Résonance musicale : de l'entraînement moteur au système miroir

Daniele Schön

Institut de neurosciences des systèmes, U1106

Marseille, JPS 2012

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

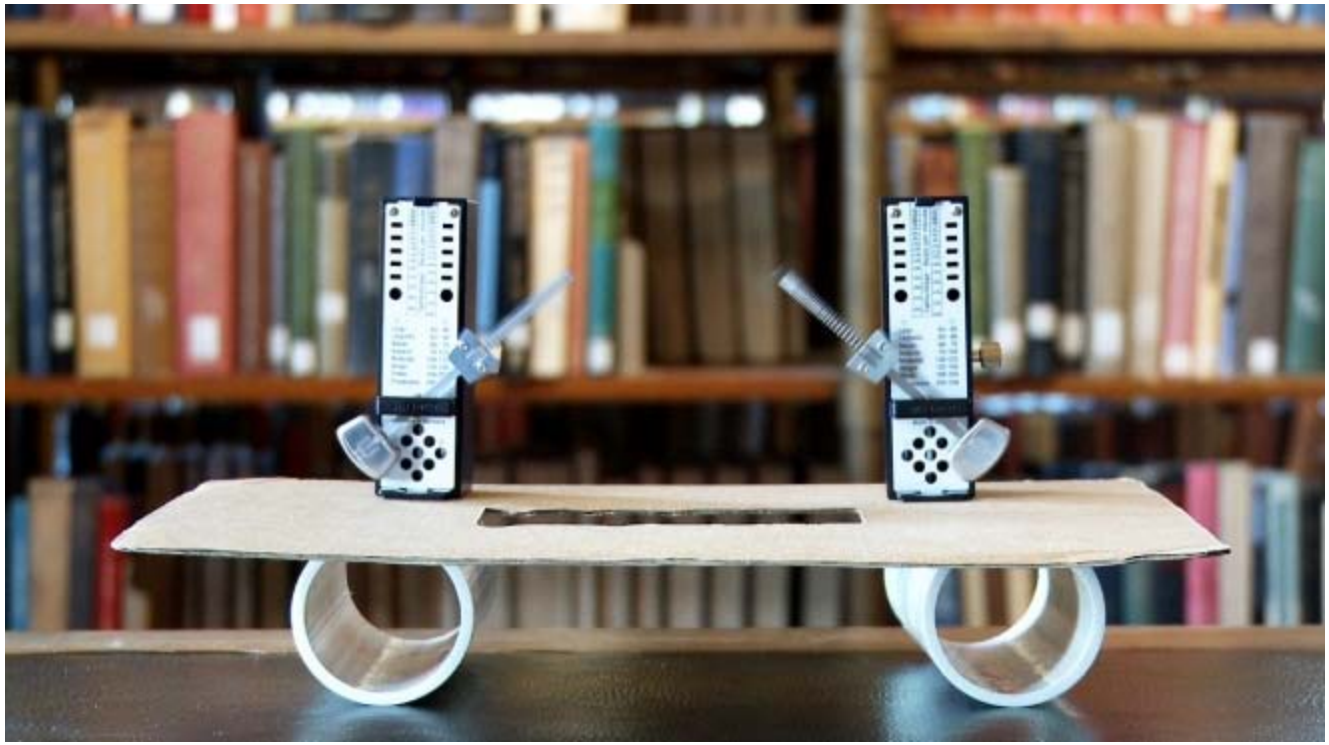
UNIVERSITE DE LA MEDITERRANEE AIX - MARSEILLE II

Instituts thématiques

Inserm

Institut national de la santé et de la recherche médicale

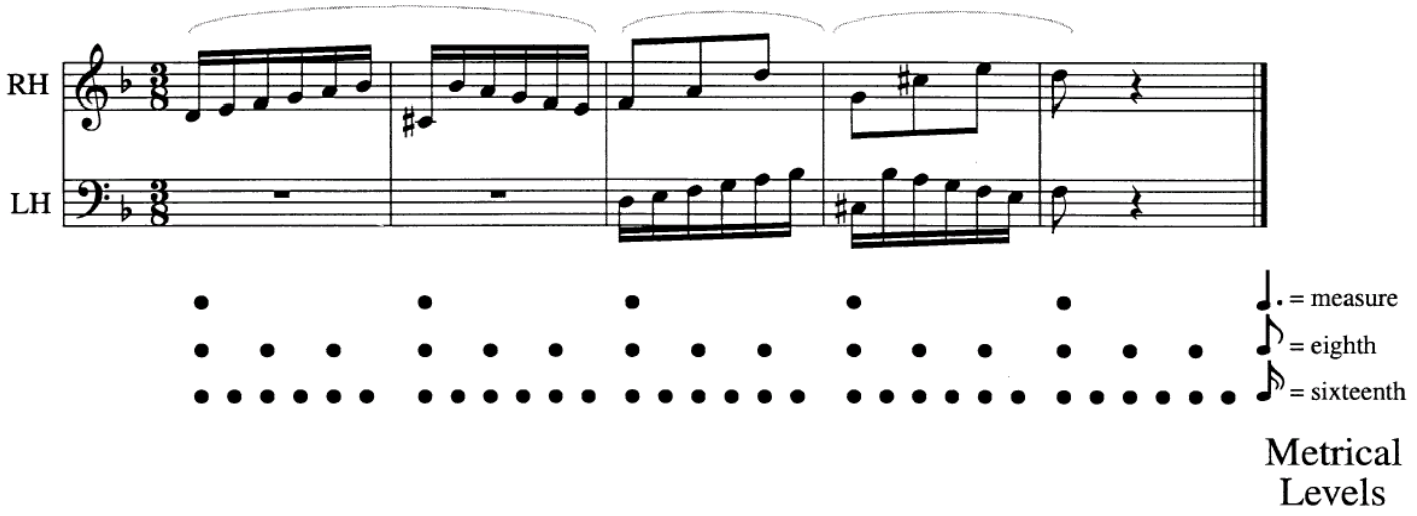
Oscillations



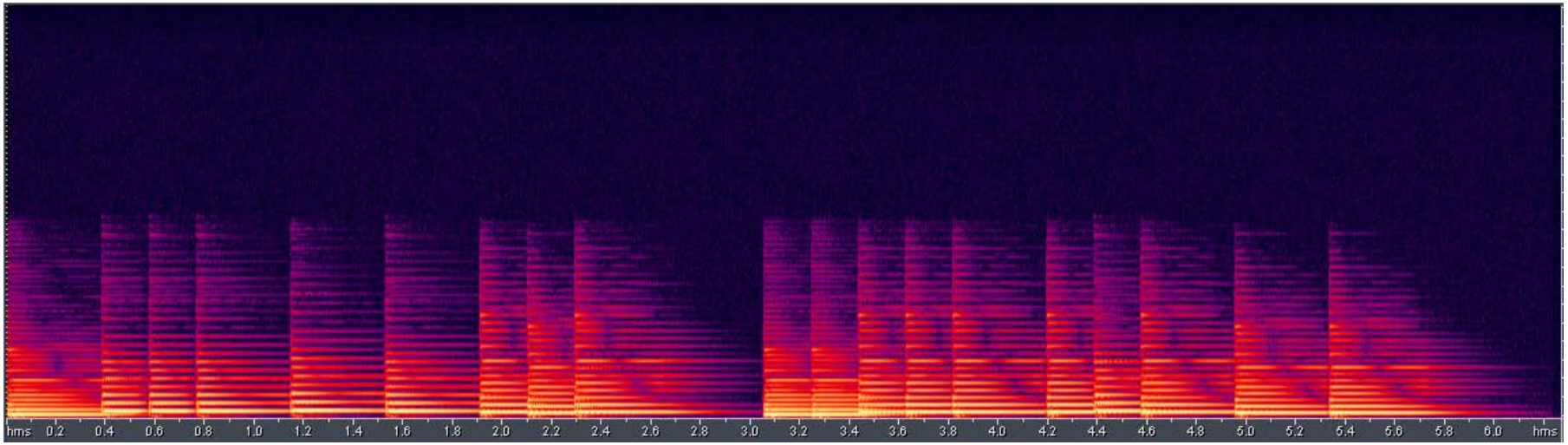
oscillations

Mètre dans la musique

- Organises les notes dans le temps
- Permet de percevoir les pulsations
- Est structuré d'une manière hiérarchique



Mètre comme propriété émergeante



Orientation de l’attention dans le temps
Dynamic Attending Theory (DAT)

L’attention varie dans le temps

↓

Variation de l’attention lorsque des oscillateurs internes synchronisent avec des périodicités de structures temporels externes (eg musique)

↓

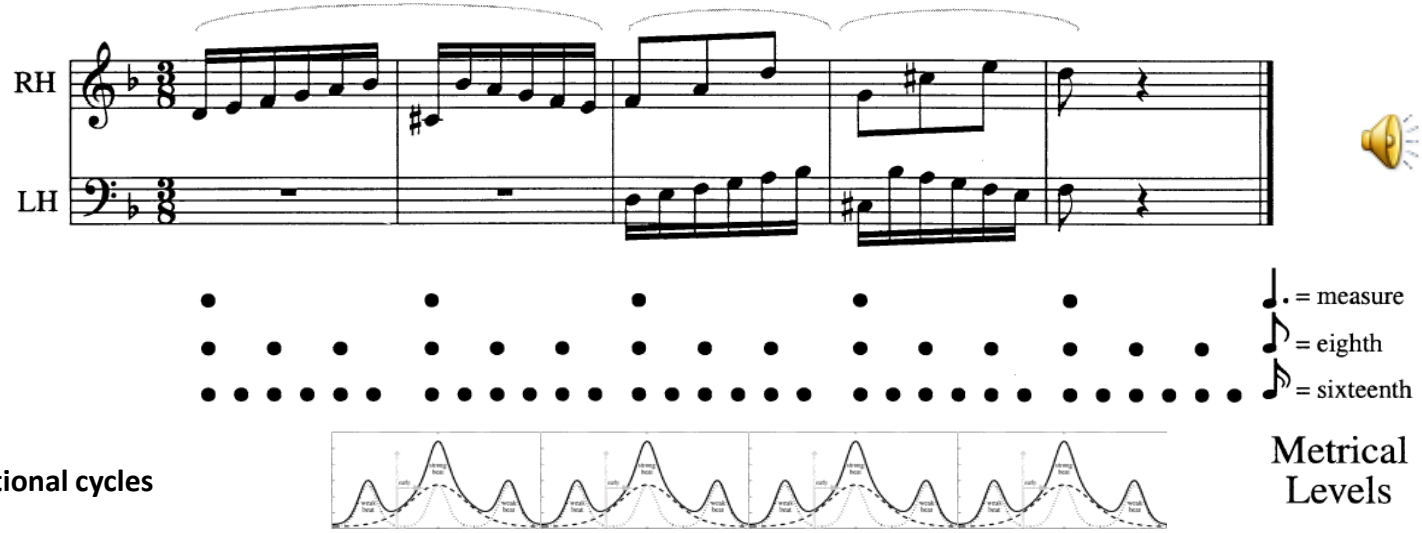
Points temporels plus ou moins attendus

↓

Au pic attentionnel le système est plus sensible (performant)

Jones, 1976

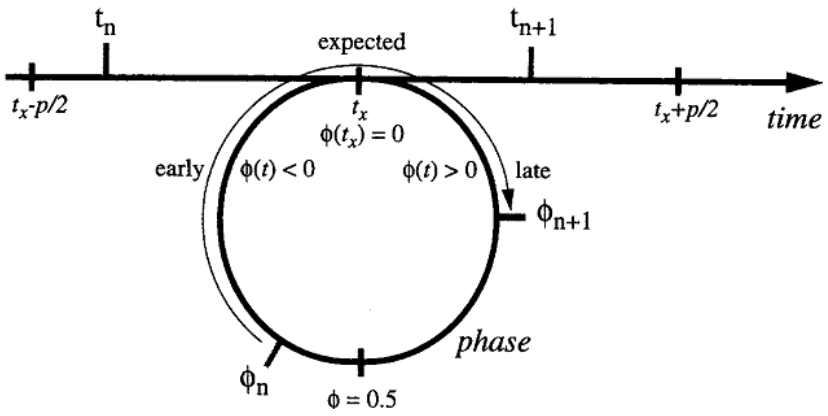
Dynamique de l'attente/Dynamics of attending



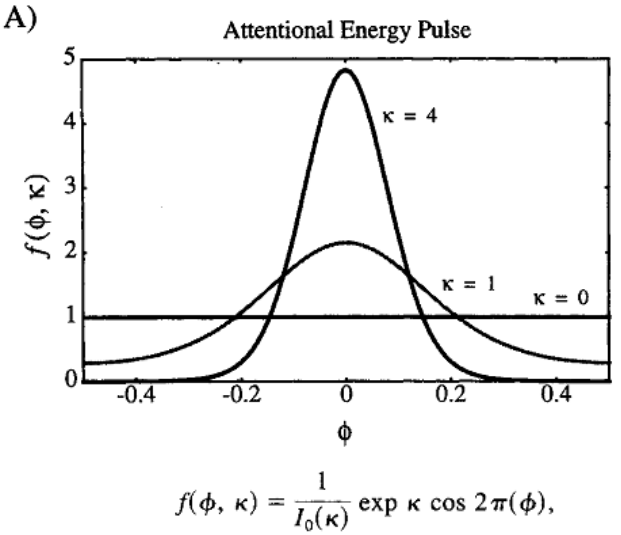
Attentional cycles

Pulse d'énergie attentionnelle à l'intérieur d'un cycle

Mapping internal oscillators and external rhythms



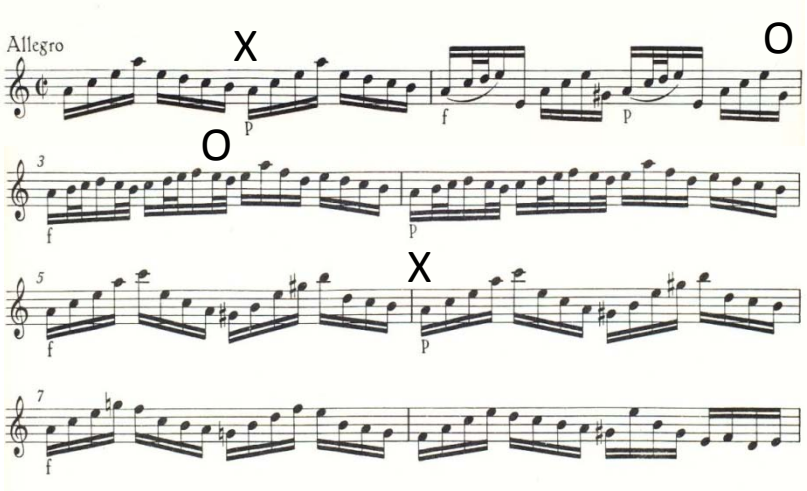
Circle map (mapping time onto phase)

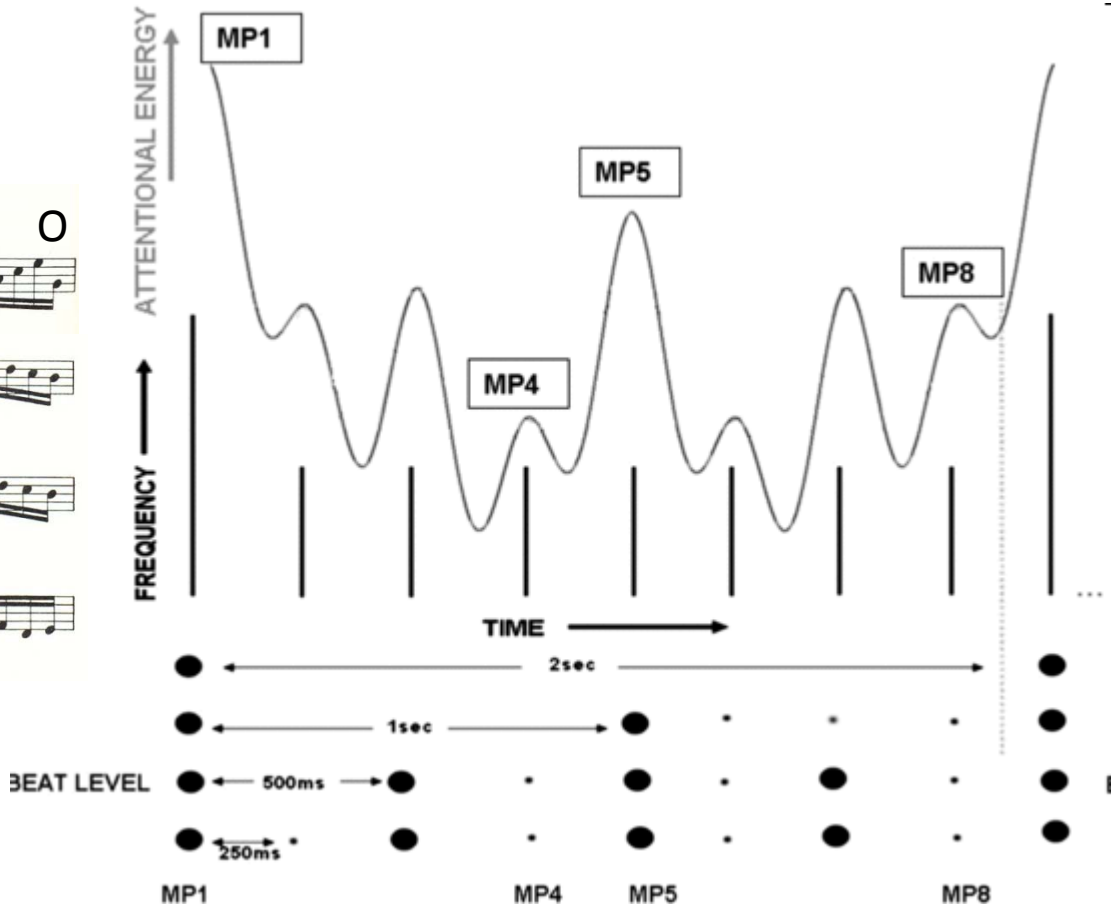


$$f(\phi, \kappa) = \frac{1}{I_0(\kappa)} \exp \kappa \cos 2\pi(\phi),$$

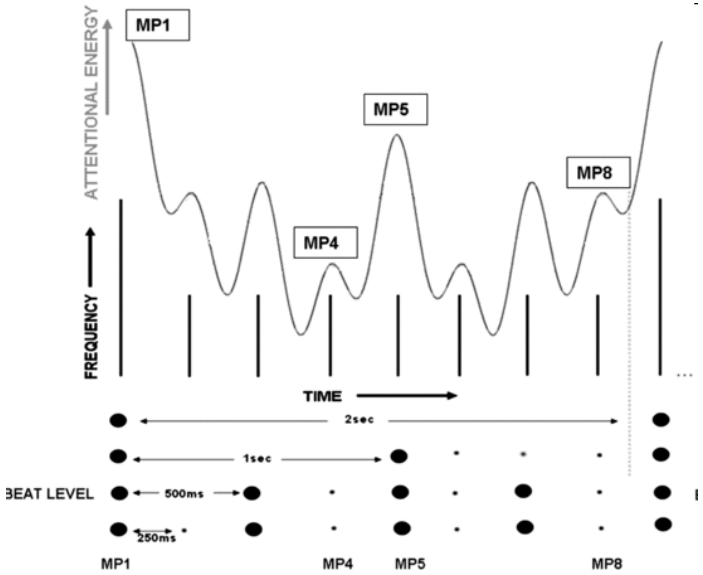
Large & Jones, 1999

Dynamics of attending

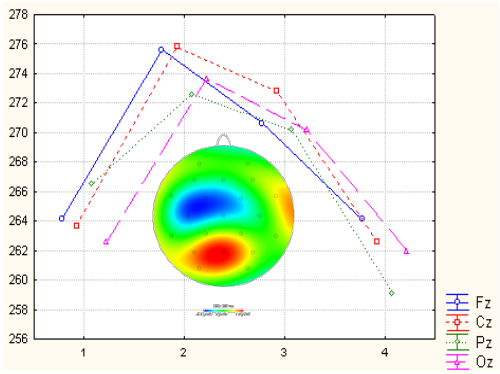




Dynamics of attending

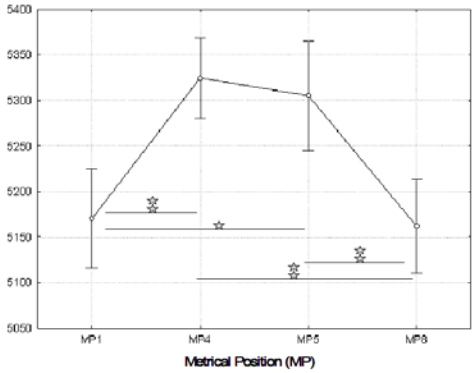


Influence de la metrique sur les PEs moteurs (N270)

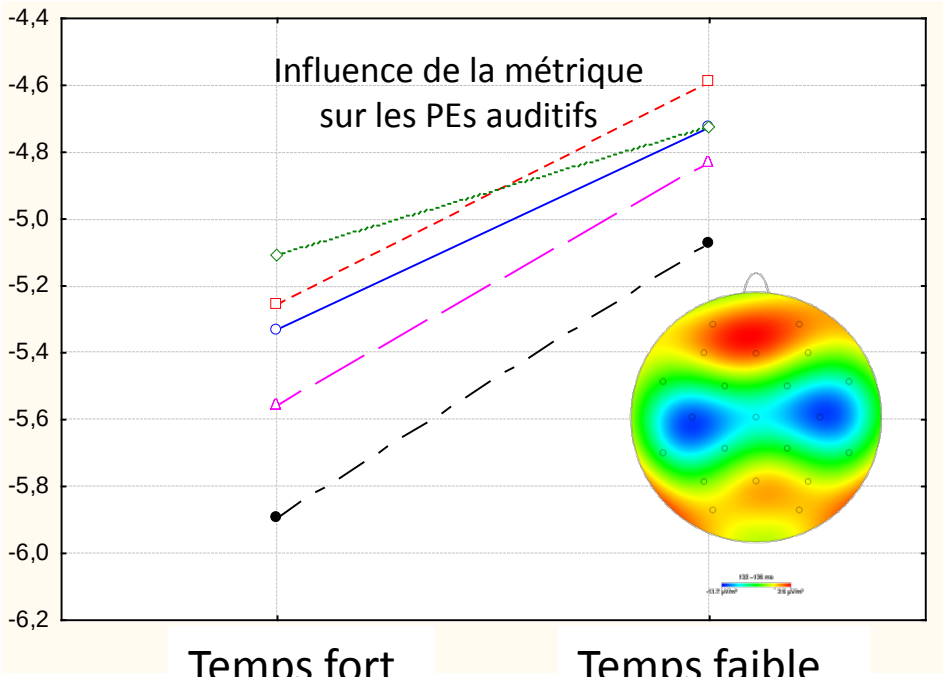


Experimental conditions

Influence de la métrique sur les TRs



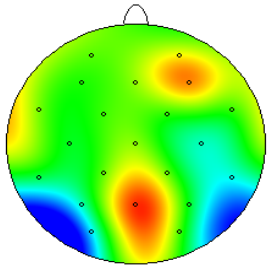
Experimental conditions



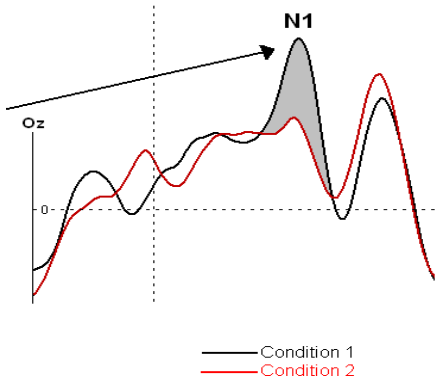
Temps fort

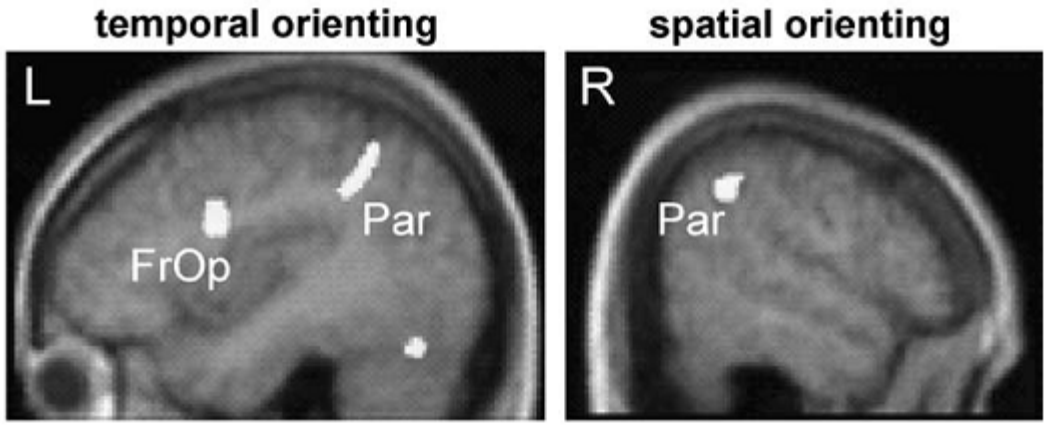
Temps faible

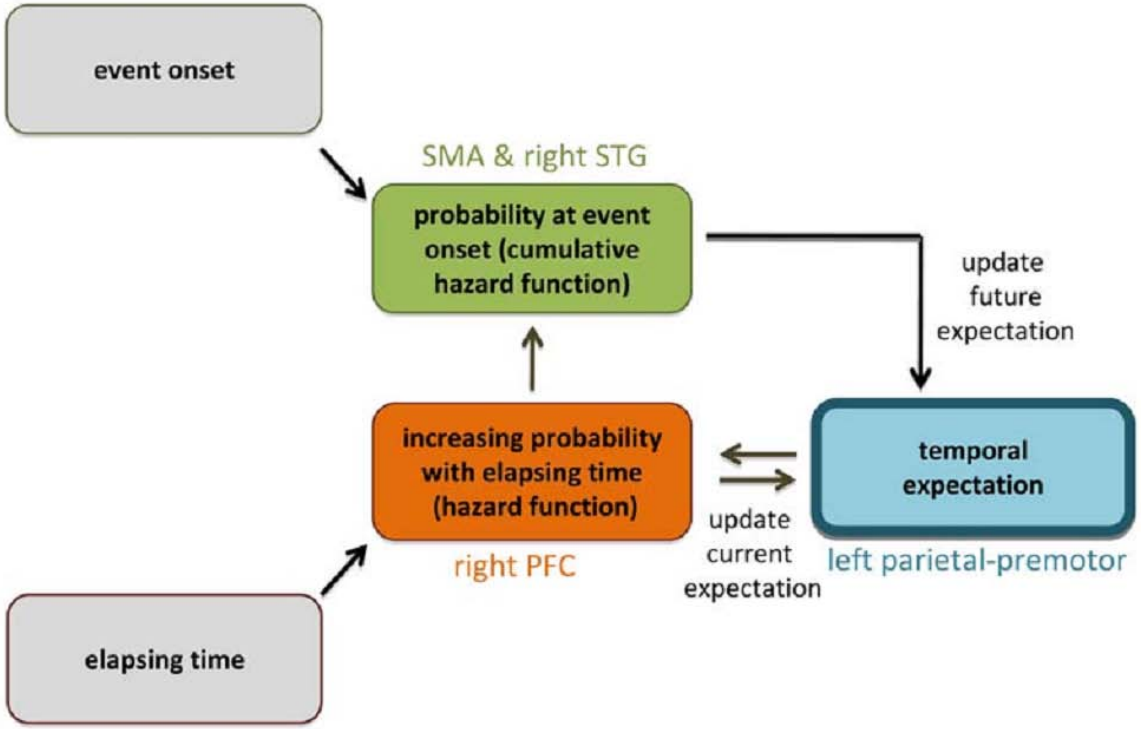
Influence de la métrique sur les Pes visuels



150 - 174 ms

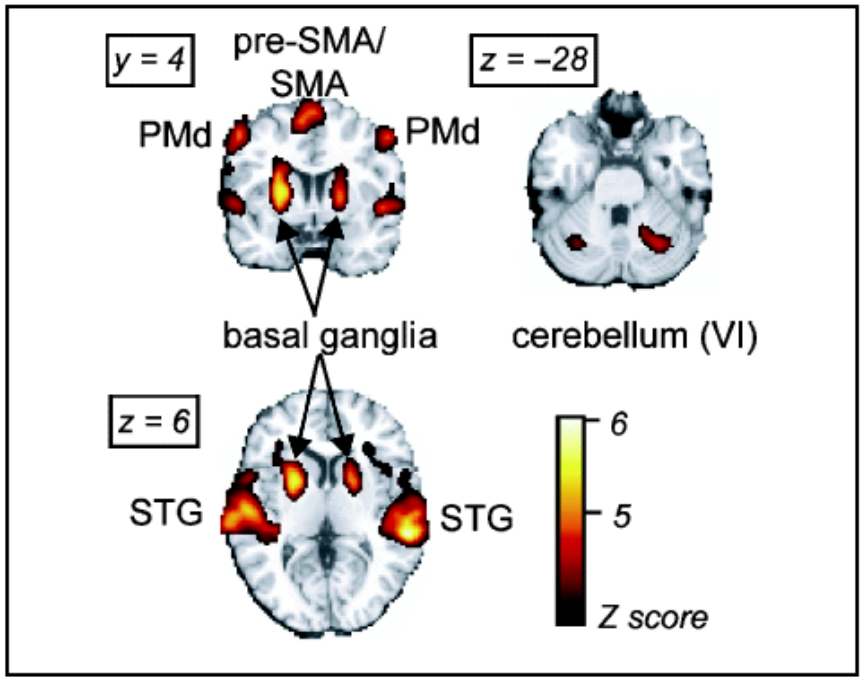




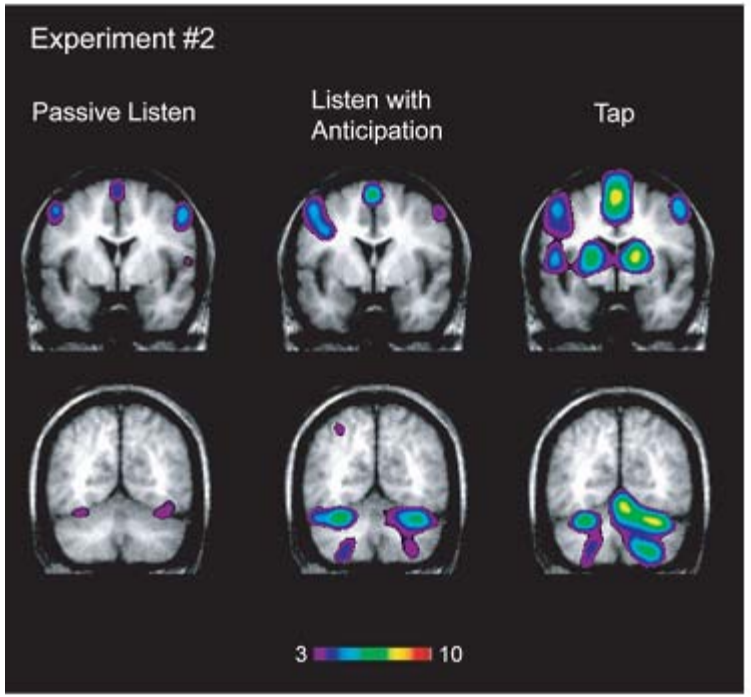


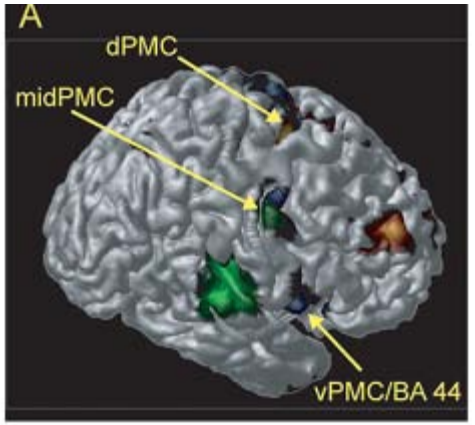
Coull 2004 & 2009

Listening to musical rhythms recruits motor regions



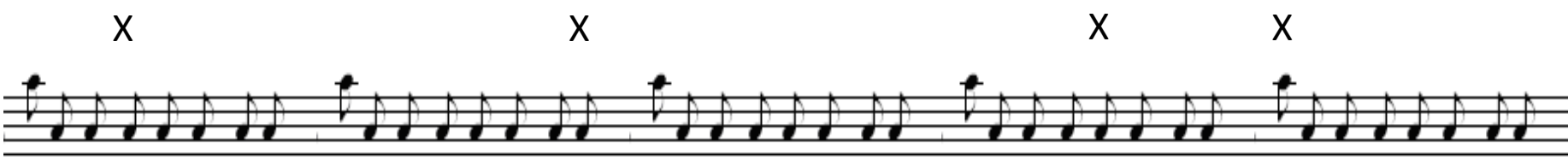
Grahan & Brett, 2007

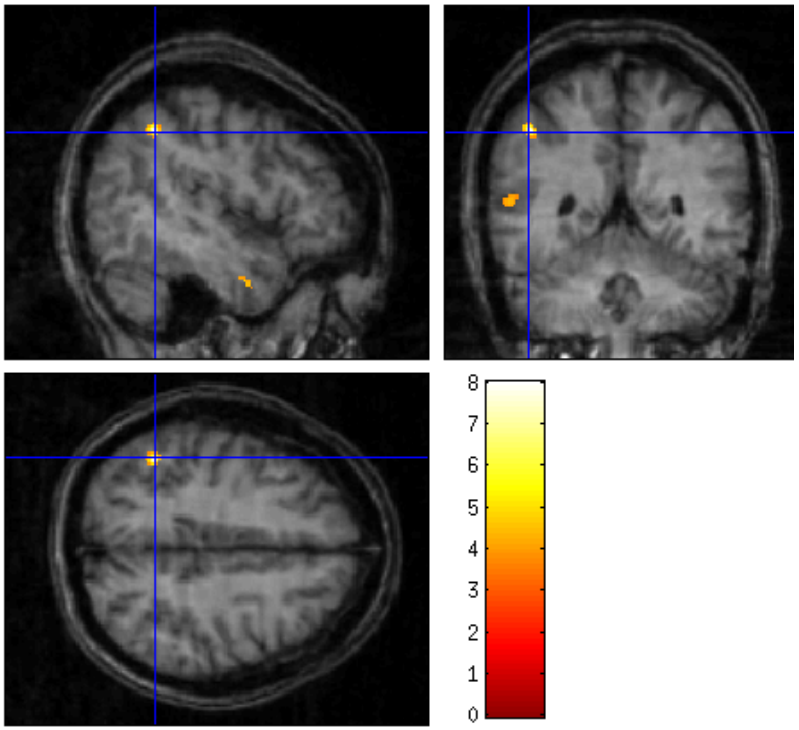


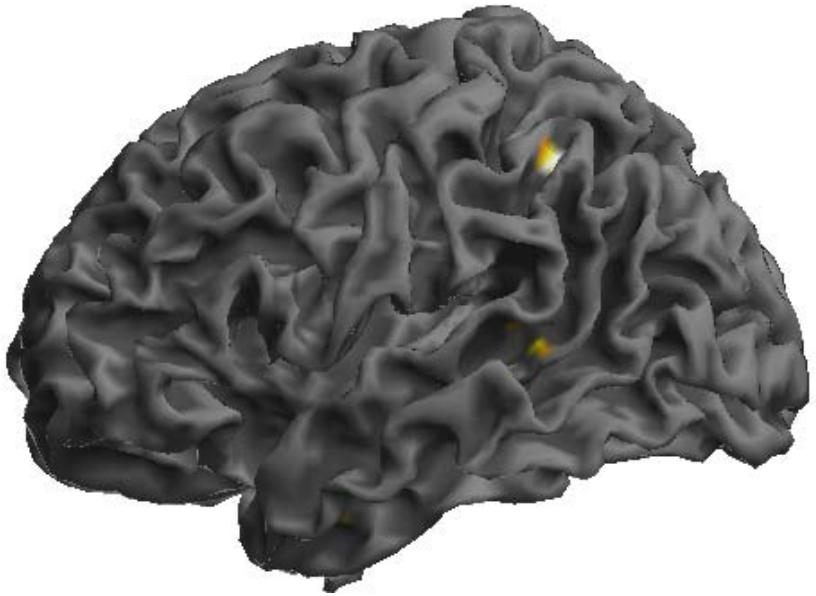


Chen et al., 2011

Effet du mètre



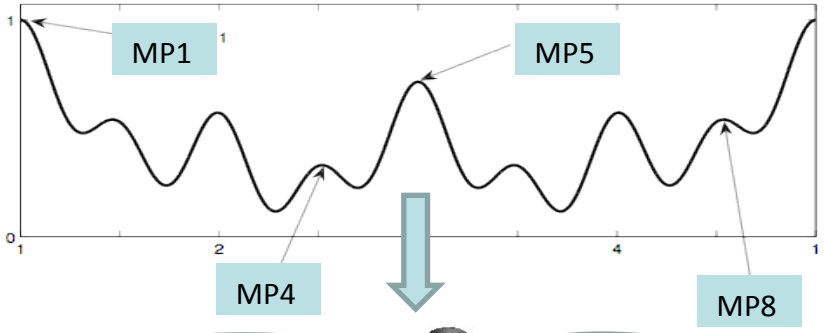


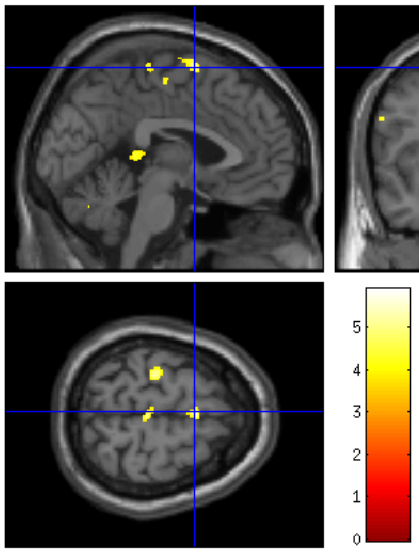


Cortex pariétal inferieur gauche

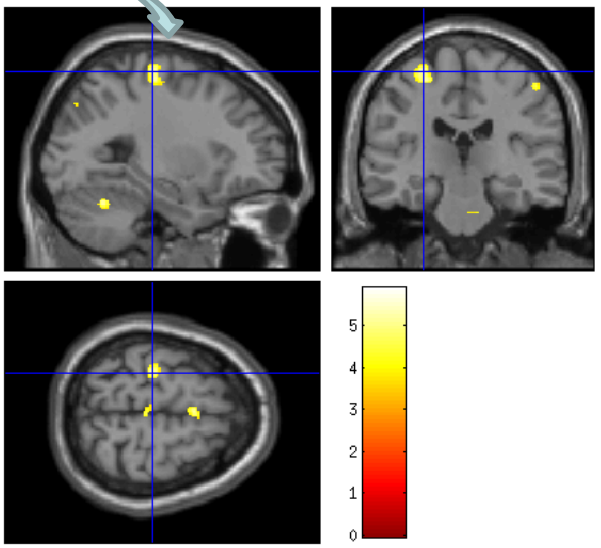
Bolger, Coull & Schön, in preparation

Connectivité

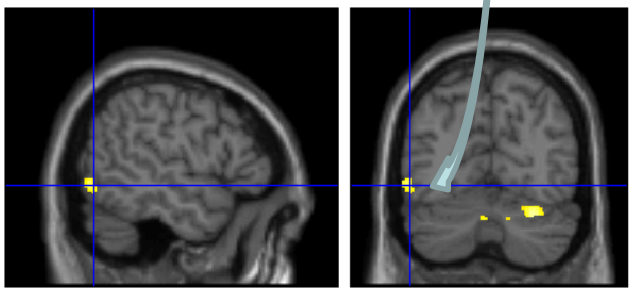




SMA



Precentral Gyrus (M1)



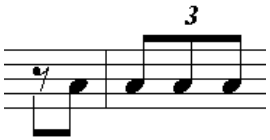
Occipital Cortex & Cerebellum

La hiérarchie métrique influence le niveau attentionnel

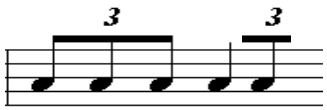
Traitement moteur et perceptif (cross-modal)

La métrique musicale permet de modifier
d’une façon implicite
l’orientation de l’attention dans le temps

Possibilité d’amorcer des structures prosodiques/rythmique langagières et faciliter le traitement de la parole



the Minimum



How are you feeling?

Role of motor representations in perception and imitation of singing

Motor resonance

Simulation theories: Perceiving through action?

- Motor activations during human motion perception (Stevens 2000, Kilner et al. 2003, Tai 2004, Ulloa 2007, Buccino et al. 2004)
- Faster imitation of human movements (Brass 2000, Kessler 2006)
- Stronger motor activations if the observer has a motor expertise (Calvo-Mérino 2005, Haslinger 2005, Cross 2006)

The same for auditory stimuli?

In **neuroimaging**:

– Motor activations while listening to vocal sounds
(Meyer 2005, Warren 2006, Chang 2009)

– Premotor activations in a musical discrimination task
(Brown & Martinez, 2007)

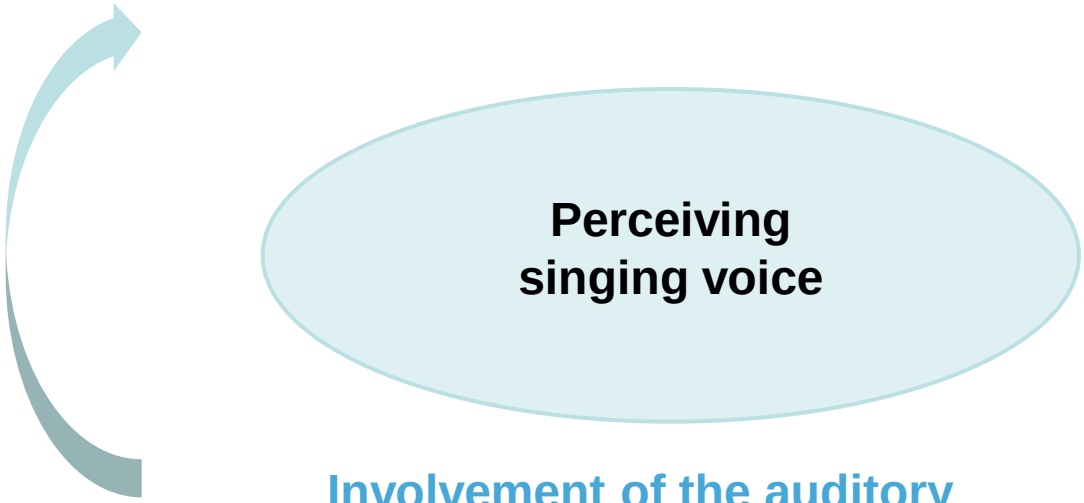
A **behavioral** observation:

Singing accuracy increases when the timbre of model is closer to the singer's timbre (Watts & Hall 2008,
Moore et al. 2008, …)

Question

Behavioral advantage for vocal compared to non-vocal stimuli ?

What link?

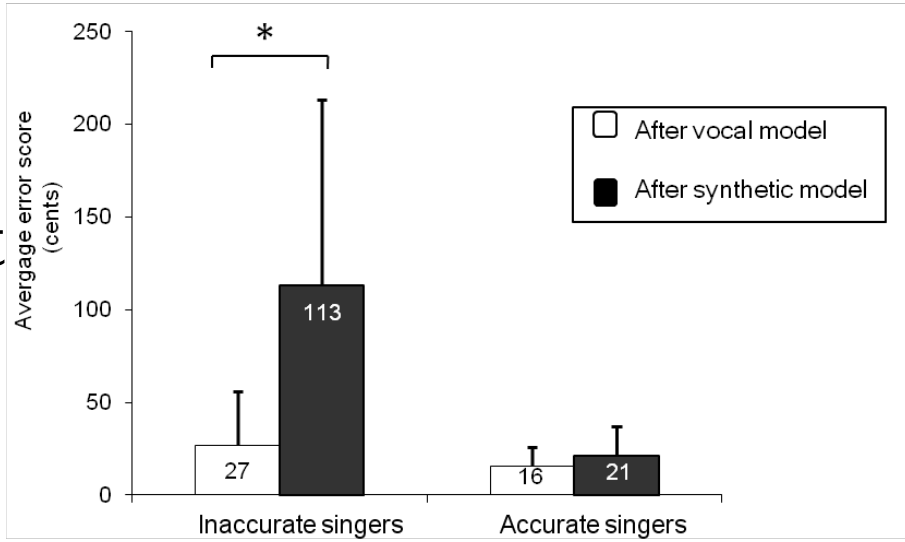


Involvement of the auditory « mirror » system?

Singing accuracy in pitch-matching

Lévêque, Giovanni, Schön (2012)

- Pitch-matching by poor and control singers
- Poor singers sang more accurately after hearing a vocal model
  - Motor representations as an help?
- No model effect in the control group
  - Ceiling effect or different strategy?

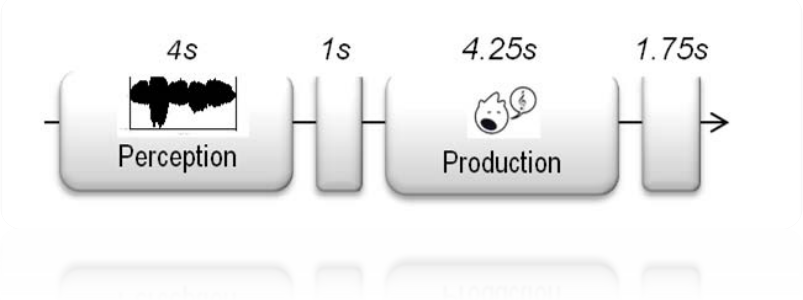


Melody repetition: an EEG study

- Melody repetition with:

– 60 **sung** melodies (sung with /o/)

– 60 **computer-generated** melodies (harmonic complex sound)



Hypothesis

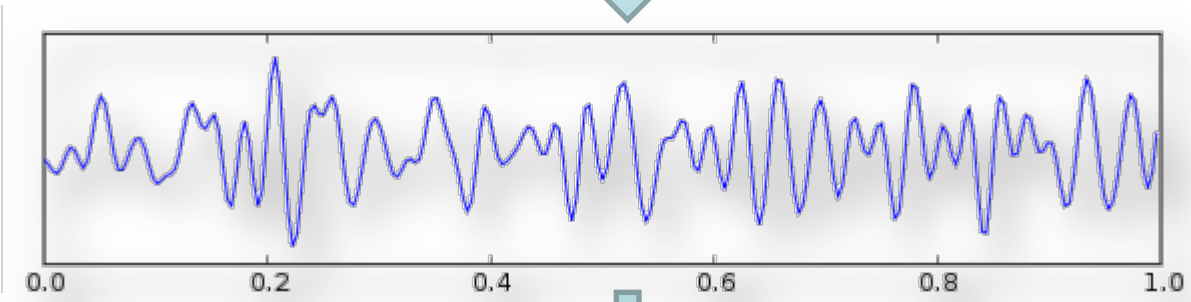
Hearing the sung melodies would induce more motor resonance than the computer-generated melodies

Beta and mu rhythm suppression during auditory perception?

Movement preparation and execution

Activity of motor and sensorimotor neuron populations

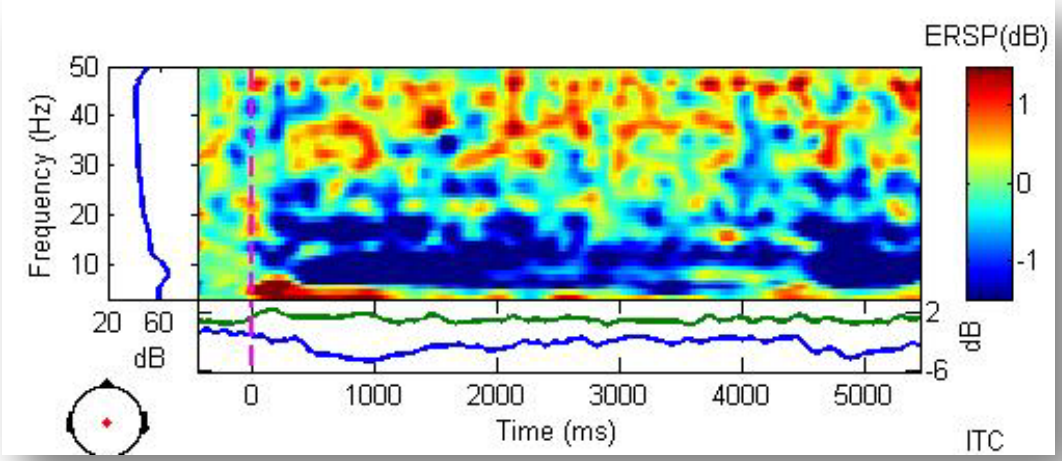
Suppression of their rest oscillatory rhythms: beta & mu



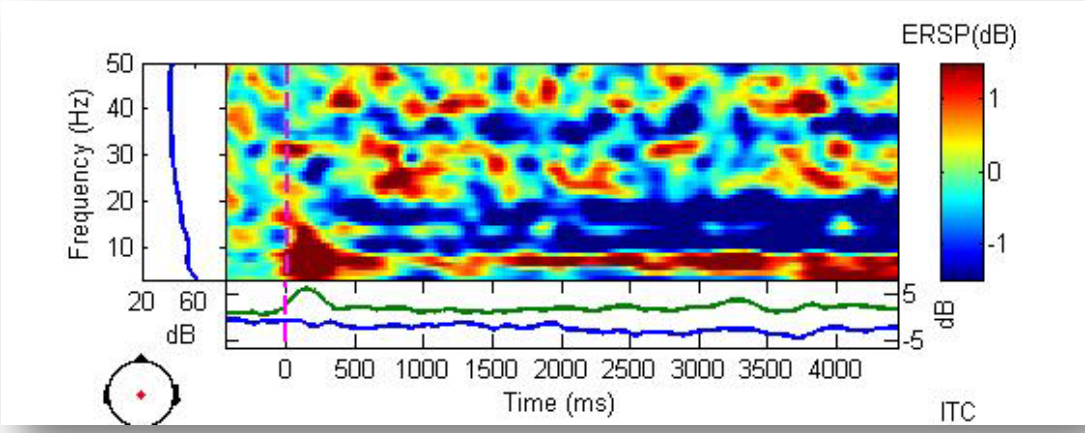
Oscillatory EEG activity during melody production and perception

Participant 9

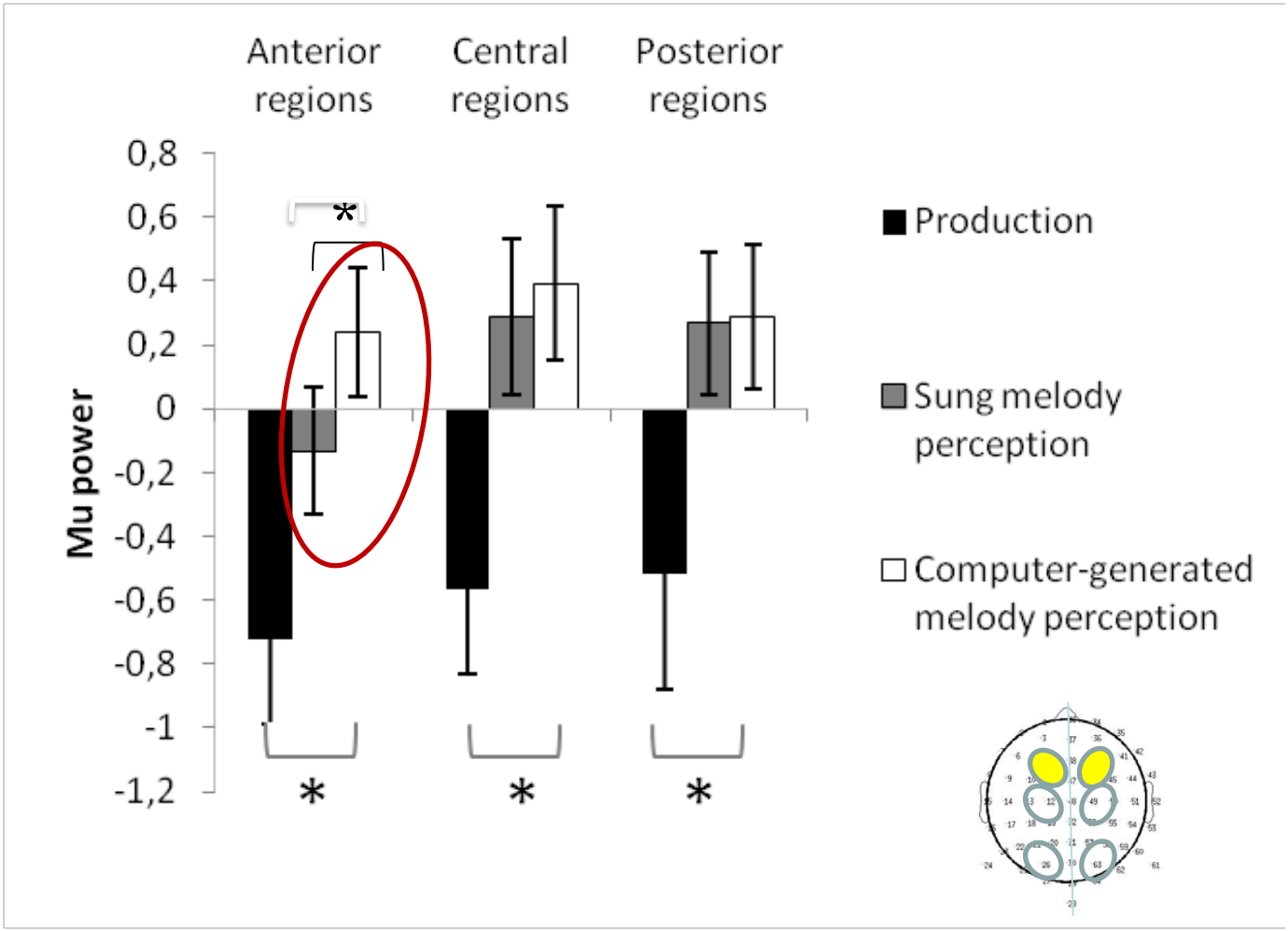
Song production



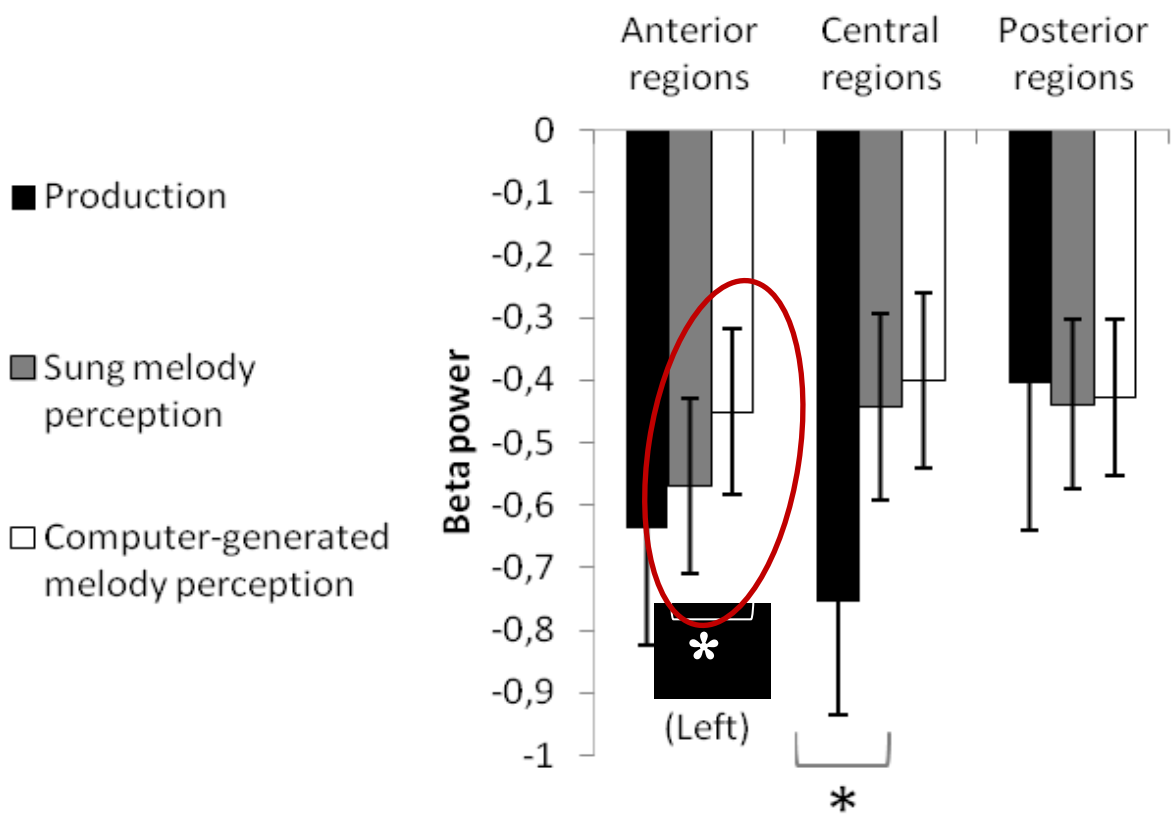
Sung melody perception



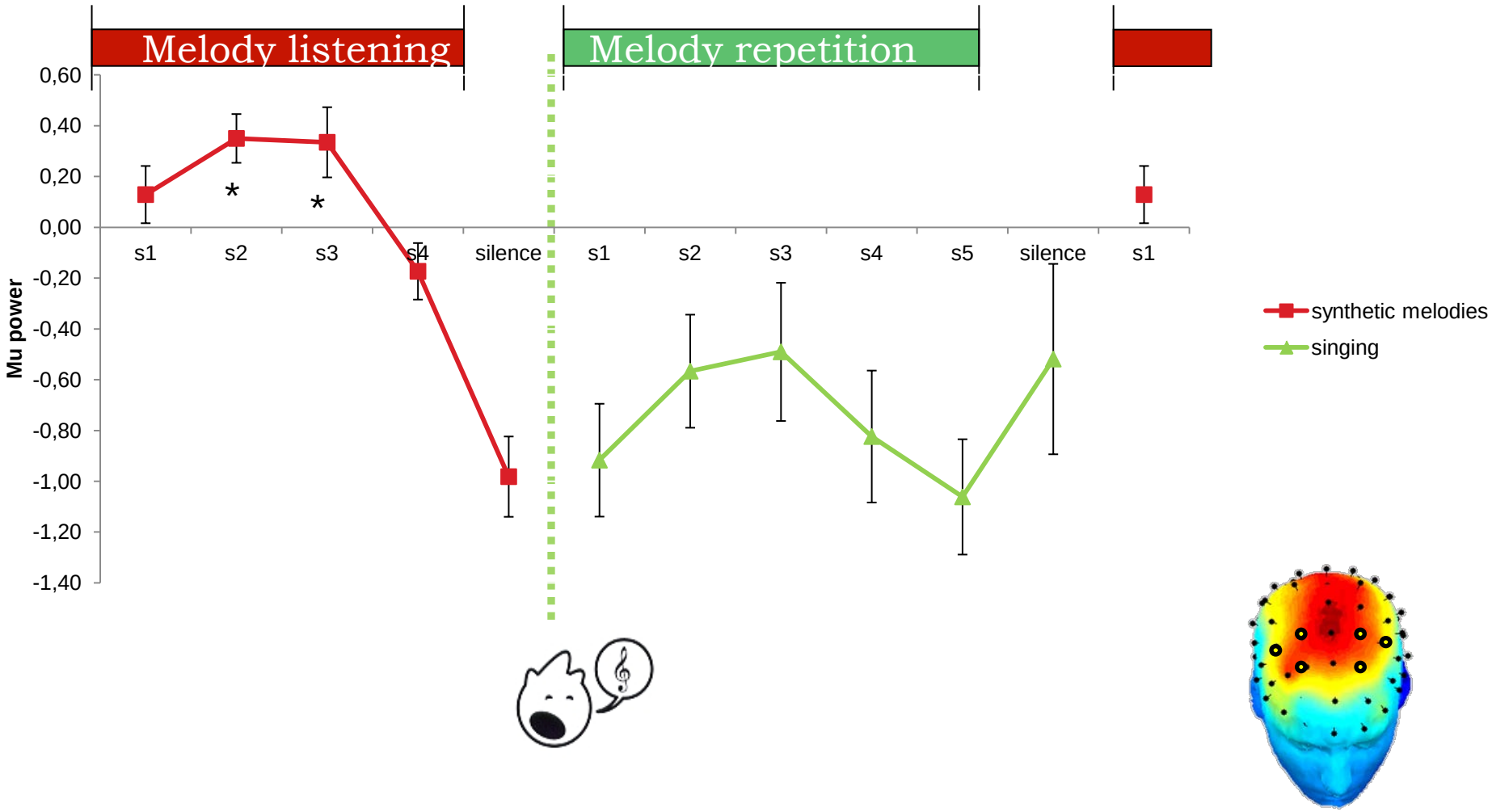
Activité mu


Anterior regions
Central regions
Posterior regions
Mu power
0,8
0,6
0,4
0,2
0
-0,2
-0,4
-0,6
-0,8
-1
-1,2
*
*
*
*
Production
Sung melody perception
Computer-generated melody perception

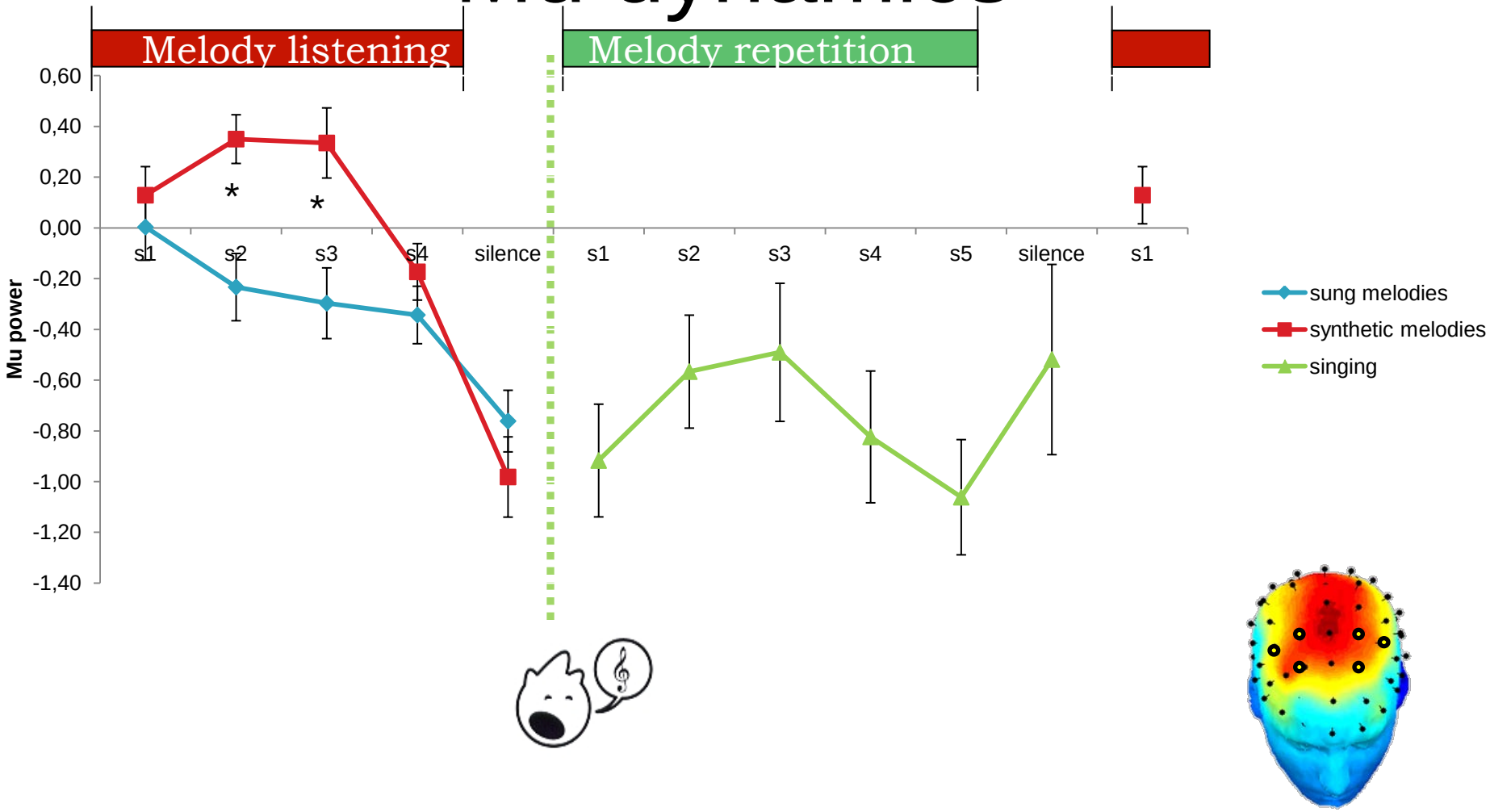
Activité beta



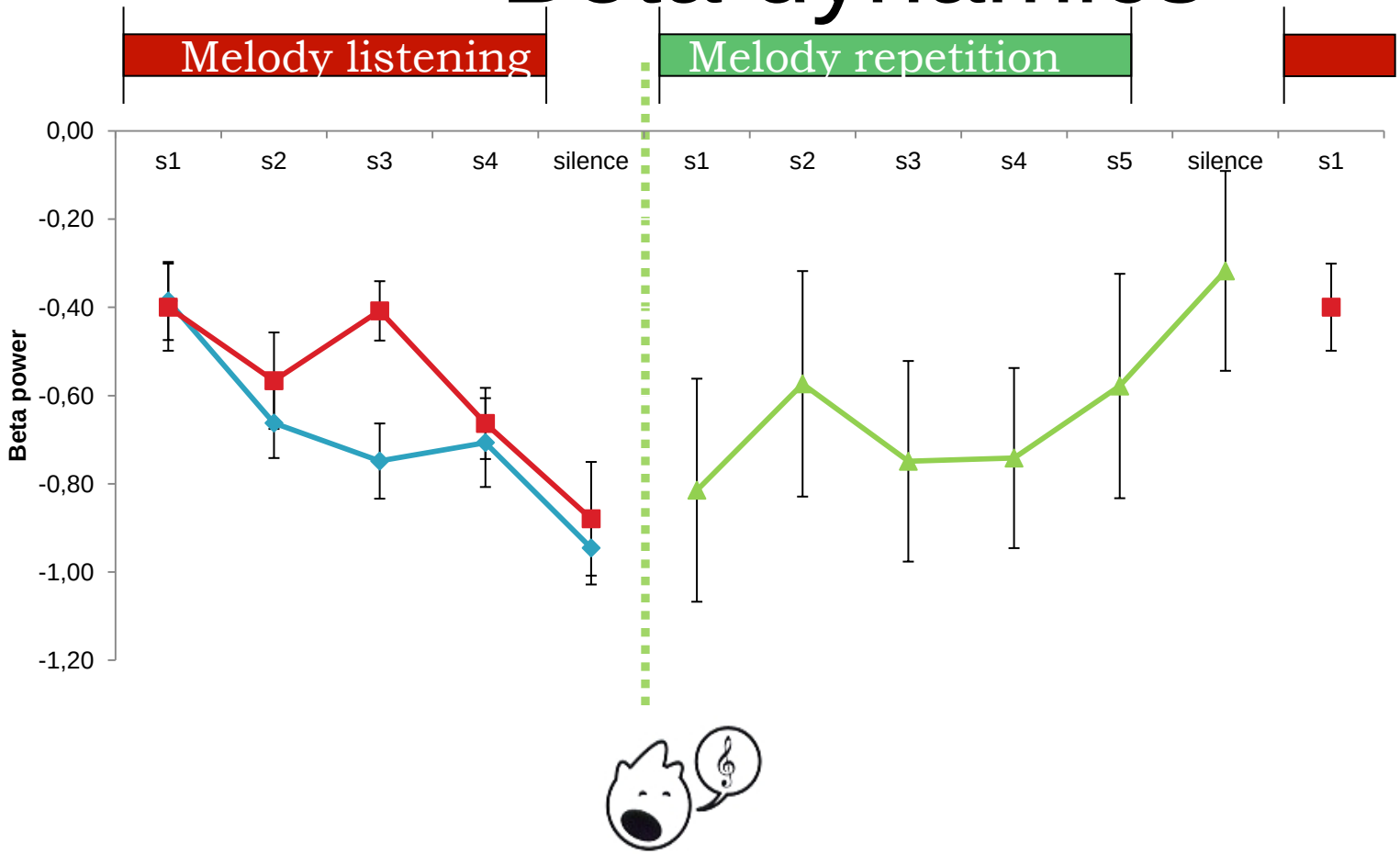
Mu dynamics

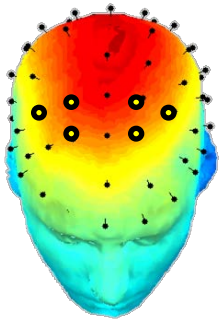

Melody listening
Melody repetition
0,60
0,40
0,20
0,00
-0,20
-0,40
-0,60
-0,80
-1,00
-1,20
-1,40
Mu power
s1
s2
s3
s4
silence
s1
s2
s3
s4
s5
silence
s1
*
*
synthetic melodies
singing

Mu dynamics

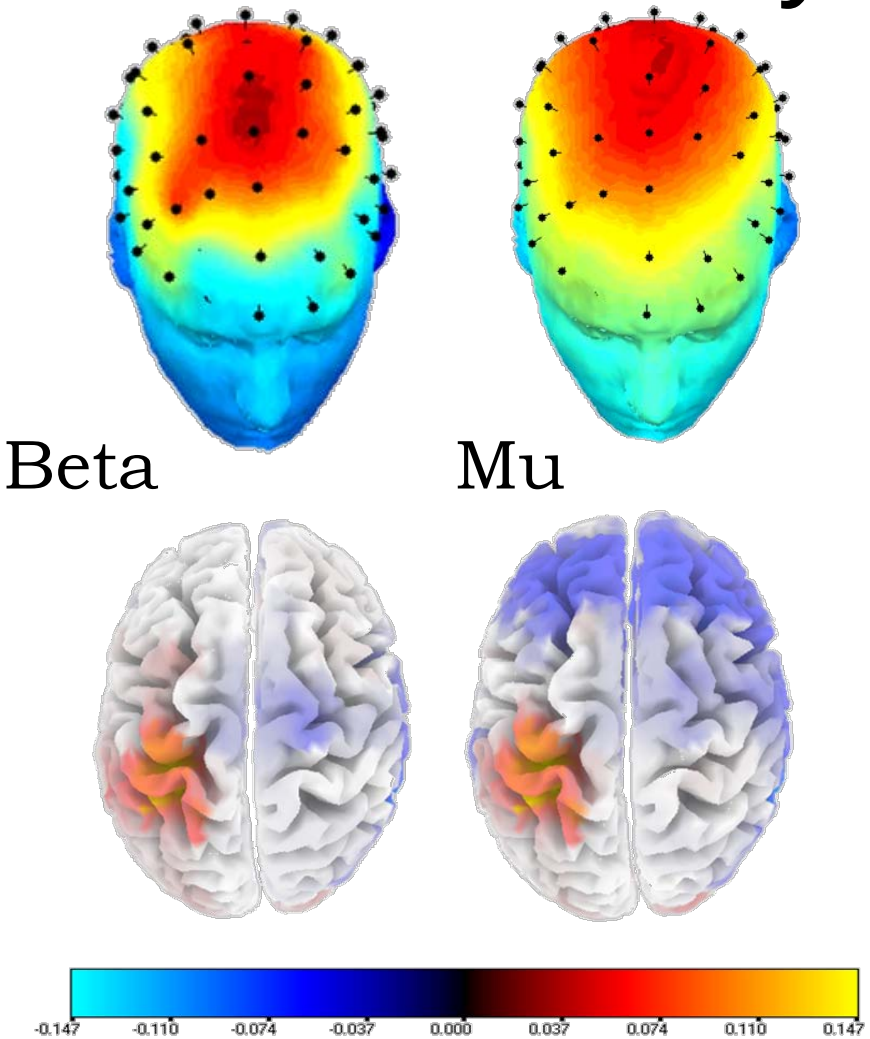

Melody listening
Melody repetition
0,60
0,40
0,20
0,00
-0,20
-0,40
-0,60
-0,80
-1,00
-1,20
-1,40
Mu power
s1
s2
s3
s4
silence
s1
s2
s3
s4
s5
silence
s1
*
*
sung melodies
synthetic melodies
singing

Beta dynamics





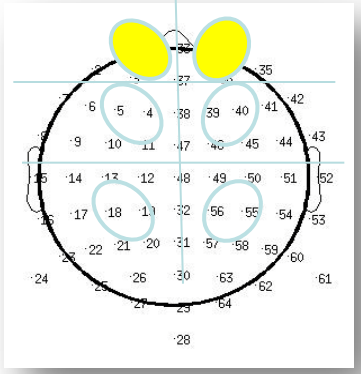
Carte et source des rythmes

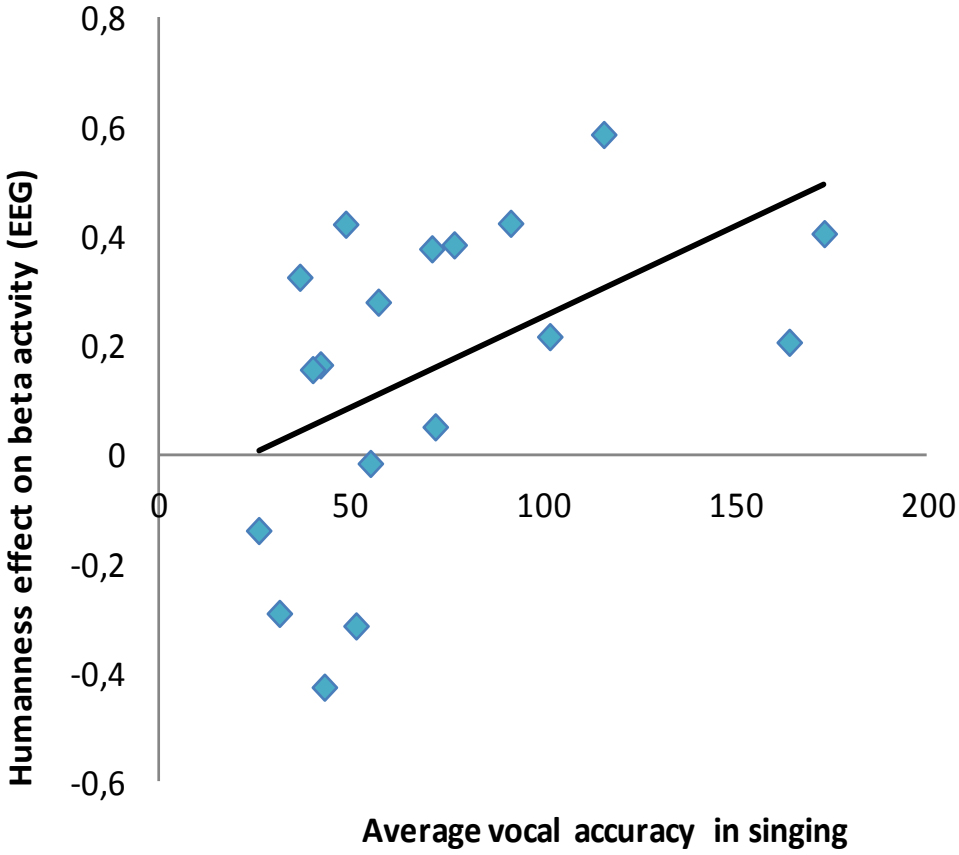


Vocal accuracy and motor resonance

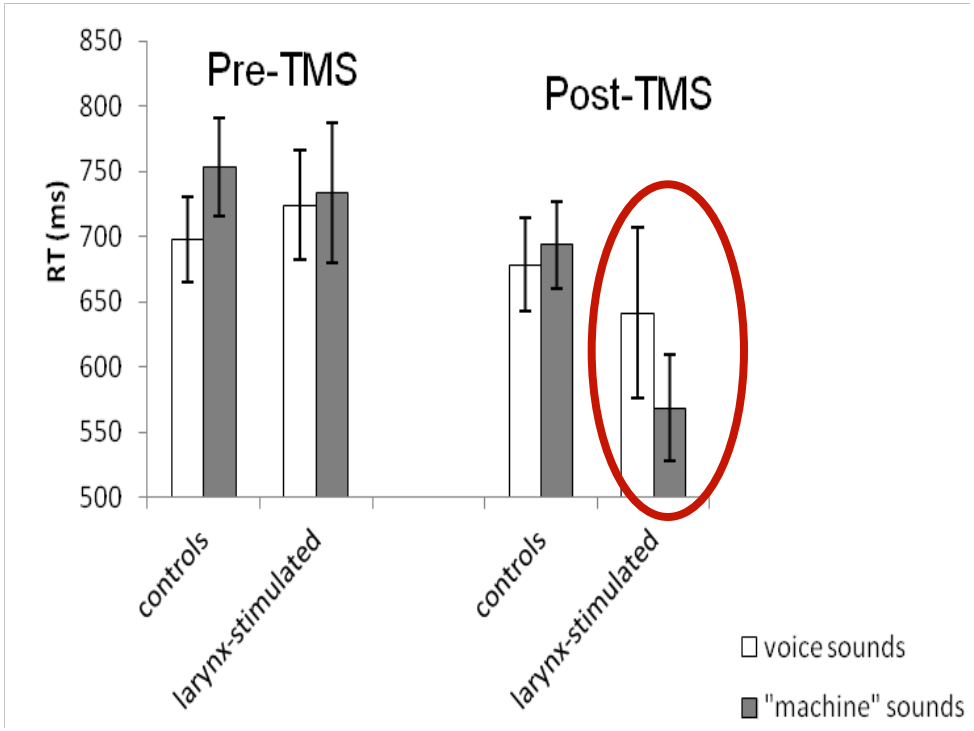
- Participants with poorer singing accuracy had more motor resonance for voice perception

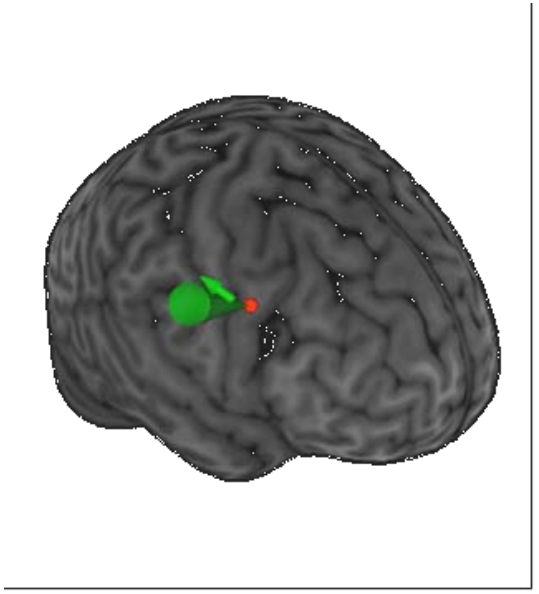
Spearman Correlation, r=0.567, p<.05



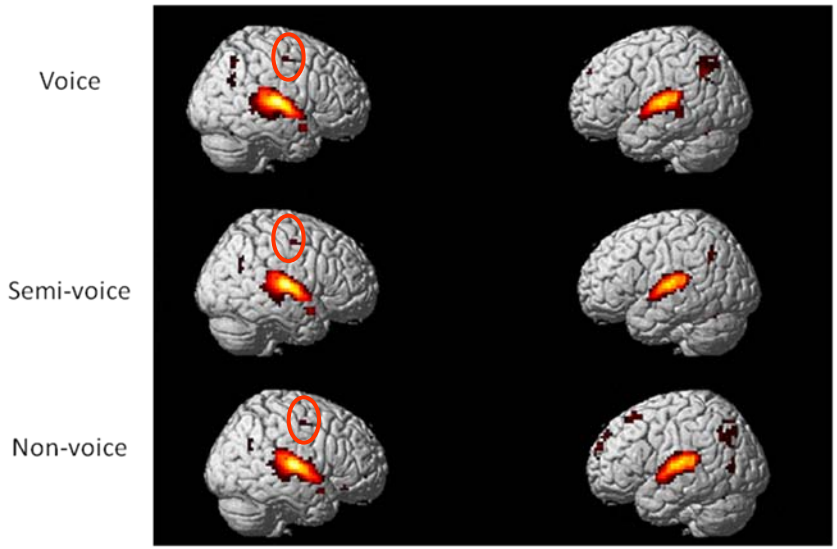


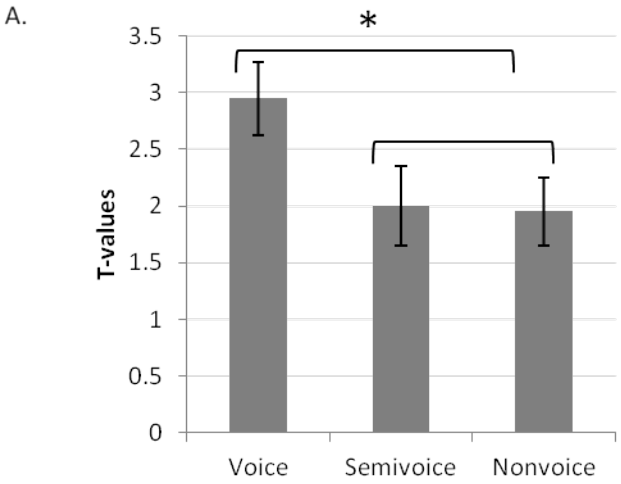
Inhibiting the premotor larynx area and measuring how it affects a perceptive task



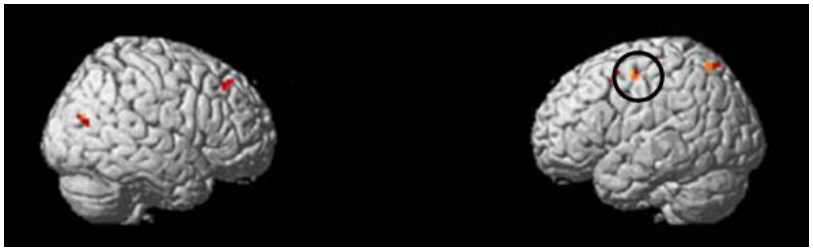


Longer reaction time for vocal versus non-vocal sounds after larynx area stimulation (p=0,01)



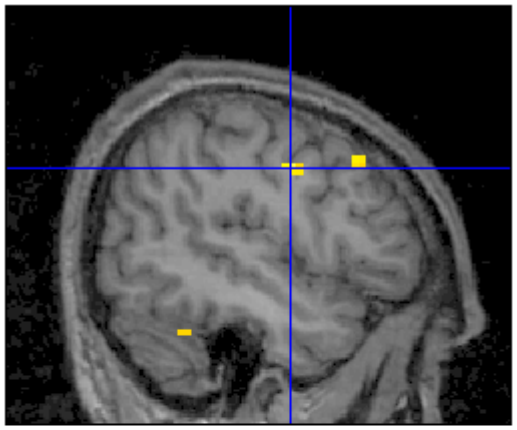


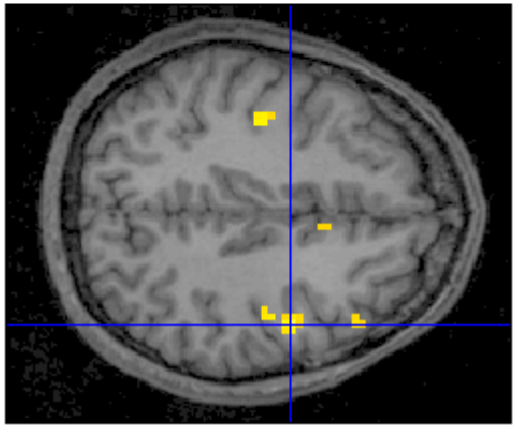
- Activité motrice pendant l'écoute
- Modulation par l'aspect « humain »
- Modulation en fonction de la justesse des individus
- Changement de la connectivité entre aires motrices et auditives par le degrée d'humanité

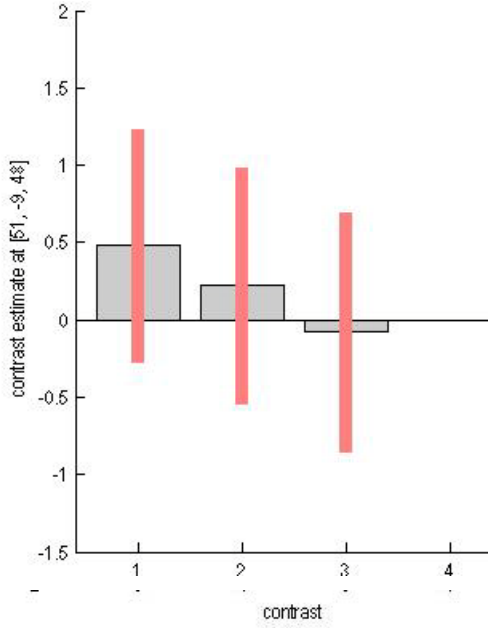


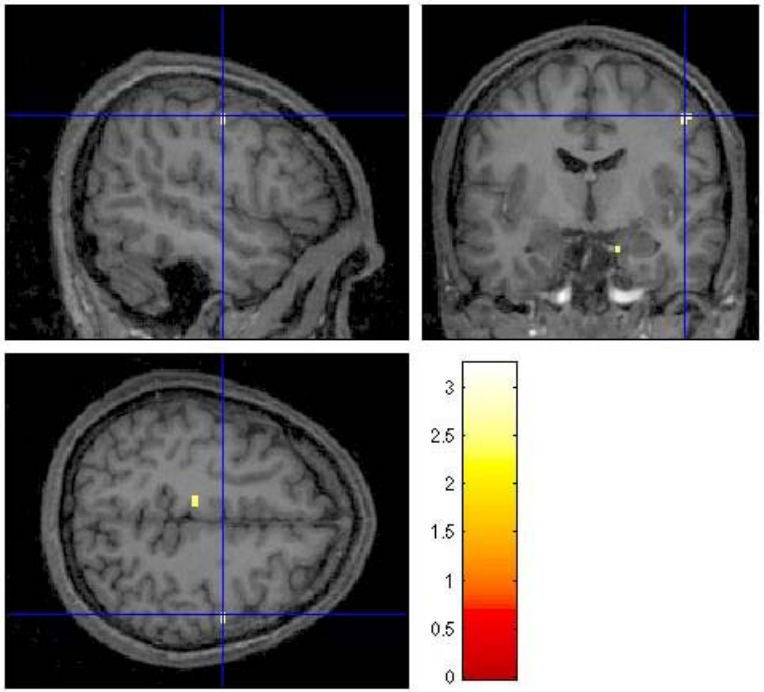
Variabilité interindividuelle

Sujet 7 qui chante

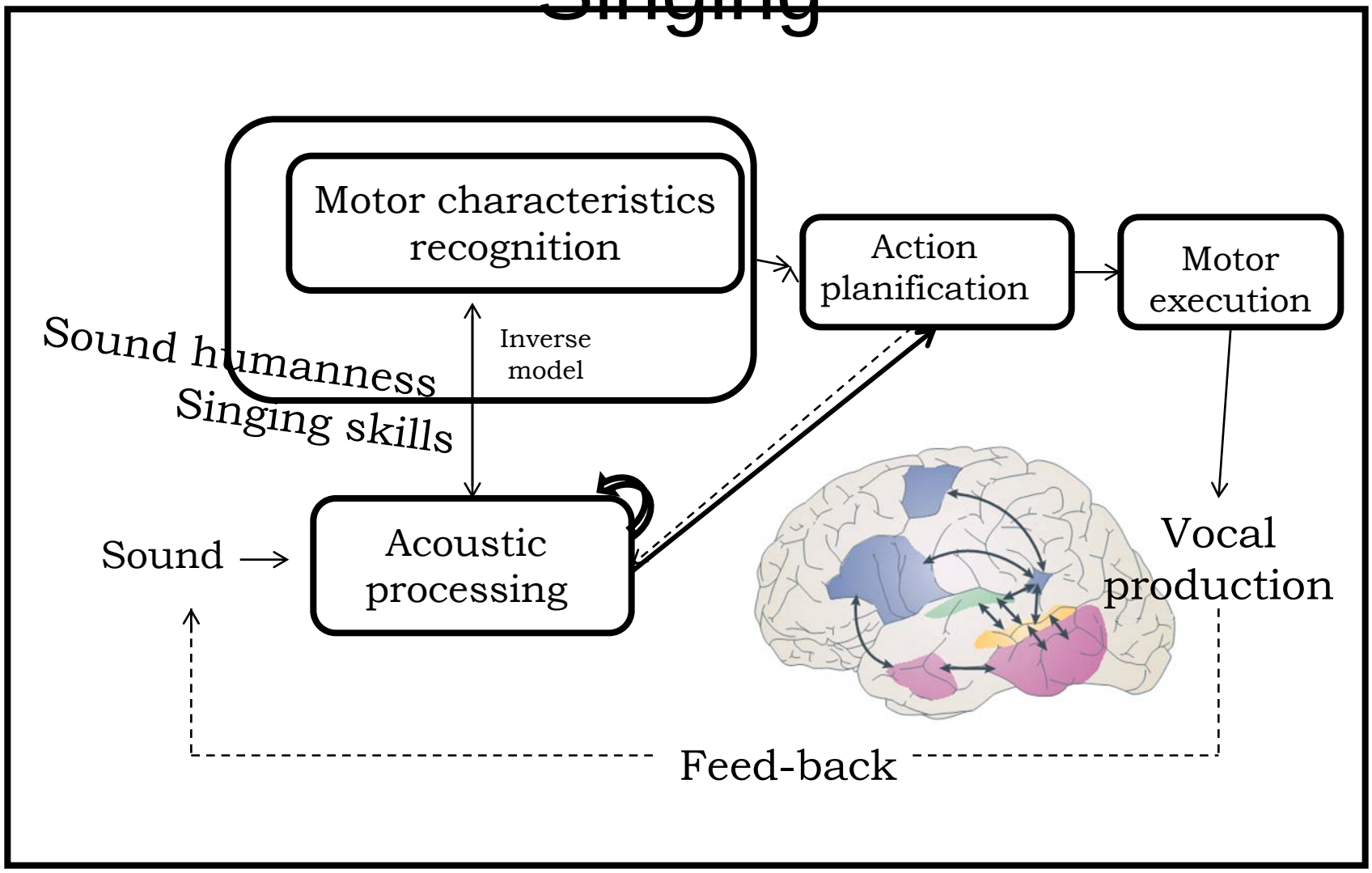








Singing


Motor characteristics recognition
Action planification
Motor execution
Inverse model
Sound humanness
Singing skills
Sound
Acoustic processing
Vocal production
Feed-back

Conclusions

- Avantage pour la voix humaine
- Implications de rythmes sensorimoteurs pendant l'écoute de la voix chantée
  - Plus important pour la voix naturelle que pour des sons «synthetique »
  - Plus important pour les mauvais chanteurs
- Les connections audio-motrices sont influencées par la reproductibilité

Yohana Lévêque

Deirdre Bolger

Wiebke Trost

Vera Tsogli

Nia Cason

2010-2013

SEVENTH FRAMEWORK PROGRAMME

MARIE CURIE ACTIONS

AGENCE NATIONALE DE LA RECHERCHE

ANR