

Tunes stuck in your brain: neural contributions of auditory, spontaneous cognition and affective networks

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Agenda

- Background
- INMI and cortical structure
- INMI and functional connectivity at rest

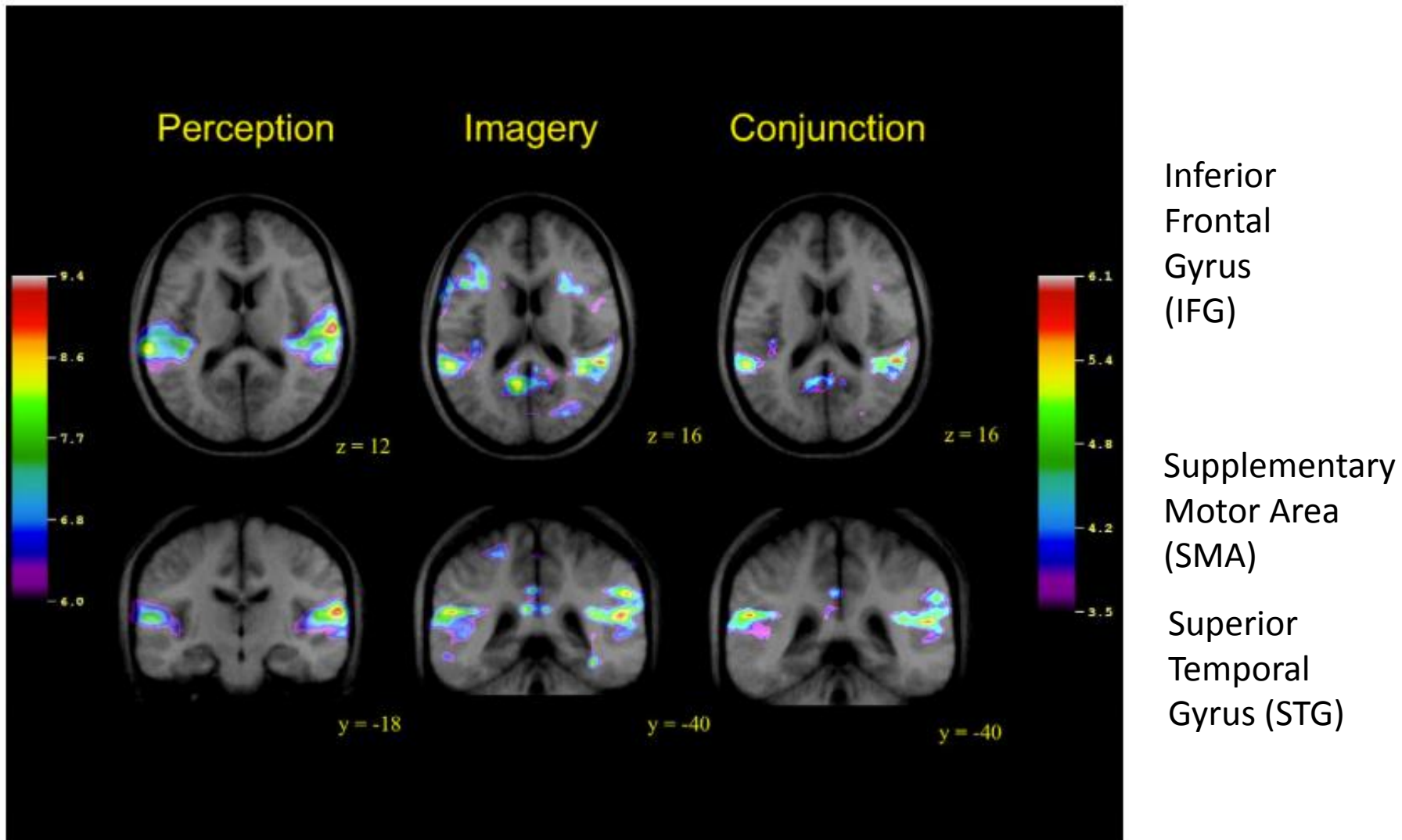
Involuntary Musical Imagery

- Definition
 - Involuntary Musical Imagery (INMI) is the experience of a short, repeated excerpt of music, looping in one's head, unbidden to the mind and without conscious control
- Involuntary Musical Imagery Scale (IMIS)
- Hypothesis on the brain basis : intersection between three mechanisms
 - Musical imagery
 - Default Network
 - Emotional networks

Farrugia, Jakubowski, Cusack & Stewart (2015) Consciousness and Cognition

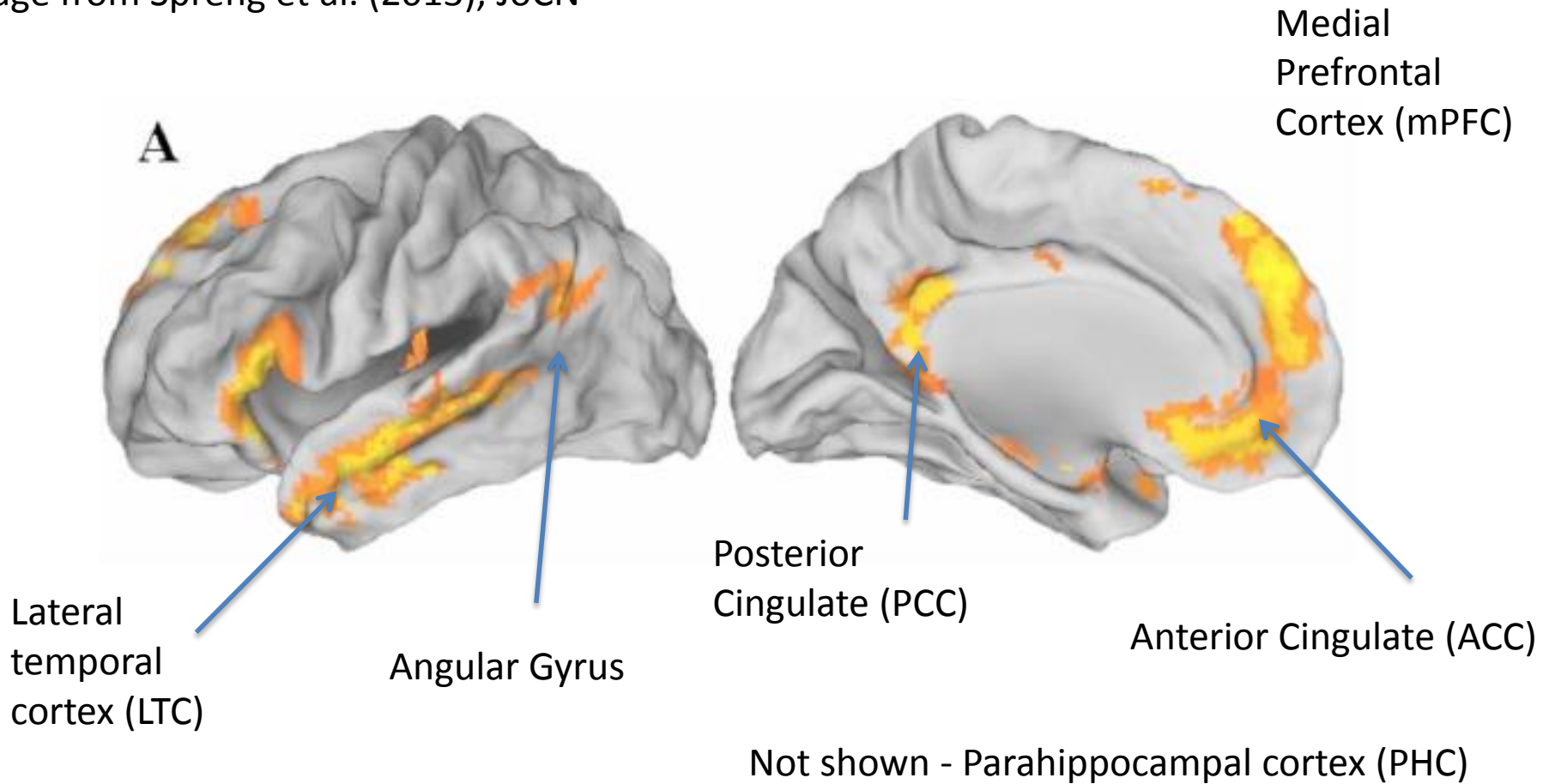
The Involuntary Musical Imagery Scale – (IMIS) Floridou, Williamson, Müllensiefen & Stewart, (2015) Psychomusicology: Music, mind and Brain.

Musical Imagery in the brain



Default Network

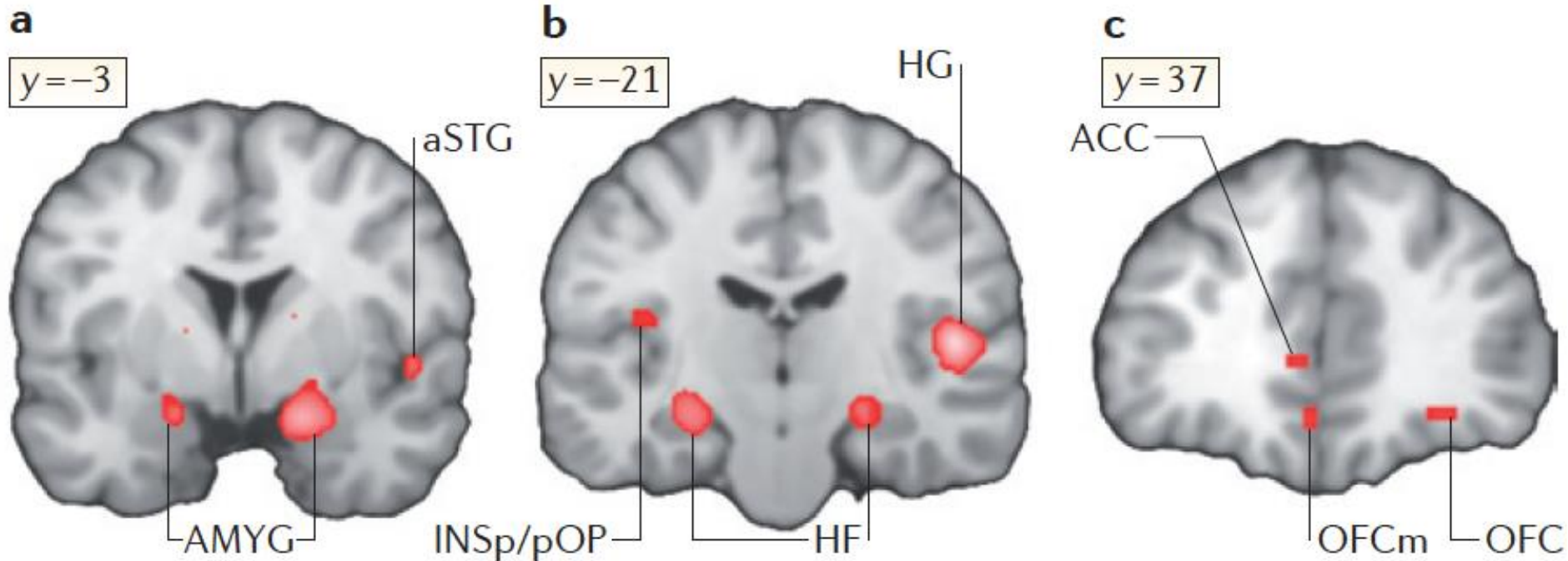
Image from Spreng et al. (2013), JoCN



Activates at rest, during self-directed thoughts

Serves as an integrative network in spontaneous thoughts (Andrews-Hanna et al. 2014, ANYAS)

Music-evoked emotions



HF : Hippocampal Formation

AMYG: Amygdala

INS: Insula

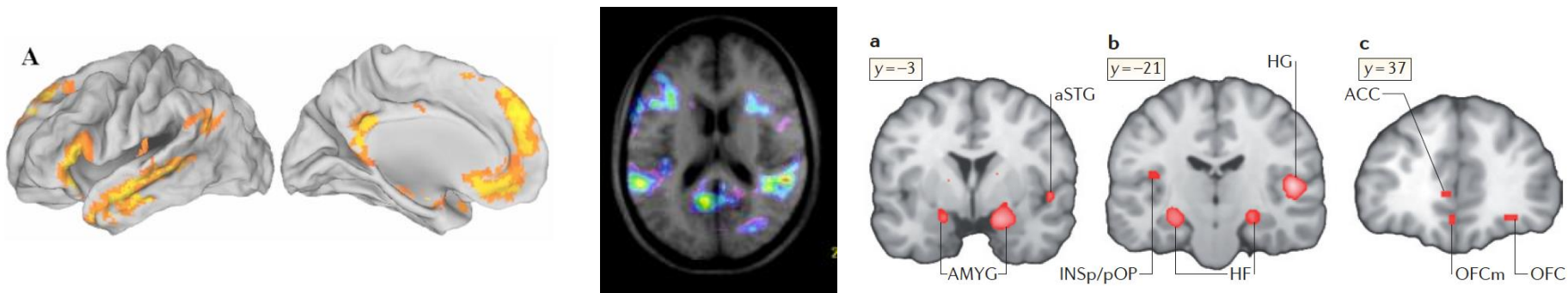
HG : Heschl's gyrus

STG: Superior Temporal Gyrus

OFC: Orbitofrontal
Cortex

Neural networks of INMI

- Hypothesis
 - Brain regions involved in music perception and music imagery : STG, HG and IFG
 - Brain regions involved in emotions evoked by music: ACC, INS, PHC
 - Brain networks of spontaneous cognition including Default Network : ACC, PCC, PHC, AG



Structural MRI and Involuntary Musical Imagery

- How to measure these individual differences ?

Farrugia, Jakubowski, Cusack & Stewart (2015) Consciousness and Cognition

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	Negative Valence	Movement	Personal Reflections	Help
1. I try hard to get rid of my earworms	.85			
2. It worries me when I have an earworm stuck in my head	.64			
3. I find my earworms irritating	.87			
4. My earworms agitate me	.83			
5. The experience of my earworms is unpleasant	.85			
6. I wish I could stop my earworms	.79			
7. When I get an earworm I try to block it	.86			
8. The rhythms of my earworms match my movements		.78		
9. The way I move is in sync with my earworms		.87		
10. When I get an earworm I move to the beat of the imagined music		.74		
11. My earworms result from unresolved matters			.72	
12. Personal issues trigger my earworms			.78	
13. The content of my earworms mirrors my state of worry or concern			.80	
14. I find my earworms help me focus on the task that I'm doing				.84
15. Earworms help me when I'm trying to get things done				.83

Structural MRI and Involuntary Musical Imagery

- How to measure these individual differences ?
- Structural MRI data collected at CBU (Cambridge)
 - 40 subjects – T1 high resolution scan
 - Measurements of Cortical Thickness and Voxel-based morphometry (Gray Matter Volume - GMV)

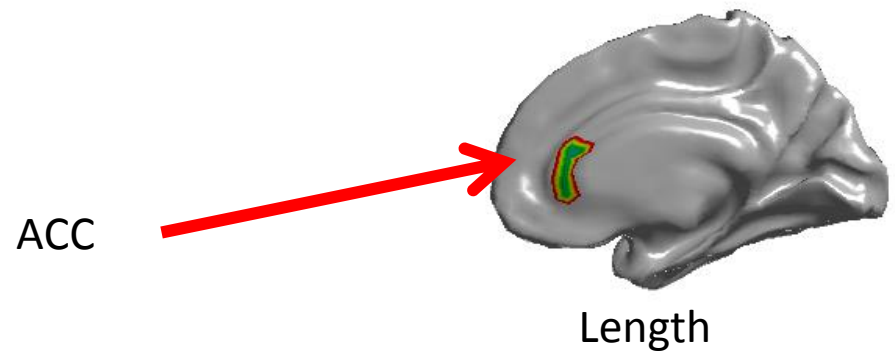
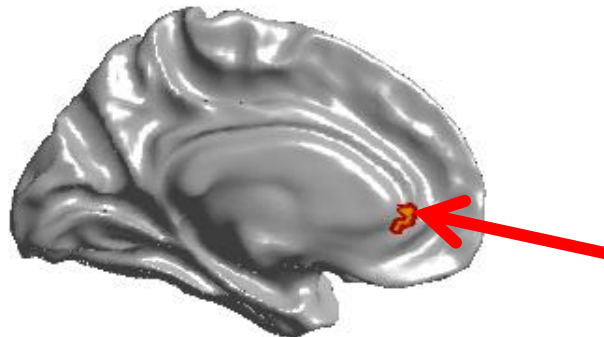
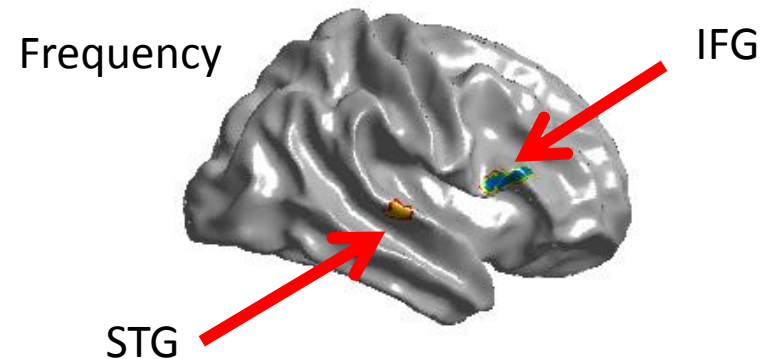
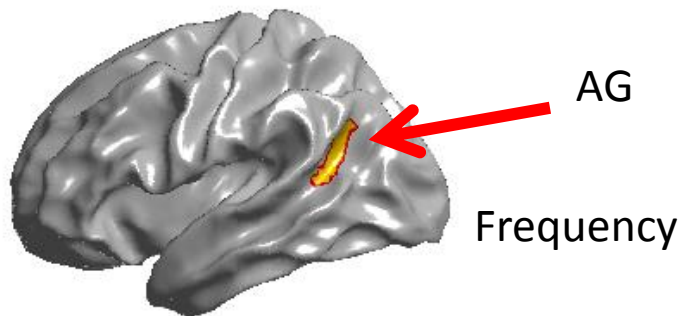


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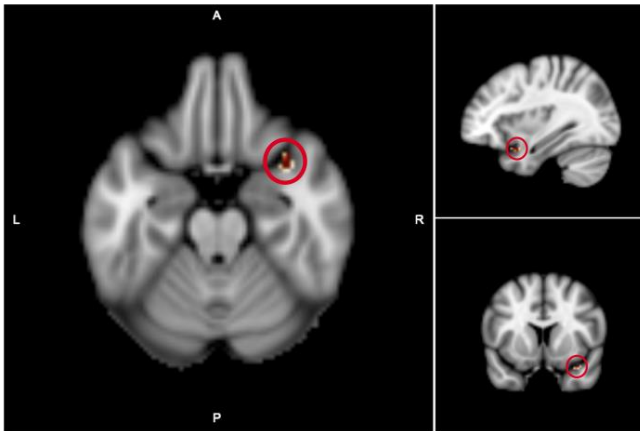
INMI and brain structure

- Frequency and length of INMI - decreased
Cortical thickness

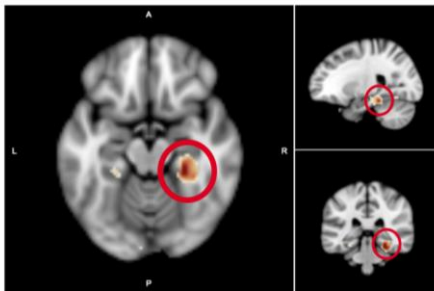


INMI and brain structure

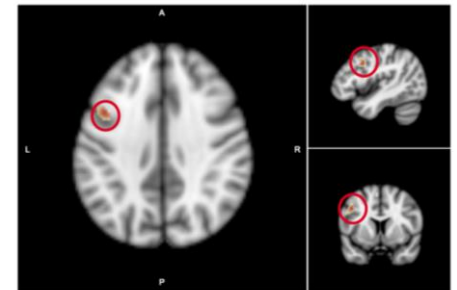
- Affective/ emotional aspects of INMI (VBM)



“Negative Valence” associated with increased GMV in Right Temporal pole / insula



“Help” associated with increased GMV in right PHC and decreased GMV in left middle frontal gyrus

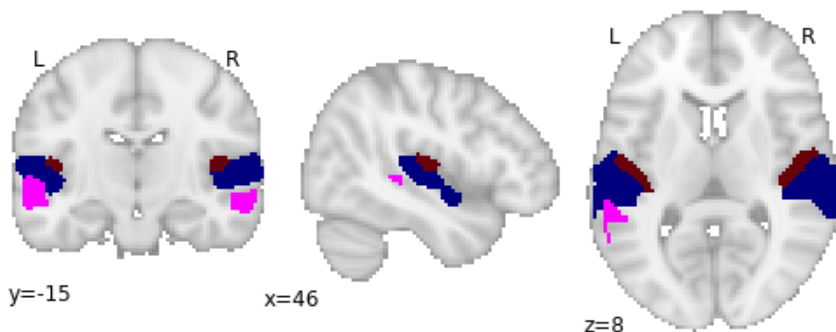


Involuntary Musical Imagery

- INMI and brain structure
 - Frequency related to the structure of fronto-temporal cortices (similar to voluntary imagery), and Default Network
 - Affective aspects are related to emotion areas and Default Network
- Default Network, functional connectivity and INMI ?

Functional connectivity at rest and INMI

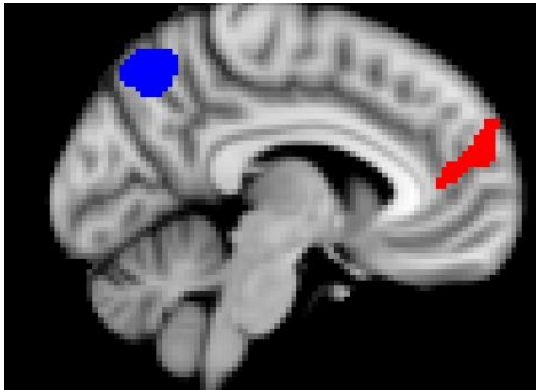
- 40 subjects, 10 minutes resting-state scan
- IMIS
- Functional Connectivity - seed regions:
 - Right PHC
 - 3 Auditory seed regions from Linke & Cusack 2015



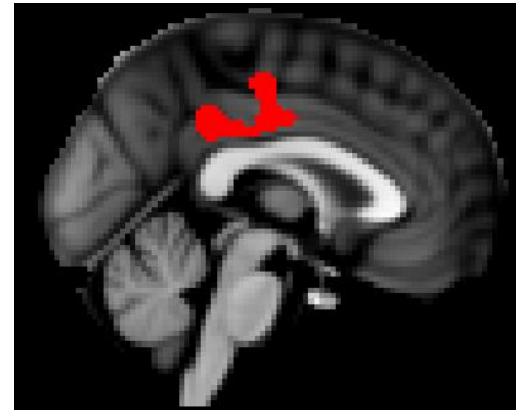
Heschl's Gyrus
Non-primary Auditory Cortex
Middle Temporal Gyrus –
auditory association

Functional connectivity at rest and INMI

- The coupling between non-primary auditory regions and Default Network influences the frequency of INMI



AC <-> medial PFC (red)
AC <-> precuneus (blue)



MTG <-> PCC / SMA ?

Red – increased frequency
Blue – decreased frequency

Functional connectivity at rest and INMI

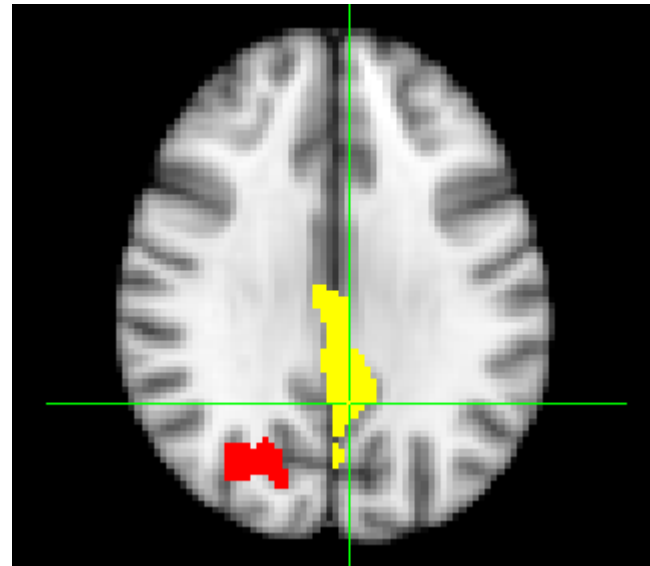
- The coupling between primary auditory (Heschl) and Default Network influences the length of the section of music experienced as INMI

HG <-> PCC



Yellow – longer length

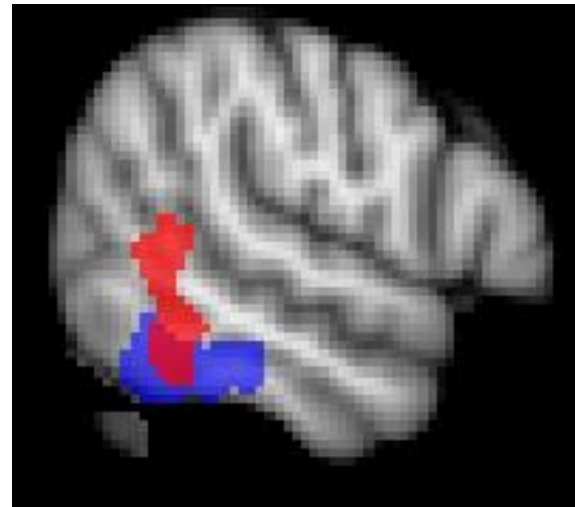
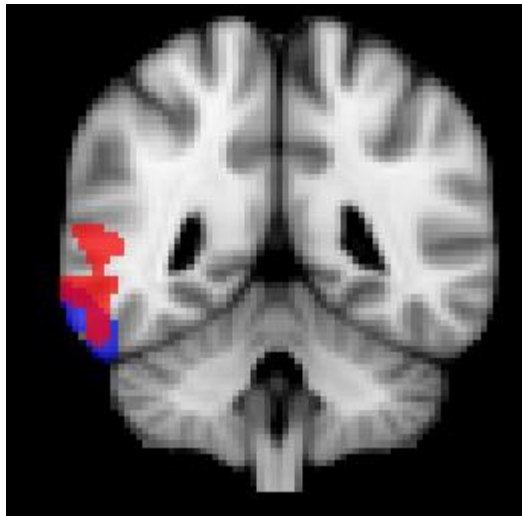
HG <-> right Lat. Occ. cortex



Red- shorter length

Functional connectivity at rest and INMI

- Coupling within DN subsystems linked to affective aspects of INMI
 - PHC <-> lateral temporal connectivity: memory retrieval system



right PHC <-> Lateral Temporal Cortex / Temporo-parietal

Red – increased “Negative Valence”

Blue – Increased “Help”

Discussion

- 3 lines of thought
 - Network interactions underlying INMI triggering
 - Cognitive mechanisms related to INMI
 - Neural correlates of affective processing of INMI

Discussion 1/3

- INMI triggers and network interactions
 - Recent exposure -> residual auditory activity amplified or dampened by DN
 - Low attention states -> High DN activity activates auditory networks
 - Mood states -> structure of emotion areas, link between DN and memory retrieval
 - Memory associations - link between DN and memory retrieval
- Similar to network interactions in spontaneous thoughts
 - Dynamic coupling between Default, Fronto-parietal control and Dorsal Attention network (Spreng et al. 2010, 2013; Andrews-Hanna, Smallwood & Spreng 2014)

Discussion 2/3

- Cognitive mechanisms related to Spontaneous cognition and INMI
 - Delay discounting and task-unrelated thoughts (Bernhart et al. 2013)
 - Meta-cognition (Baird et al. 2013)
 - Thought Suppression / Inhibition ? (Beaman & Williams 2010, 2013, Beaman et al. 2015)
 - Memory retrieval - role of emotions

Discussion 3/3

- Neural correlates of affective processing of INMI
 - Structure of right PHC and Temporal Pole
 - Connectivity between right PHC and LTC – a memory retrieval network ?
 - Negative aspects linked to dysfunctions in limbic networks ?
 - Similarities with tinnitus and hallucinations
 - Musical obsessions (Taylor et al 2014) and OCD

Acknowledgments

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- Kelly Jakubowski, Georgina Floridou
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- Sofia Valk (MPI Leipzig), Roberto Toro (Institut Pasteur, Paris)

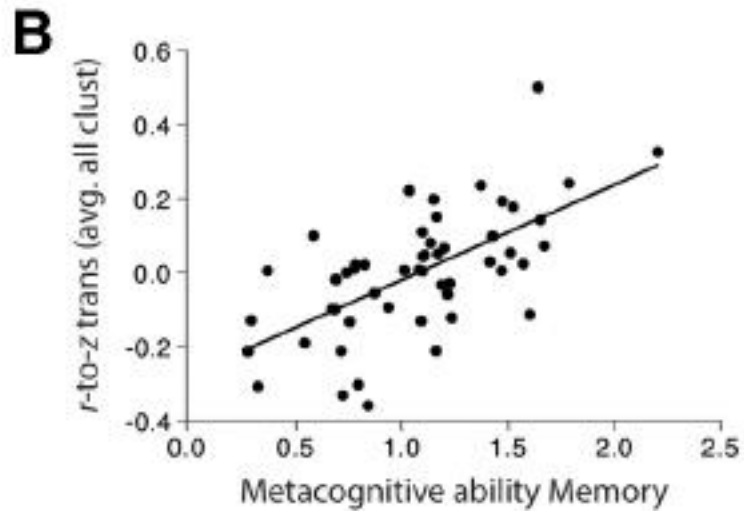
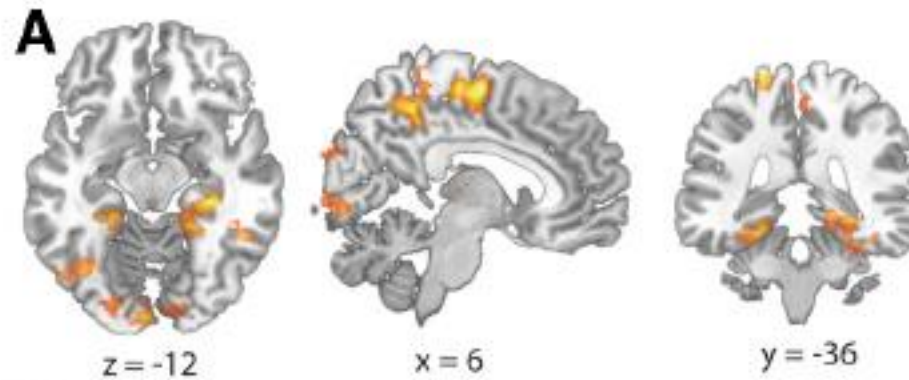
Thanks!

- Questions ?

Discussion

- Similarity with Musical imagery and perception
- Emotional aspects – an anatomical “trait” ?
- The Default Network as an integrative network, coupled with auditory networks ?
 - Links semantic memories, self-generated thoughts...
 - ... with auditory activity
- Findings are in line with INMI triggers

Metacognition



Metacognition

