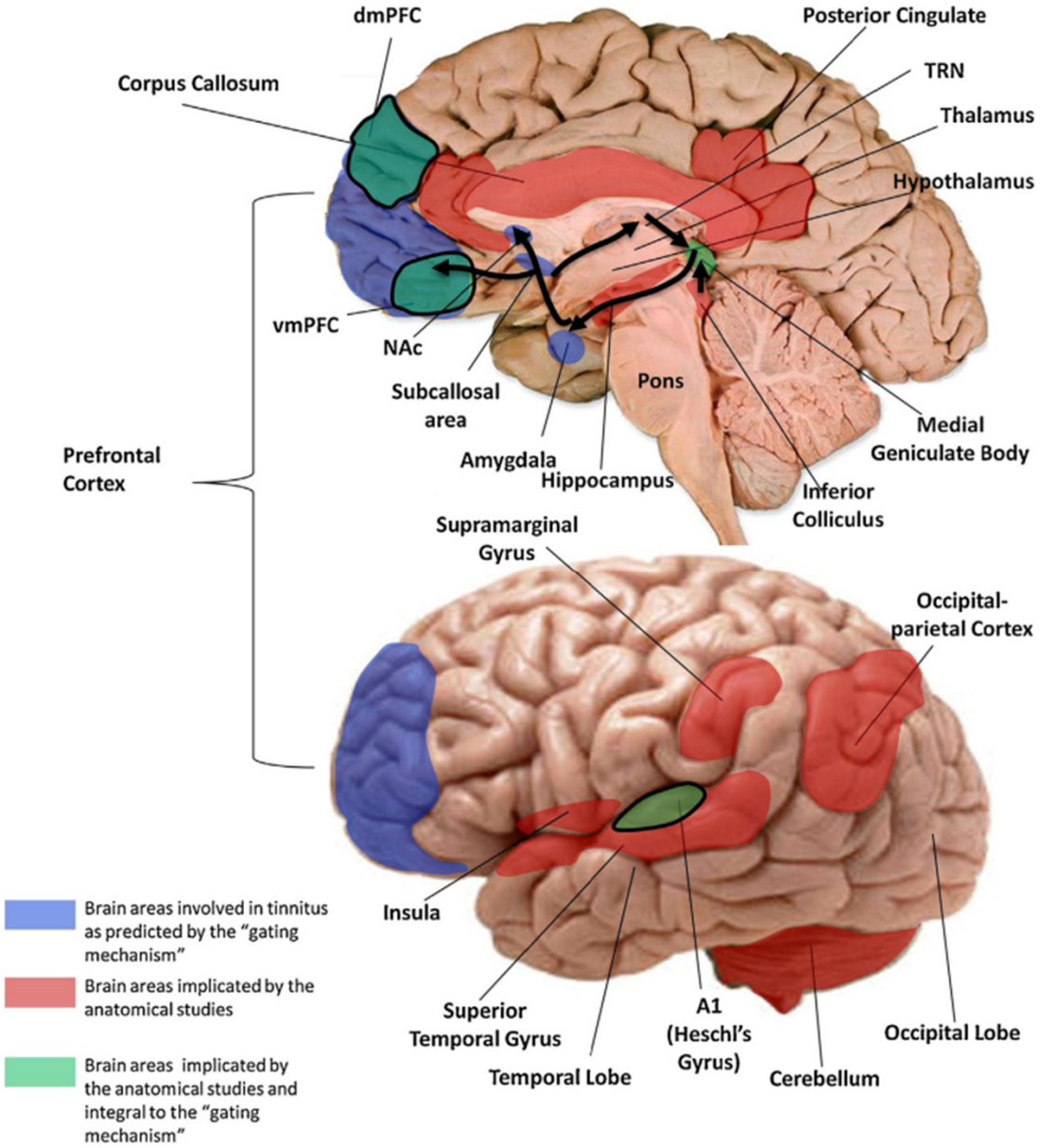
The tinnitus triad: auditory, attentional and emotional circuits start to ally.

Resting-state EEG in tinnitus persons



Vanneste & De Ridder (2012), Front Sys Neurosci

Neuroanatomical alterations in tinnitus individuals



Adjamian et al. (2014)