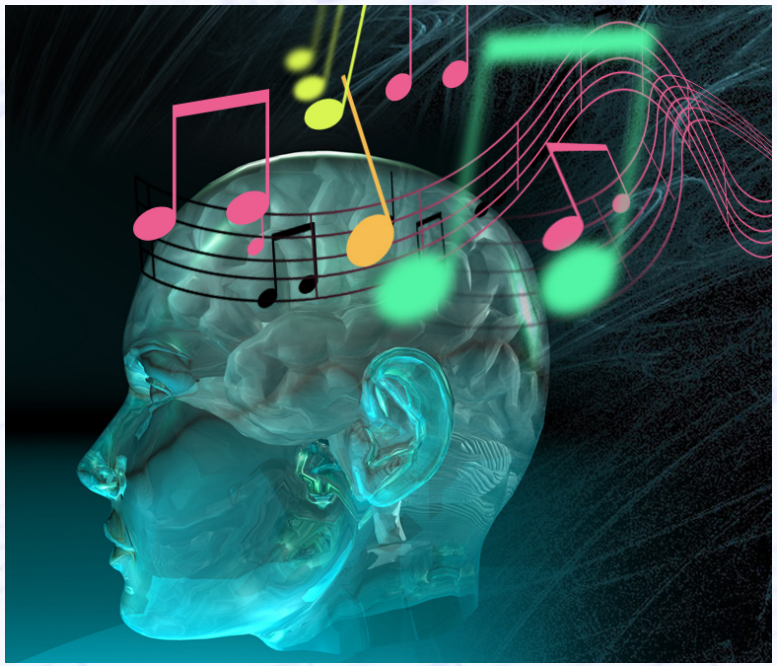


Neuroscience de la musique

Isabelle Peretz

Professeure en psychologie

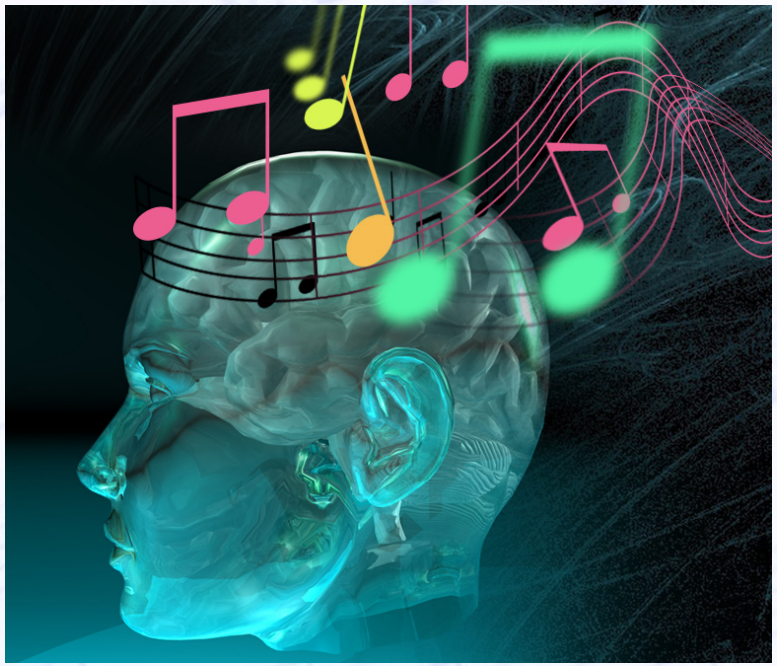
BRAMS, Université de Montréal

Conférencière invitée, Collège de France

Université de Montréal

COLLÈGE DE FRANCE 1530

Brams



Neuroscience de la mélodie

Isabelle Peretz

Professeure en psychologie

BRAMS, Université de Montréal

Conférencière invitée, Collège de France

Université de Montréal

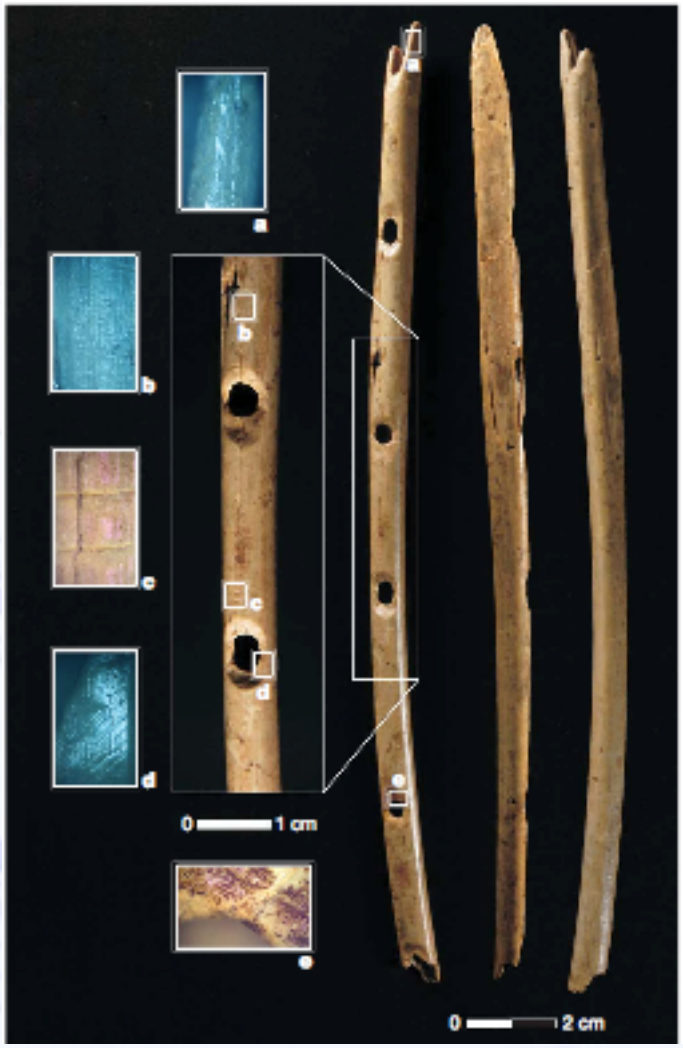
COLLÈGE DE FRANCE 1530

Brams

La musique transcende le temps, l'espace et la culture

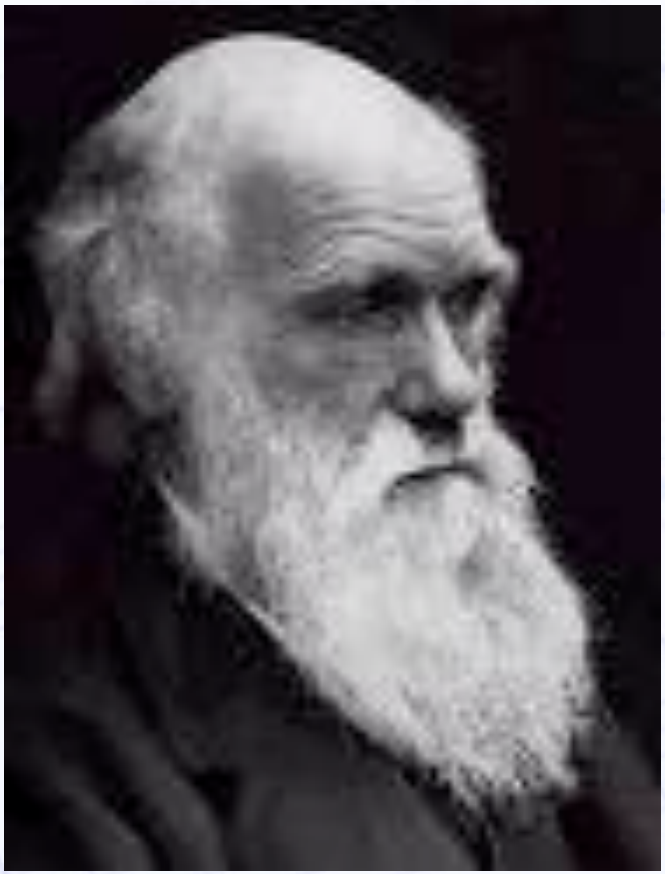
Tout comme la parole, la musique:

- ✓ Remonte à la pré-histoire
- ✓ Universelle
- ✓ Un trait humain?
- ✓ Acquise très tôt et spontanément
- ✓ Code auditivo-vocal élaboré
- ✓ Mobilise de nombreux systèmes (perception, motricité, émotions, mémoire, attention, imagination,...)

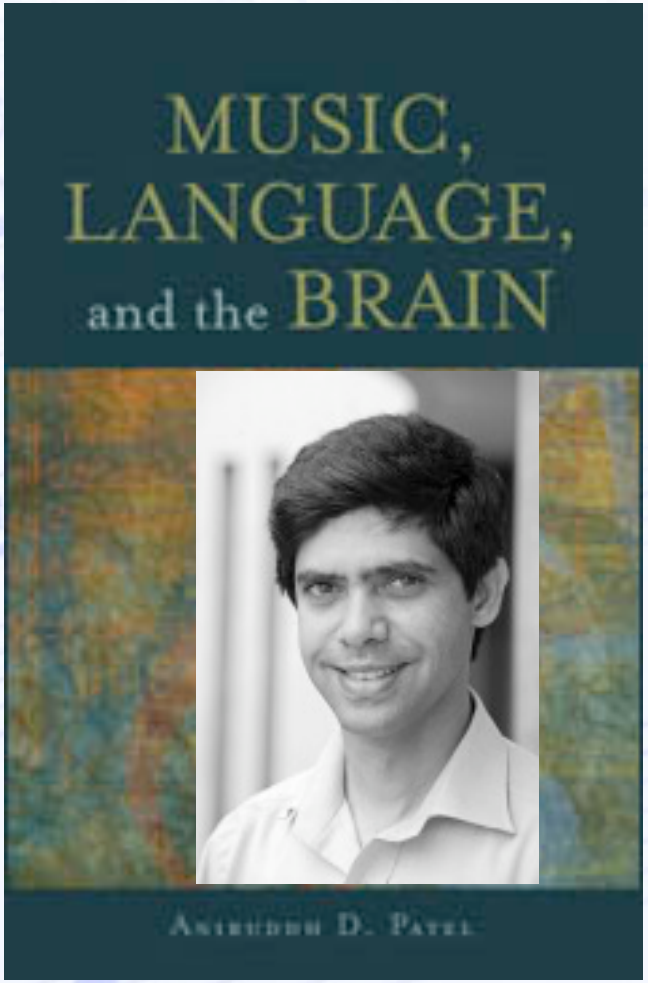


Conard et al., Nature, 2009

"As neither the enjoyment nor the capacity of producing musical notes are faculties of the least use to man in reference to his daily habits of life, they must be ranked among the most mysterious with which he is endowed" (Darwin, 1871)



La musique, est-elle un dérivé du langage ?



L'aphasie congénitale: du comportement aux gènes

- Phenotype
  - Sévère difficulté à reproduire mots et non-mots
  - Apraxie oro-faciale
- Particularités cérébrales
  - Niveau de matière grise anormale dans le noyau caudé, le gyrus frontal inférieur (Broca), dans le Gyrus angulaire (Wernicke) et le putamen.
- Gènes
  - Héréditaire
  - FOXP2

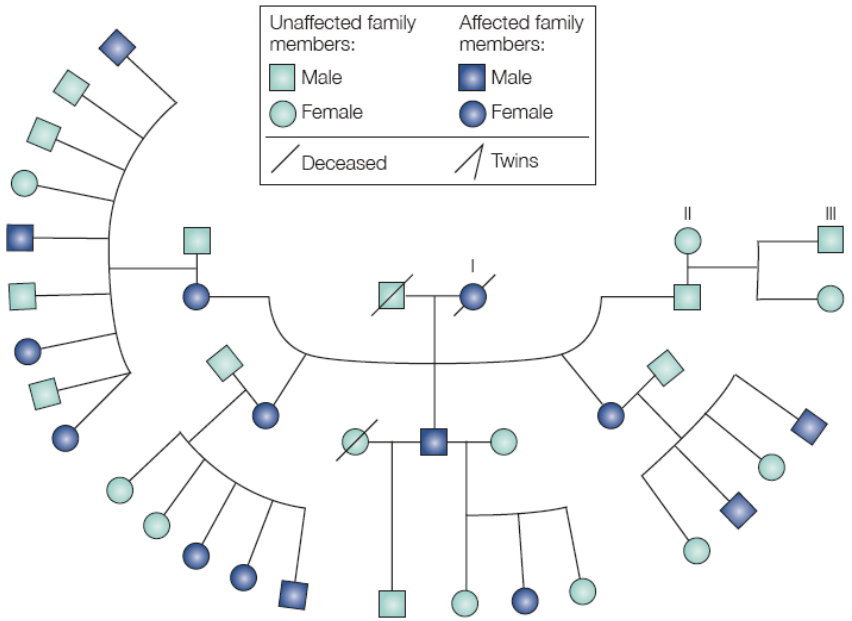


Figure 1 | **Pedigree of the KE family.** I, II and III represent the generations. Modified, with permission, from S FG 25 © (2002) Oxford University Press.

Vargha-Khadem et al (2005) *Nature Reviews/Neuroscience*

L'aphasie congénitale: du comportement aux gènes

- FOXP2 et chant
  - Anomalie du rythme (production et perception)
  - Mélodie normale (production et perception)

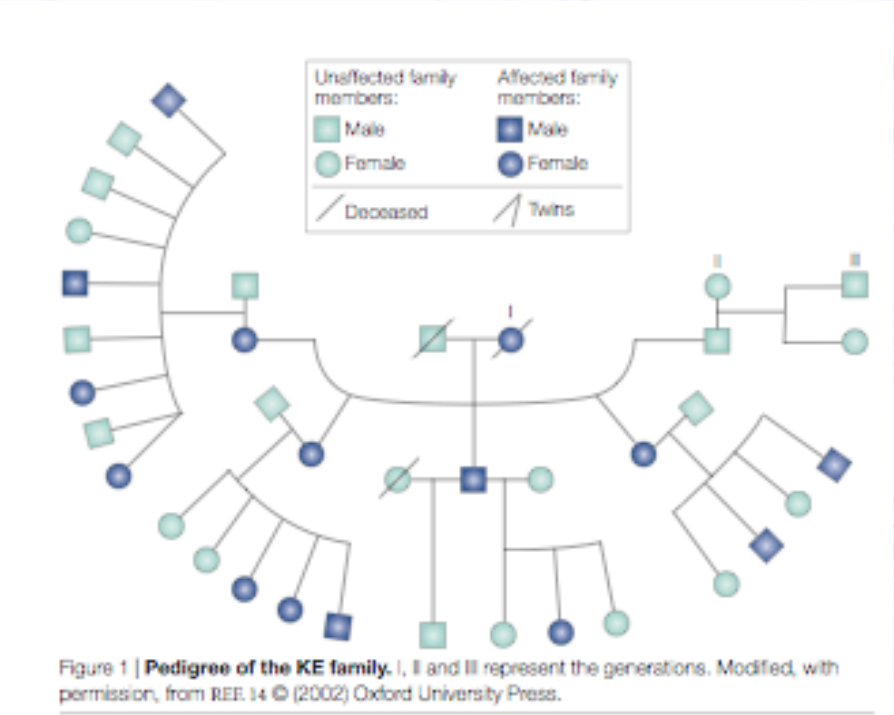


Figure 1 | **Pedigree of the KE family.** I, II and III represent the generations. Modified, with permission, from REF. 14 © (2002) Oxford University Press.

Alcock et al. (2000) *Brain & Language*

L’amusie congénitale: du comportement aux gènes

L'amusie congénitale

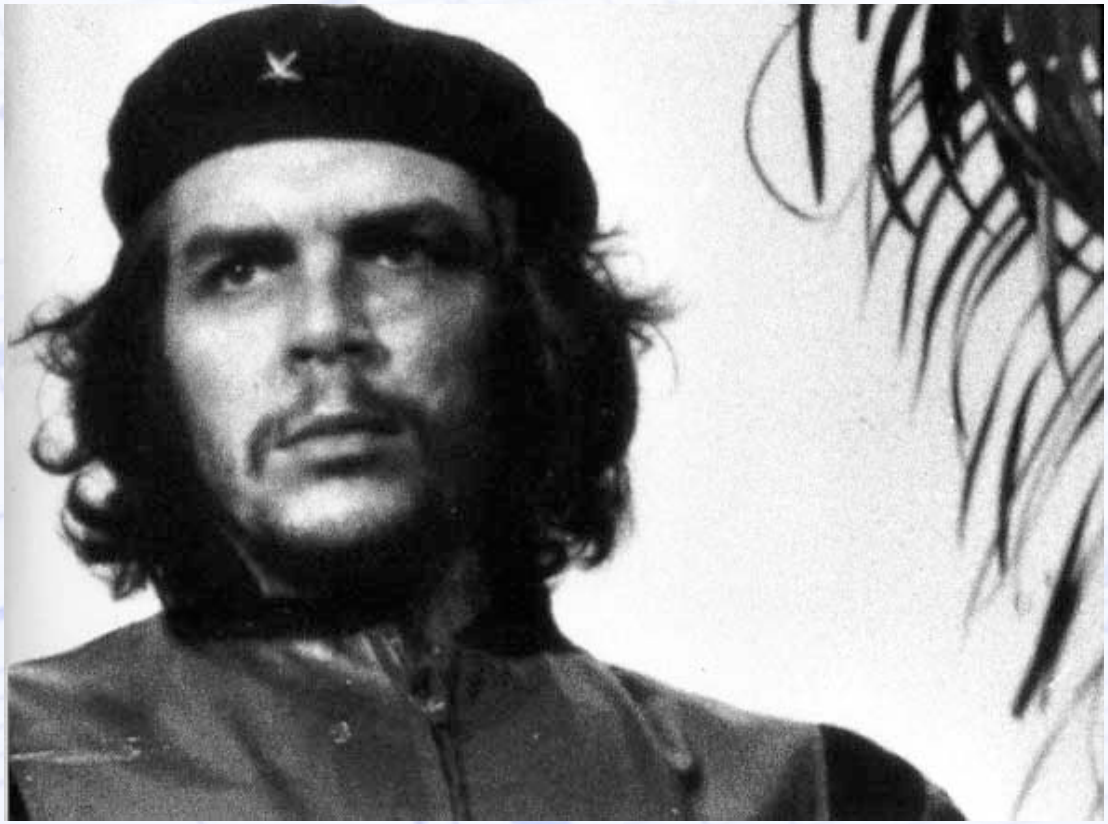
Echec à développer une compétence musicale normale alors que l'intelligence est normale et le langage aussi

- ✓ Ne savent pas s'ils chantent juste
- ✓ Echouent à reconnaître les chansons en l'absence des paroles
- ✓ Difficulté à apprendre la musique
- ✓ Aucune autre difficulté d'apprentissage

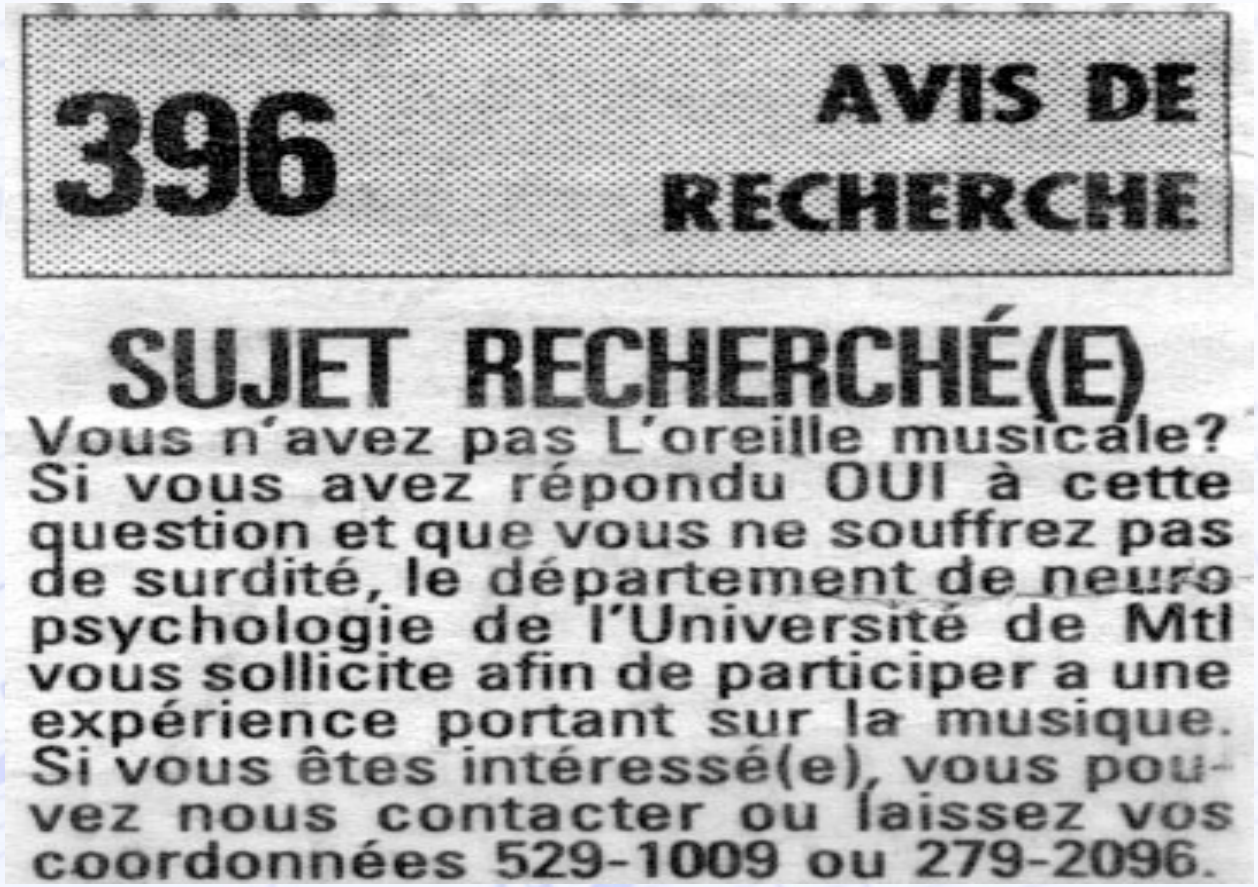
4 % de la population normale (Kalmus & Frey, 1980. *Annals of Human Genetics).*

Peretz & Hyde (2003) *Trends in Cognitive Science*

Un cas célèbre



Che Guevara

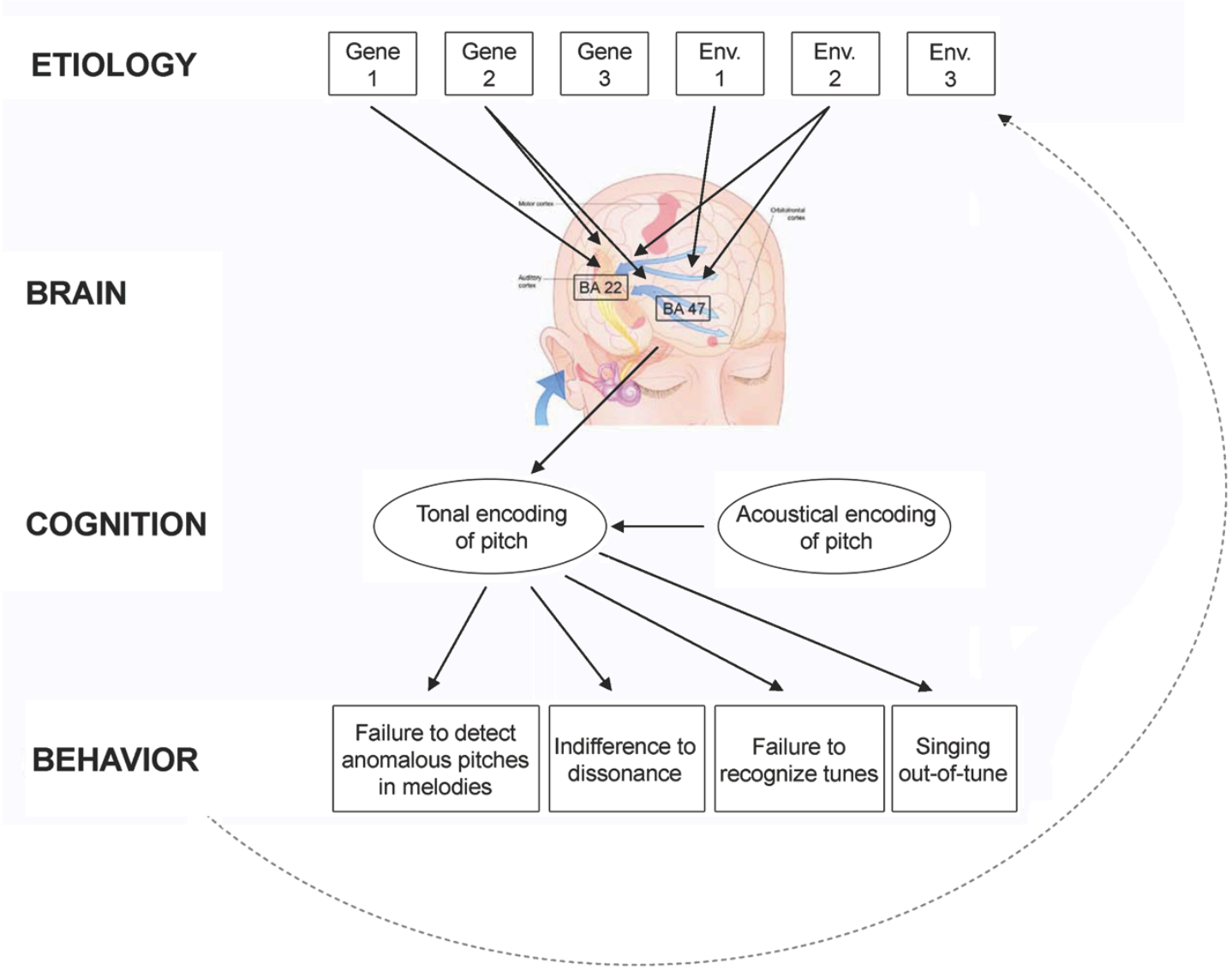


396 AVIS DE RECHERCHE

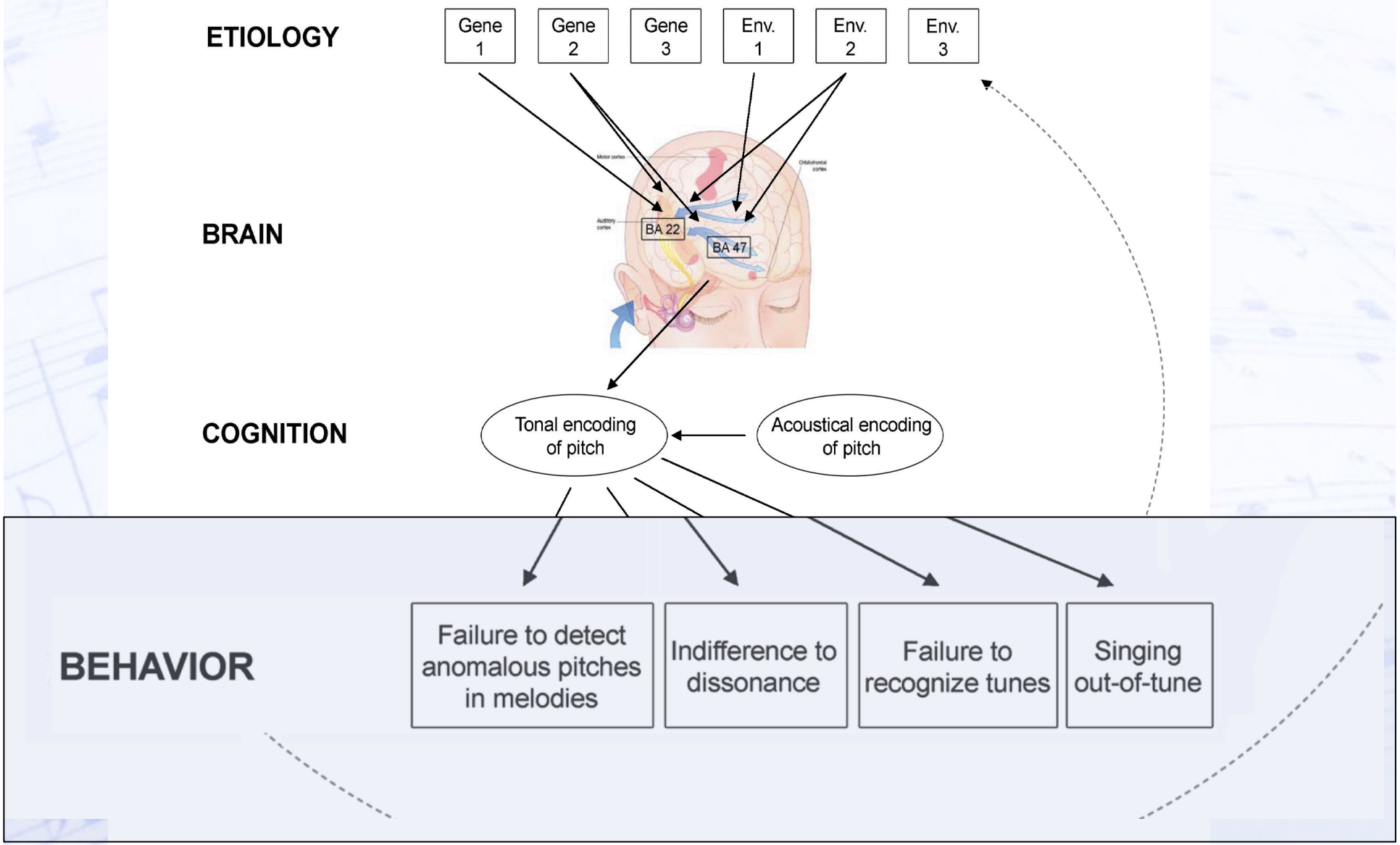
SUJET RECHERCHÉ(E)

Vous n'avez pas L'oreille musicale? Si vous avez répondu OUI à cette question et que vous ne souffrez pas de surdité, le département de neuro-psychologie de l'Université de Mtl vous sollicite afin de participer a une expérience portant sur la musique. Si vous êtes intéressé(e), vous pouvez nous contacter ou laissez vos coordonnées 529-1009 ou 279-2096.


PLAY



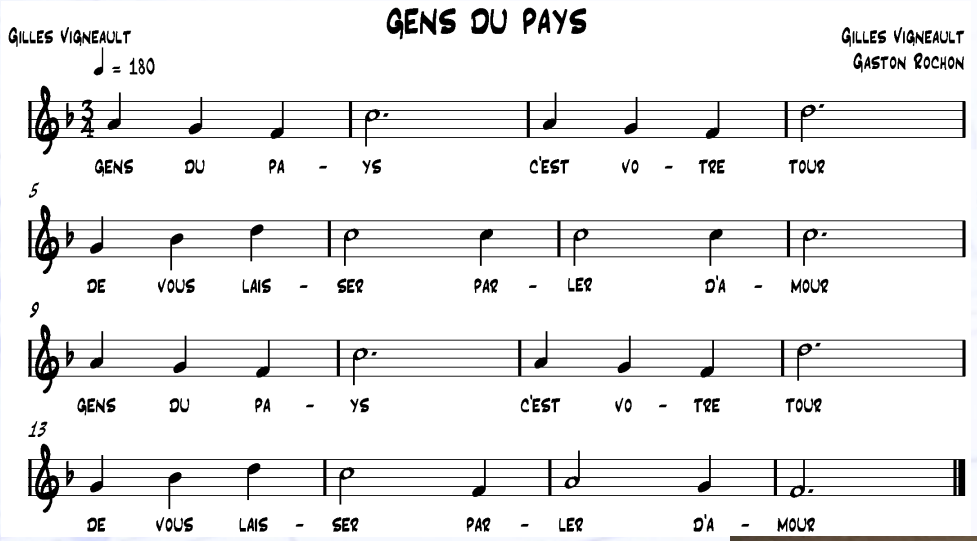
Peretz (2008) *Current Directions in Psychological Science*



Peretz (2008) Current Directions in Psychological Science

Ils ne savent pas s'ils chantent juste

« most people cannot carry a tune »
(Pinker, 1997, p. 529)



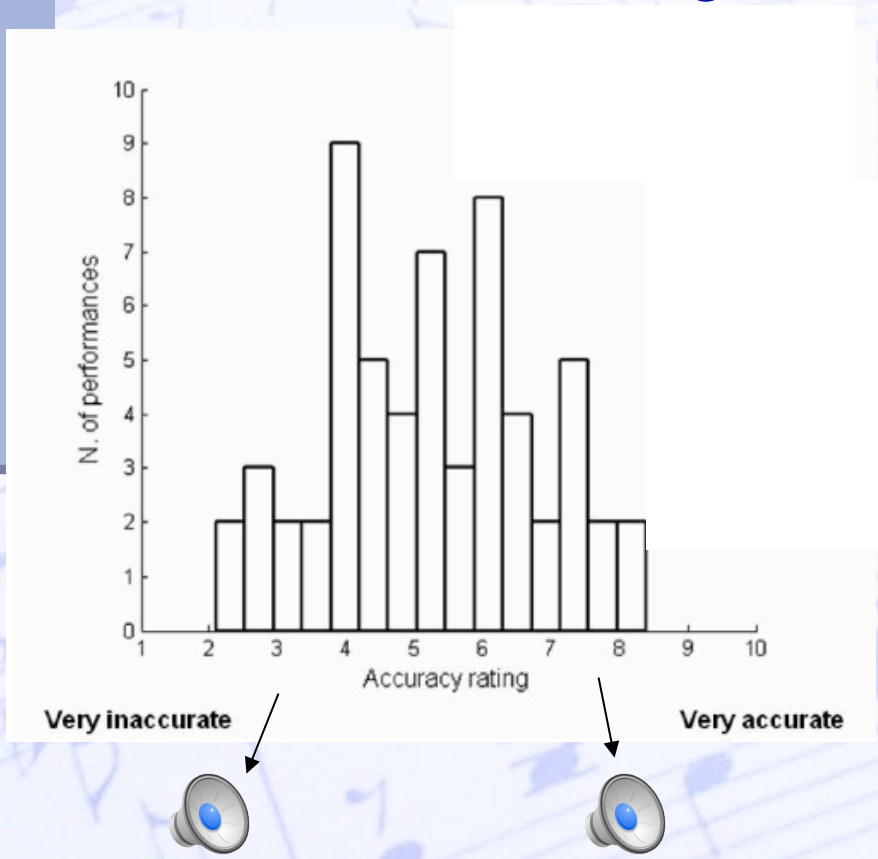
Dalla Bella, Giguère & Peretz (2007) *J.A.S.A.*

Peers' judgments

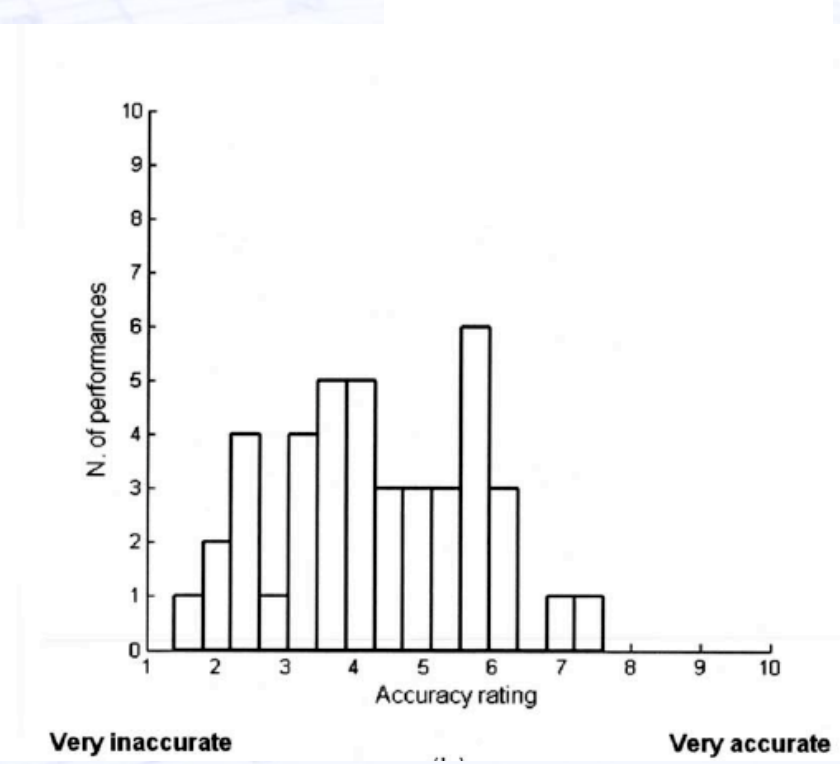
1 2 3 4 5 6 7 8 9 10

Very inaccurate *Very accurate*

Natural setting

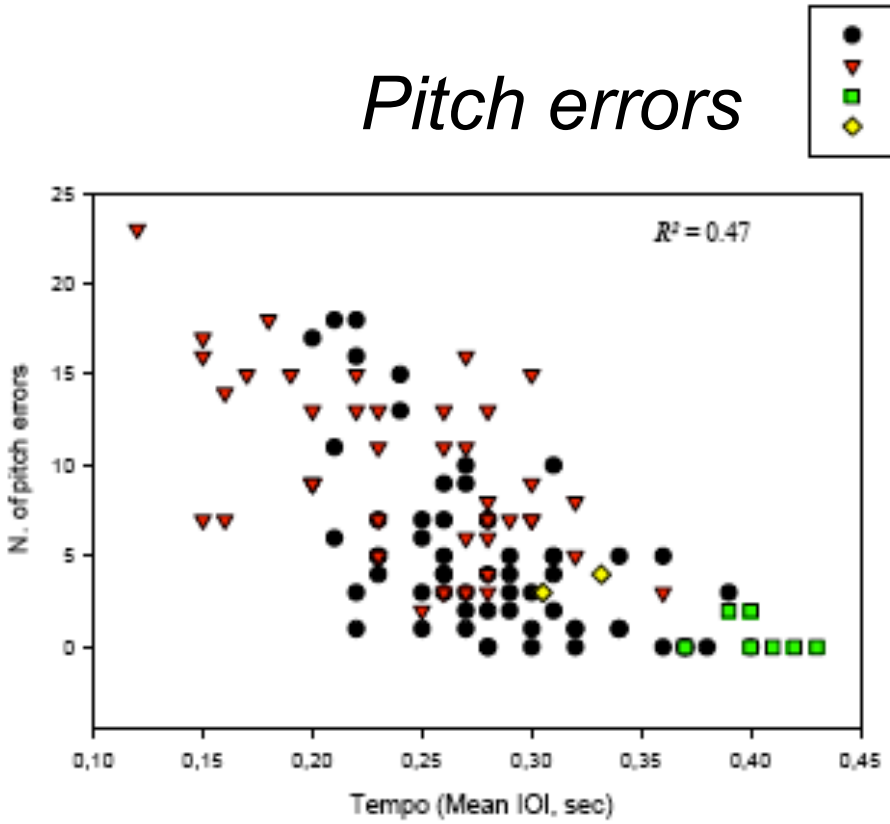


In the lab

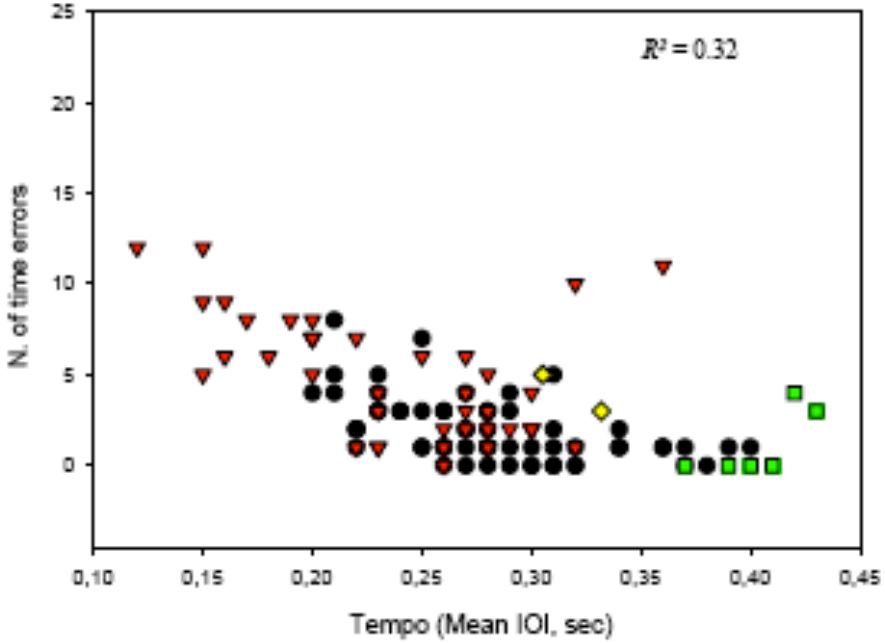


Analyses acoustiques

Pitch errors



Time errors



Dalla Bella, Giguère & Peretz (2007) *J.A.S.A*

Tout le monde peut chanter juste….ou presque

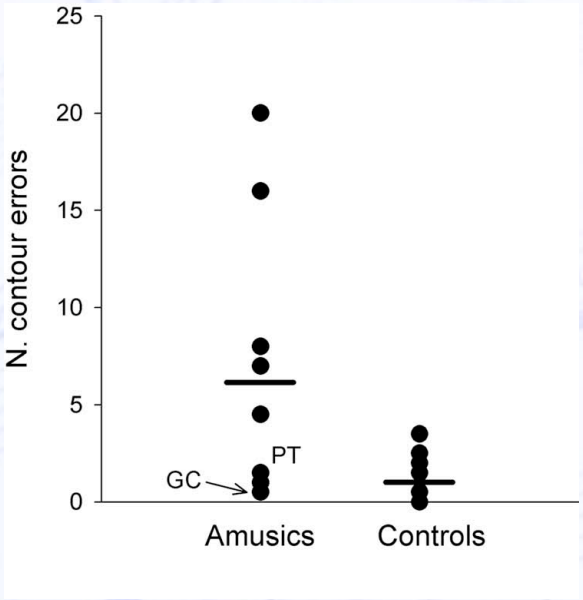
Le chant amusique

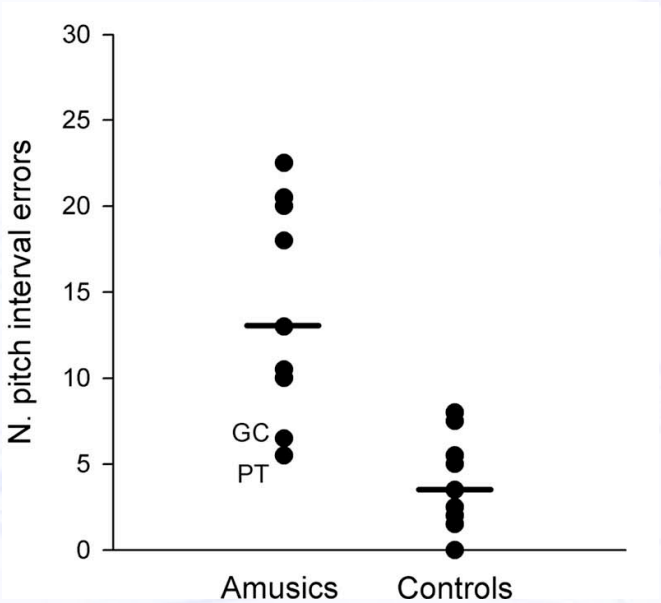
Albert

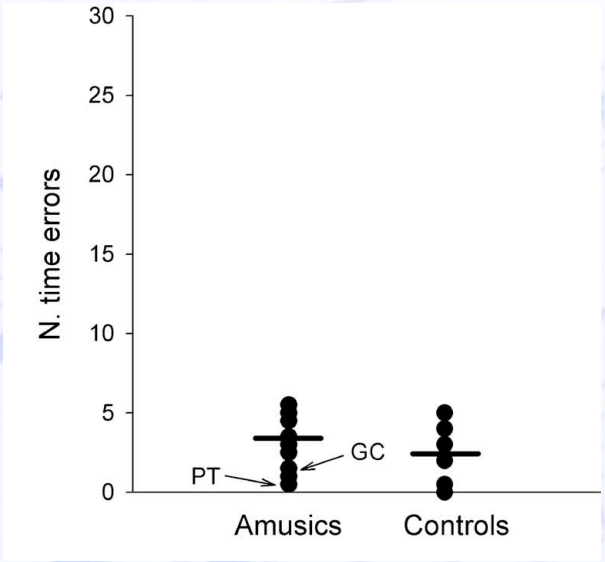
- *62 ans*
- *16 années d'étude*
- *Q.I. de 117*

Dalla Bella, Giguère & Peretz (2009) *J.A.S.A.*

Out of tune but relatively in time







Dalla Bella, Giguère & Peretz (2009) *J.A.S.A.*

Echouent à reconnaître les chansons en l’absence des paroles

paroles

De quelle chanson s'agit-il?

air

Ayotte, Peretz & Hyde (2002), *Brain*

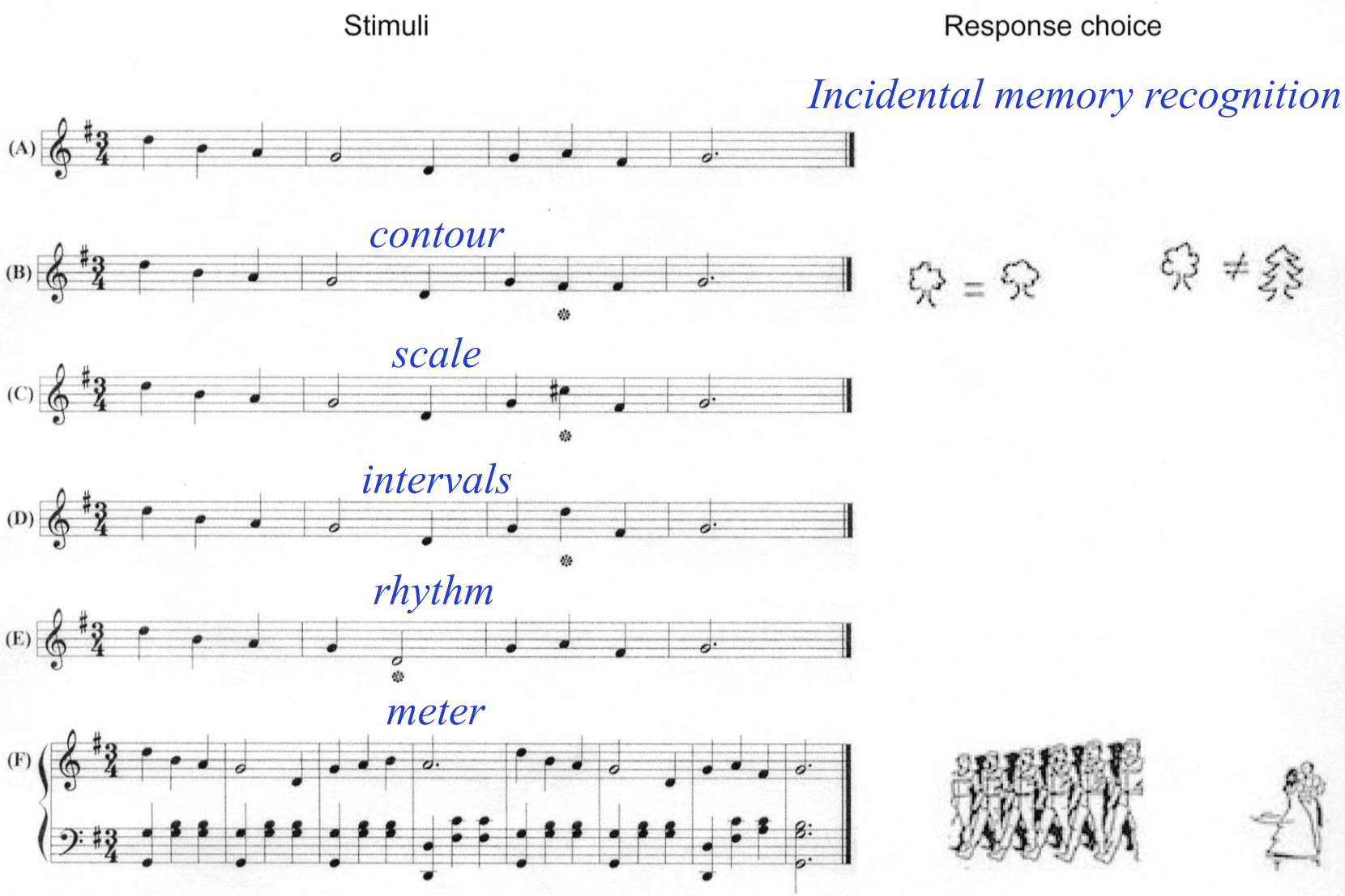
Que perçoivent-ils dans la musique ?

The Montreal Battery of Evaluation of amusia

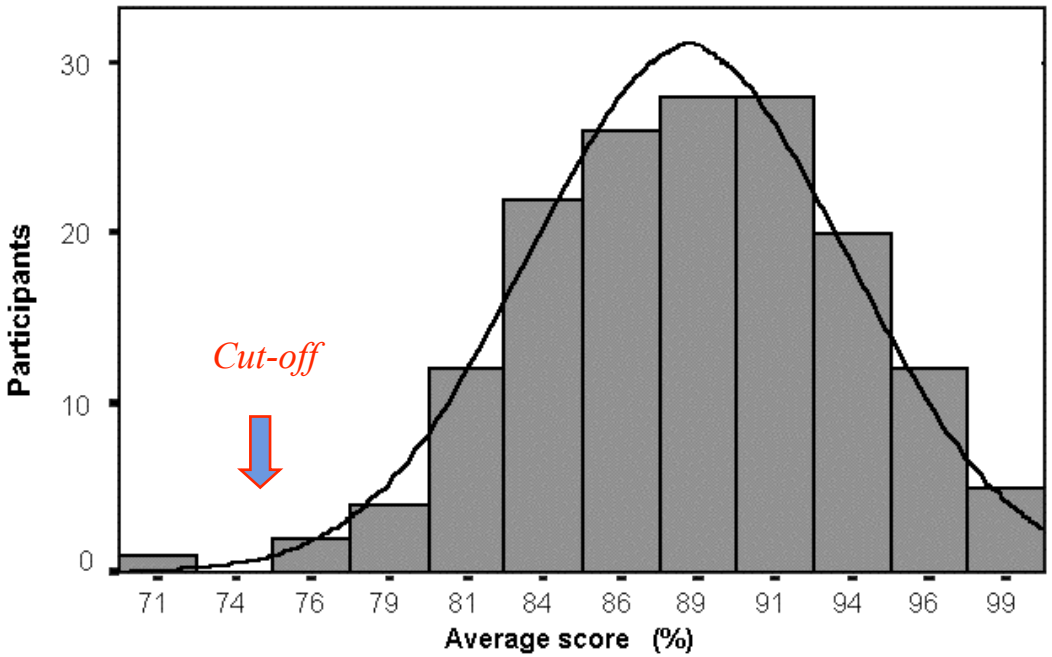
Peretz, Champod & Hyde (2003). *Annals of New York Academy of Sciences*

The Montreal Battery of Evaluation of Amusia (MBEA)

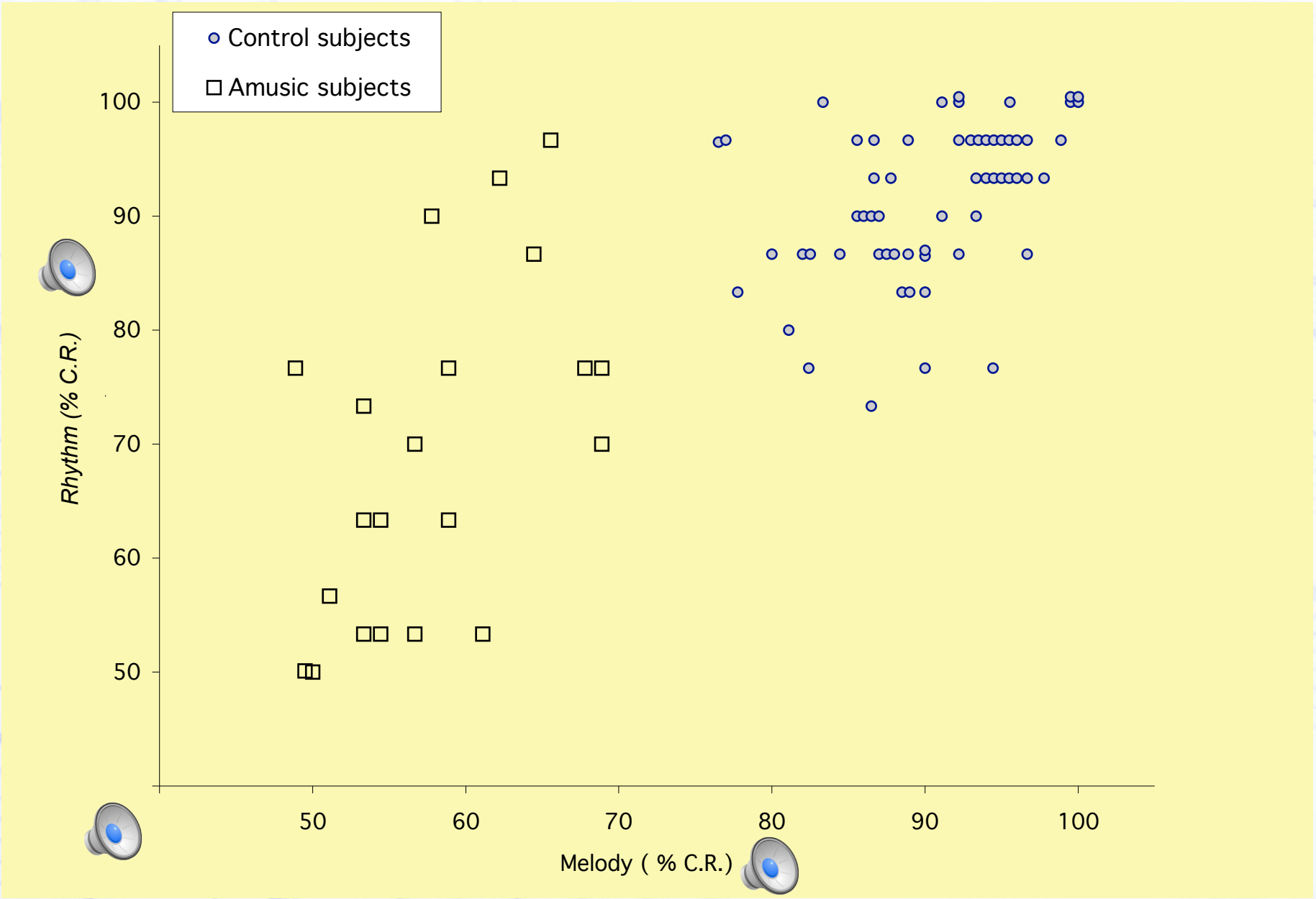
- 6 tests (30 essais par test)



400 hommes et femmes, agés de 14 à 79 ans, avec 7 à 21 années d'étude



Normes: *www.brams.umontreal.ca/peretz*

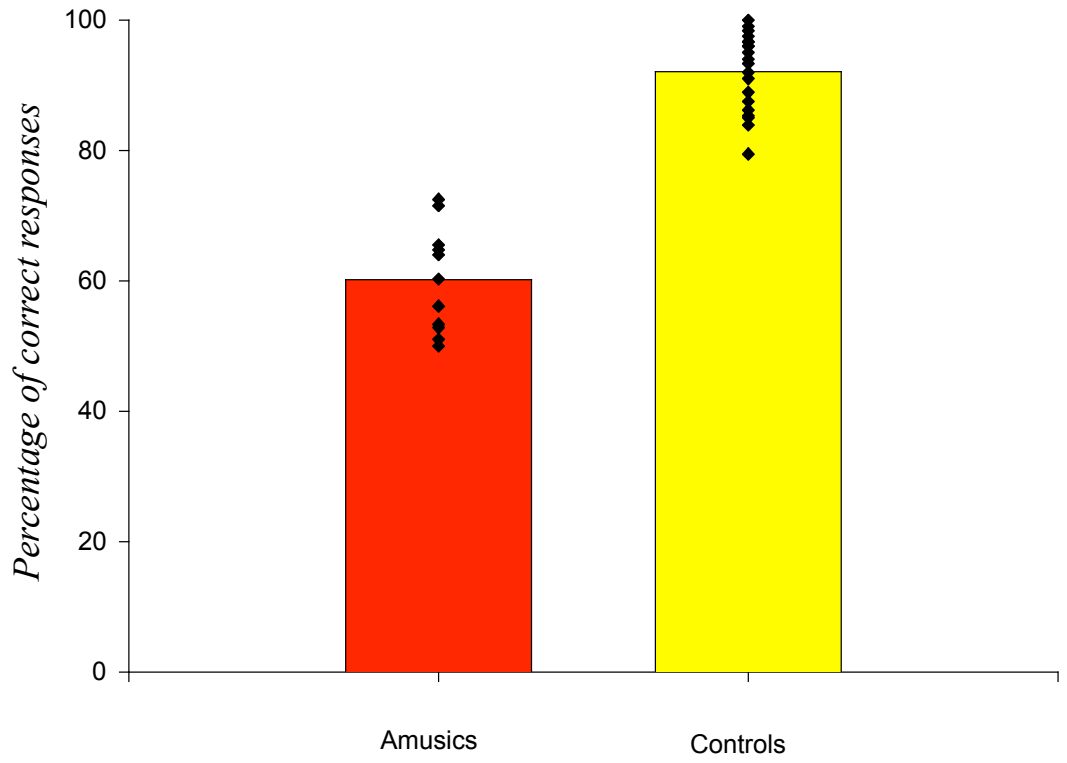


Peretz (2003). *Annals of the NYAS*

Incapables d'entendre les fausses notes

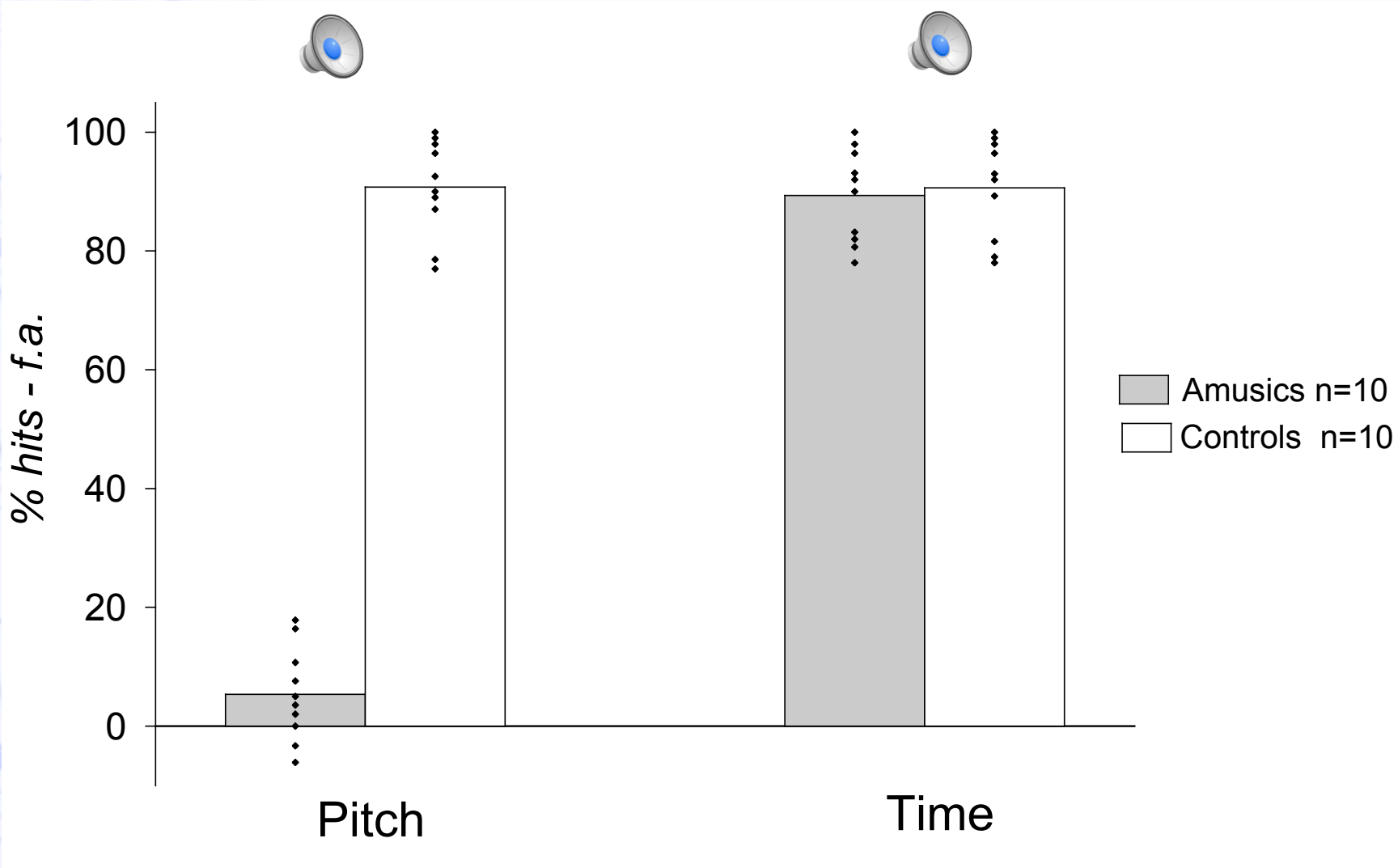
Familier

Non-familier



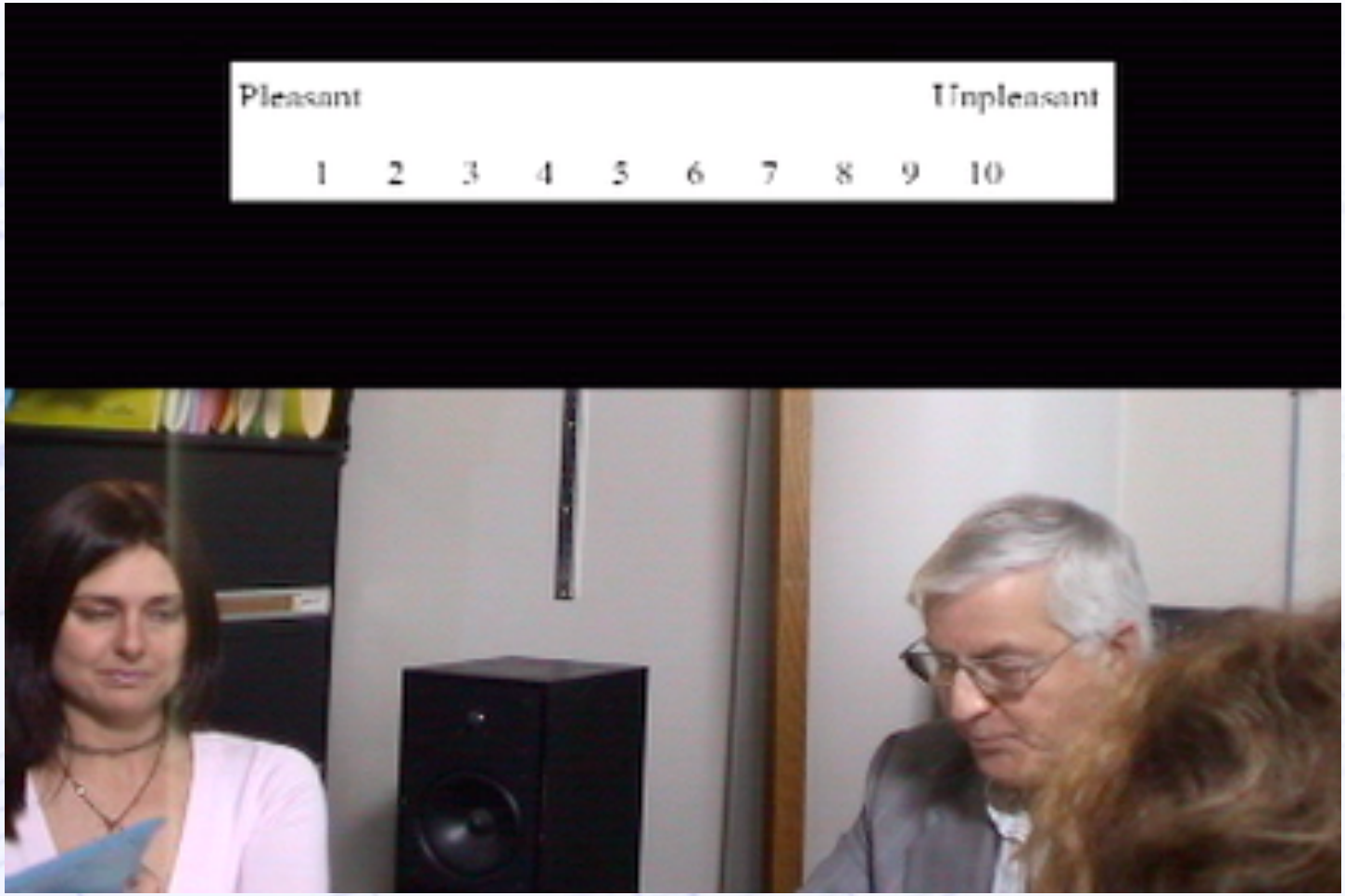
Ayotte, Peretz & Hyde (2002), *Brain*

Out-of-pitch but on-time



Hyde & Peretz (2005). *Plasticity of the central auditory system*

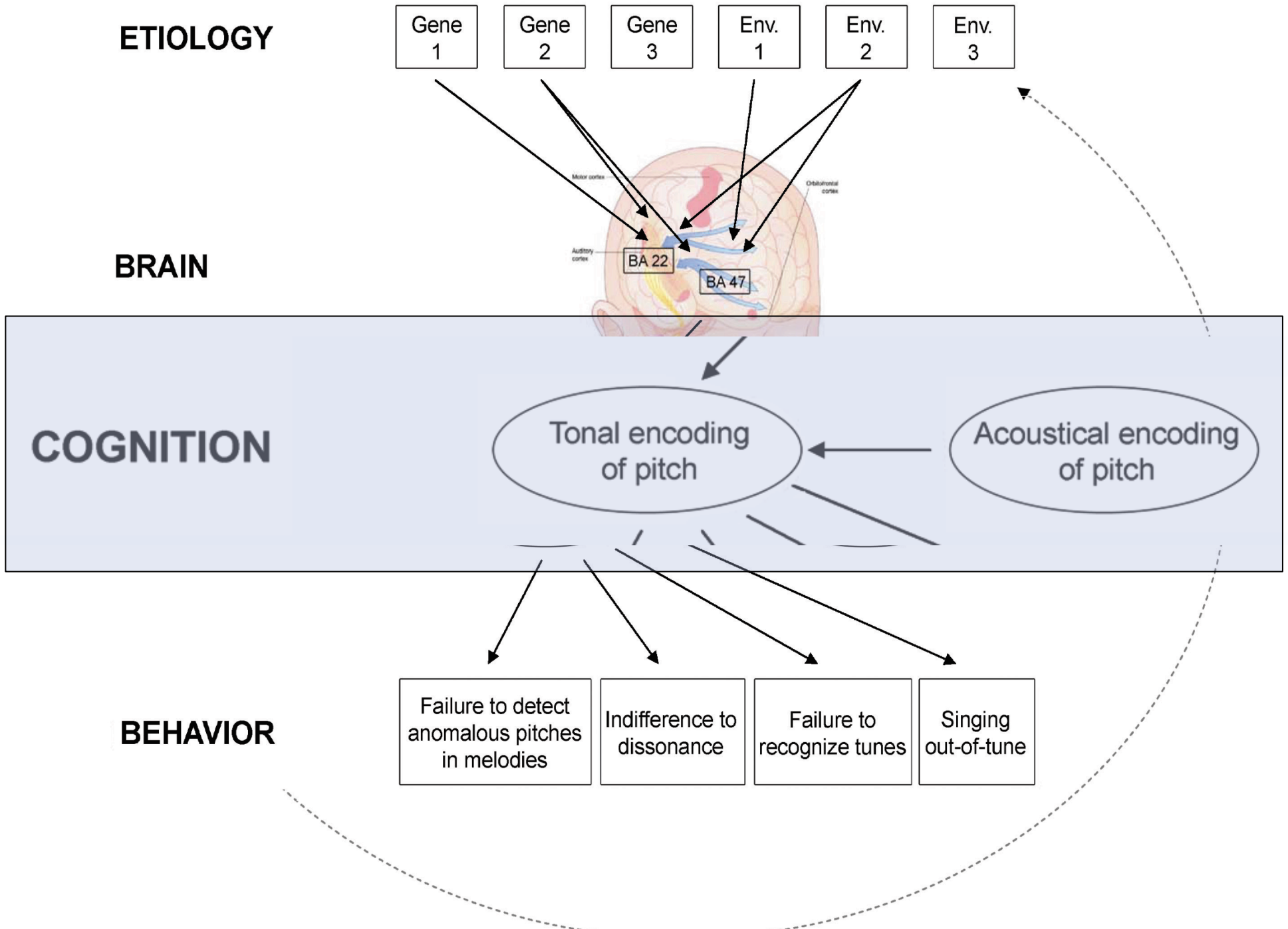
Insensibles à la dissonance



Préférence innée pour la consonance

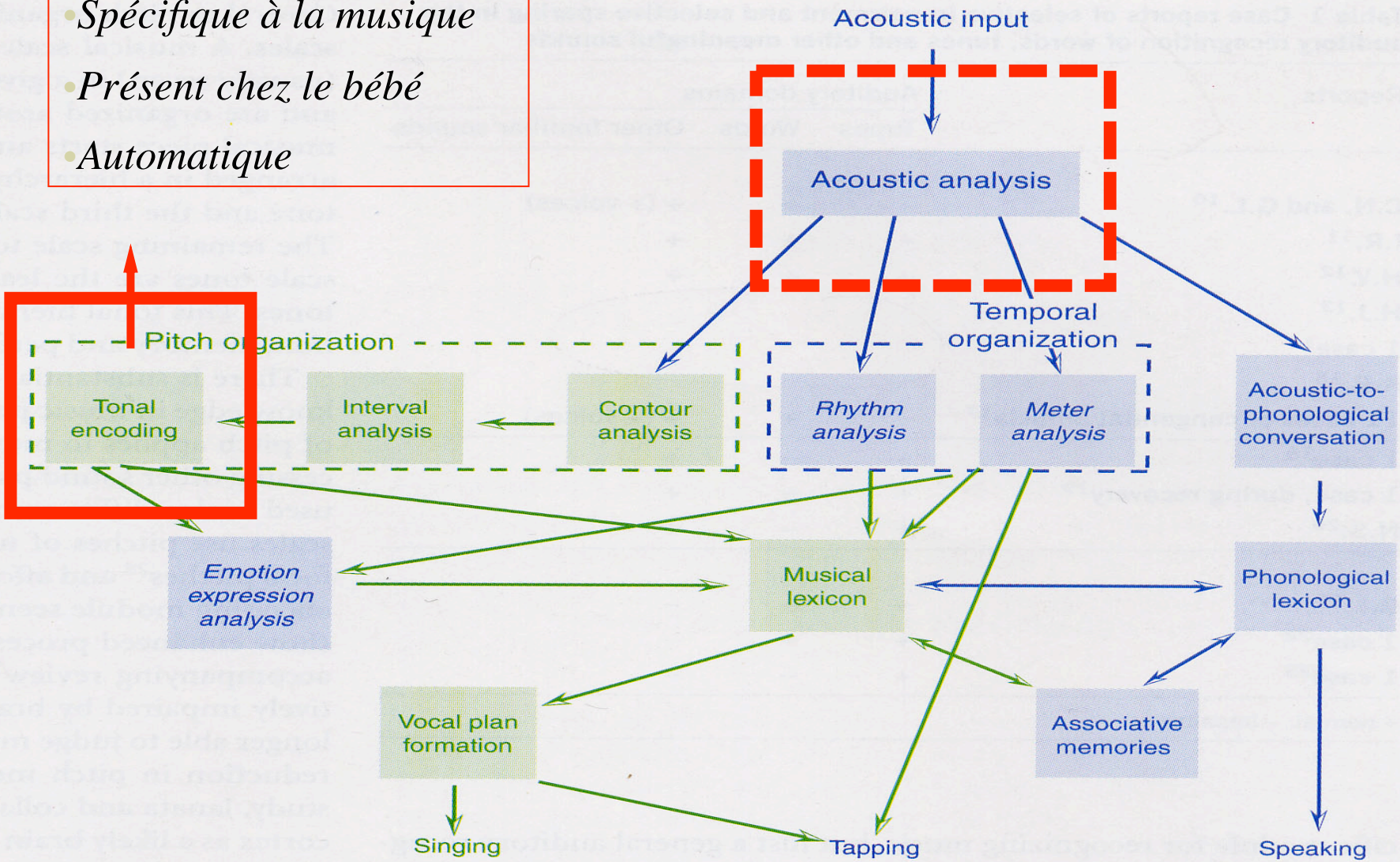
Courtoisie de Laurel Trainor

Zentner & Kagan, 1996; Trainor & Heinmiller, 1998; Masataka, 2006


ETIOLOGY
Gene 1
Gene 2
Gene 3
Env. 1
Env. 2
Env. 3
BRAIN
BA 22
BA 47
COGNITION
Tonal encoding of pitch
Acoustical encoding of pitch
BEHAVIOR
Failure to detect anomalous pitches in melodies
Indifference to dissonance
Failure to recognize tunes
Singing out-of-tune

Faulty mechanisms

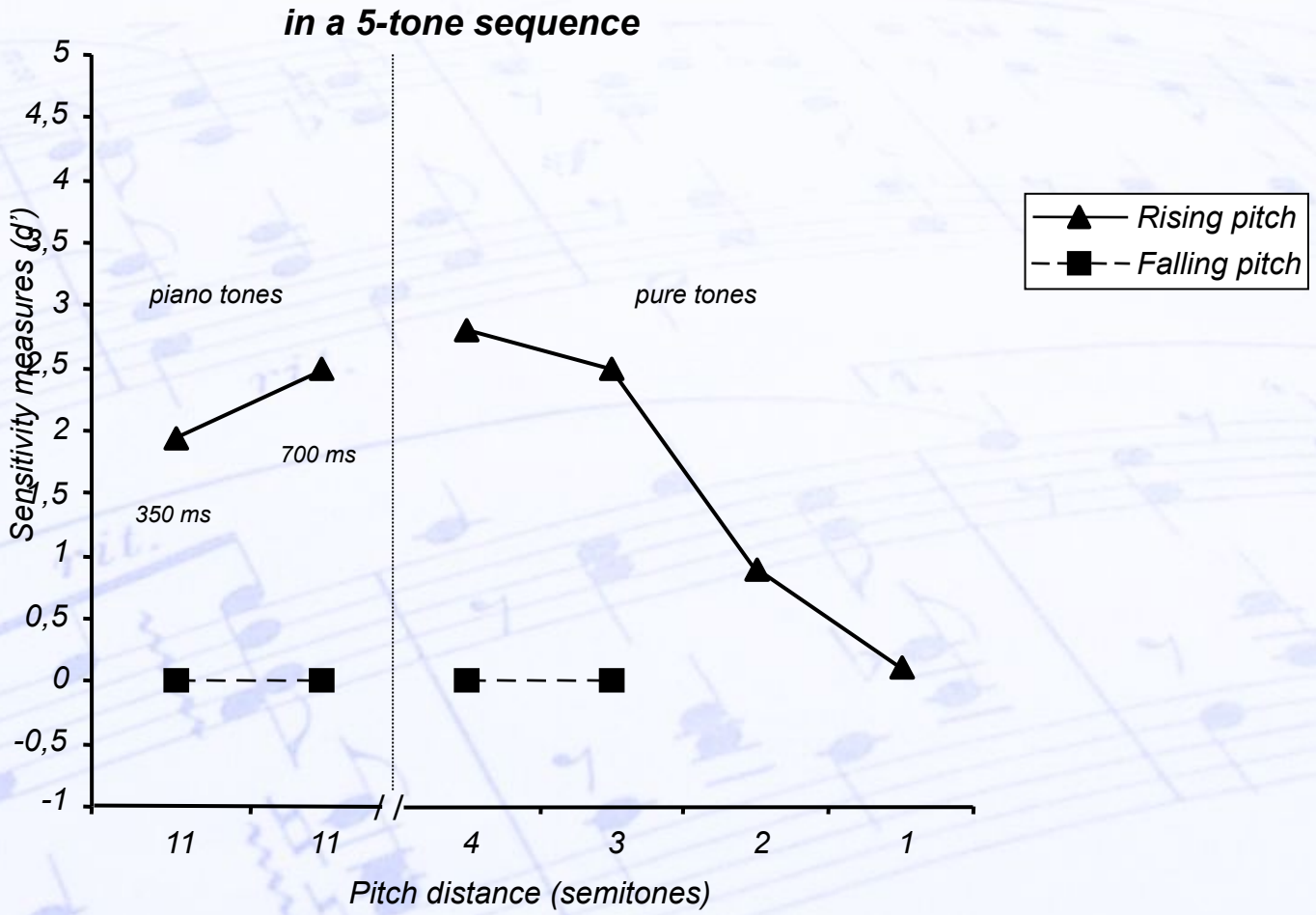
- *Spécifique à la musique*
- *Présent chez le bébé*
- *Automatique*



Peretz & Coltheart (2003) *Nature Neuroscience*

Ivelisse Robles

An aberrant pitch perception system



Pitch

No change

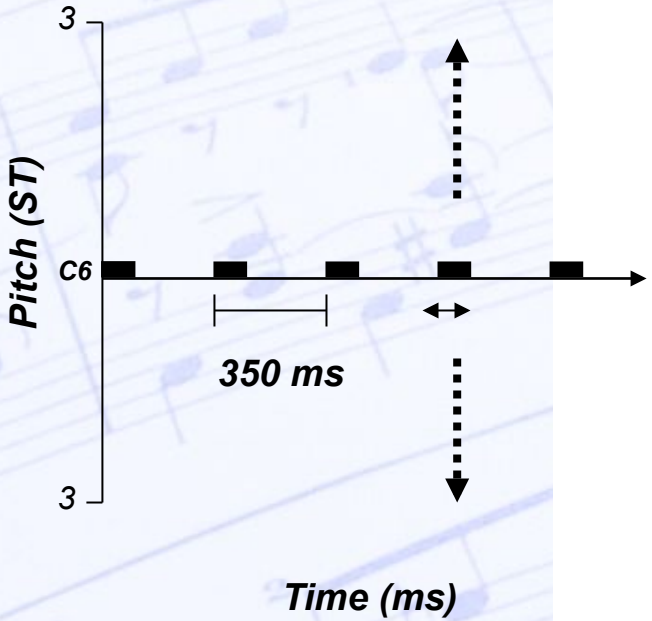
1 semitone change

1/8 of a tone change

Peretz et al. (2002) *Neuron.*

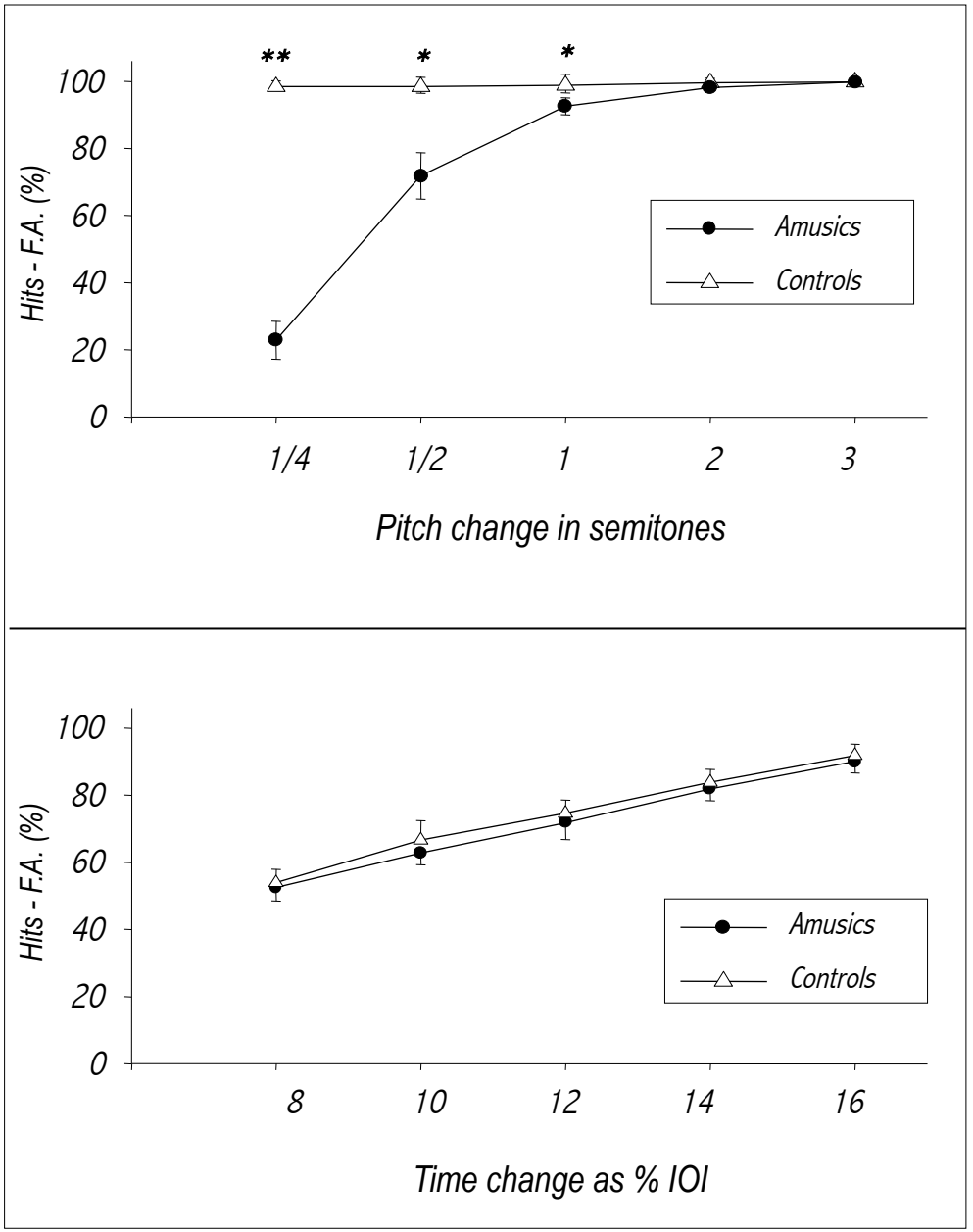
10 amusiques

(autres que Monica)



No change

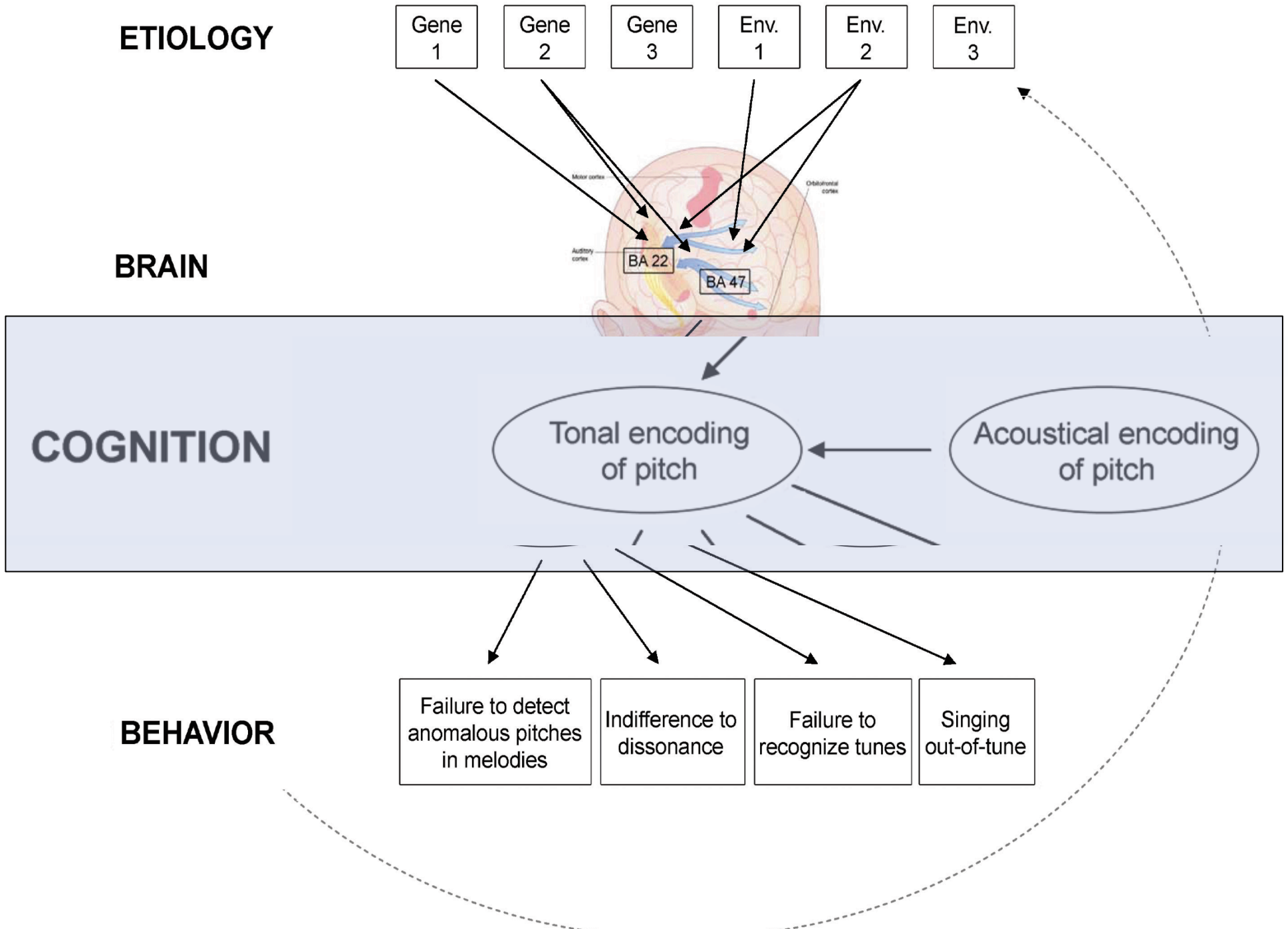
22% change



$P^{**} < 0.001$

$P^{*} < 0.05$

Hyde & Peretz (2004). *Psychological Science*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Failure to detect anomalous pitches in melodies
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Singing out-of-tune

Intonation du langage

	amusiques	*contrôles*
Final pitch changes	*94 %*	*98 %*
Internal pitch changes	*87 %*	*90 %*

Ayotte, Peretz & Hyde (2002). *Brain*

Pourquoi juste la musique ?

La musique utilise des changements subtils en hauteur

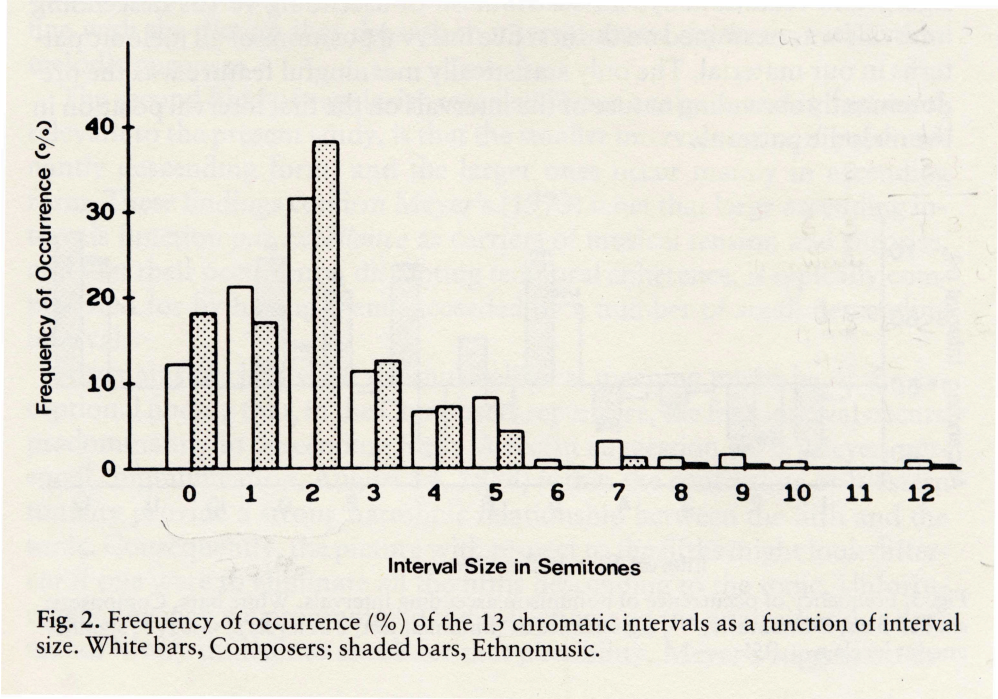


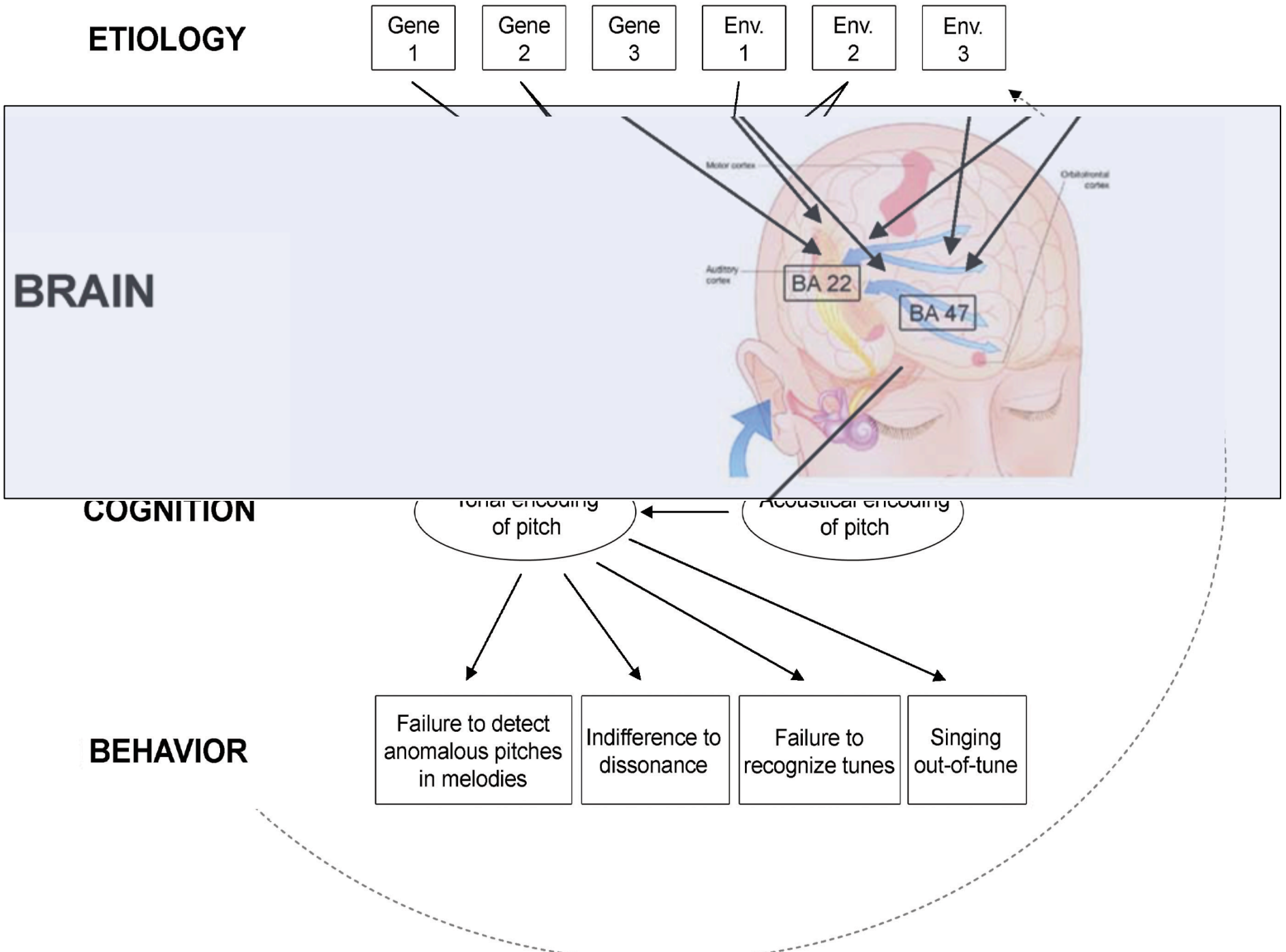
Fig. 2. Frequency of occurrence (%) of the 13 chromatic intervals as a function of interval size. White bars, Composers; shaded bars, Ethnomusic.

Vos & Troost (1989). *Music Perception*

L'intonation utilise des changements grossiers en hauteur

Sentence	Size of final pitch glide (st)	
	S	Q
He speaks French./?	-7.9	12.6
She plays the flute./?	-8.9	12.7
She forgot her book./?	-7.0	12.5
He wants to leave now./?	-4.7	12.3
He likes to drive fast cars./?	-8.6	11.7
He works ten hours a day./?	-5.2	12.8
Francis is at the restaurant./?	-5.1	7.2
The telephone doesn't work./?	-5.6	12.9
He has been in Paris for three months./?	-10.0	13.4
The supermarket is closed on Sunday./?	-9.8	11.7
He wants to buy a house next to the beach./?	-6.1	11.7
She drinks three large cups of coffee every morning	-10.1	15.5
Mean	-7.4	**12.3**
SD	2.0	1.9

Patel et al.(2008). *Music Perception*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BA 47
COGNITION
of pitch
of pitch
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Failure to recognize tunes
Singing out-of-tune

Brain morphometry

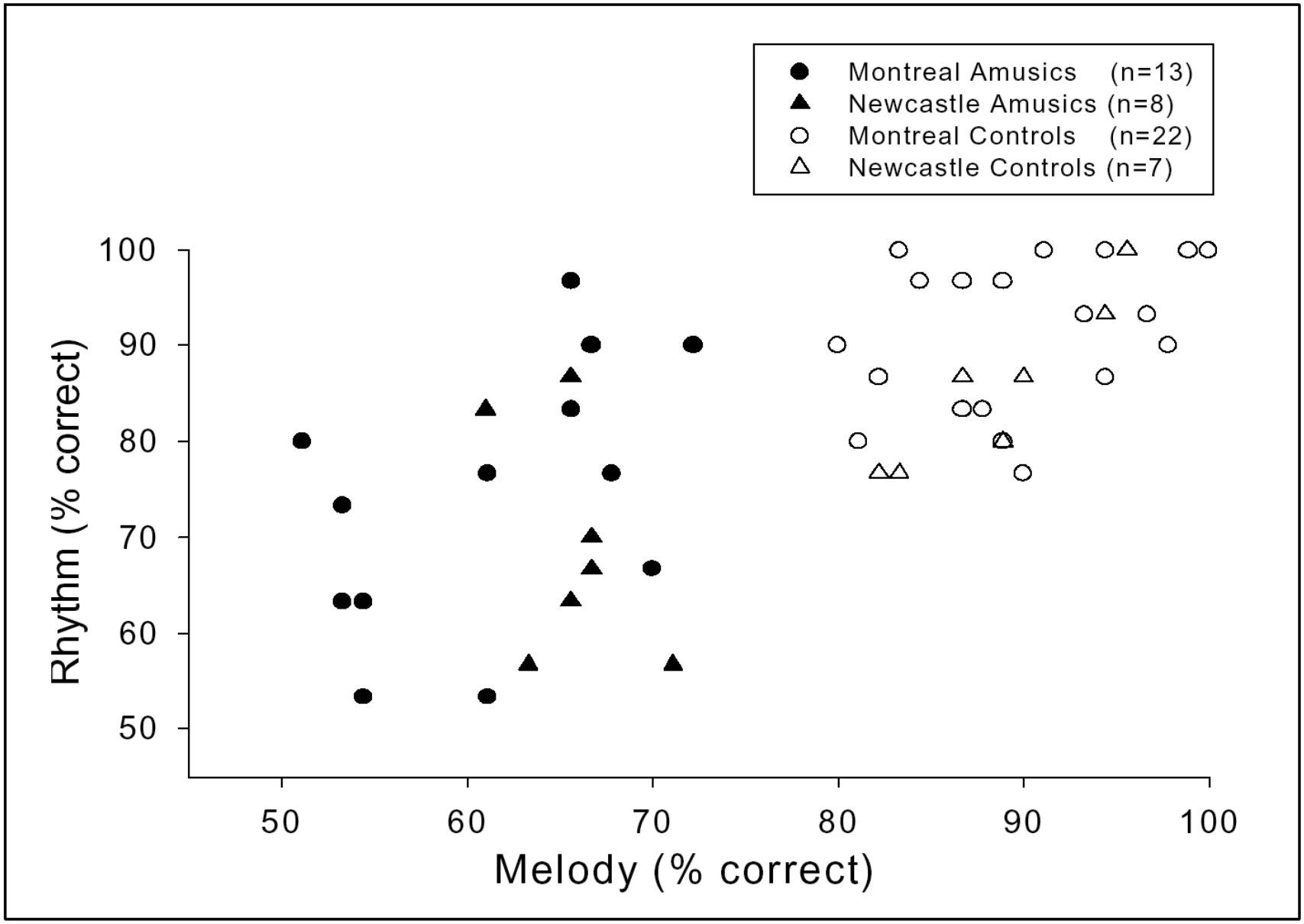
Krista Hyde

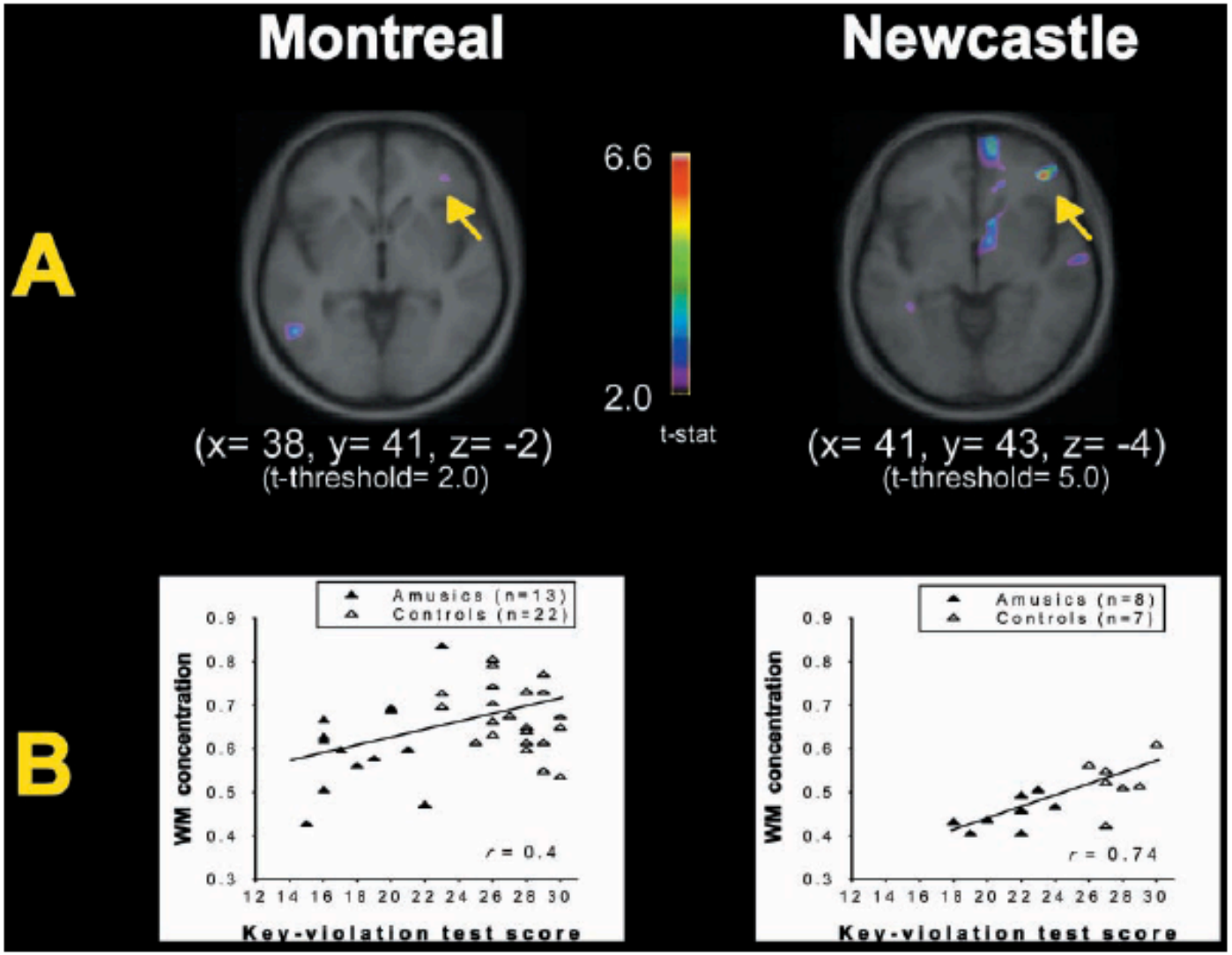
Ph.D. thesis

Robert Zatorre

Tim Griffiths

Two-site study: a replication



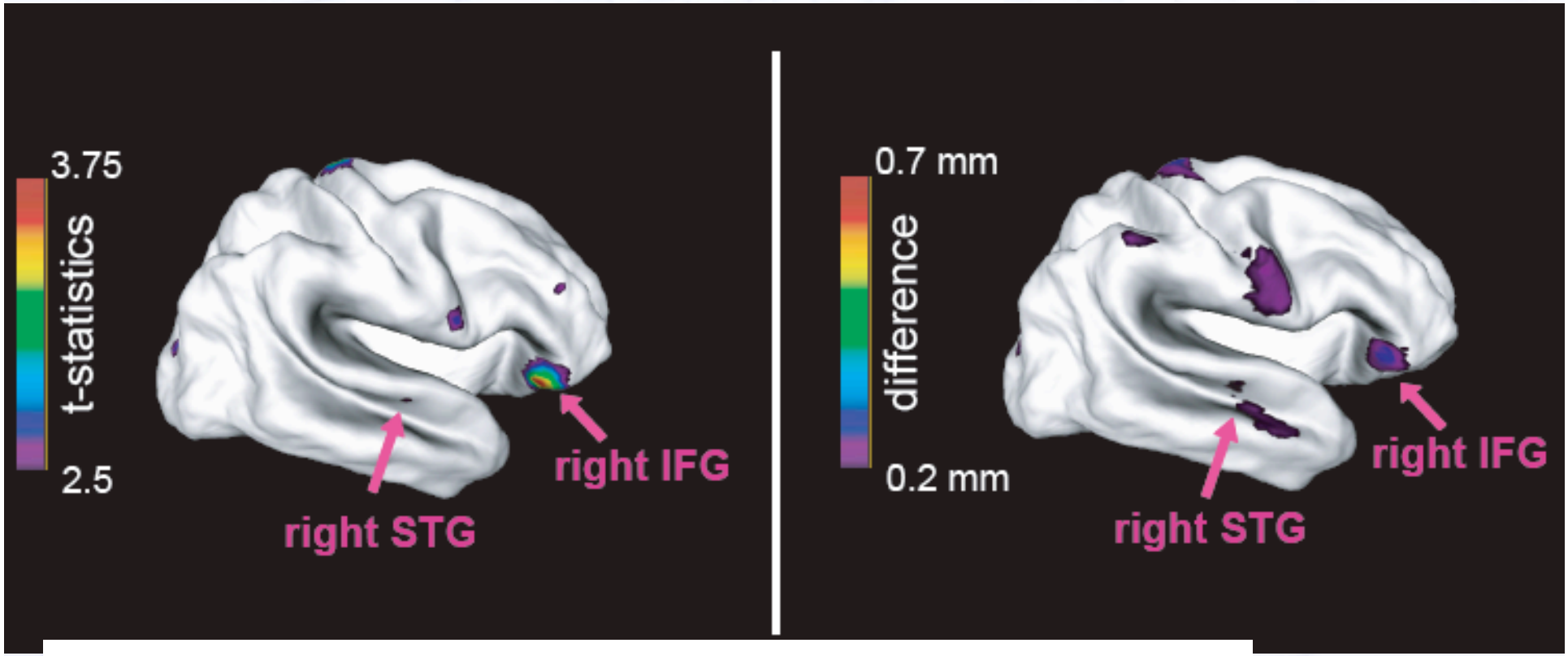


doi:10.1093/brain/awl204

Morphometry of the amusic brain: a two-site study

Krista L. Hyde,[1,2] Robert J. Zatorre,[2] Timothy D. Griffiths,[4] Jason P. Lerch[3] and Isabelle Peretz[1]

Group cortical thickness differences (21 amusics versus 26 matched controls)



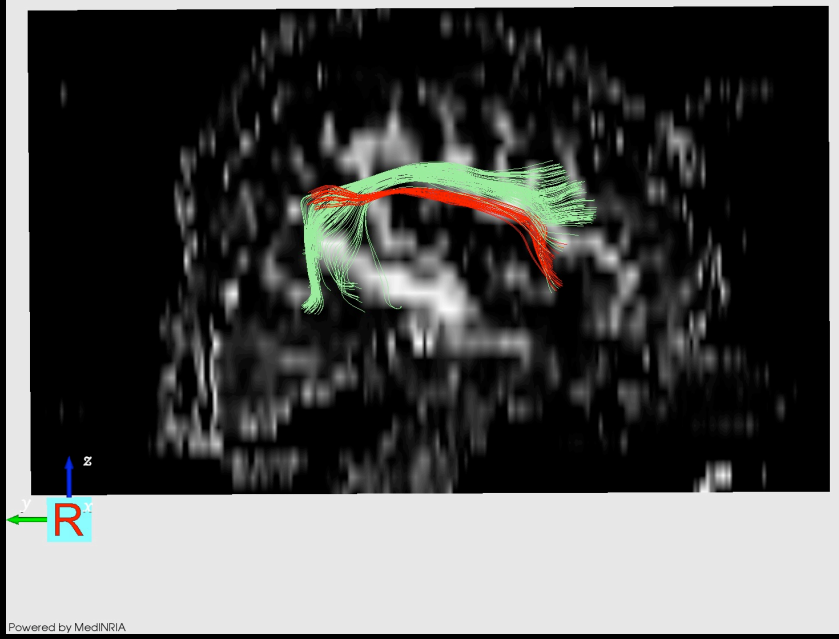
Cortical Thickness in Congenital Amusia: When Less Is Better Than More

The Journal of Neuroscience, 21, 2007

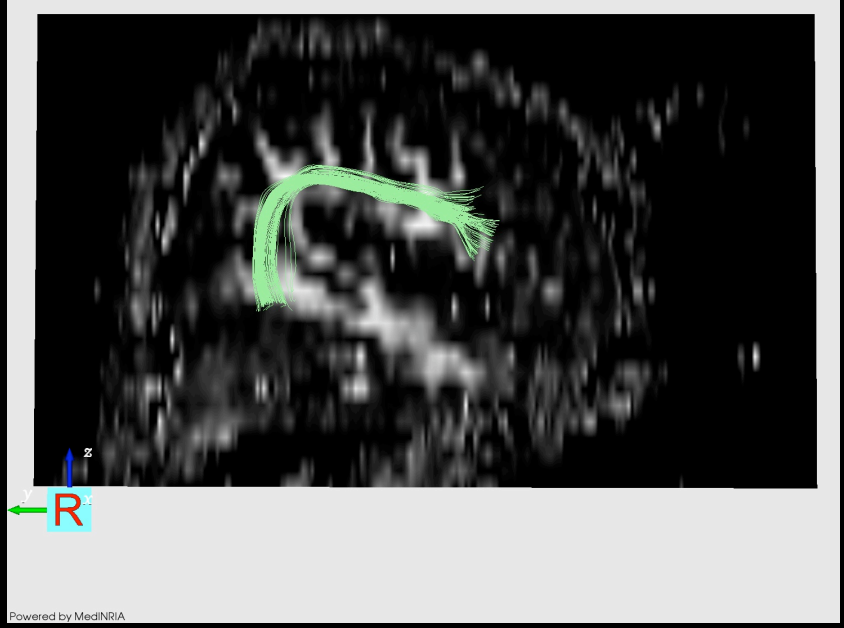
Krista L. Hyde,[1,2] Jason P. Lerch,[3] Robert J. Zatorre,[1] Timothy D. Griffiths,[4] Alan C. Evans,[1] and Isabelle Peretz[2]

Réduction du faisseau arqué supérieur droit

Control subject



Amusic subject

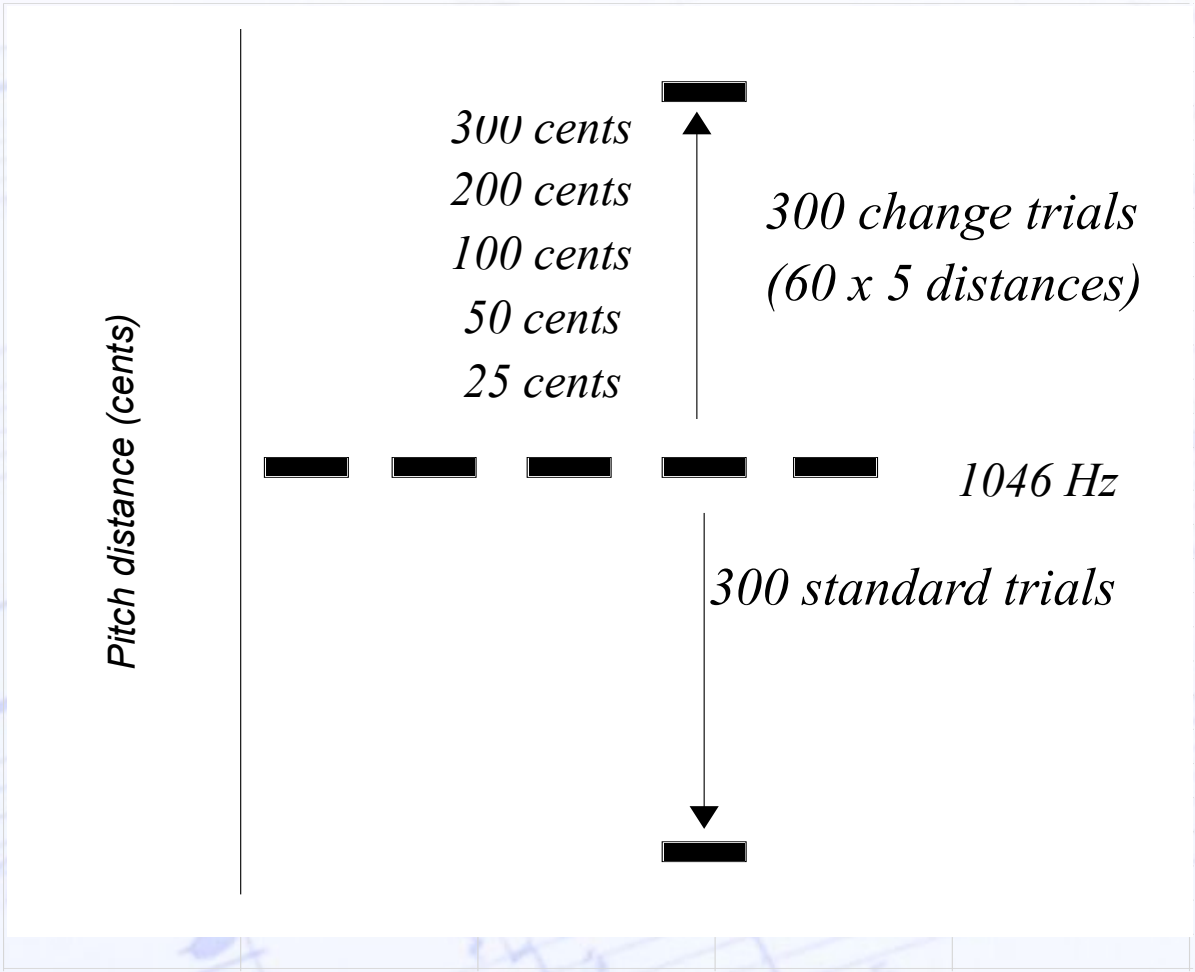


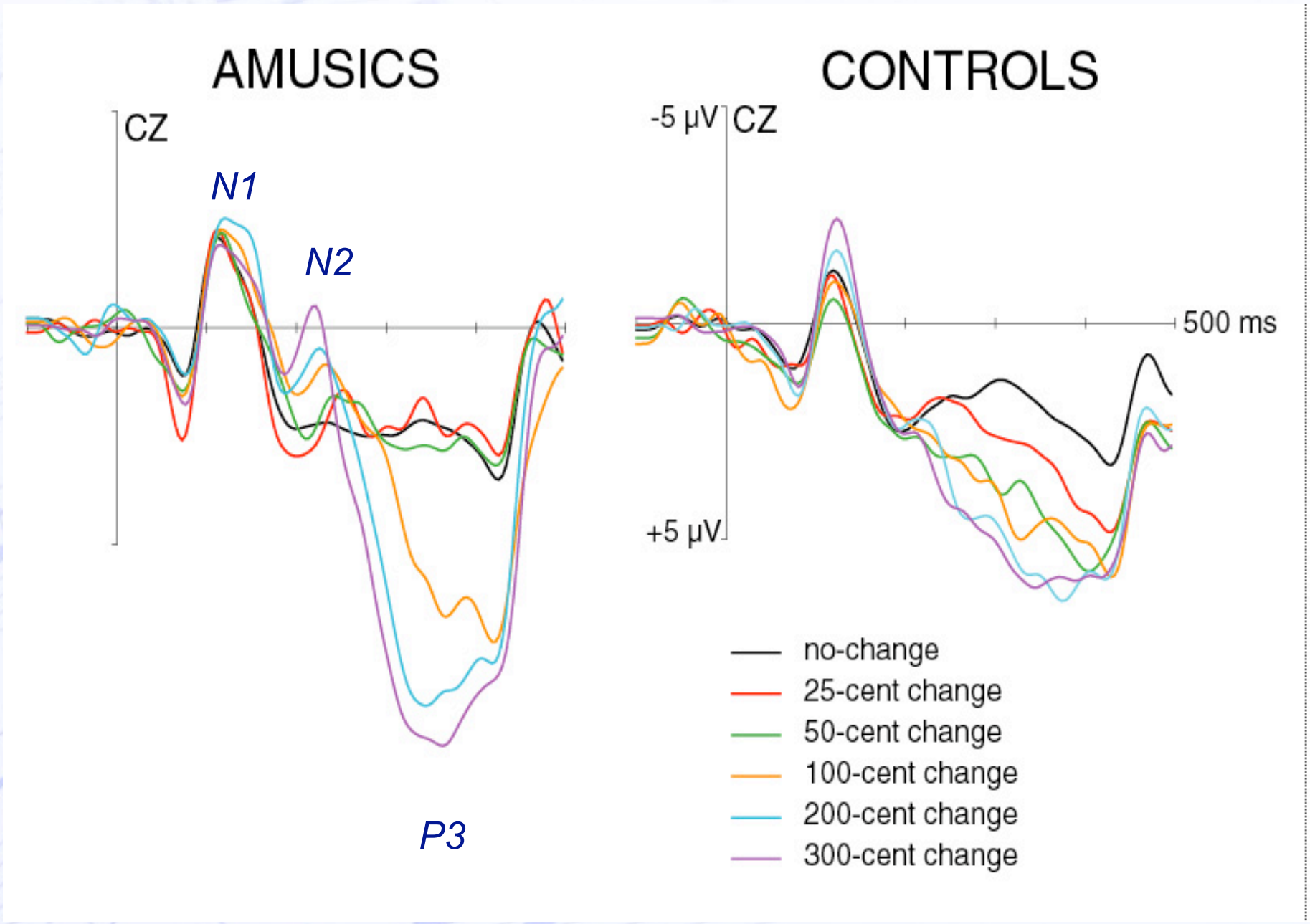
Loui et al. (2009) *J. of Neuroscience*

Réponses électriques

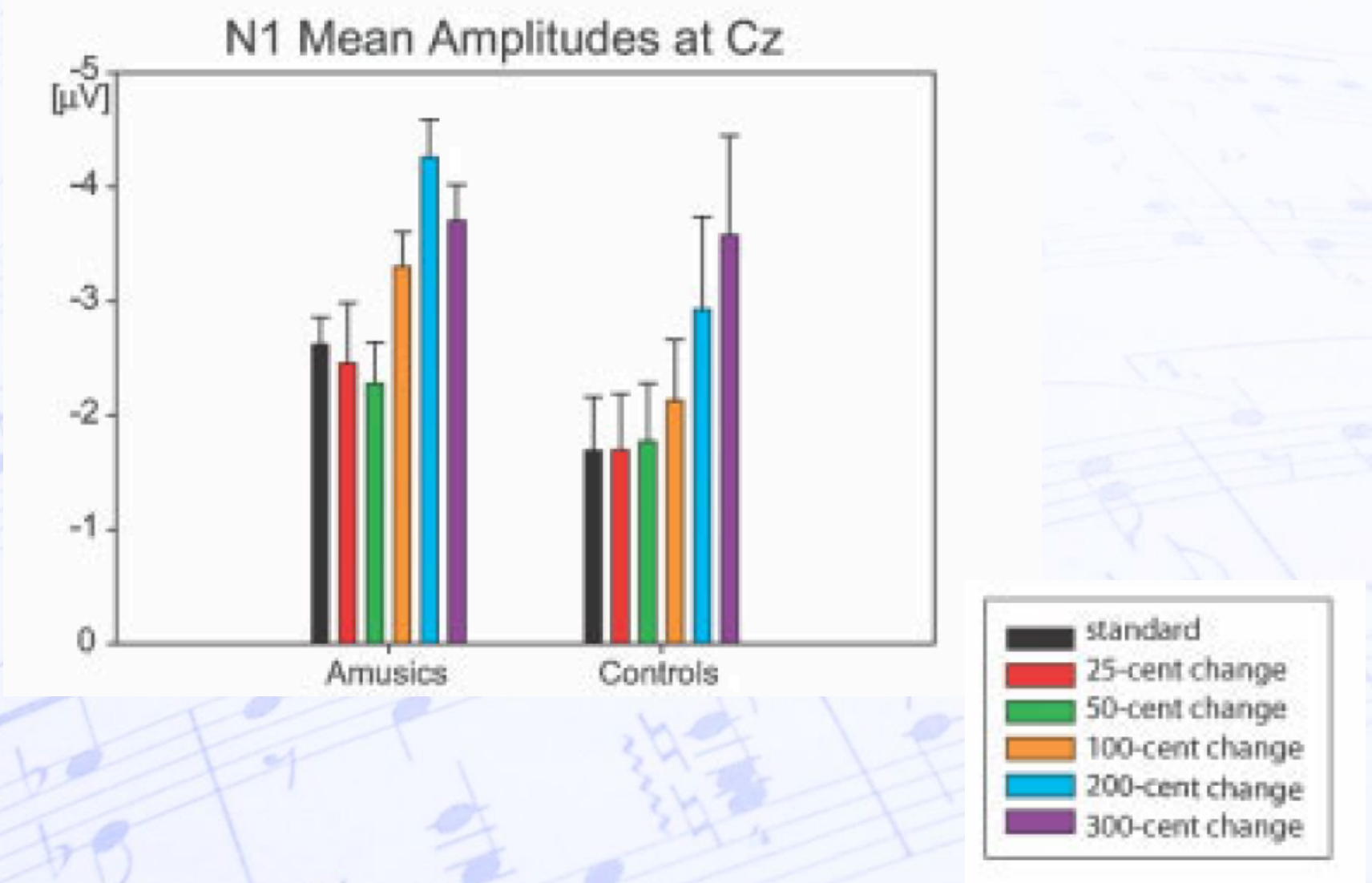
Elvira Brattico (Helsinki)

Mari Tervaniemi (Helsinki)


Pitch distance (cents)
300 cents
200 cents
100 cents
50 cents
25 cents
300 change trials
(60 x 5 distances)
1046 Hz
300 standard trials

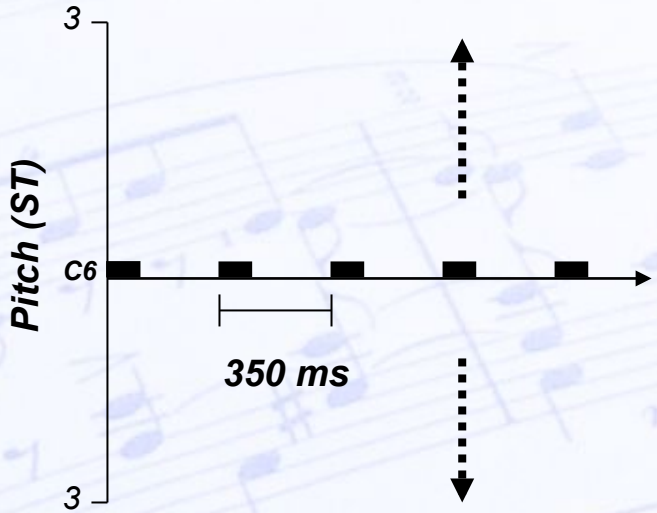


Peretz, Brattico & Tervaniemi (2005) *Annals of Neurology.*



Peretz, Brattico & Tervaniemi (2005) *Annals of Neurology.*

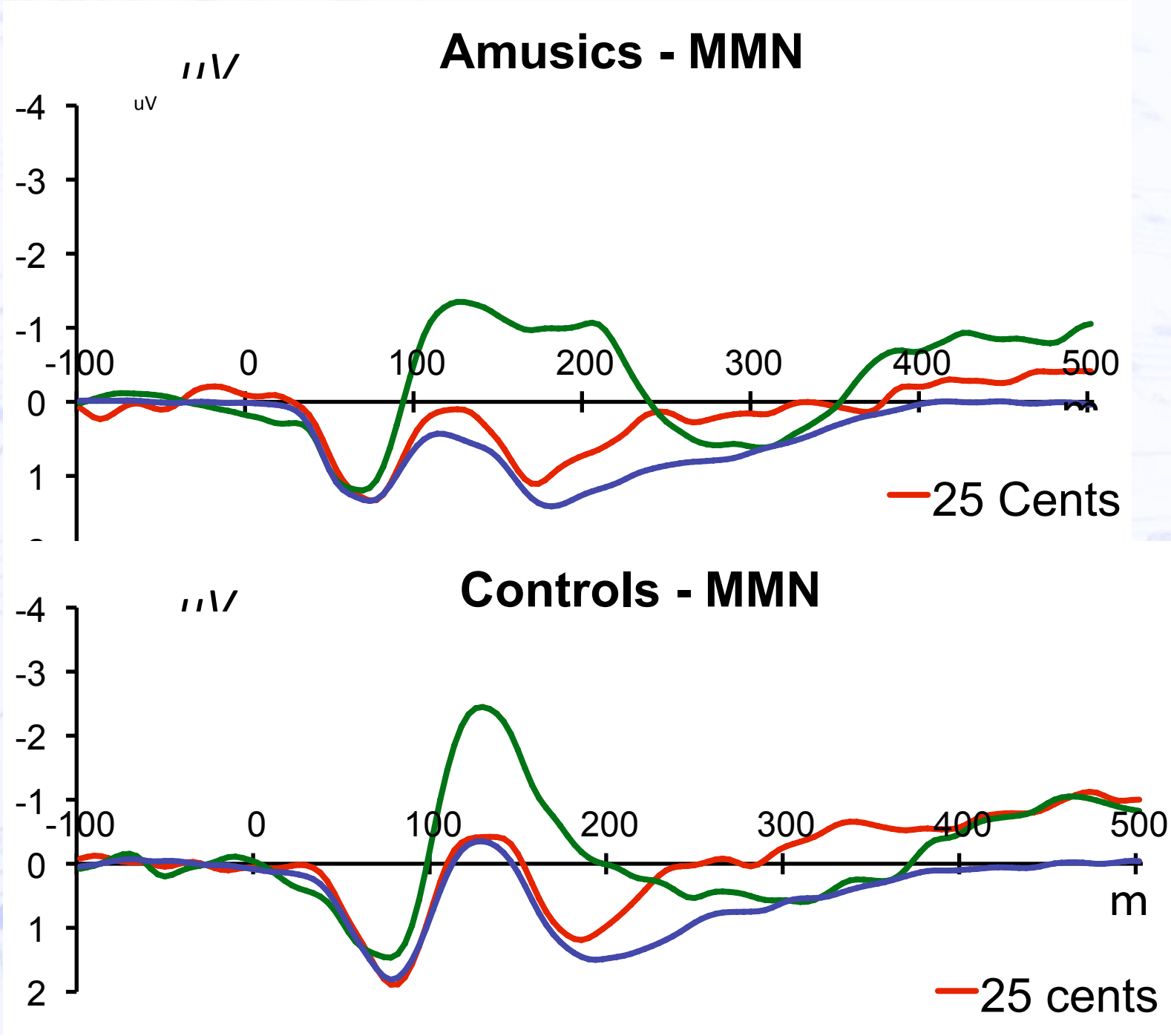
Mismatch Negativity



25 and 200 cents

Ignore condition

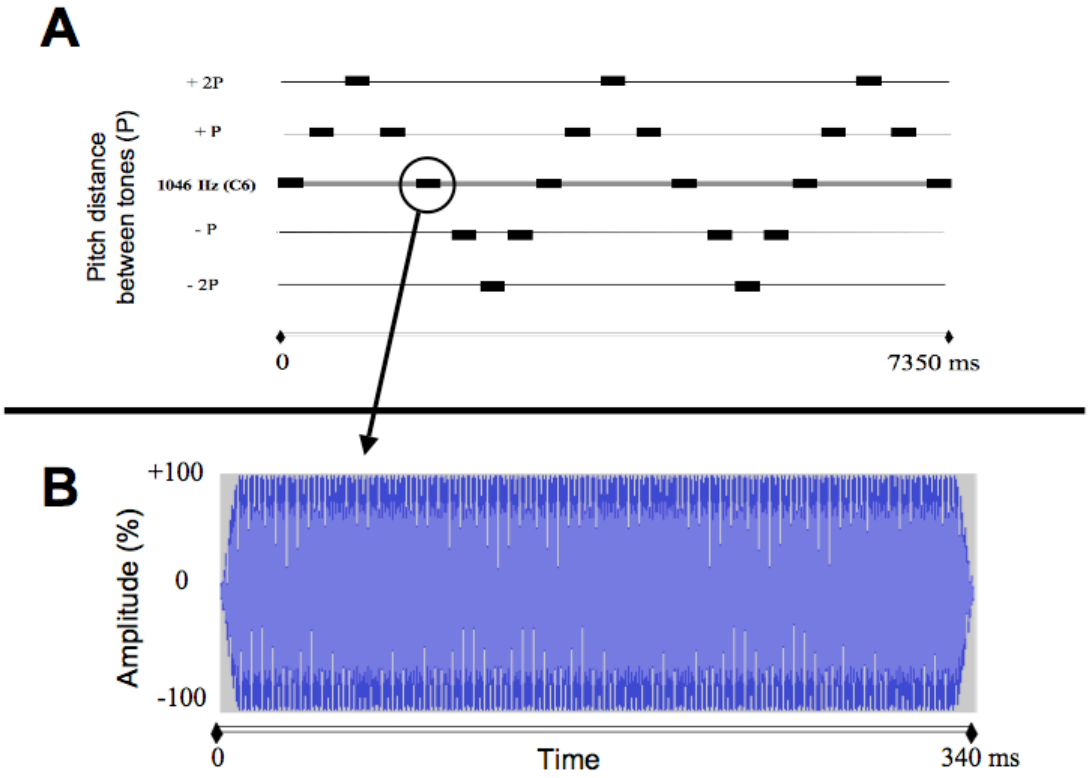
Patricia Moreau, PhD thesis

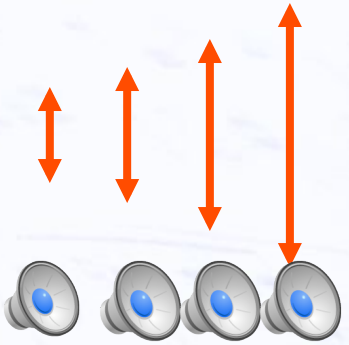

Amusics - MMN
uV
-4
-3
-2
-1
0
1
-100
0
100
200
300
400
500
25 Cents
Controls - MMN
uV
-4
-3
-2
-1
0
1
2
-100
0
100
200
300
400
500
m
25 cents

BOLD responses (fMRI)

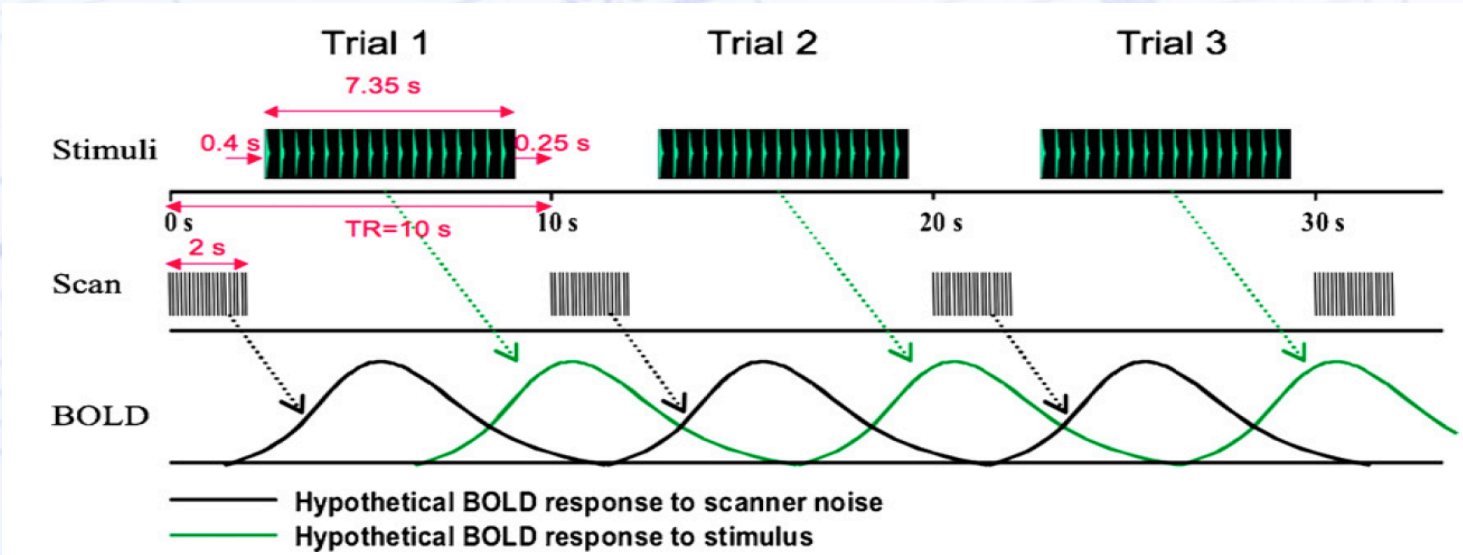
Krista Hyde
Ph.D. thesis

Robert Zatorre

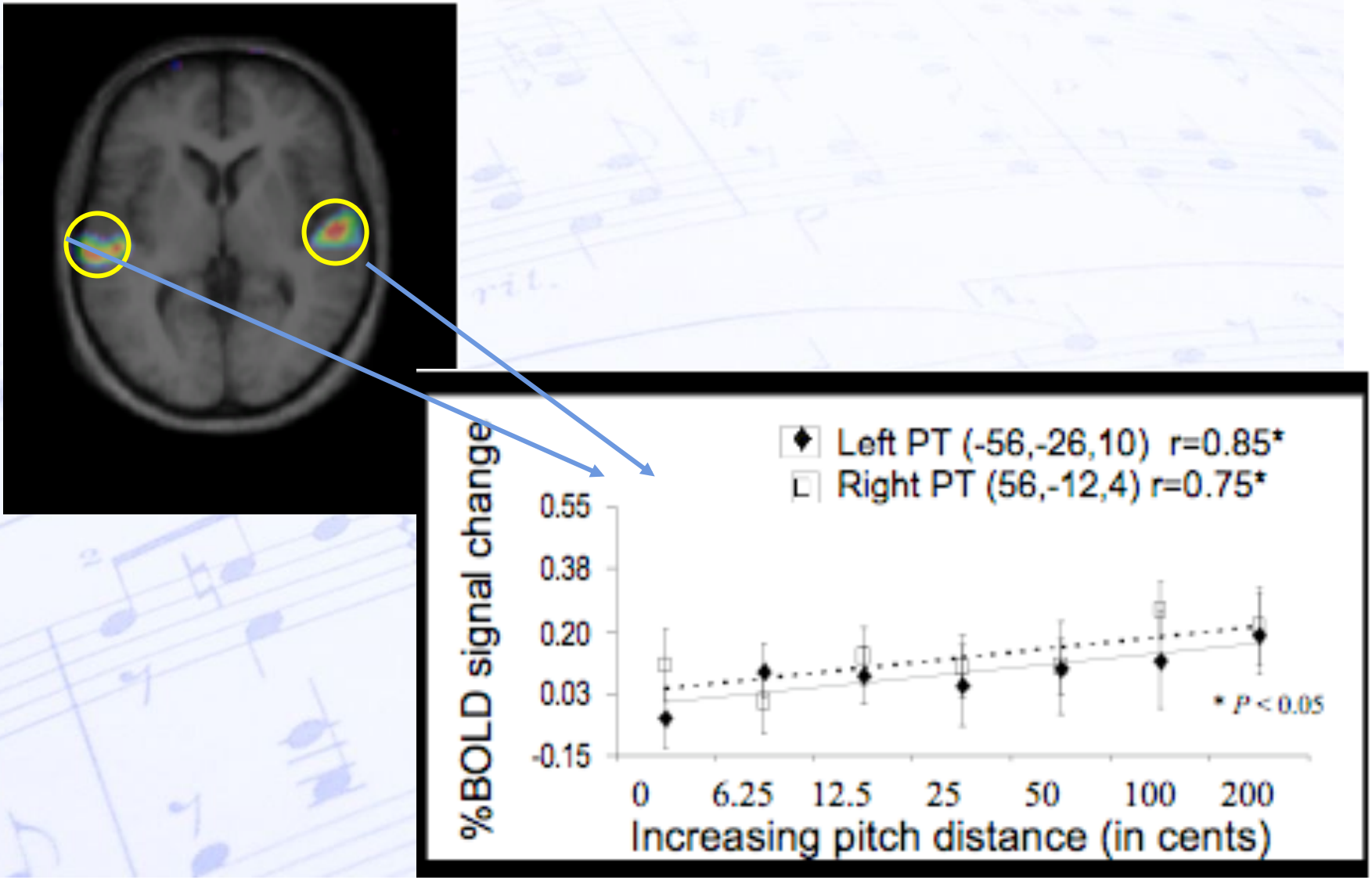




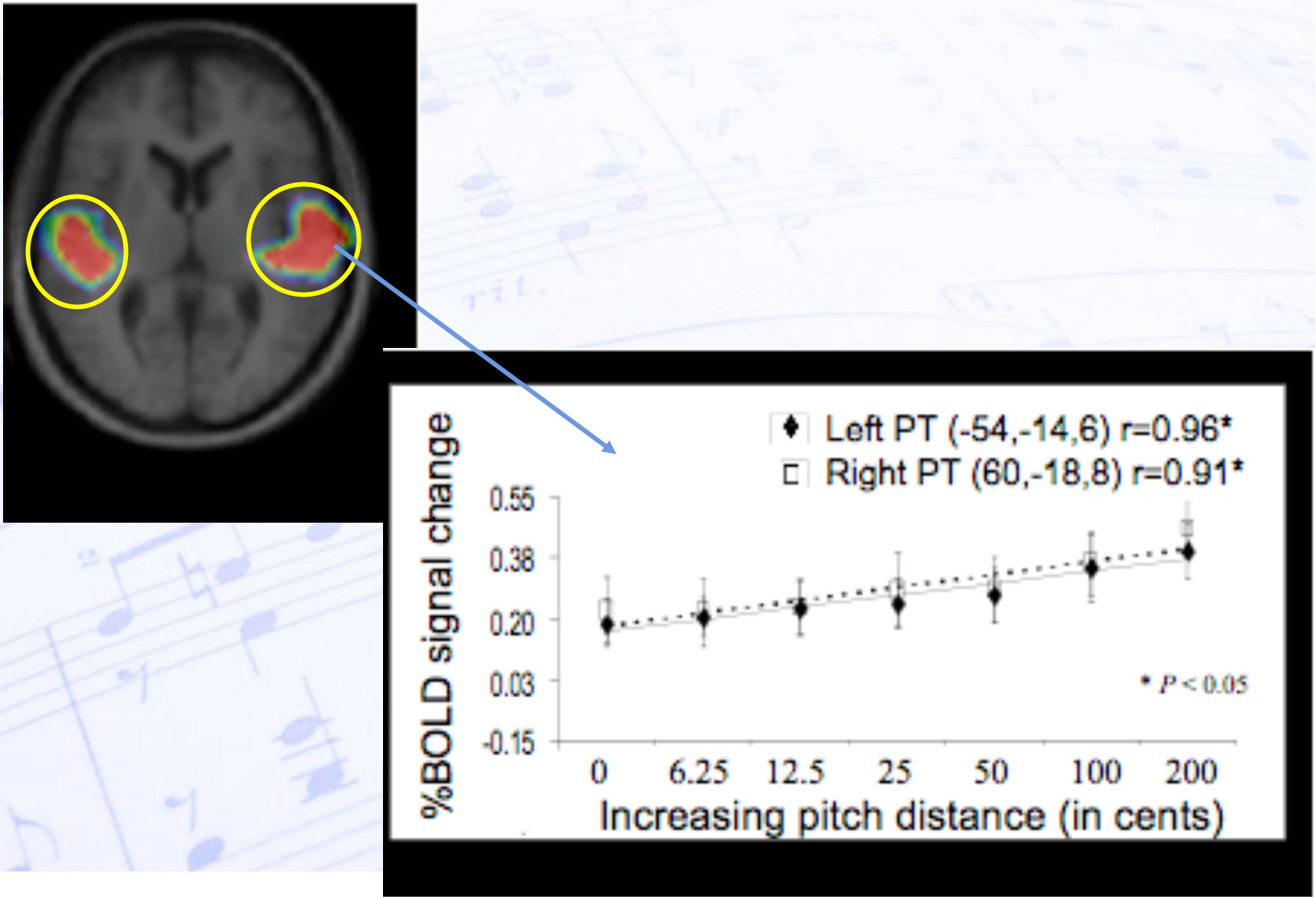
Passive listening

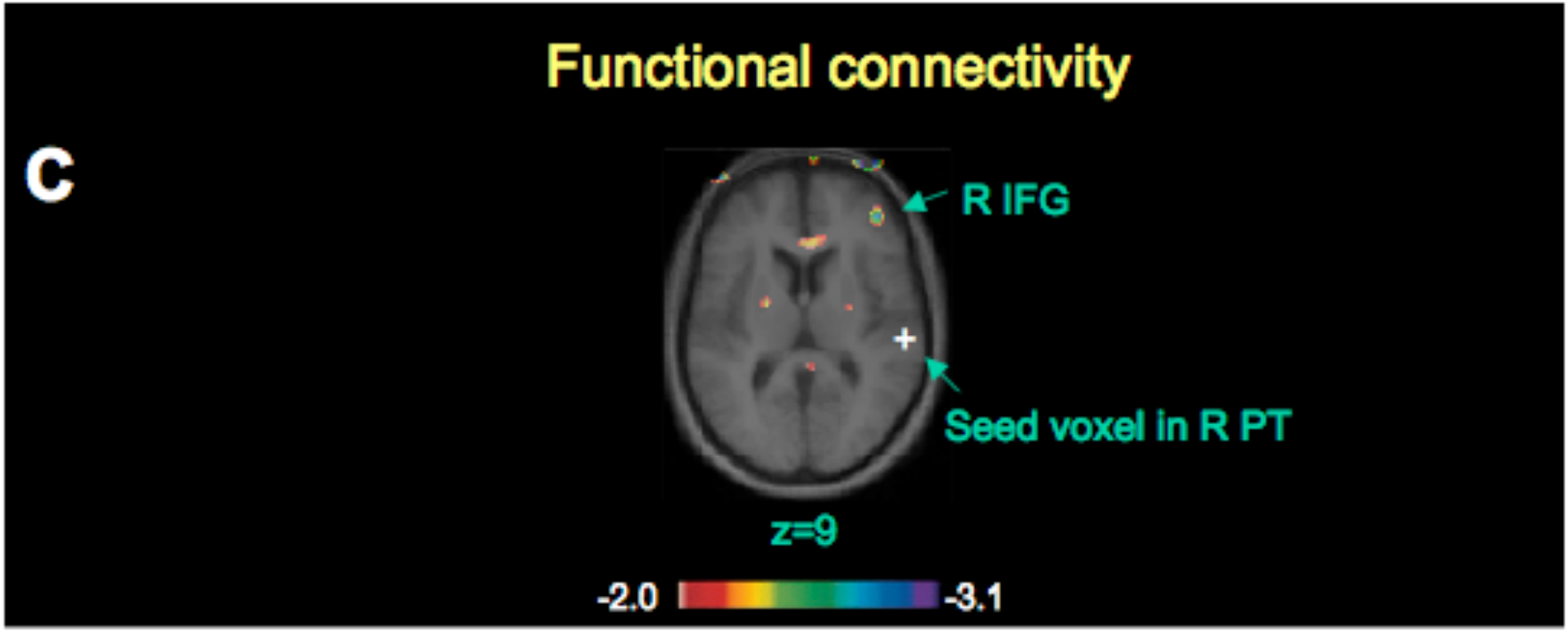


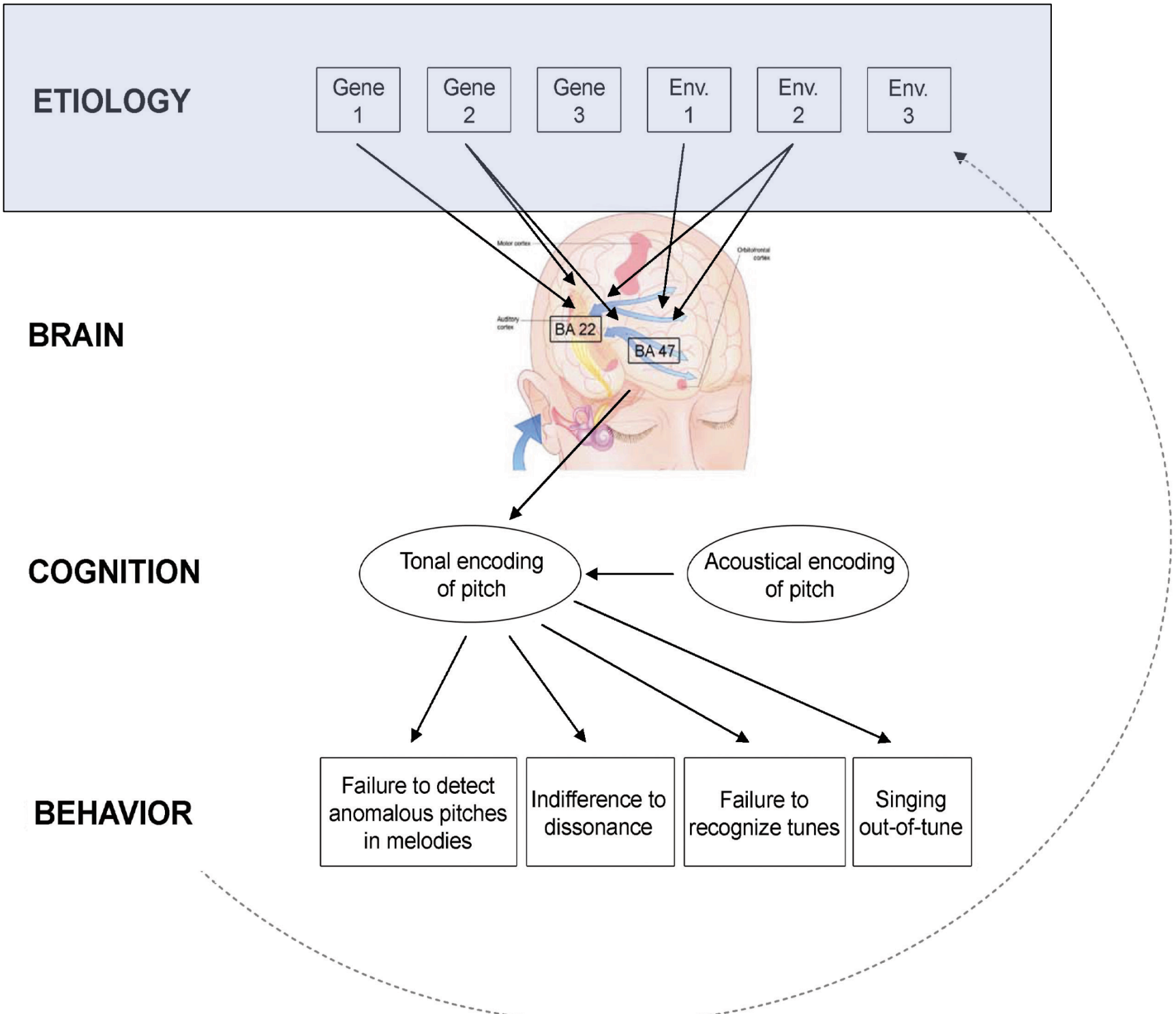
Matched controls (n=9)



Amusics (n=9)


Left PT (-54,-14,6) r=0.96*
Right PT (60,-18,8) r=0.91*
%BOLD signal change
0.55
0.38
0.20
0.03
-0.15
* P < 0.05
0
6.25
12.5
25
50
100
200
Increasing pitch distance (in cents)


Functional connectivity
C
R IFG
Seed voxel in R PT
z=9
-2.0
-3.1


ETIOLOGY
Gene 1
Gene 2
Gene 3
Env. 1
Env. 2
Env. 3
BRAIN
BA 22
BA 47
COGNITION
Tonal encoding of pitch
Acoustical encoding of pitch
BEHAVIOR
Failure to detect anomalous pitches in melodies
Indifference to dissonance
Failure to recognize tunes
Singing out-of-tune

Hérédité de l'amusie

Peretz et al. (2007) *American Journal of Human Genetics*

Table 3. Proportion of First-Degree Relatives Classified as Amusic by Test in Families of Amusic Probands and in Families of Controls

	No./Total (%) Amusic			
Group	Probands	Siblings	Offspring	All Family Members
Amusic	9/9	9/21 (43)	2/21[a] (10)	20/51 (39)
Control	0/10	2/22 (9)	0/36 (0)	2/68 (3)

[a] Corresponds to the 21 offspring who have one parent confirmed by test to be amusic.

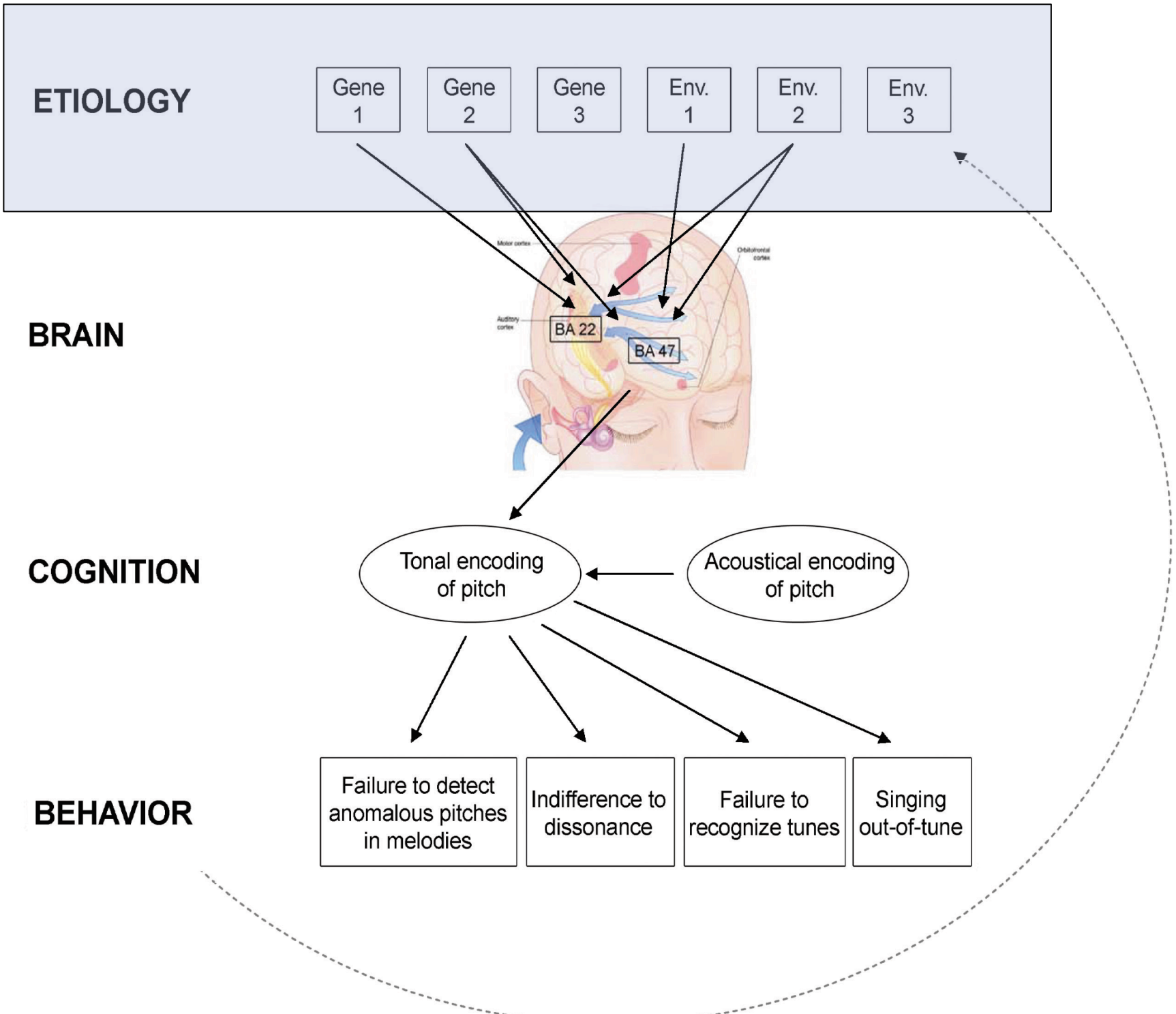
Genetic Correlates of Musical Pitch Recognition in Humans

Dennis Drayna,[1]* Ani Manichaikul,[1] Marlies de Lange,[2] Harold Snieder,[2]† Tim Spector[2]

SCIENCE VOL 291 9 MARCH 2001

rMZ, monozygotic twin; rDZ, dizygotic twin (correlation in liability)

	MZ	DZ
	0.67	0.44


ETIOLOGY
Gene 1
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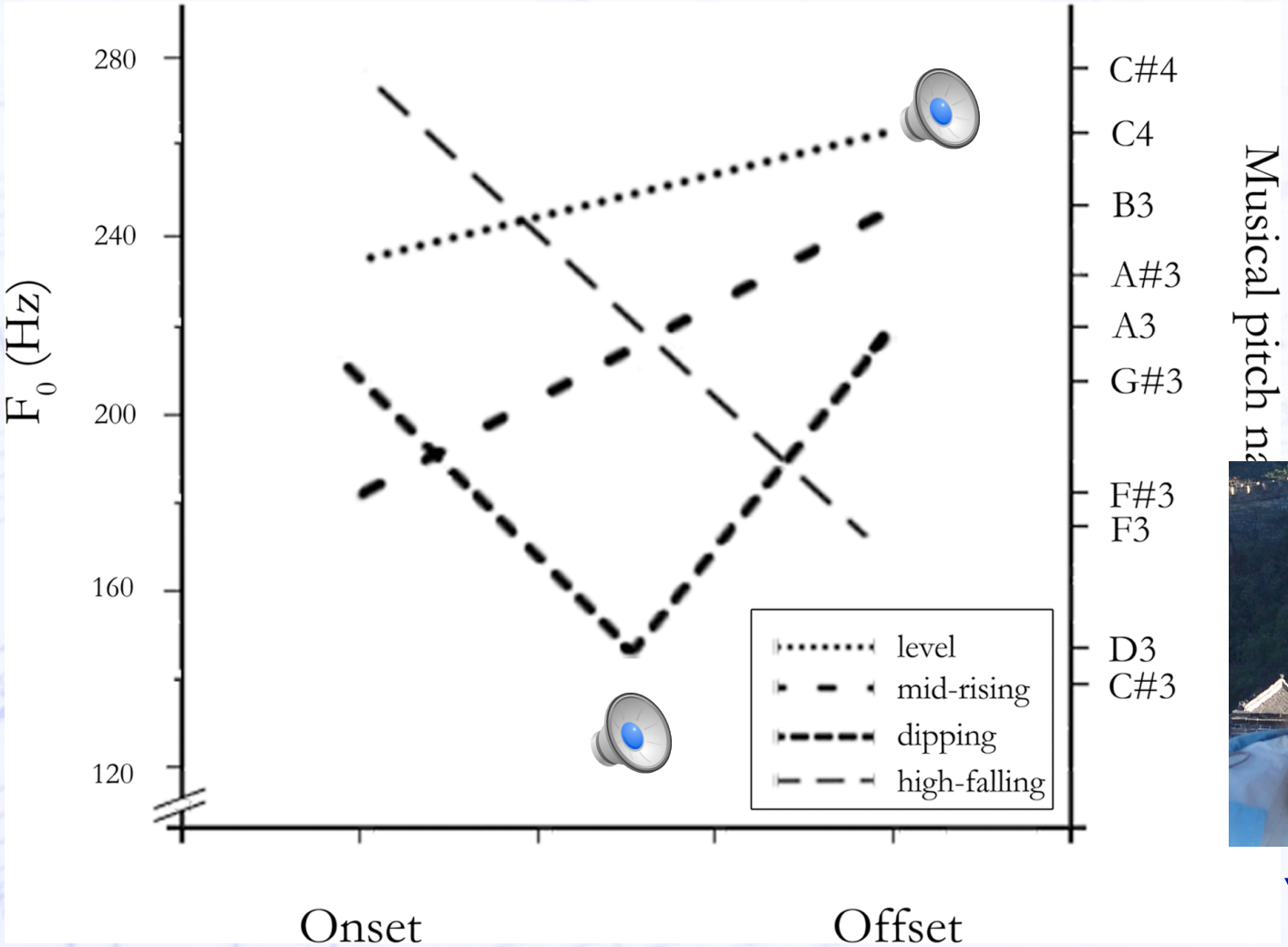
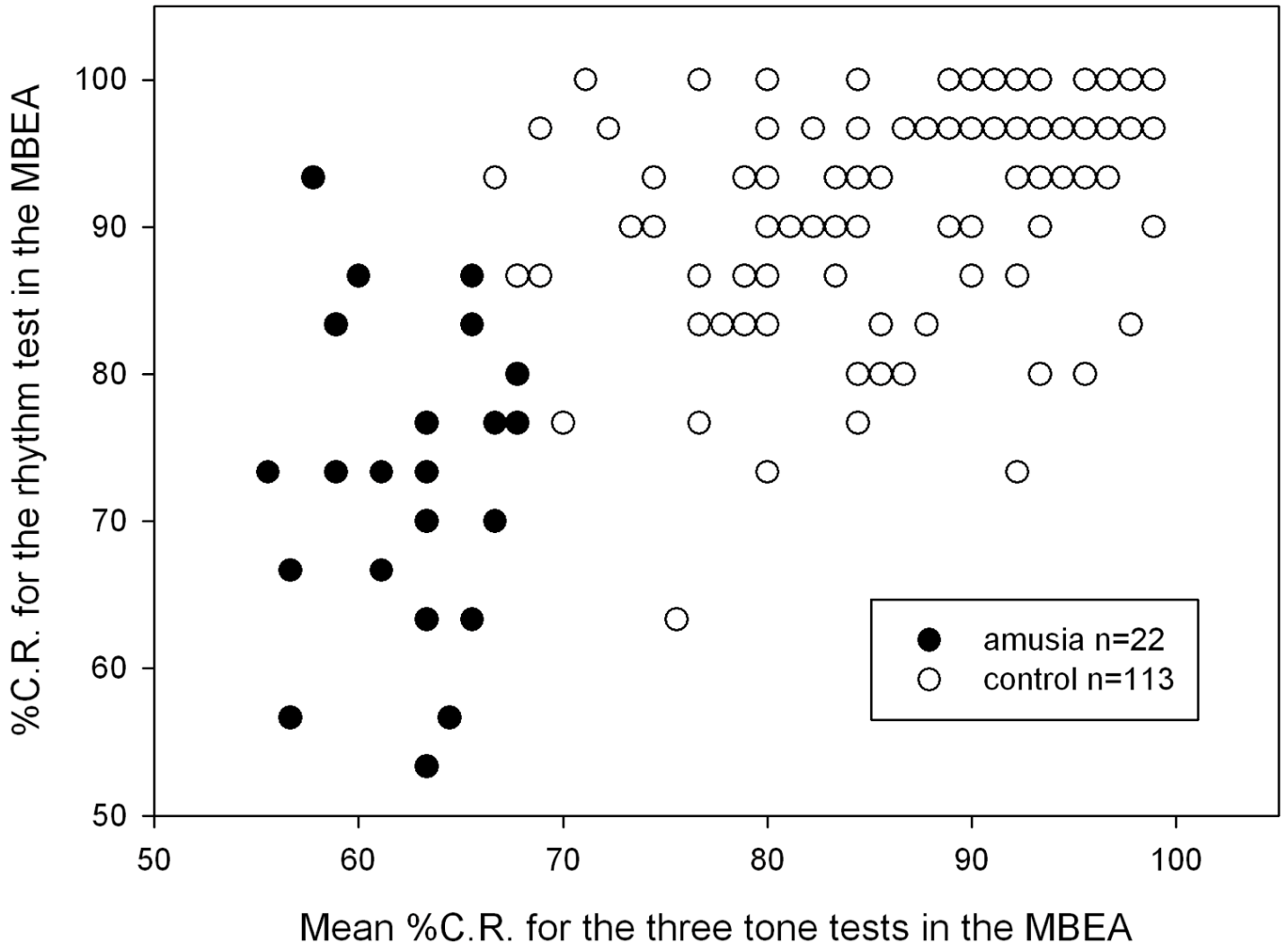
Tonal encoding of pitch
Acoustical encoding of pitch
BEHAVIOR
Failure to detect anomalous pitches in melodies
Indifference to dissonance
Failure to recognize tunes
Singing out-of-tune

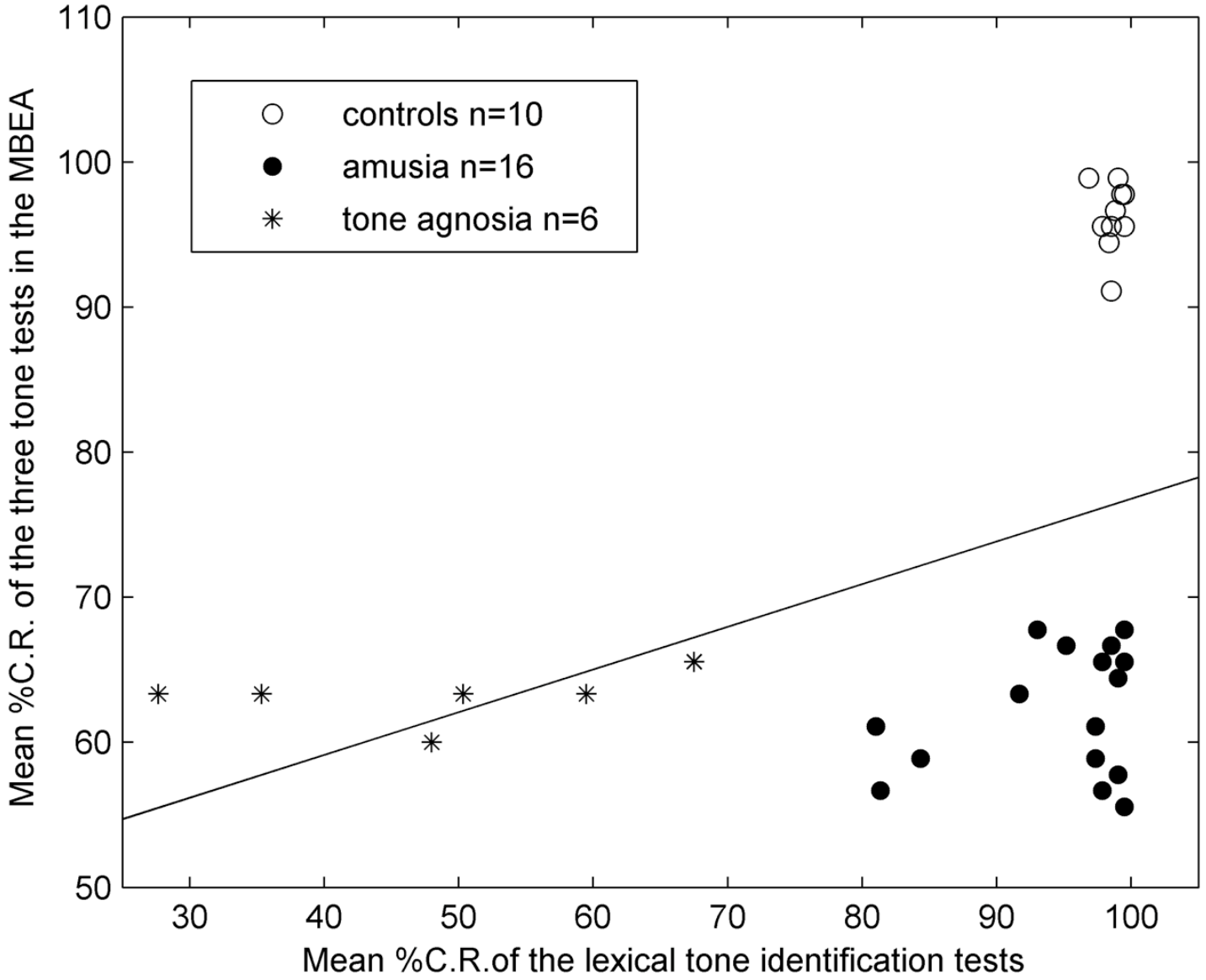
Le Mandarin utilise la hauteur pour distinguer les mots



Yun Nan

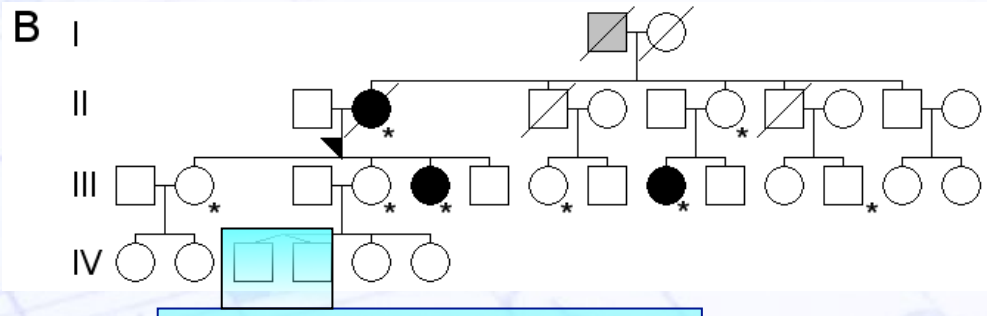
Beijing Normal University


%C.R. for the rhythm test in the MBEA
100
90
80
70
60
50
50
60
70
80
90
100
Mean %C.R. for the three tone tests in the MBEA
amusia n=22
control n=113


controls n=10
amusia n=16
tone agnosia n=6
Mean %C.R. of the three tone tests in the MBEA
Mean %C.R.of the lexical tone identification tests
110
100
90
80
70
60
50
30
40
50
60
70
80
90
100

Amusie congénitale: du comportement aux gènes

- phenotype
  - Pitch-based deficit
- Neural phenotype
  - impoverished connectivity in a right-hemisphere based network involving the inferior frontal cortex and the auditory cortex
- Genes
  - Hereditary
  - DNA analysis in progress
  - Exposure to a tonal language is not a moderating factor



DZ male twins
The affected plays music
The unaffected does not

Questions en suspens: recherche en cours

- ✓ Plasticité: est-ce qu'un entrainement ciblé chez l'enfant peut compenser pour son trouble ?
- ✓ Est-ce que l'amusie vocale existe indépendemment?
- ✓ Un problème d'"awareness" ?
- ✓ Peut-on induire l'amusie chez l'individu normal?

Pour plus d'information

www.brams.umontreal.ca/peretz

Et l'aide financière: