



Le cerveau du musicien

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Université 
de Montréal



COLLÈGE
DE FRANCE
— 1530 —

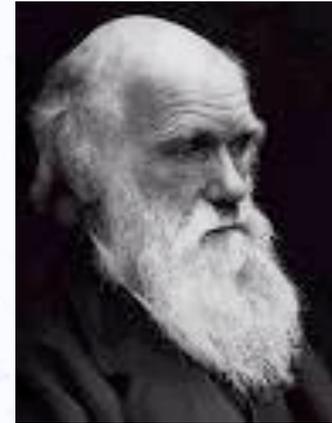
Brams ·)))

Nous naissons tous musiciens:

- ✓ Exige des milliers d'heures de pratique
- ✓ Une éducation explicite
- ✓ Seule un minorité poursuit à l'âge adulte
- ✓ Bénéfices "généraux"
- ✓ L'oreille absolue.



Evolution



Darwin 1809-1882





Courtoisie de Tecumseh Fitch

Monkey drumming reveals common networks for perceiving vocal and nonvocal communication sounds

Ryan Remedios^a, Nikos K. Logothetis^{a,b,1}, and Christoph Kayser^{a,1}

- Forme de communication non-vocale qui partagerait les mêmes circuits neuronaux que ceux impliqués dans la communication vocale (cortex auditif et amygdale)
- Suggère des origines communes
- Exprimerait la dominance sociale
- Précurseur de la performance musicale ?



PNAS, in press

Le musicien humain: Habiletés spécifiques



- Maîtrise de l'instrument (coordination sensori-motrice fine)
- Lecture et écriture
- Savoir explicite et sophistiqué
- Improvisation, composition
- Oreille absolue

Le musicien humain: les bénéfices (cognitifs)

« *Music makes you smarter* »



- La mémoire
- Le Q.I.
- L'apprentissage des langues
- Les mathématiques

Etudes corrélationnelles

Schellenberg & Peretz (2008) *TICS*

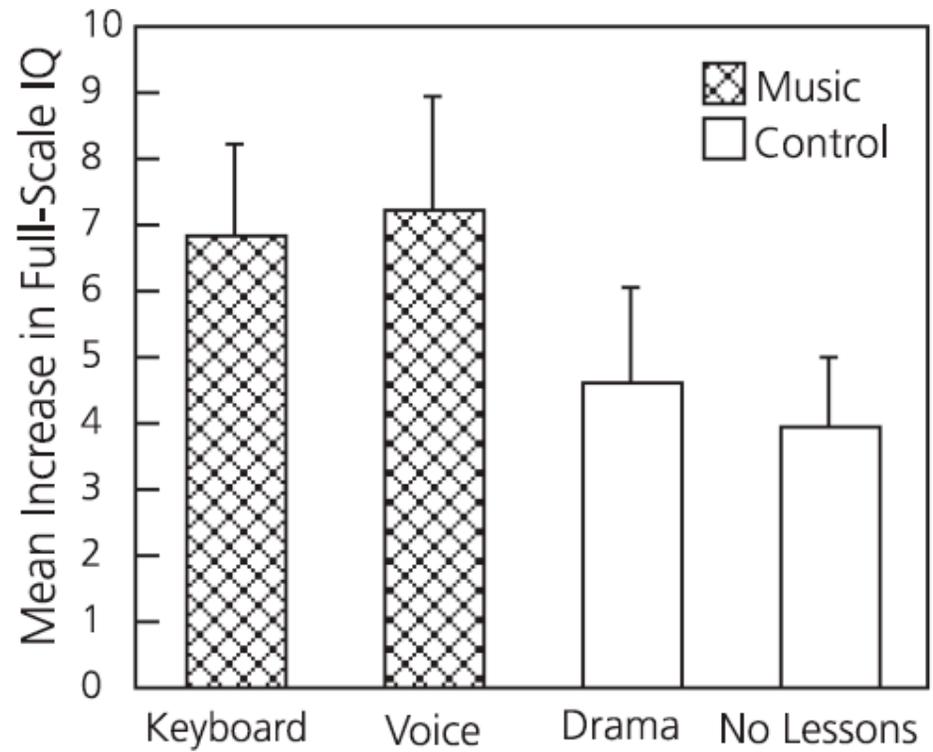
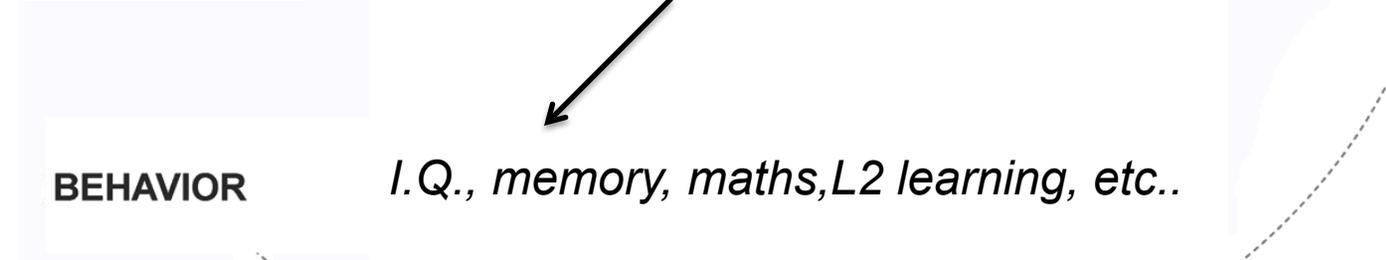
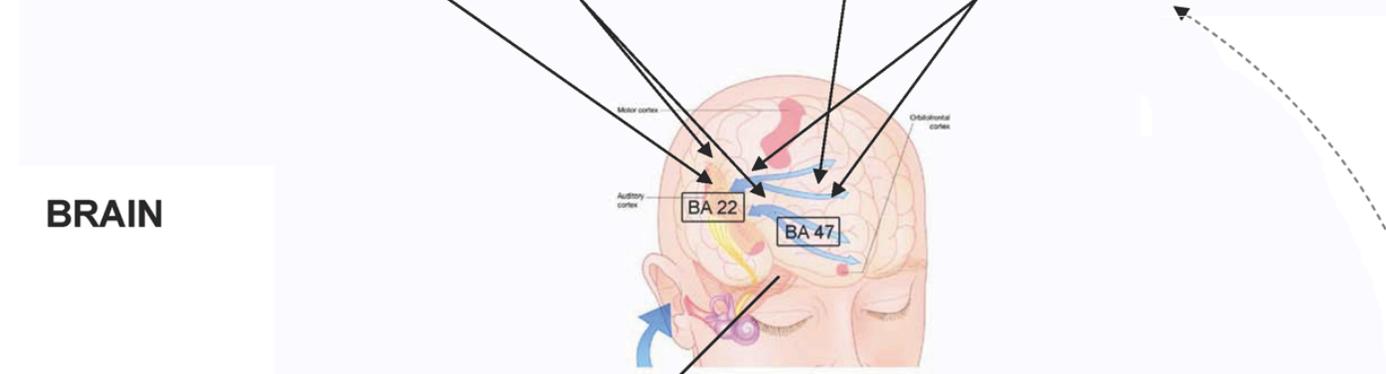
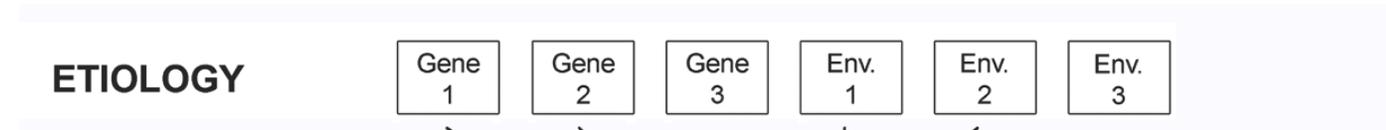


Figure 1. Mean increase in IQ as a function of group assignment. Error bars are standard errors. Reprinted from E.G. Schellenberg. (2004). Music lessons enhance IQ. *Psychological Science*, 15, 511–514.



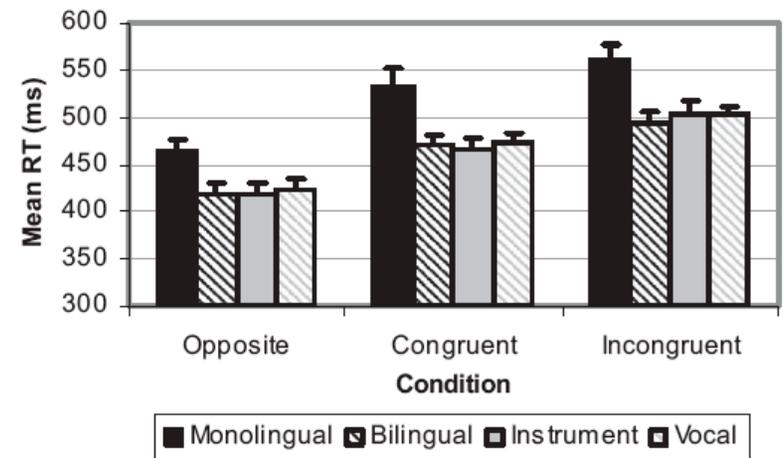
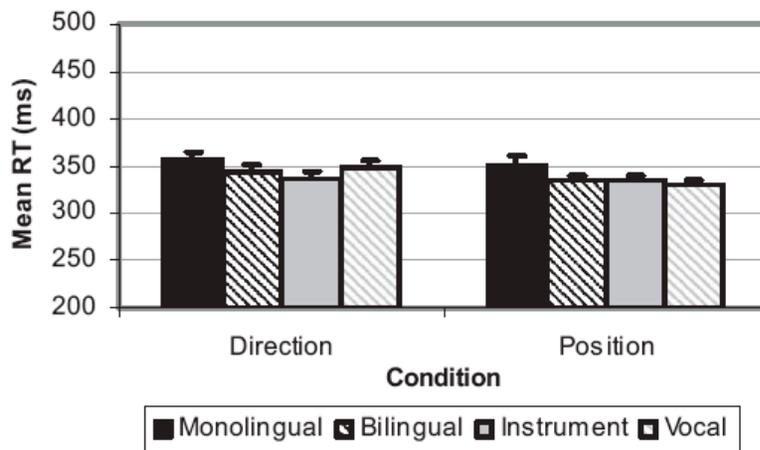
Musical Expertise, Bilingualism, and Executive Functioning

Ellen Bialystok

York University and Rotman Research Institute of Baycrest

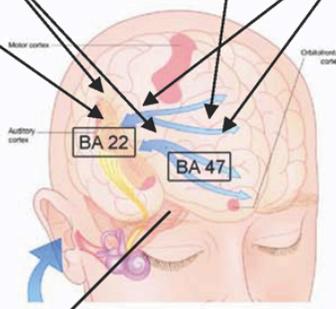
Anne-Marie DePape

York University and McMaster University





BRAIN

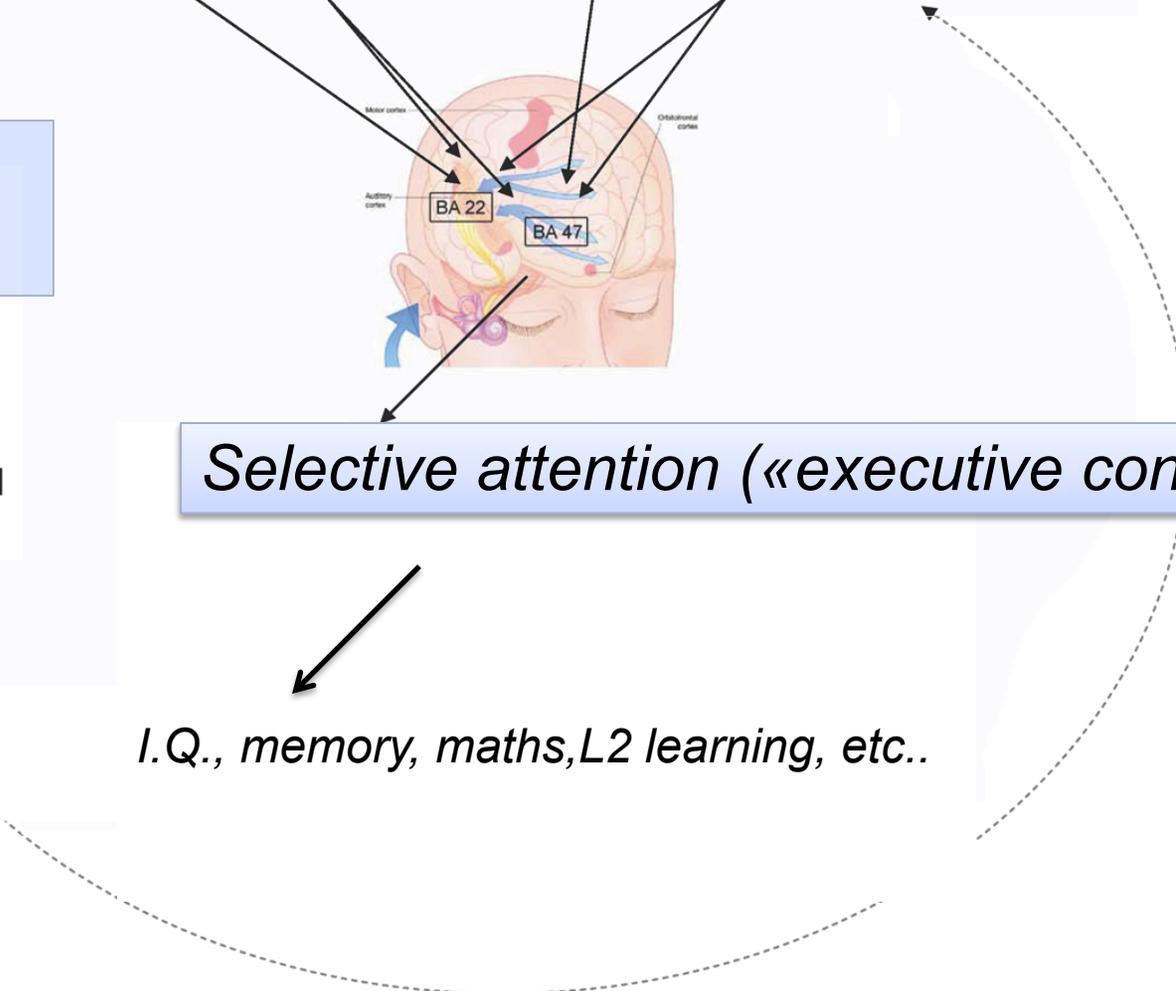


COGNITION

Selective attention («executive control»)

BEHAVIOR

I.Q., memory, maths, L2 learning, etc..



The musician's brain as a model of neuroplasticity

Thomas F. Münte, Eckart Altenmüller and Lutz Jäncke

NATURE REVIEWS | NEUROSCIENCE

VOLUME 3 | JUNE 2002 |

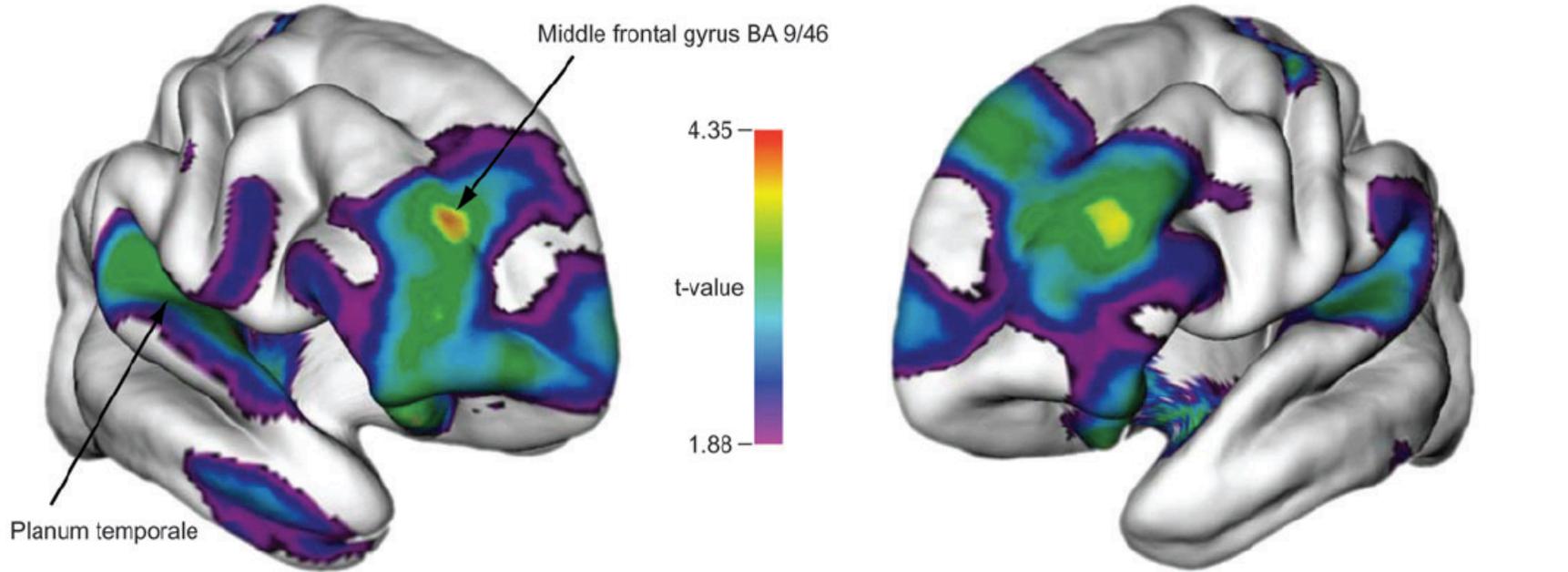


- Degré d'expertise variable et quantifiable (experience-dependent plasticity)
- Etude expérimentale possible (re: pre-existing and predisposing anatomy)
- Différences individuelles

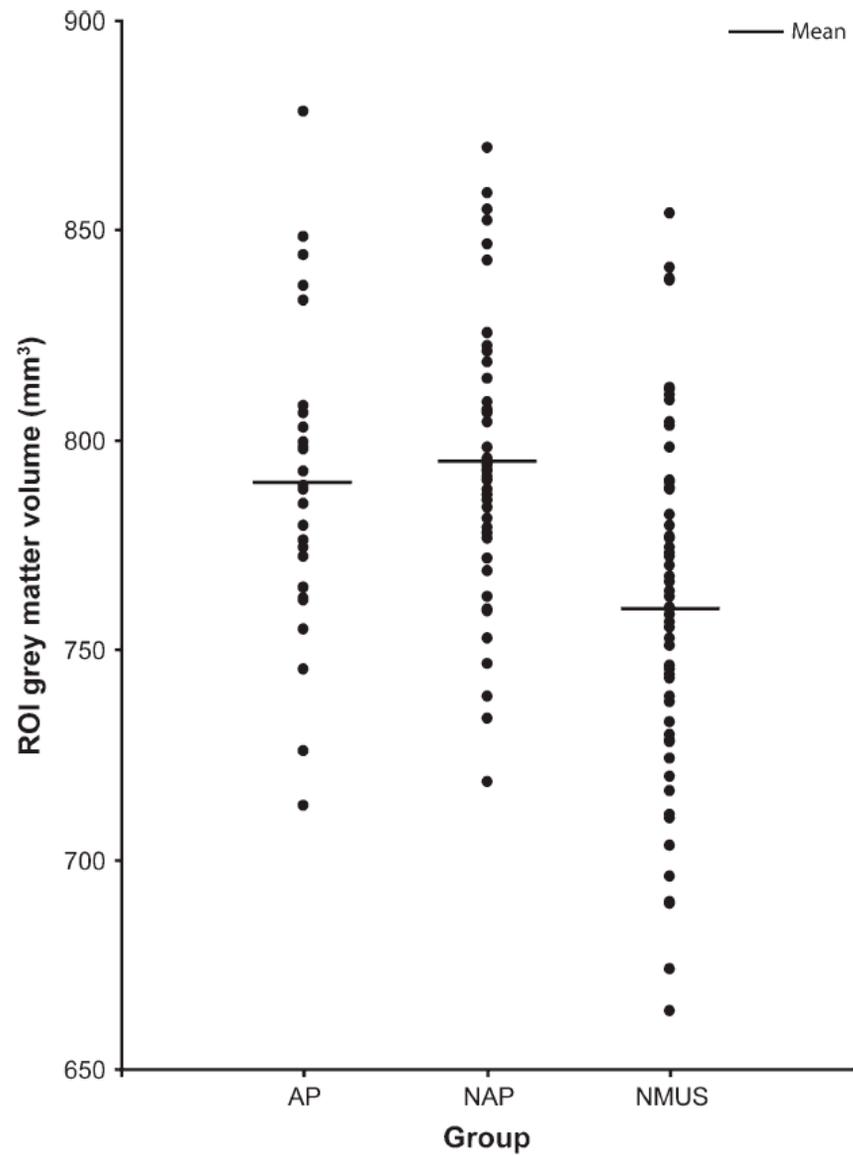
Anatomical differences

a) Cortical thickness: musicians > non-musicians (RH)

b) Cortical thickness: musicians > non-musicians (LH)



Bermudez et al. (2009) *Cerebral Cortex*;
voir aussi Schlaug et Pantev



Bermudez et al. (2009) *Cerebral Cortex*

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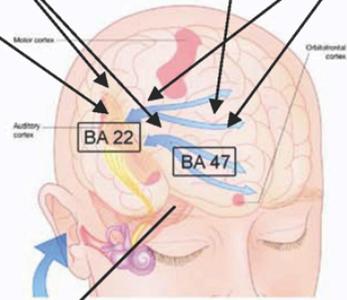


- ✓ Stabilisation de connexions transitoires (Pruning, Hebbian competition)?
- ✓ Désinhibition de connexions silencieuses ?
- ✓ Fenêtre de maturation sous contrôle génétique ?
- ✓ Réorganisation liée à l'expérience ?

ETIOLOGY

- Gene 1
- Gene 2
- Gene 3
- Env. 1
- Env. 2
- Env. 3

BRAIN

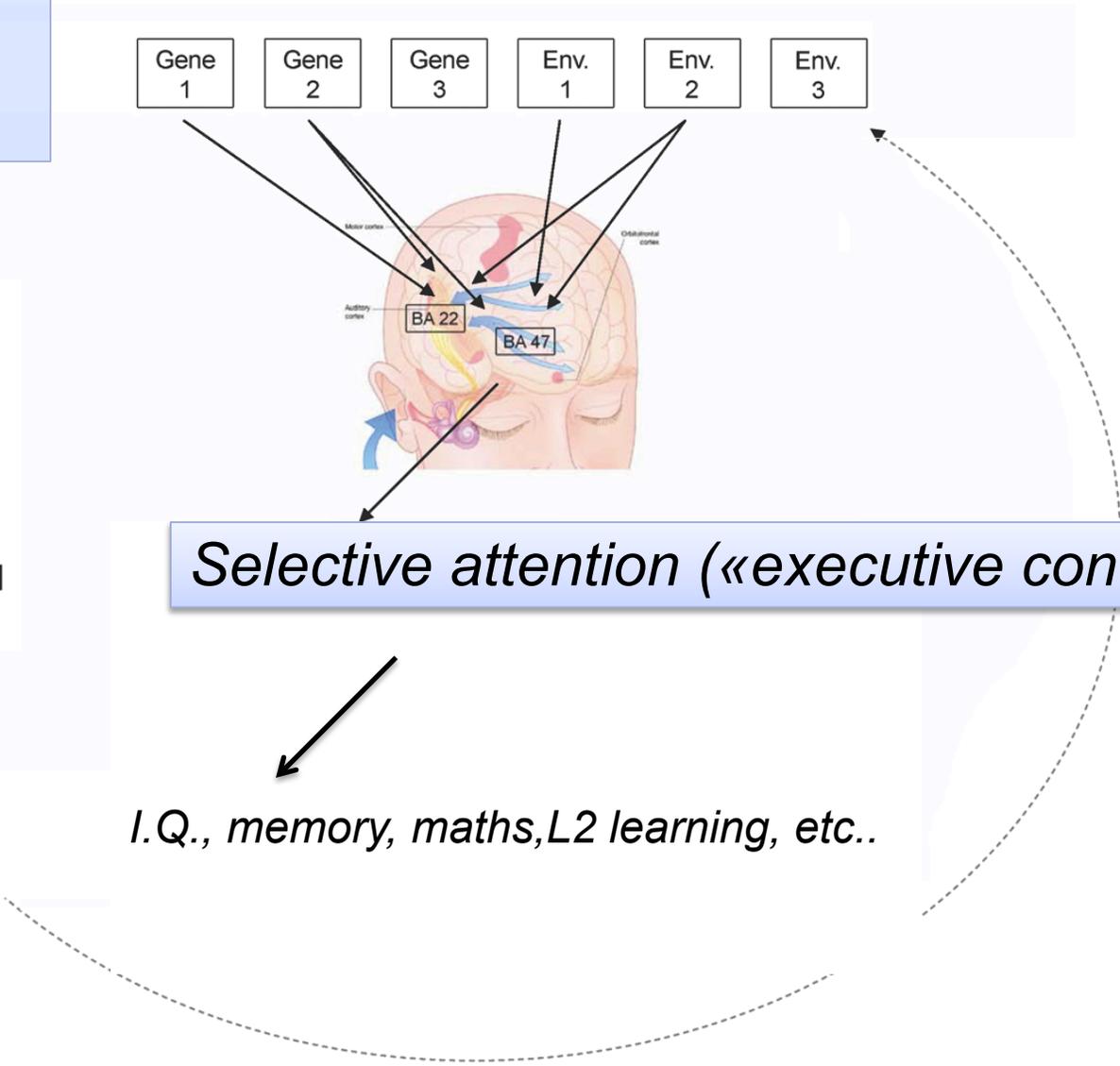


COGNITION

Selective attention («executive control»)

BEHAVIOR

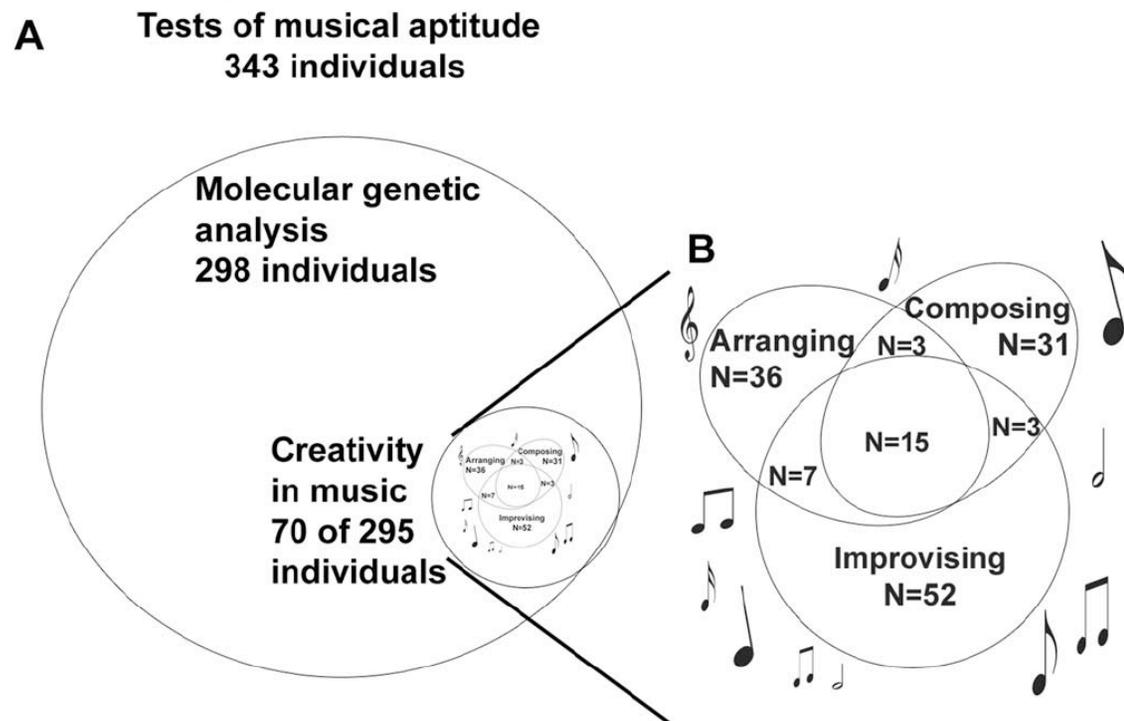
I.Q., memory, maths, L2 learning, etc..



Genome-wide linkage scan for loci of musical aptitude in Finnish families: evidence for a major locus at 4q22

J. Medical Genetics 2008

K Pulli,¹ K Karma,² R Norio,³ P Sistonen,⁴ H H H Göring,⁵ I Järvelä^{1,6}



Musical Aptitude Is Associated with AVPR1A-Haplotypes

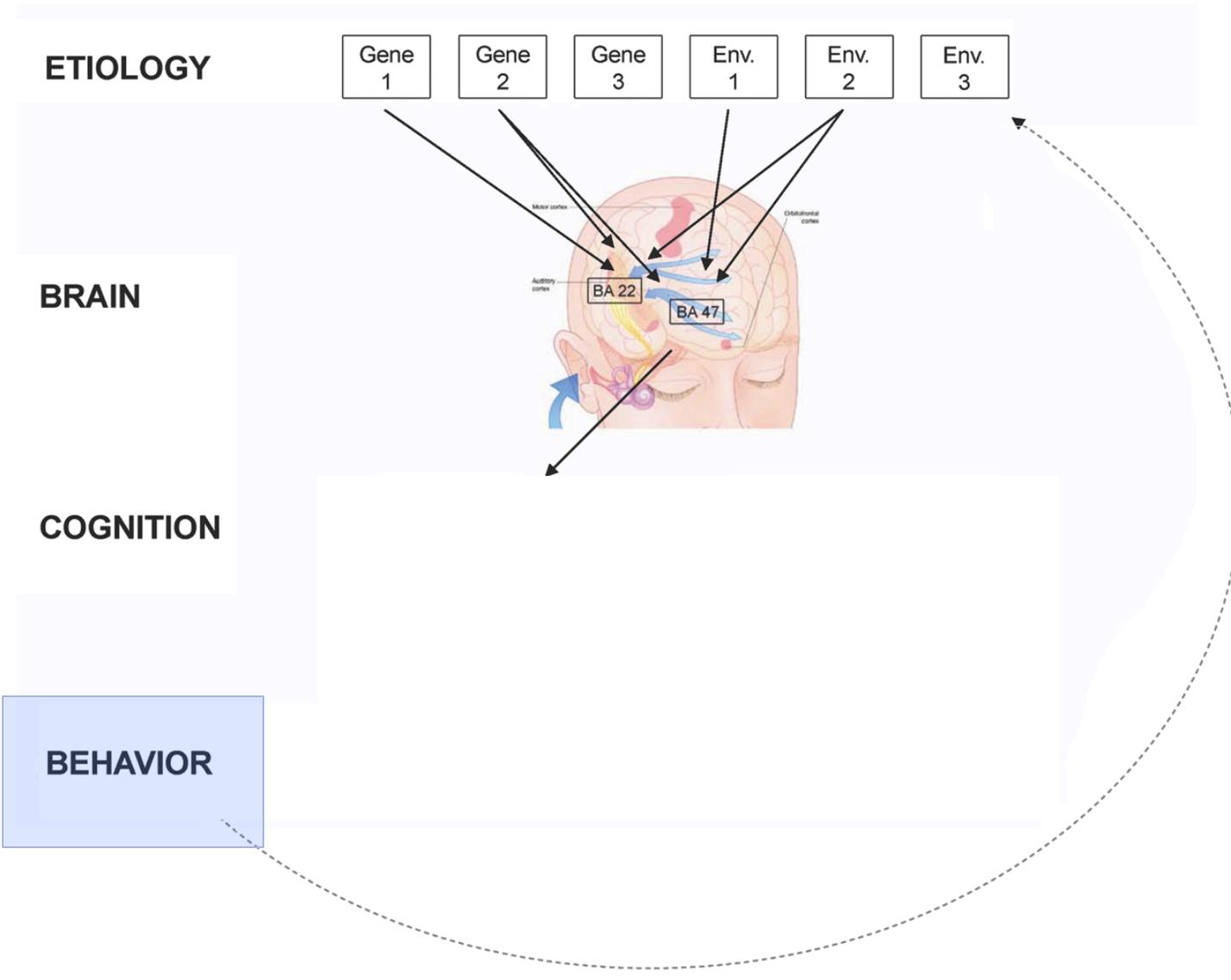
Liisa T. Ukkola^{1*}, Päivi Onkamo², Pirre Raijas³, Kai Karma⁴, Irma Järvelä^{1,5}

PloS One 2009



L'oreille absolue

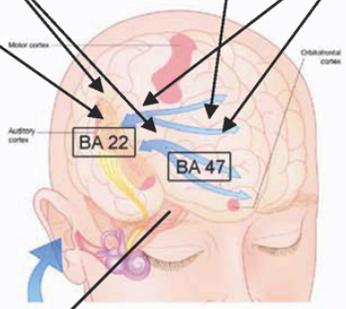




ETIOLOGY

Gene 1 Gene 2 Gene 3 Env. 1 Env. 2 Env. 3

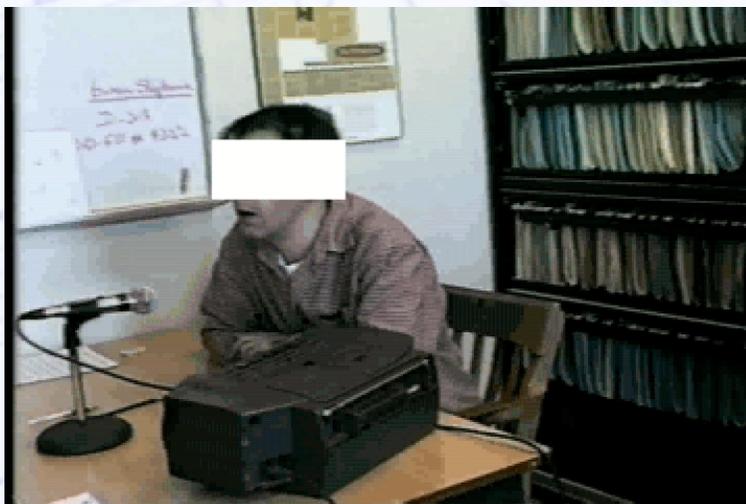
BRAIN



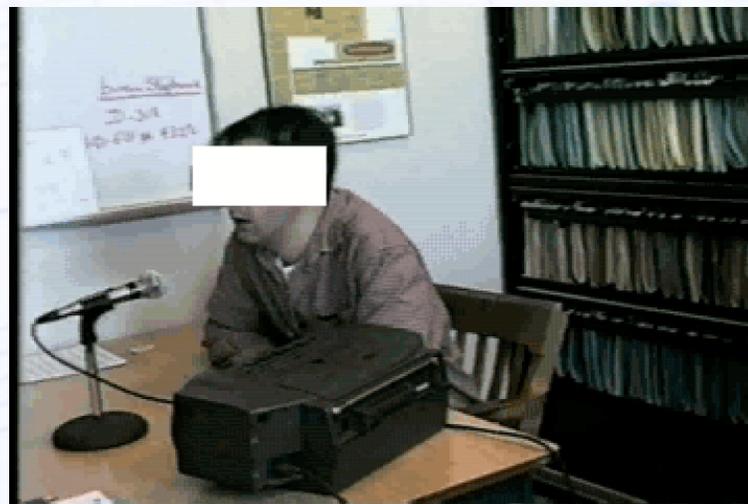
COGNITION

BEHAVIOR

Piano tones



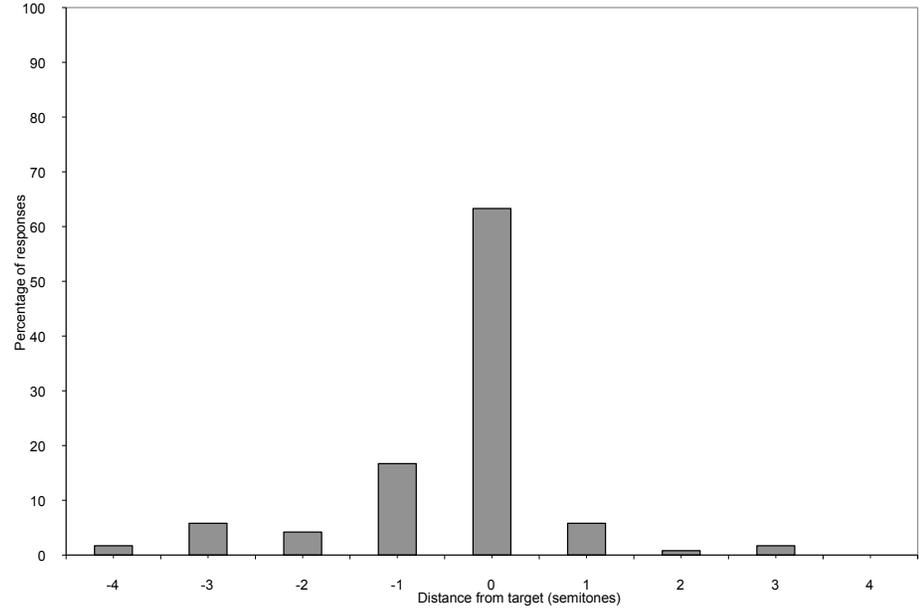
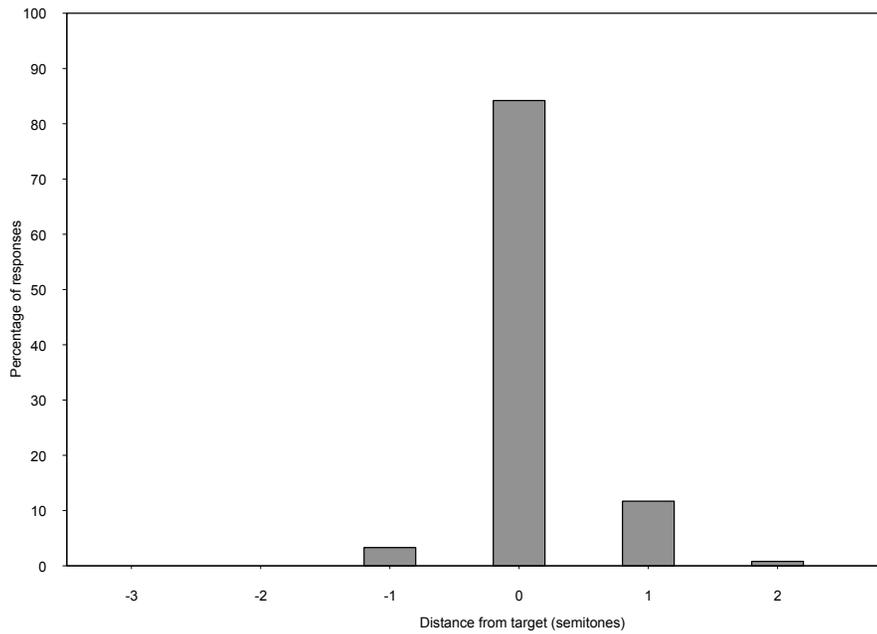
Sung tones



Identification (pitch label) task

Piano tones

Sung tones



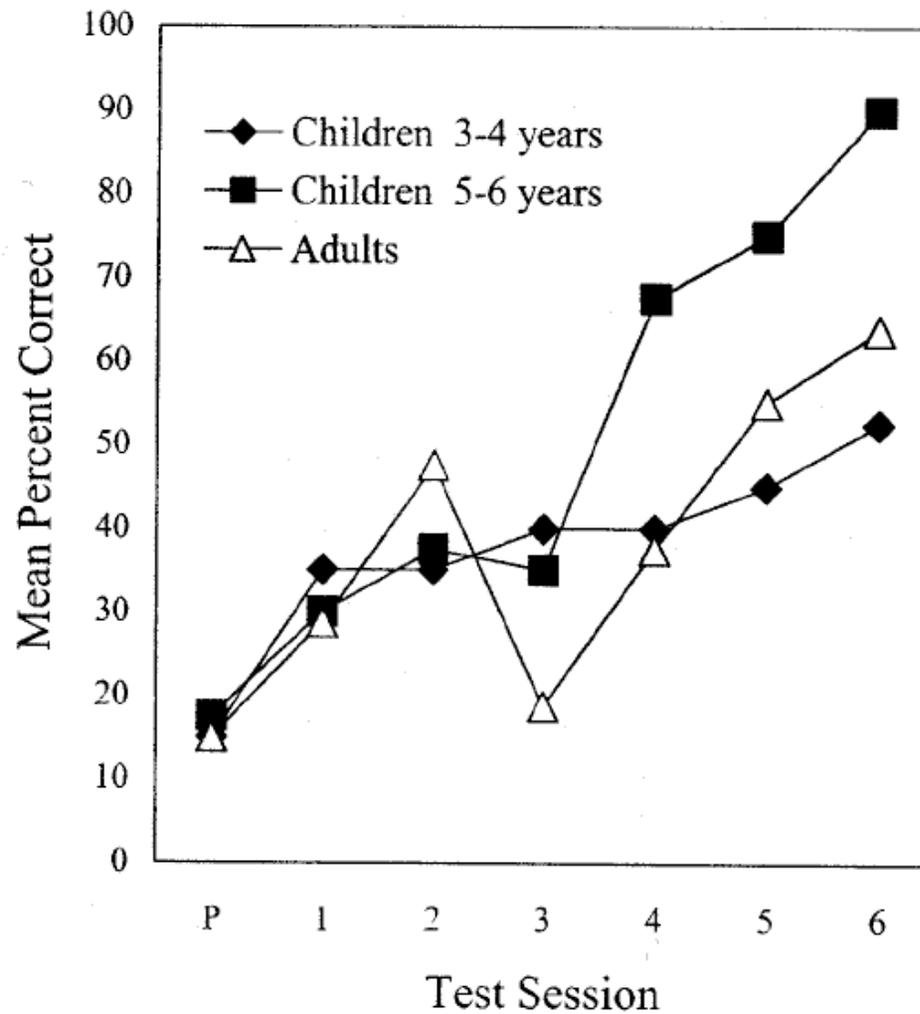
L'oreille absolue est une habileté « encapsulée »

- L'oreille absolue semble conférer peu d'avantage
- Association automatique et irrépressible
- Acquisée par simple exposition avant l'âge de 9 ans
- Rare

Origines de l'oreille absolue

- ✓ De nombreuses espèces animales montrent un traitement préférentiel pour la hauteur absolue (et non relative)
- ✓ L'oreille relative pourrait être spécifique à l'humain
- ✓ Le bébé porterait plus attention à la hauteur absolue que l'adulte mais utilise l'oreille relative en mémoire (Saffran, 2003; Platinga & Trainor, 2005)
- ✓ Tout le monde possède un certain degré (imprécis) d'oreille absolue en mémoire à long terme (Schellenberg & Trehub, 2003)
- ✓ L'oreille absolue est impossible à acquérir à l'âge adulte

Période critique



Russo, Windell & Cuddy (2003) *Music Perception*

Une oreille plus fine ?

La majorité des musiciens débute la formation musicale durant la période critique, et ne développent pas l'oreille absolue



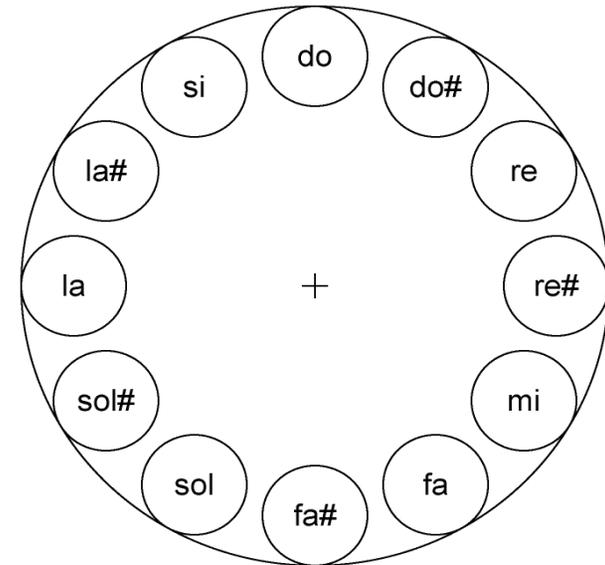
Students	Gender	Age at onset of musical training	Years of musical training
AP-musicians	4 M, 5 F	5.3 (1.1)	17.5 (1.0)
Non-AP musicians	3 M, 6 F	5.6 (1.2)	16.7 (1.6)
Non-musicians	4 M, 8 F		



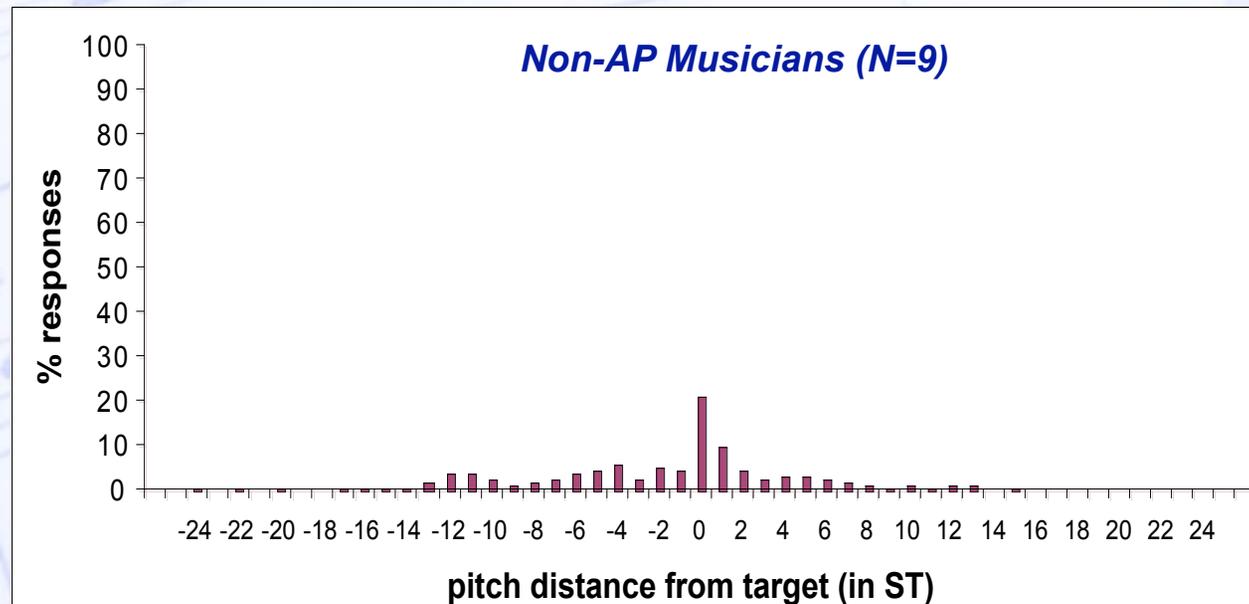
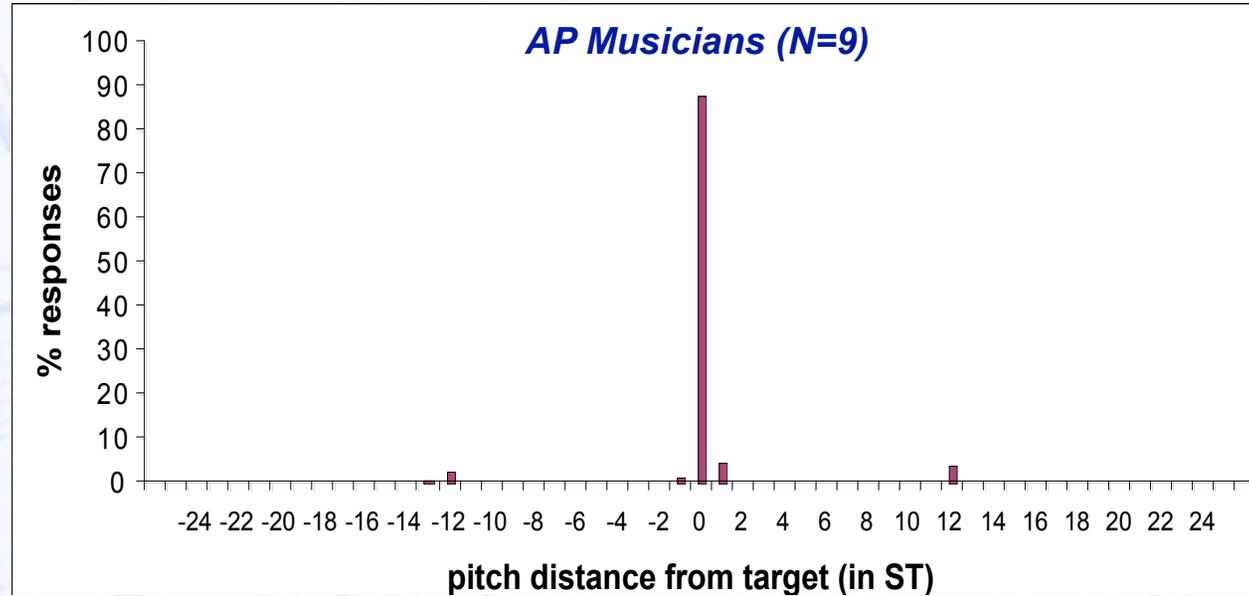
Hyde & Peretz, unpublished data

Test of Absolute pitch (Bermudez et al.(2009) *Cerebral Cortex*)

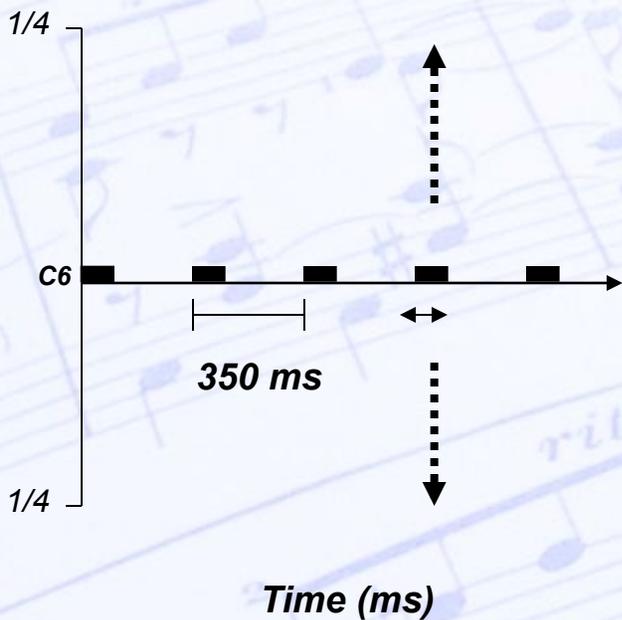
- 108 inverse sine-wave tones of 1 s
- 24 pitches over 3 octaves (C3 to B5) with varying intensity, random order
- Criterion: 75 % of CR



Performance on Absolute Pitch (AP) test

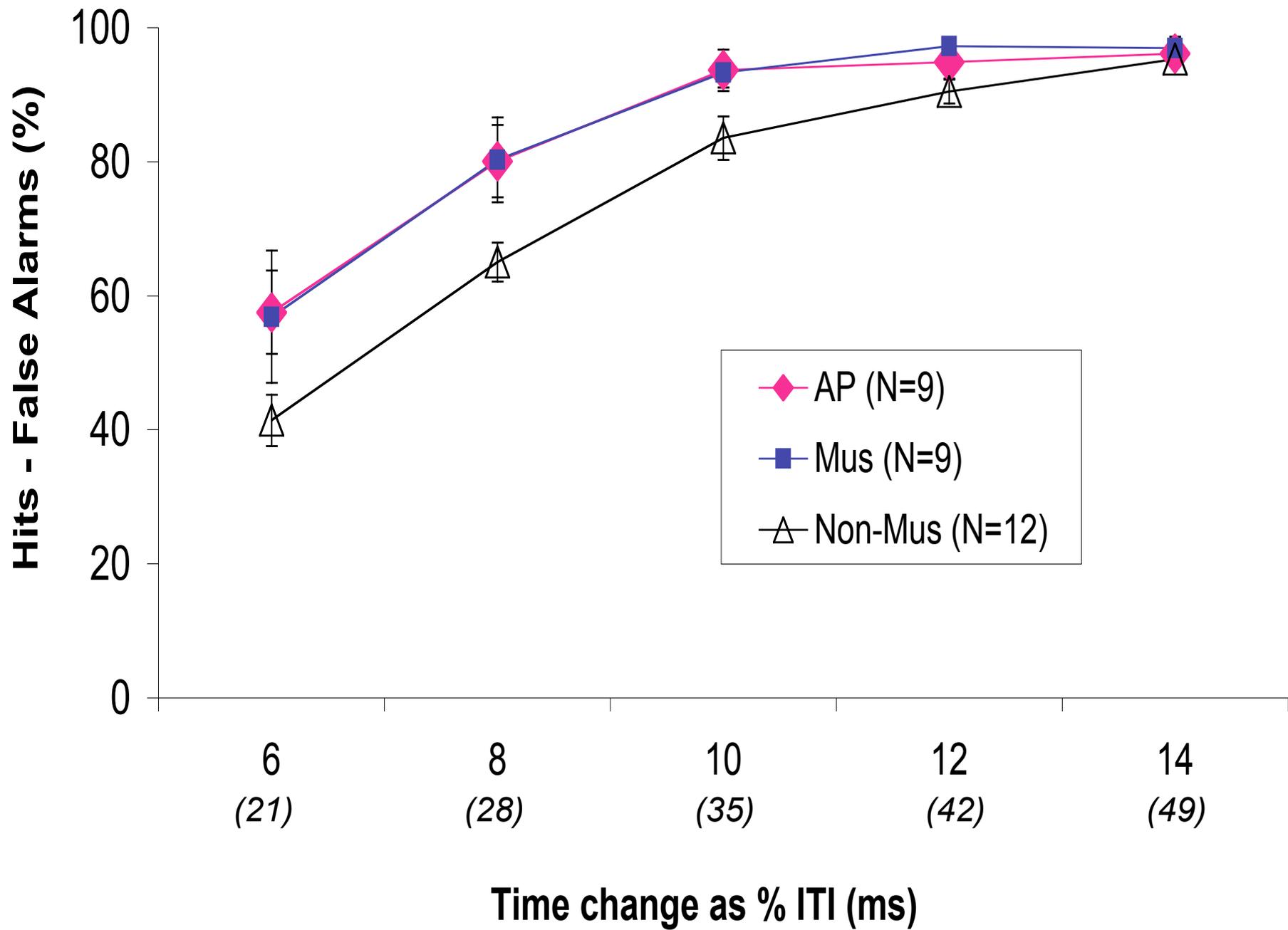


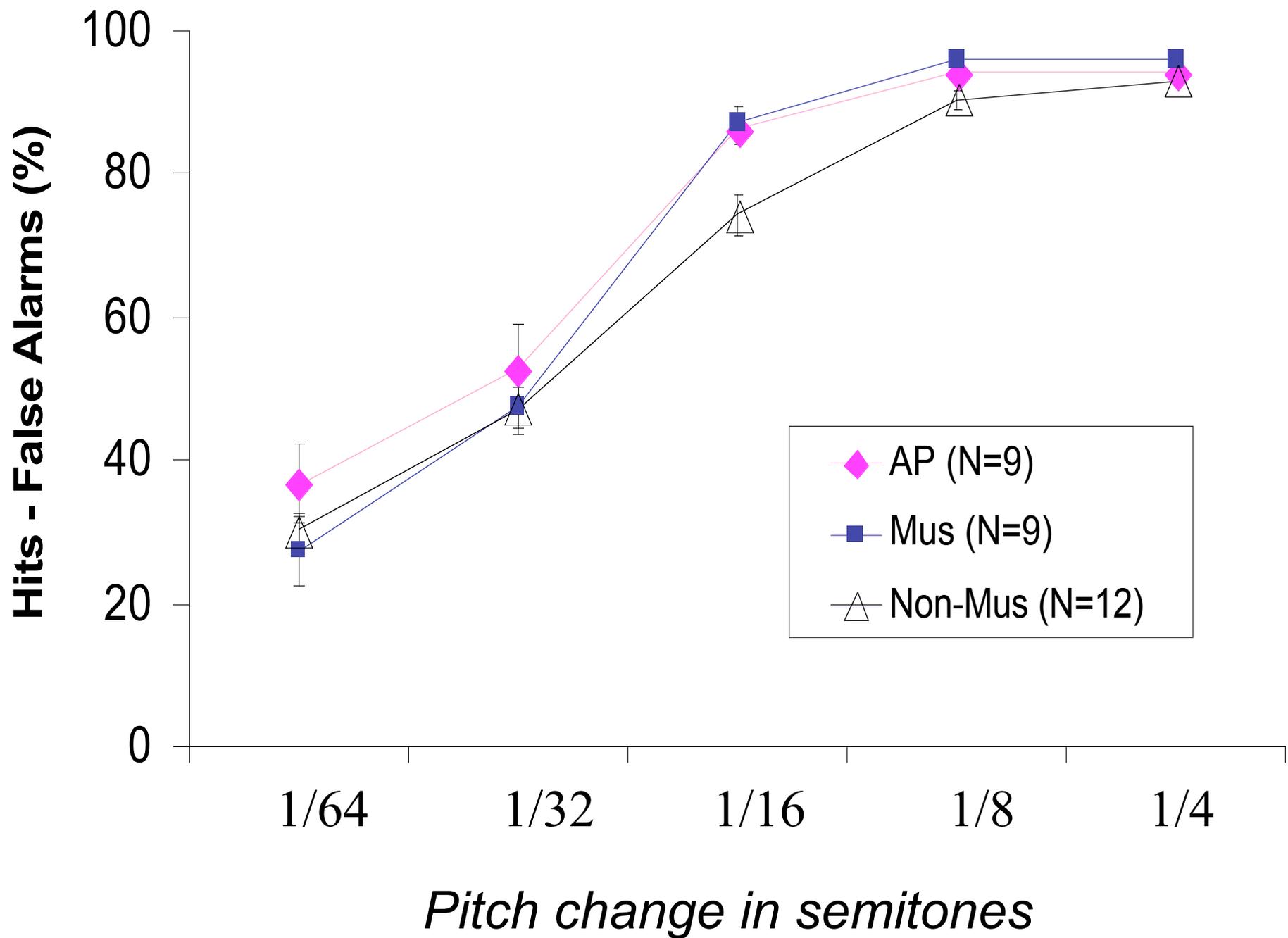
pitch



time







- L'oreille absolue ne semble pas s'expliquer par une acuité plus fine
- Par contre, l'expertise musicale confère un avantage général en perception auditive



Habilitété « encapsulée »: le cas de l'autisme

Q.I. = 70



Mottron et al. (2000) *Neurocase*

Une forme de synesthésie ?

0 1 2 3 4 5 6 7 8 9

« *Vermillion has a sound like a tuba and a parallel can be drawn with a loud drum beat* »

Kandinsky

Synaesthesia

When coloured sounds taste sweet

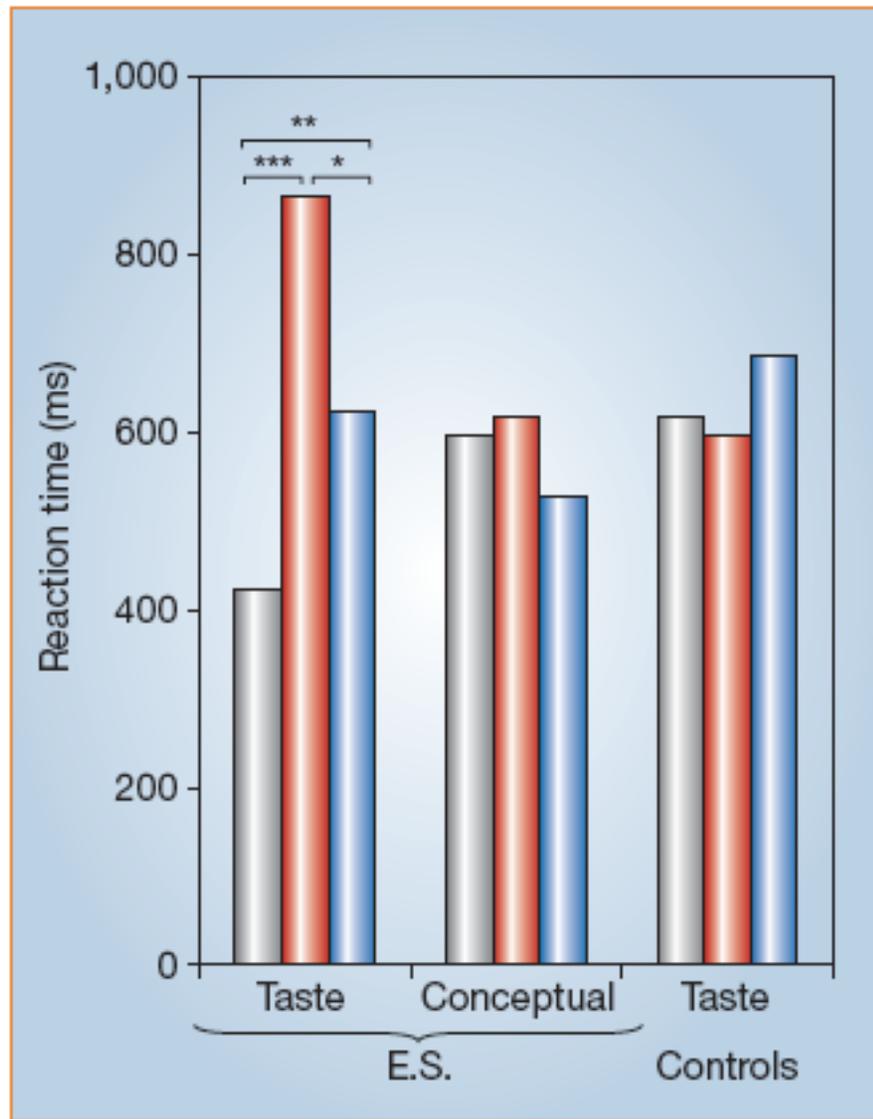


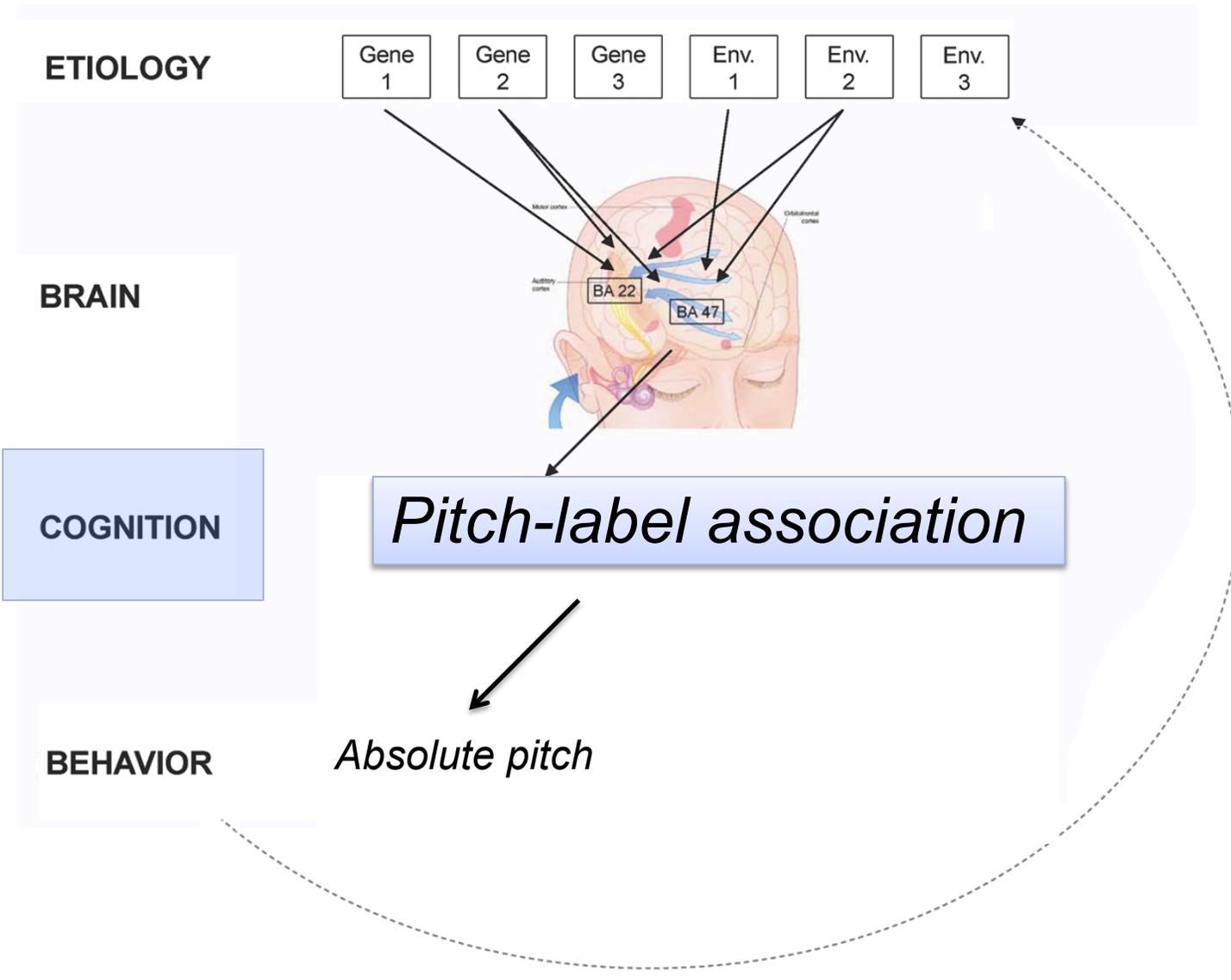
Table 1 Tastes triggered by tone intervals

<i>Tone interval</i>	<i>Taste experienced</i>
Minor second	Sour
Major second	Bitter
Minor third	Salty
Major third	Sweet
Fourth	(Mown grass)
Tritone	(Disgust)
Fifth	Pure water
Minor sixth	Cream
Major sixth	Low-fat cream
Minor seventh	Bitter
Major seventh	Sour
Octave	No taste

Tout comme l'oreille absolue, la synesthésie

- ✓ Trait familial
- ✓ Rare: 1-5%
- ✓ Systématique, automatique
- ✓ Confère peu d'avantage
- ✓ Au niveau neuronal:
 - Un échec de l'élagage naturel (neural pruning) entre régions adjacentes
 - Forme de désinhibition (unmasking of latent connectivity)
 - Pourrait s'apprendre à l'âge adulte (?)

Hubbard & Ramachadran (2005) Neuron



Le cas de Jonathan:

- Doctorat en éducation musicale
- Instrument: flûte
- début: 11 ans
- Dispensé des cours de solfège (oreille absolue)



*Peter Pfordresher,
University of Buffalo*

Lecture vocale

18 first lines of familiar songs to sight-read

- with note names (solfege)
- with lyrics

Examples:

JOYEUX ANNIVERSAIRE

$\text{♩} = 100$

The image shows a musical score for the song 'Joyeux Anniversaire'. It consists of three systems of music. The first system is in 3/4 time, with a tempo marking of quarter note = 100. It features a treble clef and a key signature of one flat (B-flat). The lyrics are: 'JO - YEUX AN - NI - VER - SAIRE JO - YEUX AN - NI - VER - SAIRE JO - YEUX'. The second system continues the melody in the treble clef with lyrics: 'AN - NI - VER - SAI - RE JO - YEUX AN - NI - VER - SAIRE'. Below this, a bass clef line provides a harmonic accompaniment with lyrics: 'CE QUI CAU - SE MON TOUR - MENT AU CLAIR DE LA LU - NE MON A - MI PIER - ROT'. The third system is in a new key signature of two sharps (D major) and contains the lyrics: 'PRÉ - TE MOI TA PLU - ME POUR É - CRIRE UN MOT'. The score includes various musical notations such as notes, rests, and bar lines.

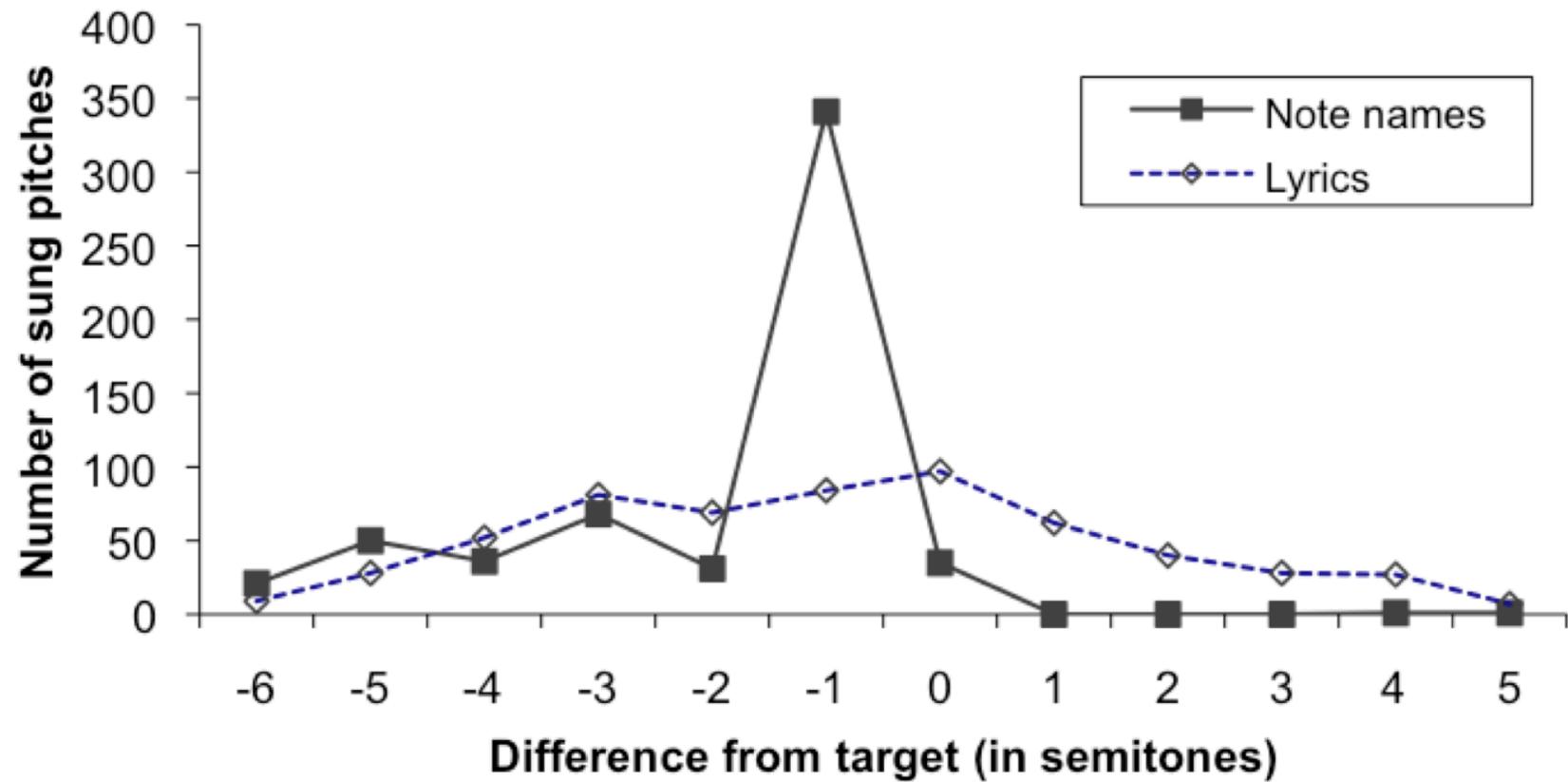
JO - YEUX AN - NI - VER - SAIRE JO - YEUX AN - NI - VER - SAIRE JO - YEUX

AN - NI - VER - SAI - RE JO - YEUX AN - NI - VER - SAIRE

CE QUI CAU - SE MON TOUR - MENT
AU CLAIR DE LA LU - NE MON A - MI PIER - ROT

PRÉ - TE MOI TA PLU - ME POUR É - CRIRE UN MOT

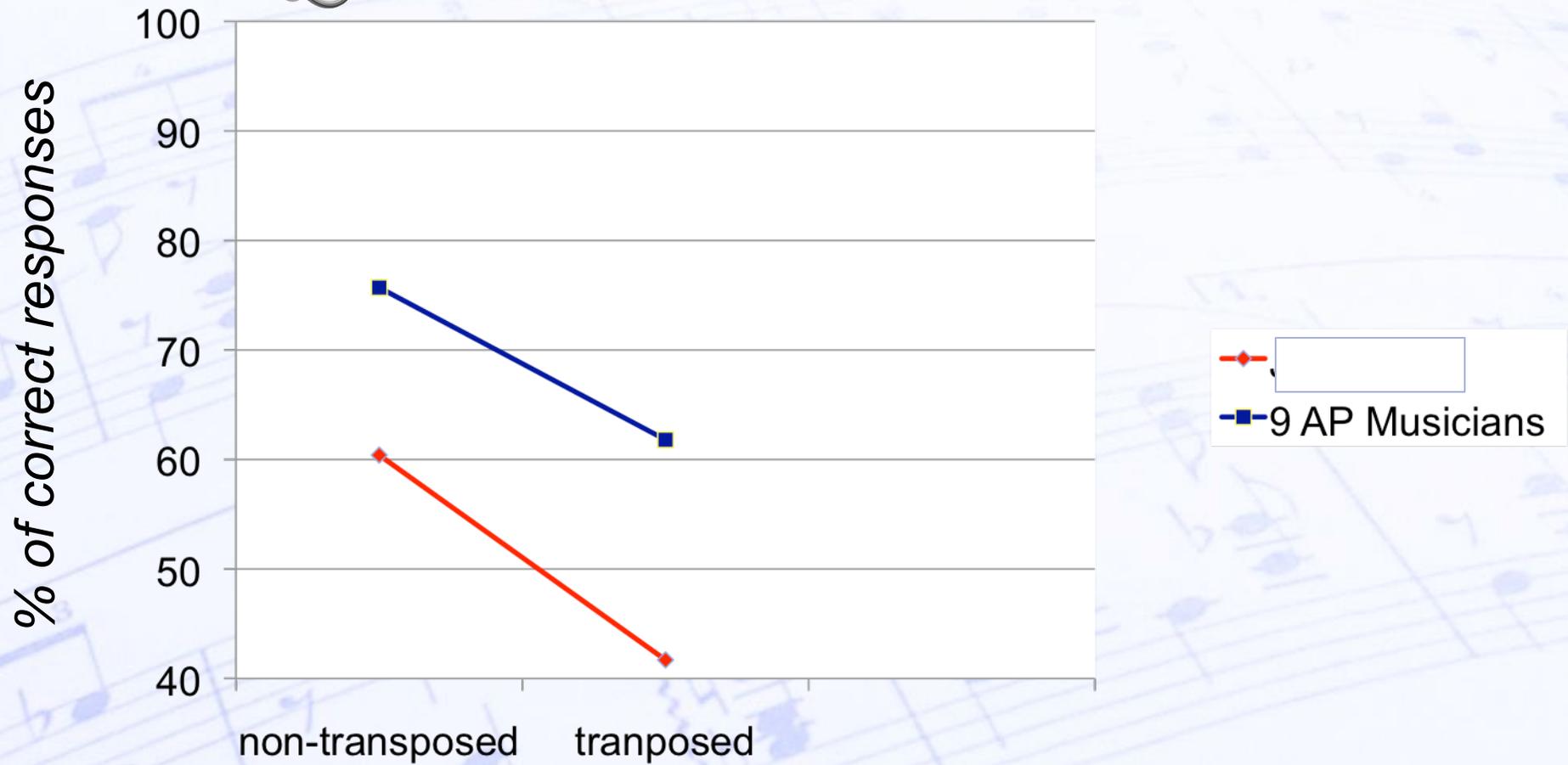
A stroop-like effect

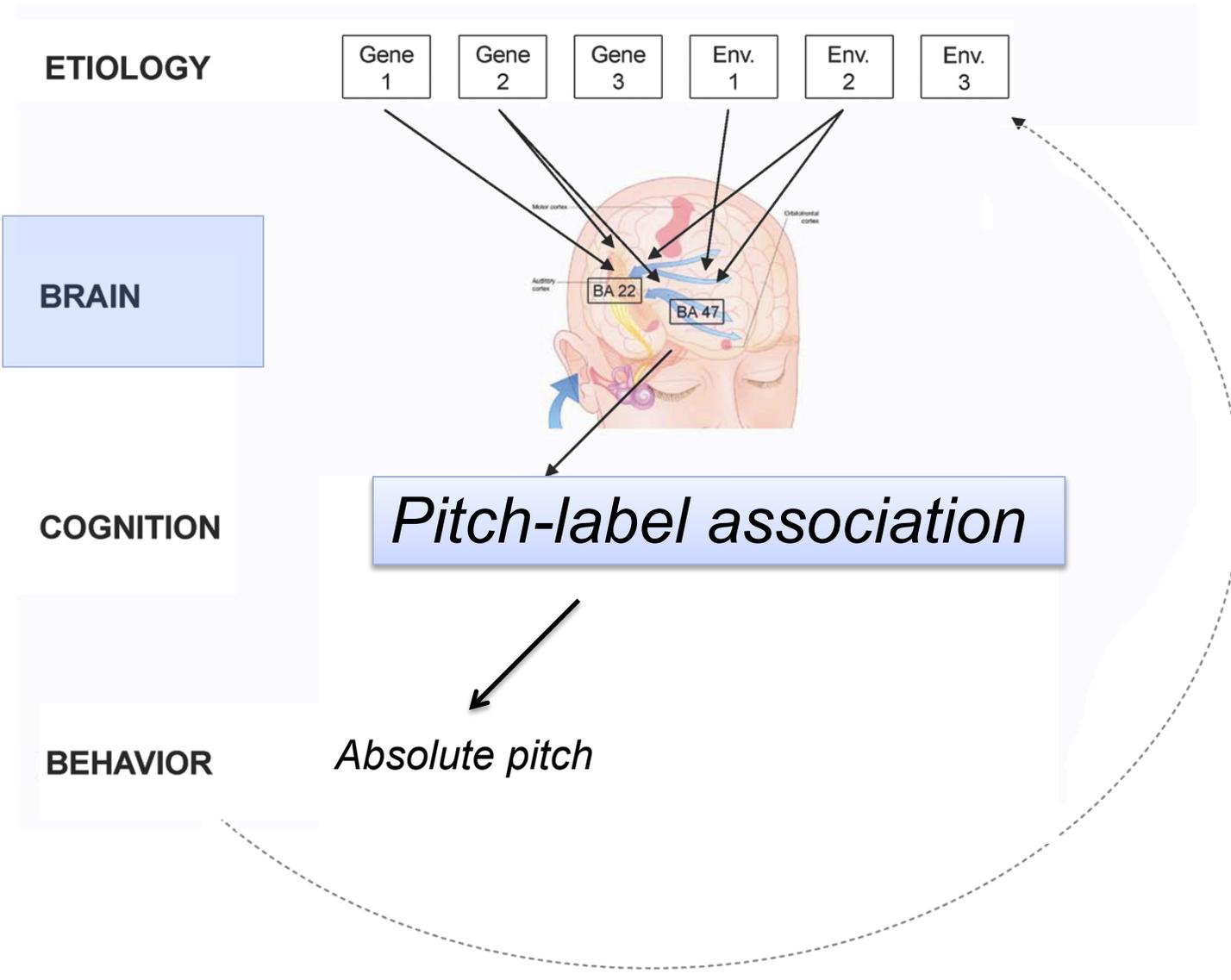




Miyazaki (2004) Japanese Psychological Research

With interfering note names

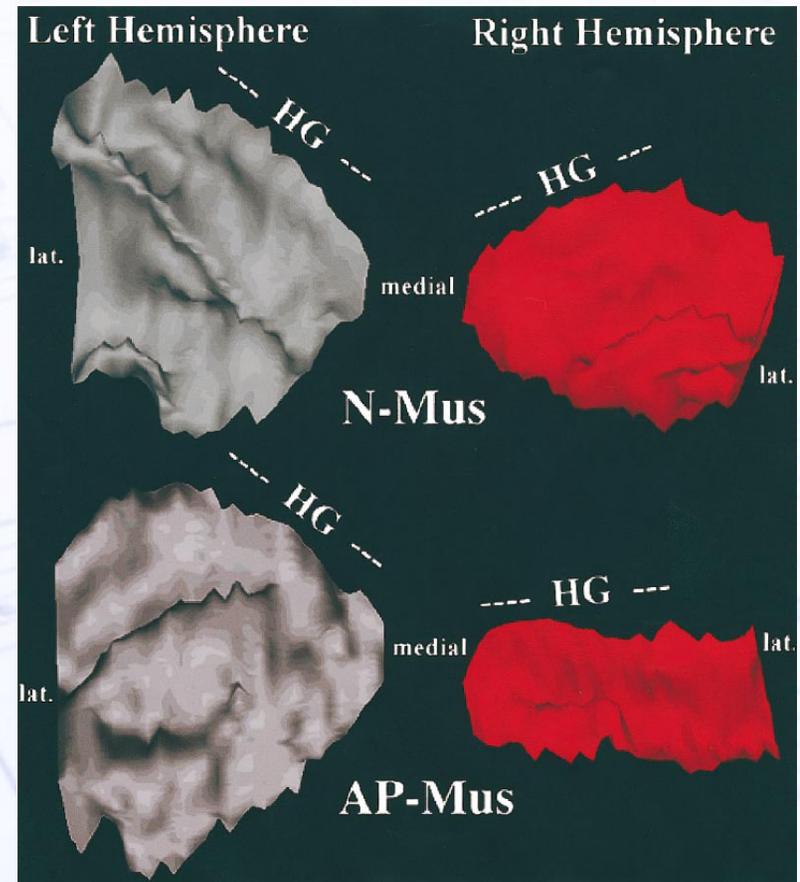


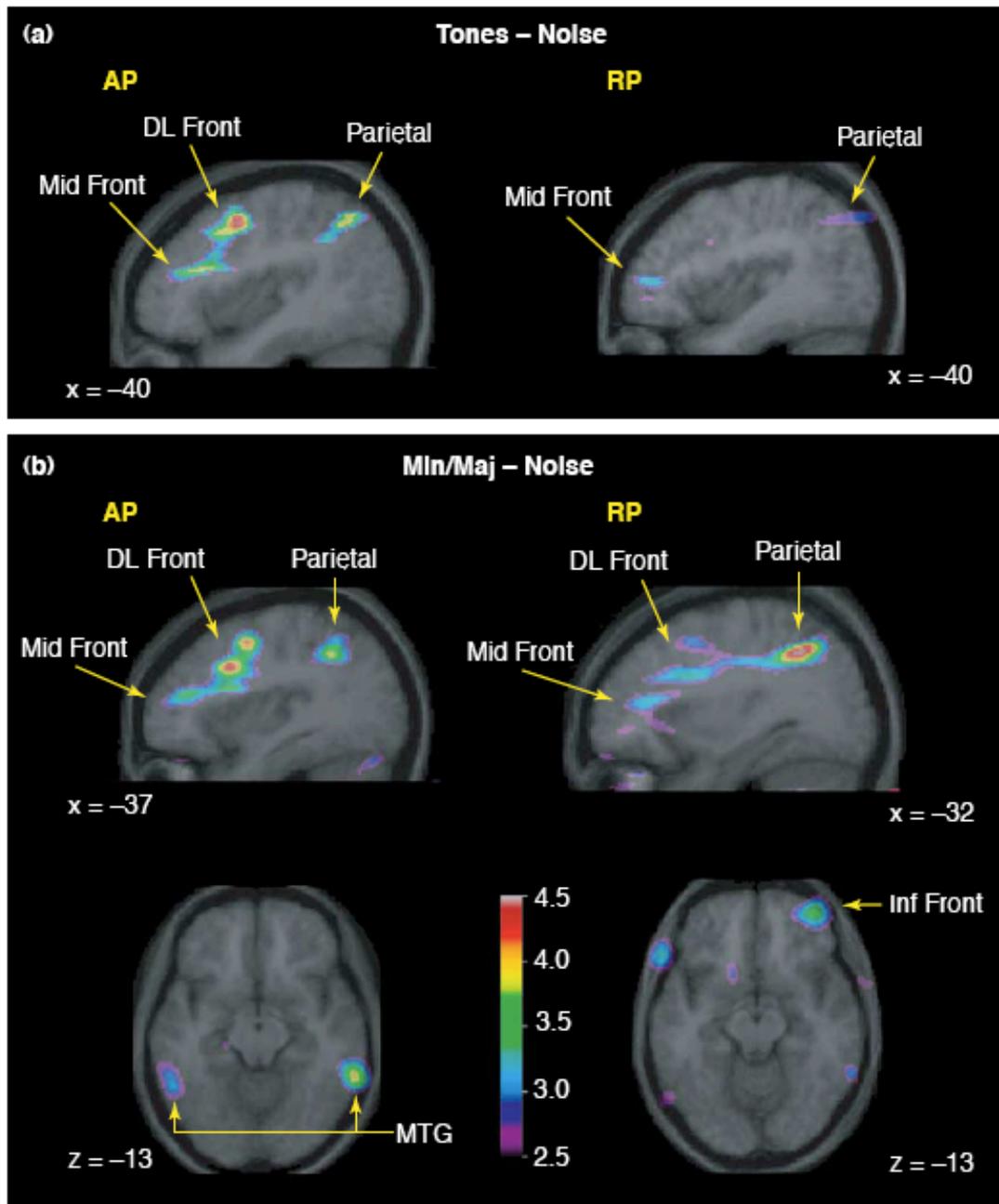


Anatomie de l'oreille absolue

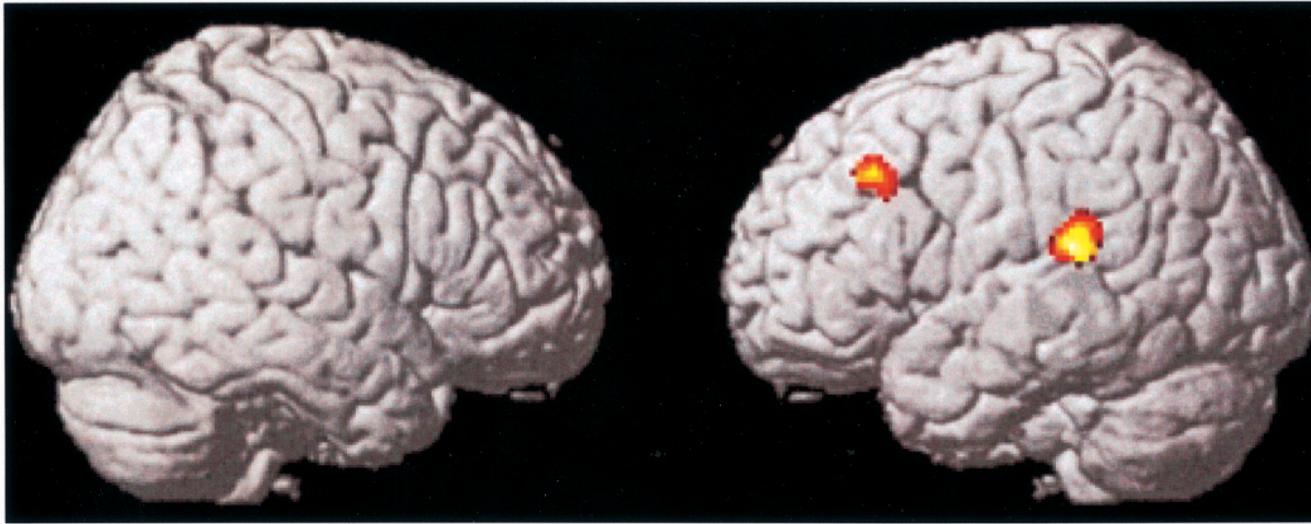
Increased asymmetry
of the planum
temporale

(Schlaug et al, 1995;
Zatorre et al, 1998;
Keenan et al., 2001)

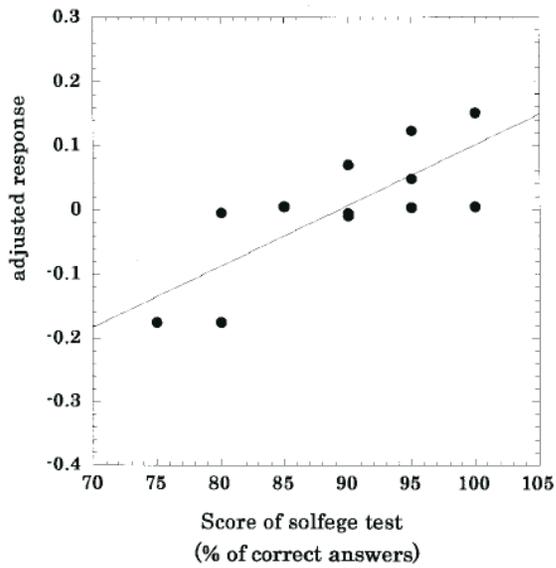




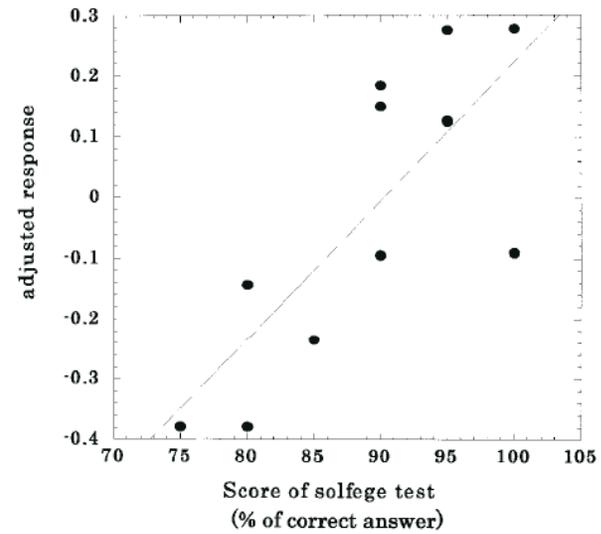
Zatorre et al. (1998) *PNAS*



a



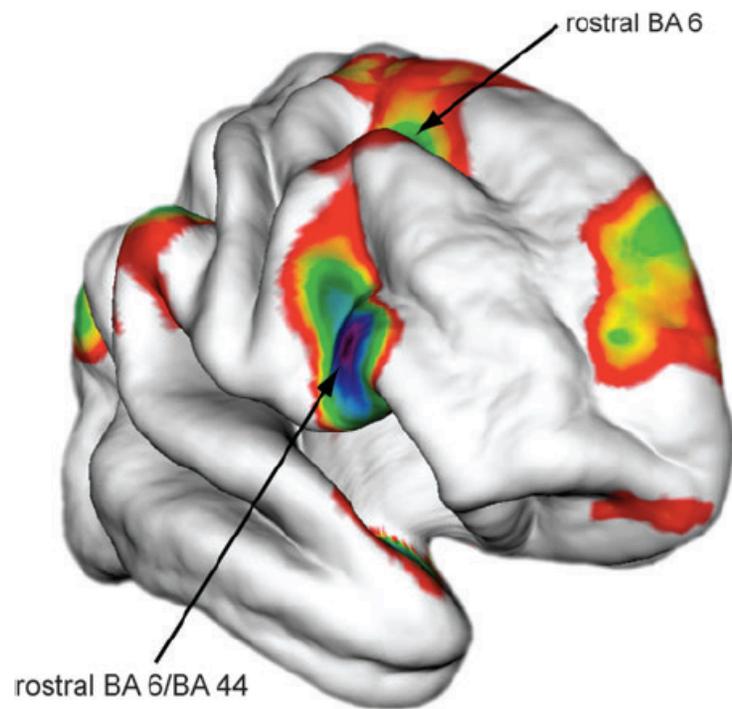
b



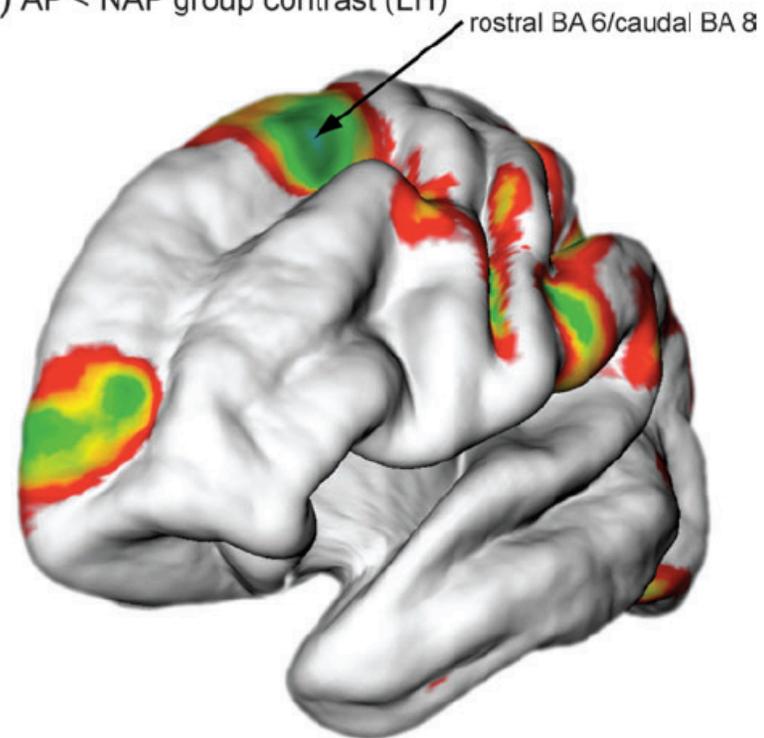
c

Ohnishi et al. (2001) *Cerebral Cortex*

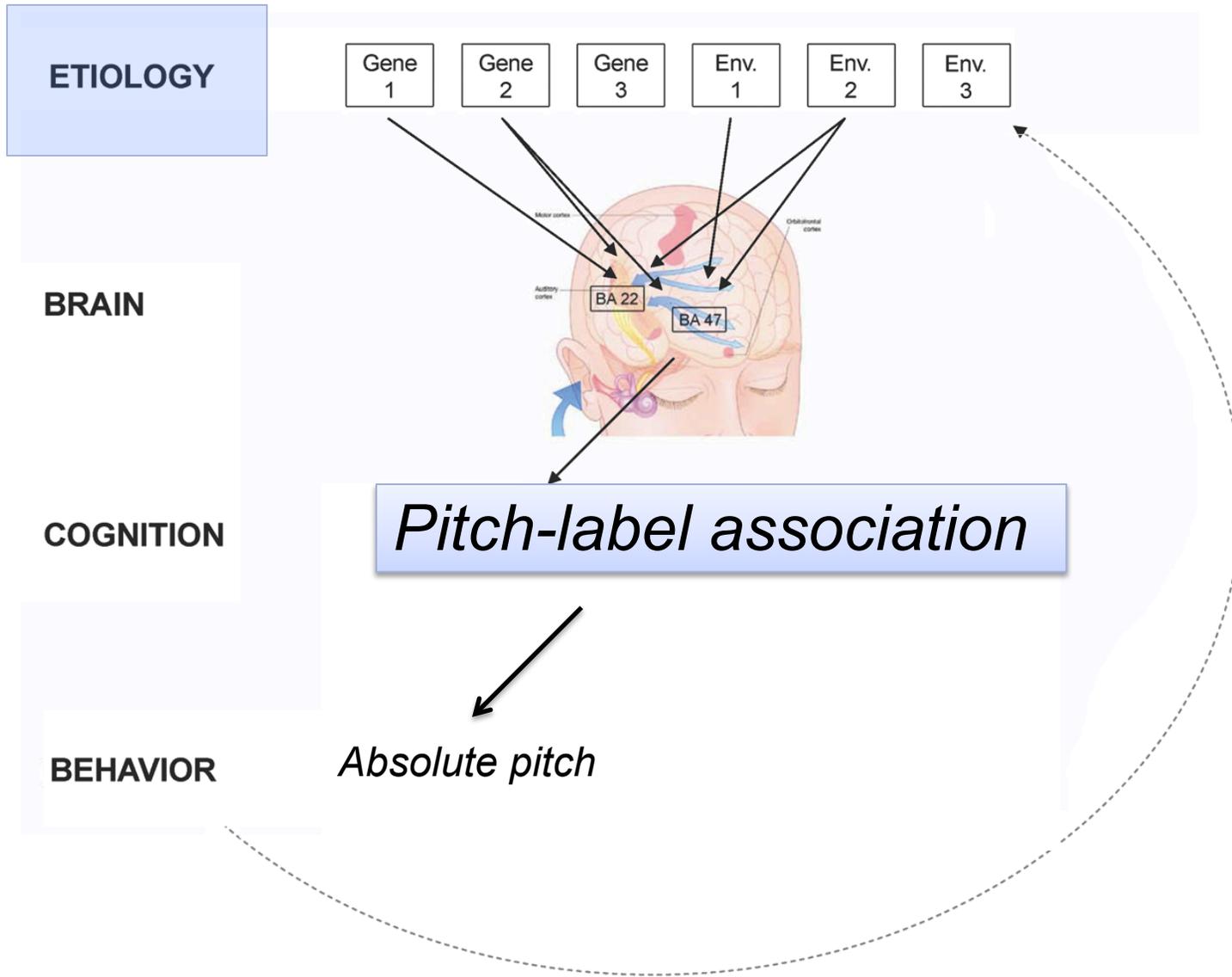
a) AP < NAP group contrast (RH)



b) AP < NAP group contrast (LH)



Bermudez et al (2009) *Cerebral Cortex*



Genome-wide Study of Families with Absolute Pitch Reveals Linkage to 8q24.21 and Locus Heterogeneity

Elizabeth Theusch,^{1,2} Analabha Basu,¹ and Jane Gitschier^{1,2,3,*}

Table 1. Description of Families Used in Linkage Analysis

	Eu/AJ/I	Eu^a	E Asian
No. of families	54	45	19
No. of individuals genotyped	220	184	61
No. of AP individuals genotyped	128	108	40
No. of AP sibling pairs	73	65	16
No. of AP avuncular pairs	8	3	1
No. of AP cousin and distant pairs	5	5	4
No. of AP relative pairs ^b	86	73	21

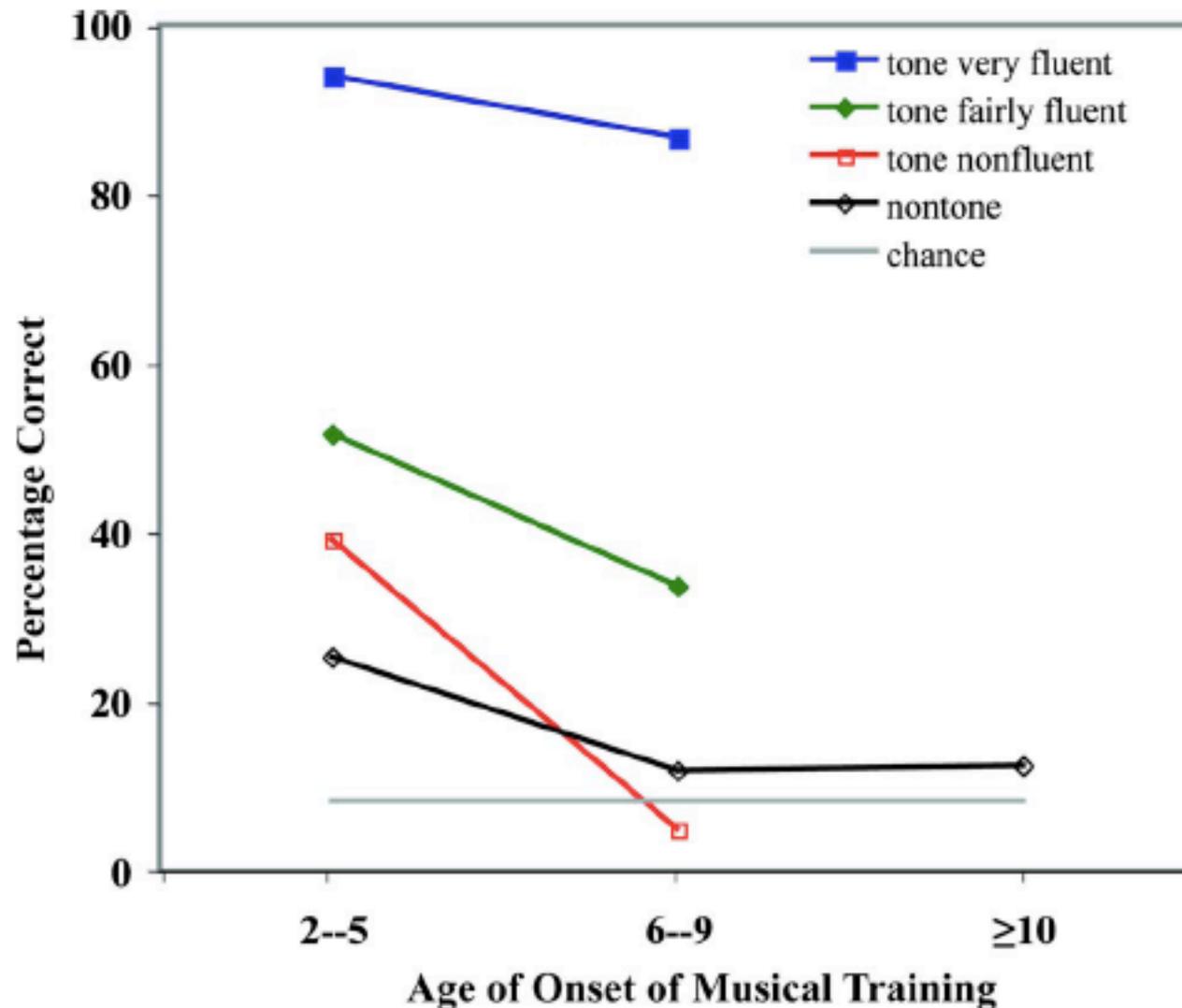
^a The European descent (Eu) sample set is a subset of the Eu/AJ/I sample set, excluding one Indian and eight Ashkenazi Jewish families.

^b AP parent-child pairs were not included in the relative-pairs count.

Absolute pitch among students in an American music conservatory: Association with tone language fluency

Diana Deutsch^{a)} and Kevin Dooley

J. Acoust. Soc. Am. **125** (4), April 2009



Questions en suspend

- ✓ Influence de la méthode d'enseignement (fixed-do vs. movable-do)
- ✓ Bénéfices
- ✓ Forme de synesthésie



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