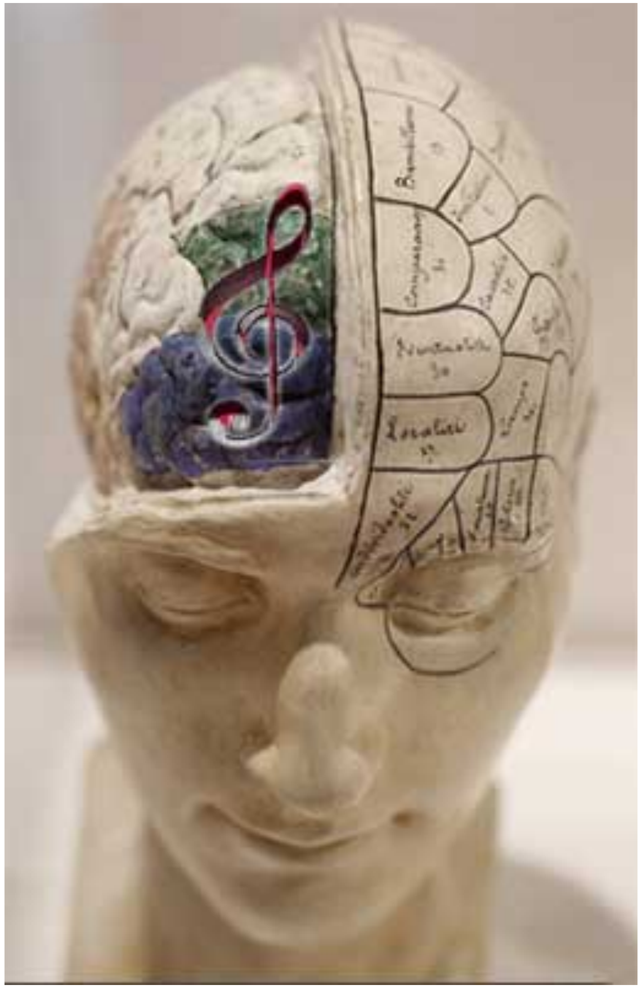

Cerveau et musique
Vers une nouvelle science de l'apprentissage



- Apprendre la musique : quel effet sur notre cerveau (et celui de nos enfants)?

La musique modifie le cerveau:
Plasticité cérébrale chez les musiciens

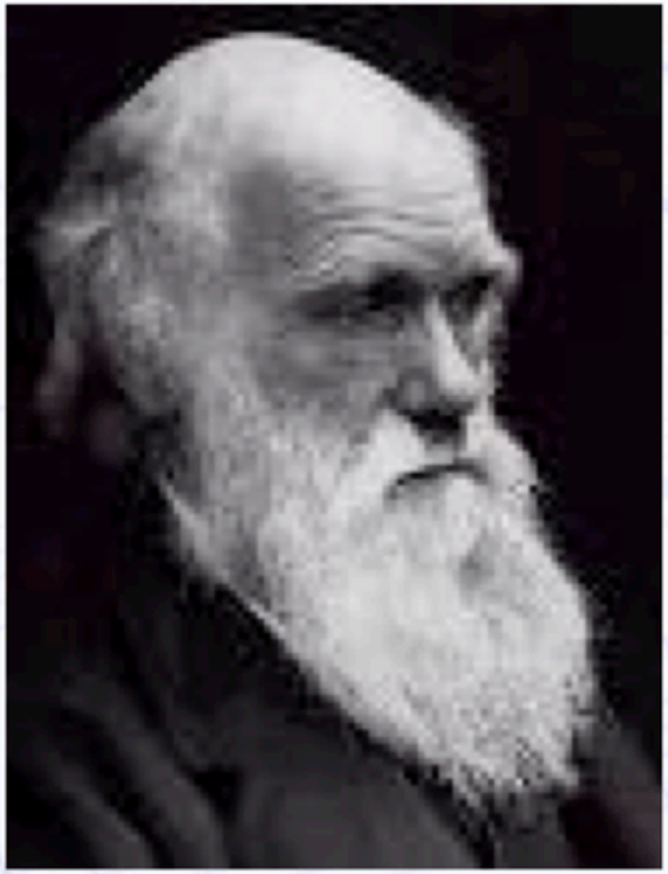
Émotion musicale : les neurones miroirs, échange et partage

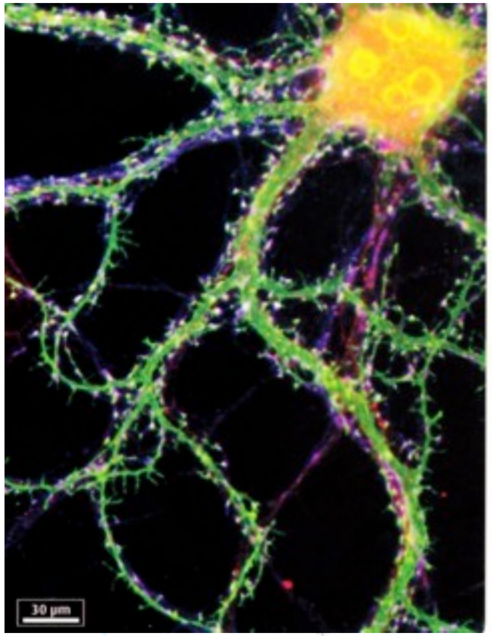
La musique comme outil de rééducation : une nouvelle voie pour traiter les enfants dyslexiques

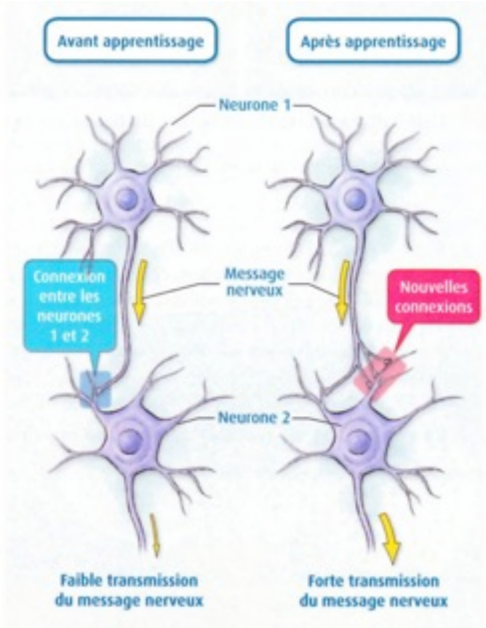
1ere partie

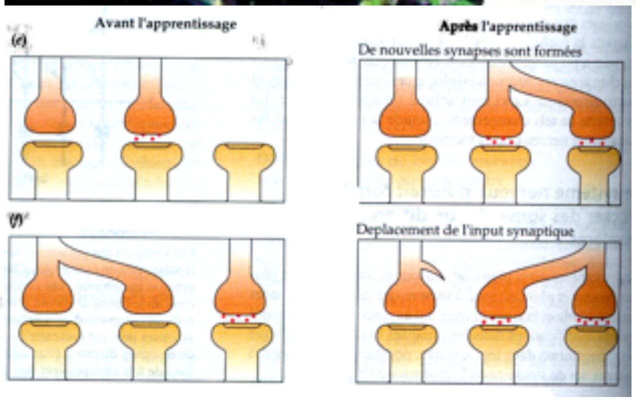
LE CERVEAU DU MUSICIEN : UN MODÈLE DE PLASTICITÉ CÉRÉBRALE

"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 <u>most mysterious</u> with which he is endowed" (Darwin, 1871)

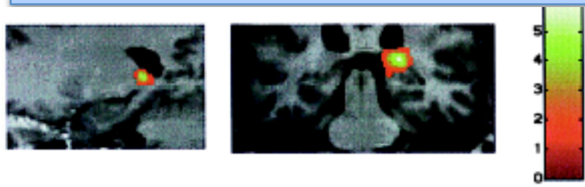


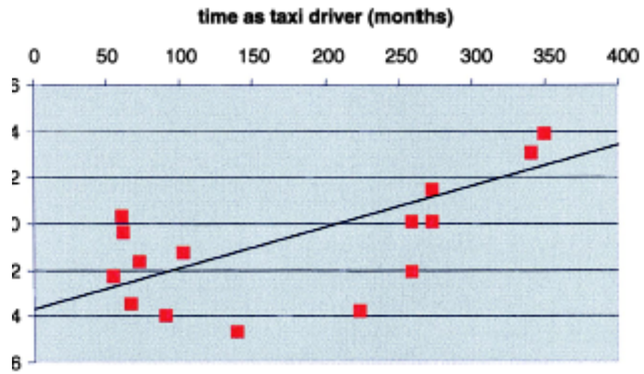






Zones de plus forte densité de pixels chez les chauffeurs de taxi londoniens





Juggling training in naive adults

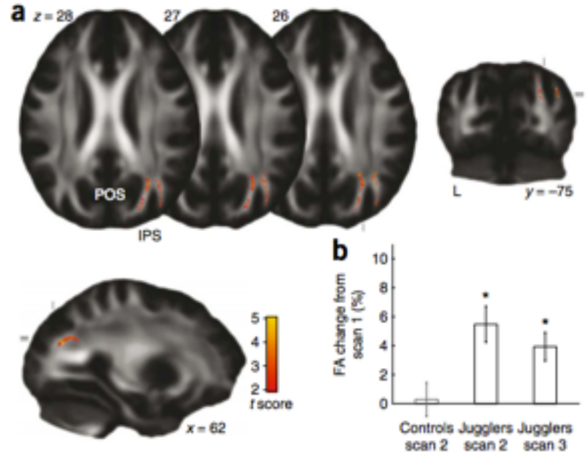
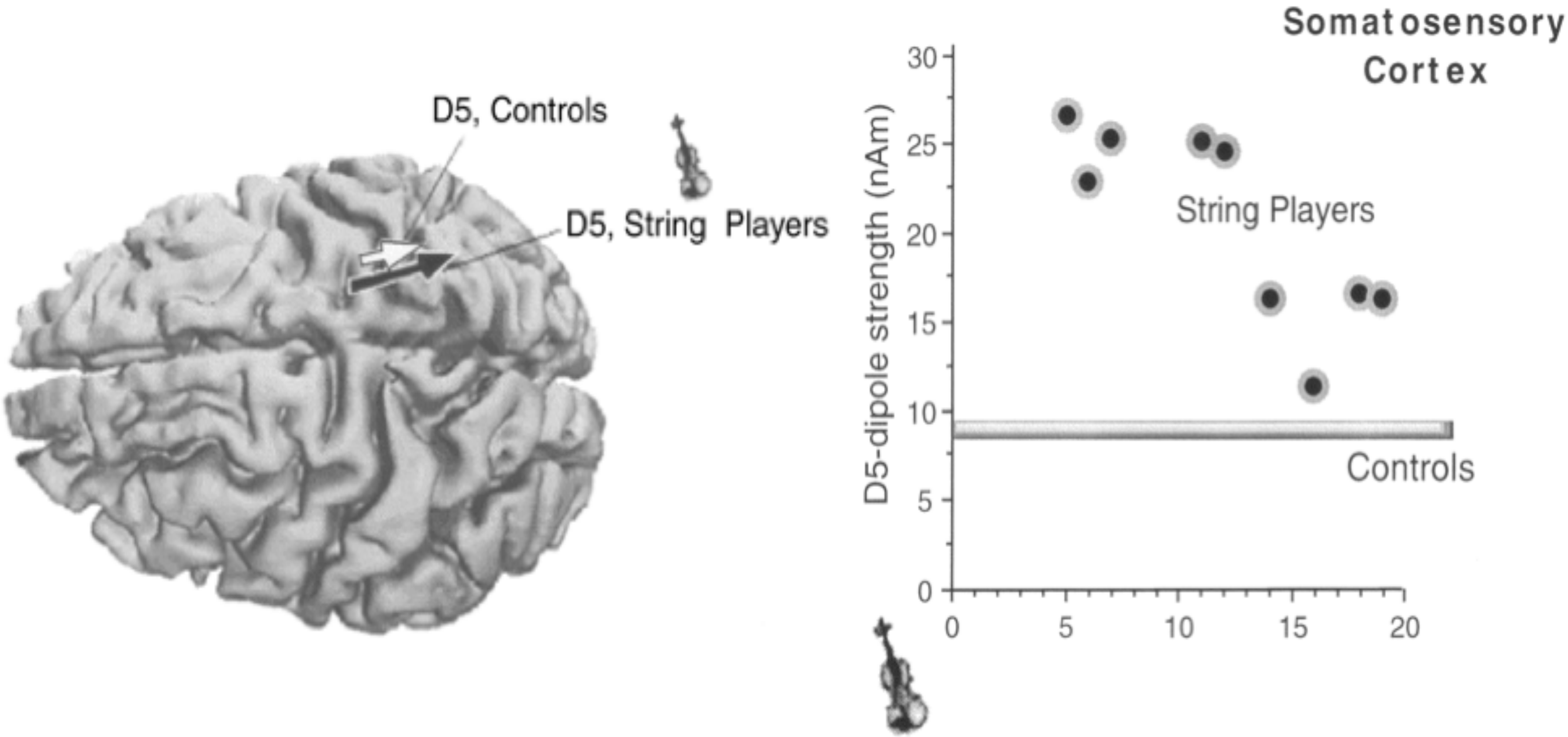
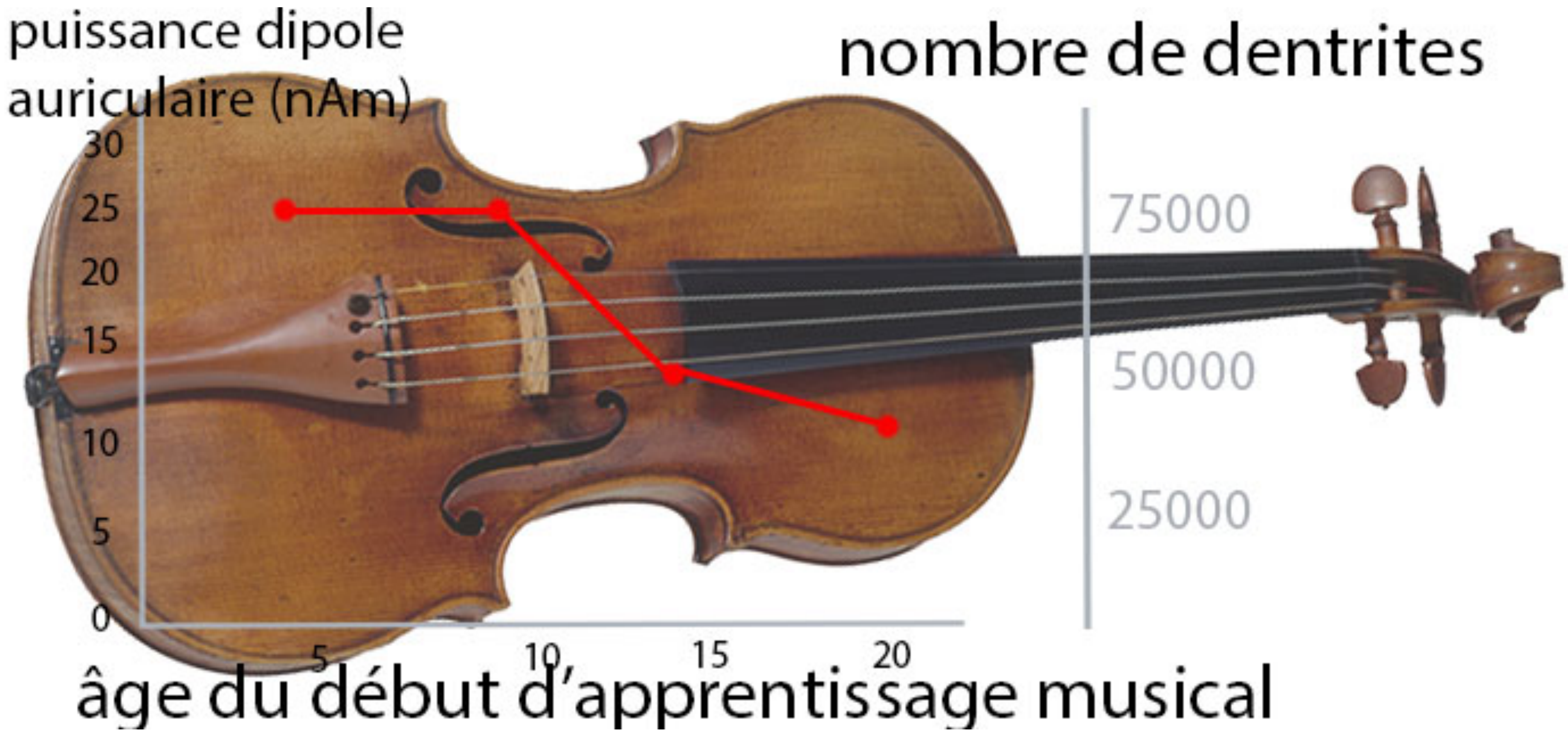


Figure 1 Fractional anisotropy increases after juggling training.



Left hand fifth finger in string instrument players (MEG study, Elbert et al., 1998).
Larger dipole in right somatosensory area. Effect of learning age.


puissance dipole auriculaire (nAm)
30
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âge du début d'apprentissage musical
nombre de dentrites
75000
50000
25000

Effects of Music Training on the Child's Brain and Cognitive Development

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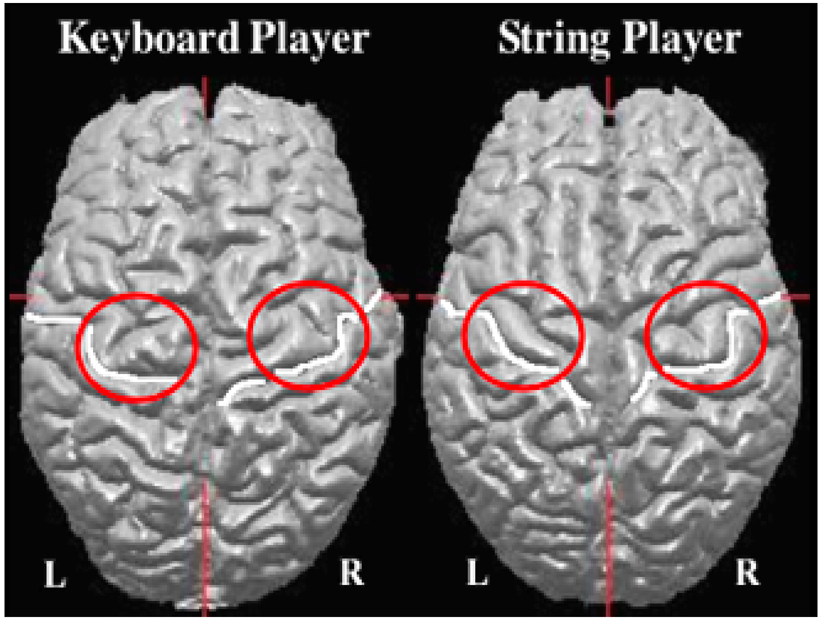

professional keyboard players, who reported approximately twice as much weekly practice time as the amateur musicians, have significantly more gray matter in several brain regions, including the primary sensorimotor cortex, the adjacent superior premotor and anterior superior parietal cortex bilaterally, mesial Heschl's gyrus (primary auditory cortex), the cerebellum, the inferior frontal gyrus, and part of the lateral inferior temporal lobe, than either the amateur musicians or the nonmusicians.

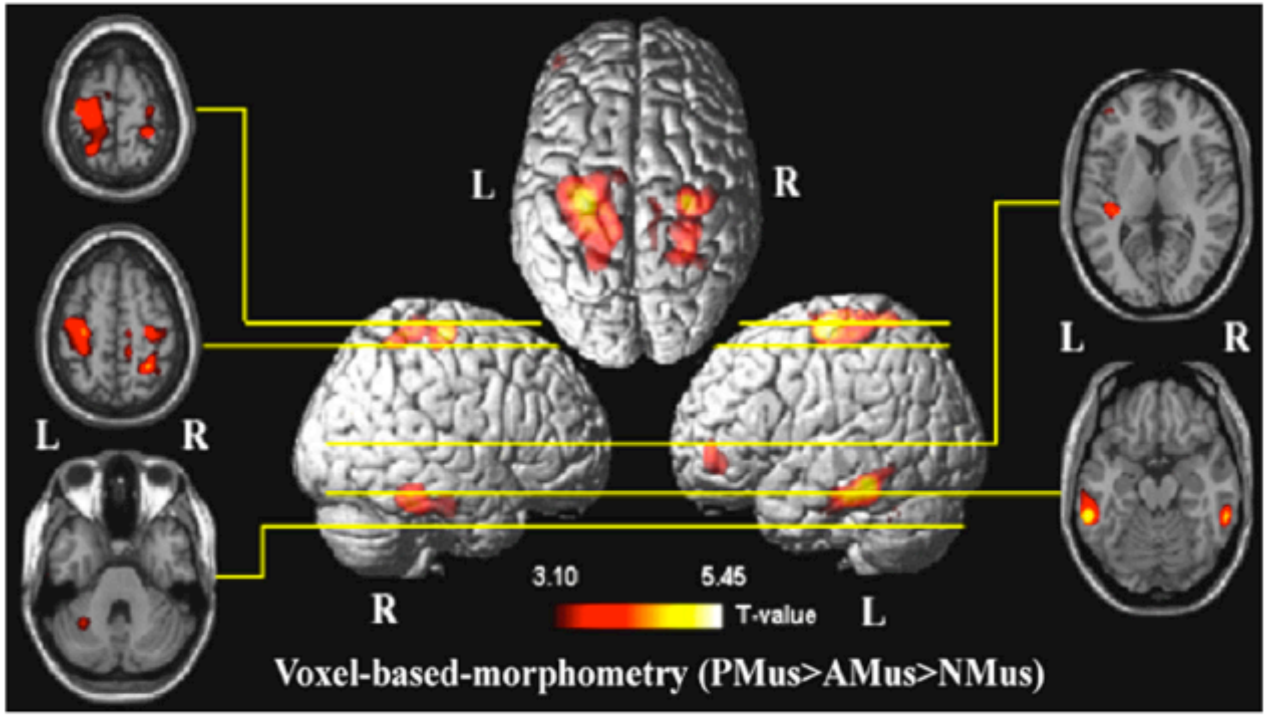

FIGURE 1. A voxel-based morphometric analysis of nonmusicians compared with amateur and professional musicians.

European Journal of Neuroscience, Vol. 24, pp. 1832–1834, 2006

doi:10.1111/j.1460-9568.2006.05031.x

Specialization of the specialized in features of external human brain morphology

Marc Bangert and **Gottfried Schlaug**
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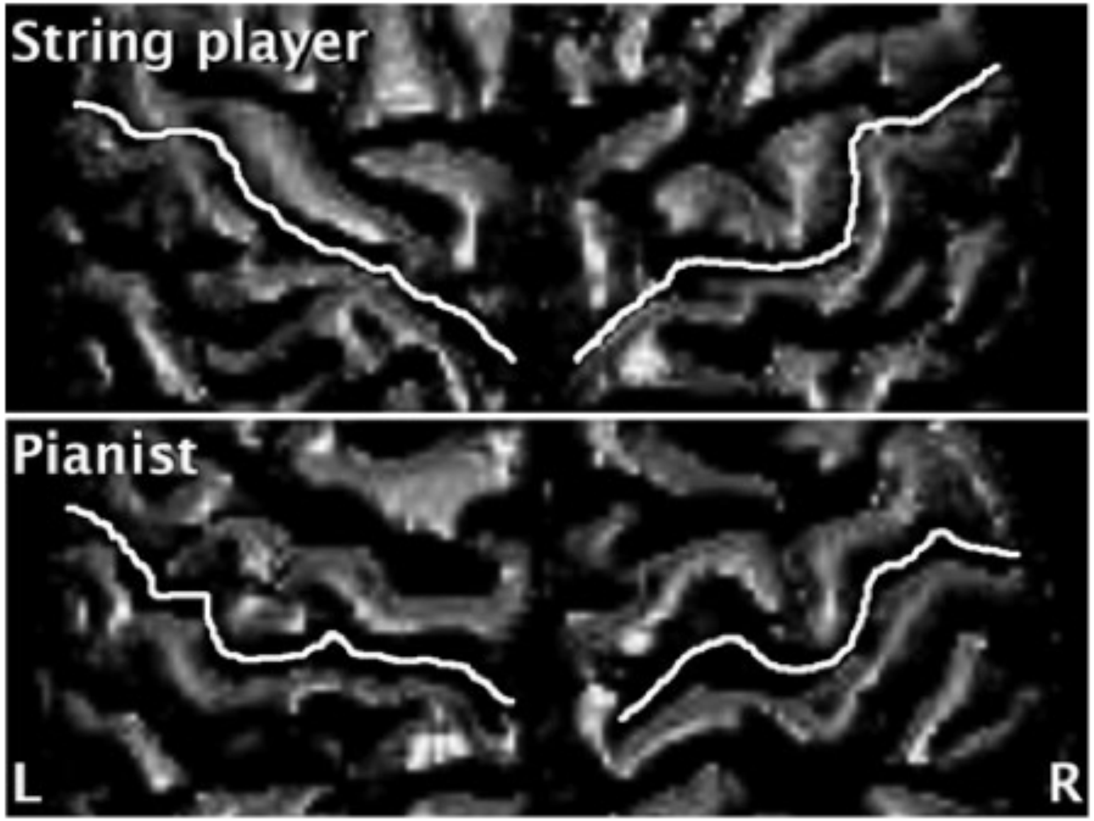
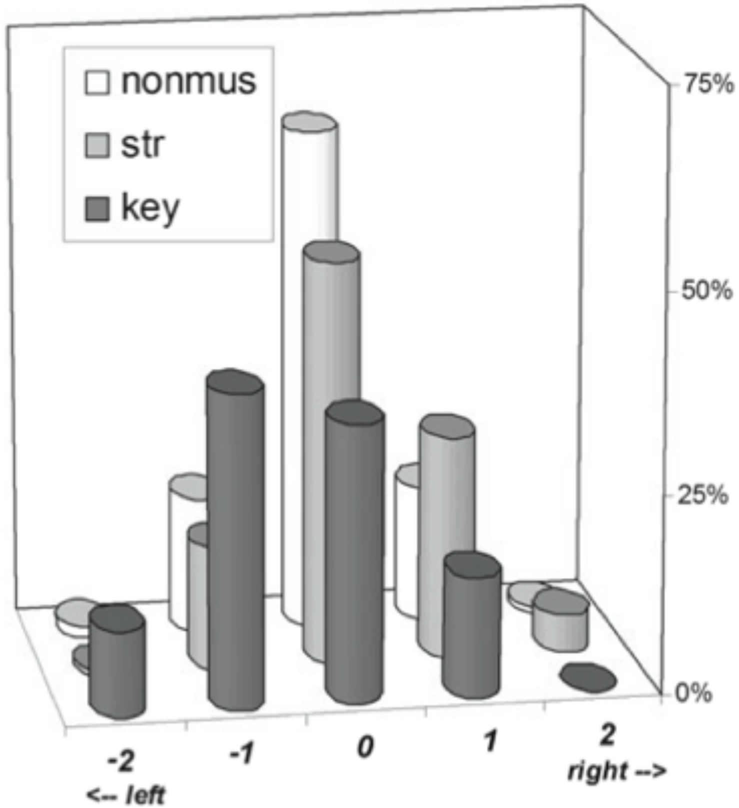
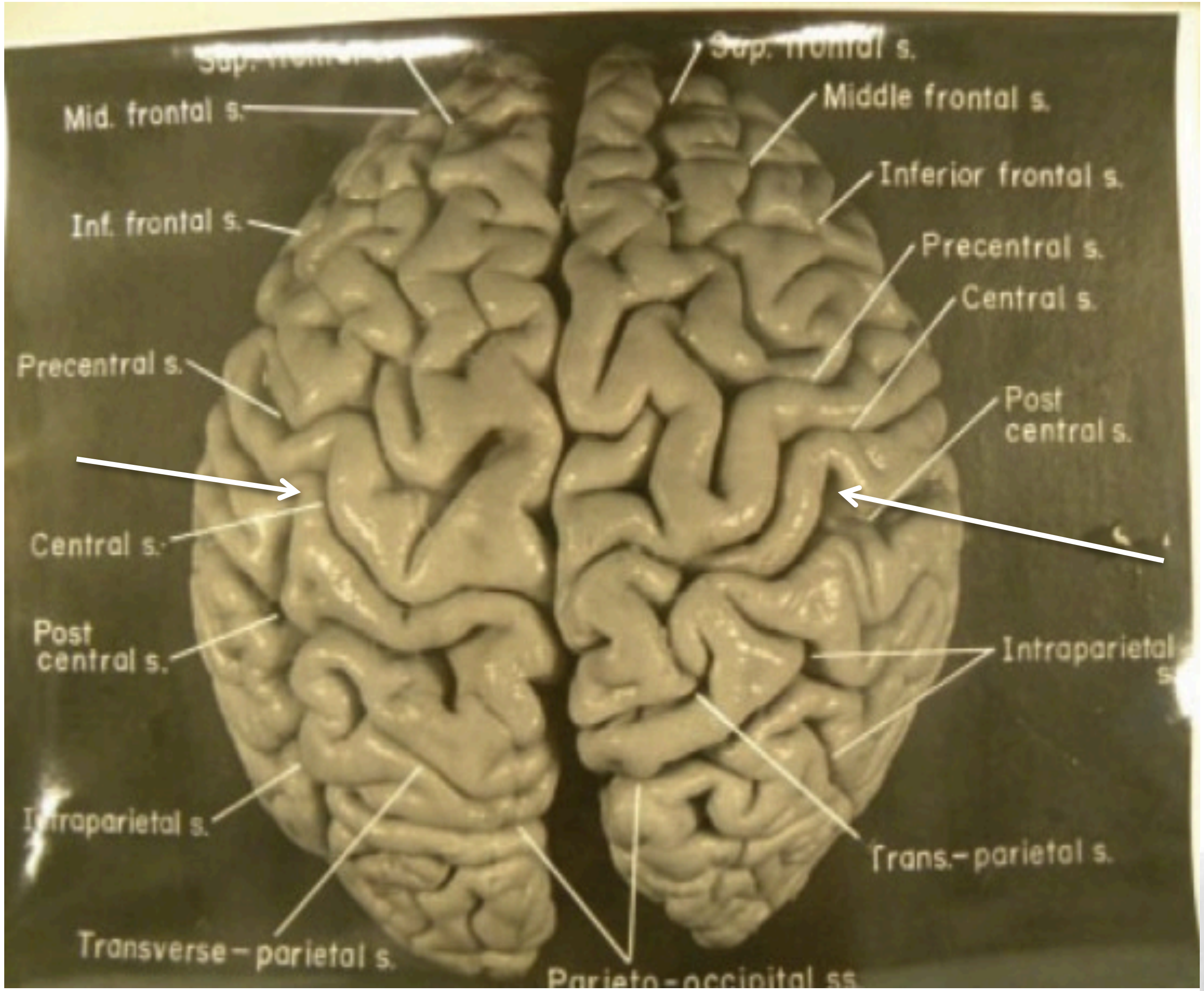
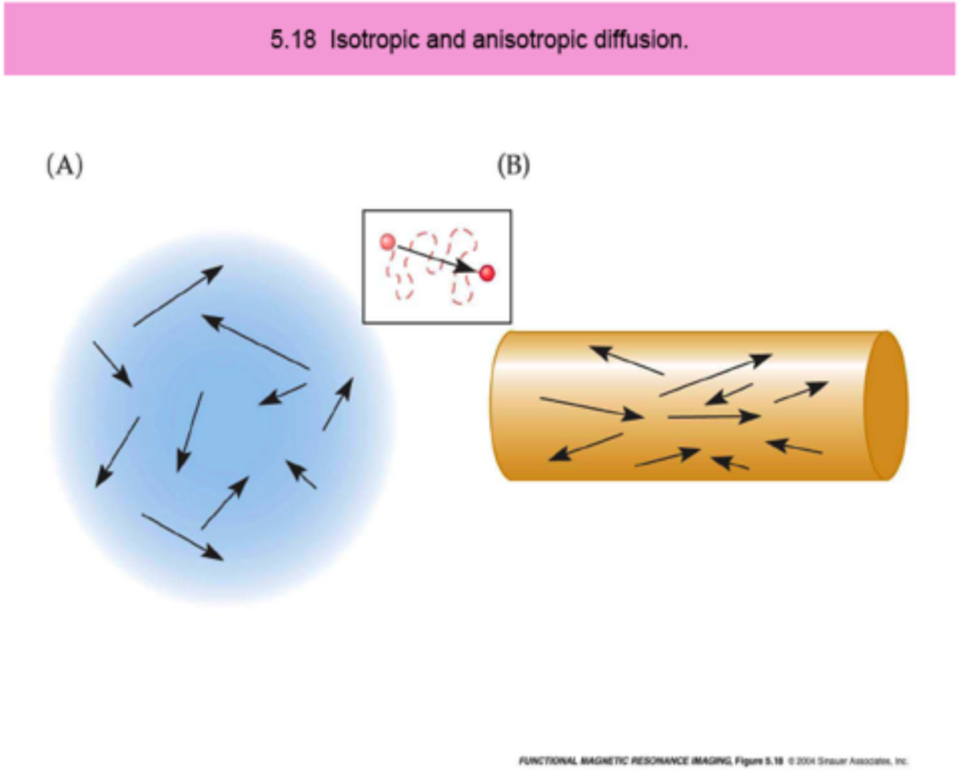
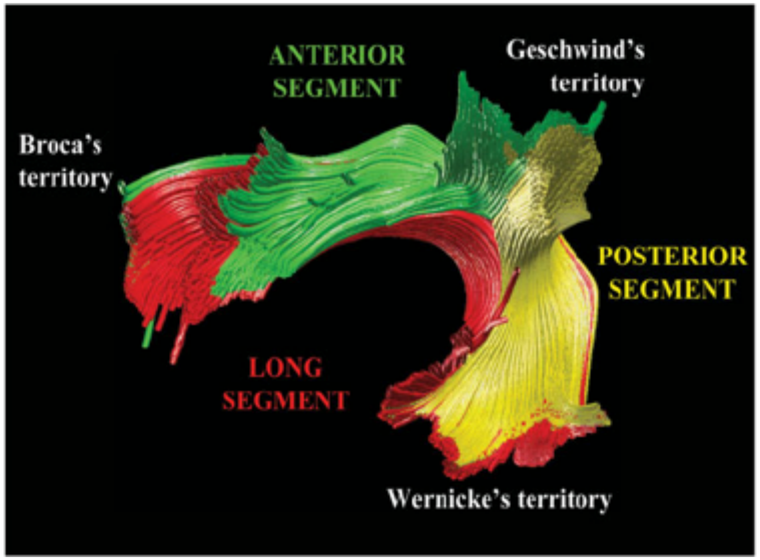






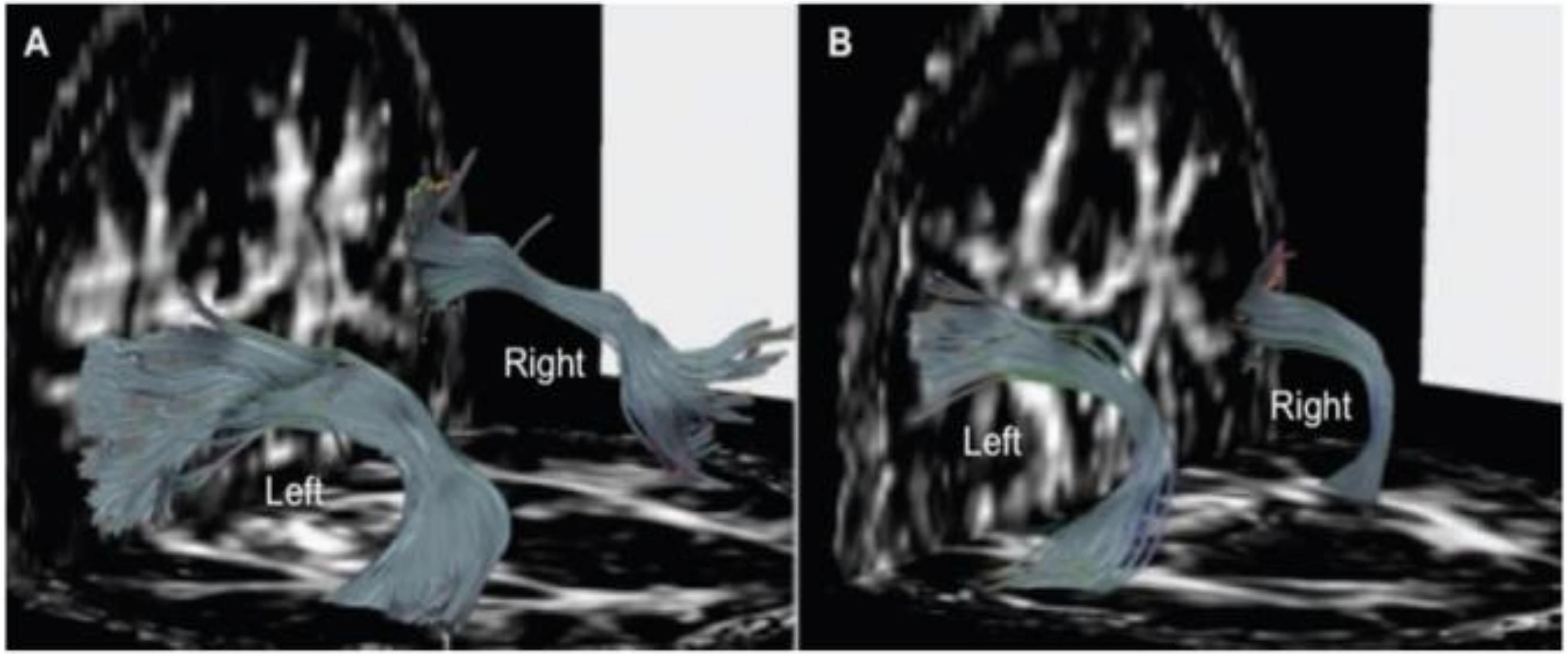
Sup. frontal s.
Mid. frontal s.
Inf. frontal s.
Precentral s.
Central s.
Post
central s.
Intraparietal s.
Transverse-parietal s.
Parieto-occipital ss.
Middle frontal s.
Inferior frontal s.
Precentral s.
Central s.
Post
central s.
Intraparietal
s.
Trans.-parietal s.





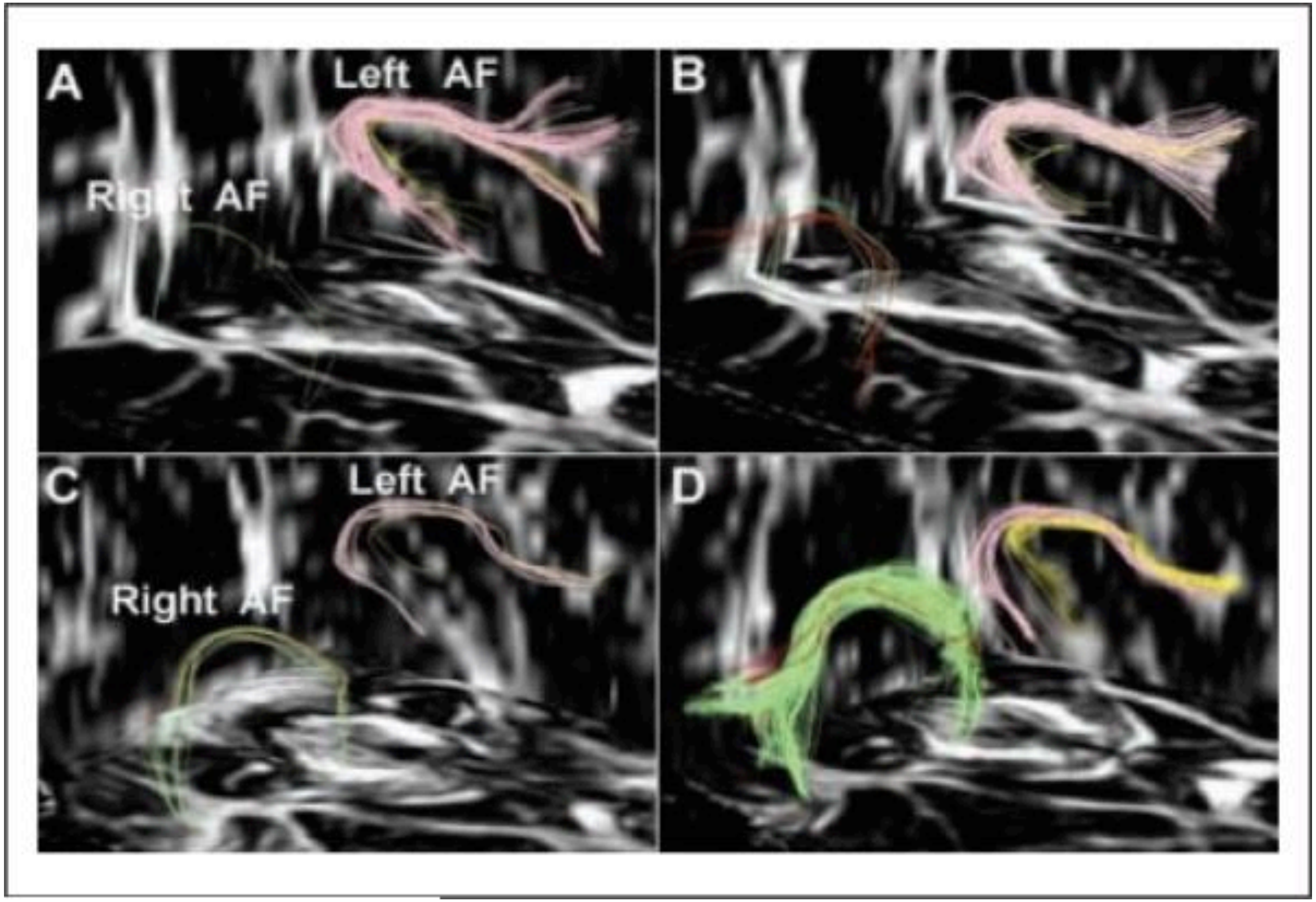
Diffusion tensor imaging (D.T.I.)

(A) The arcuate fasciculus of a healthy 65-year-old instrumental musician



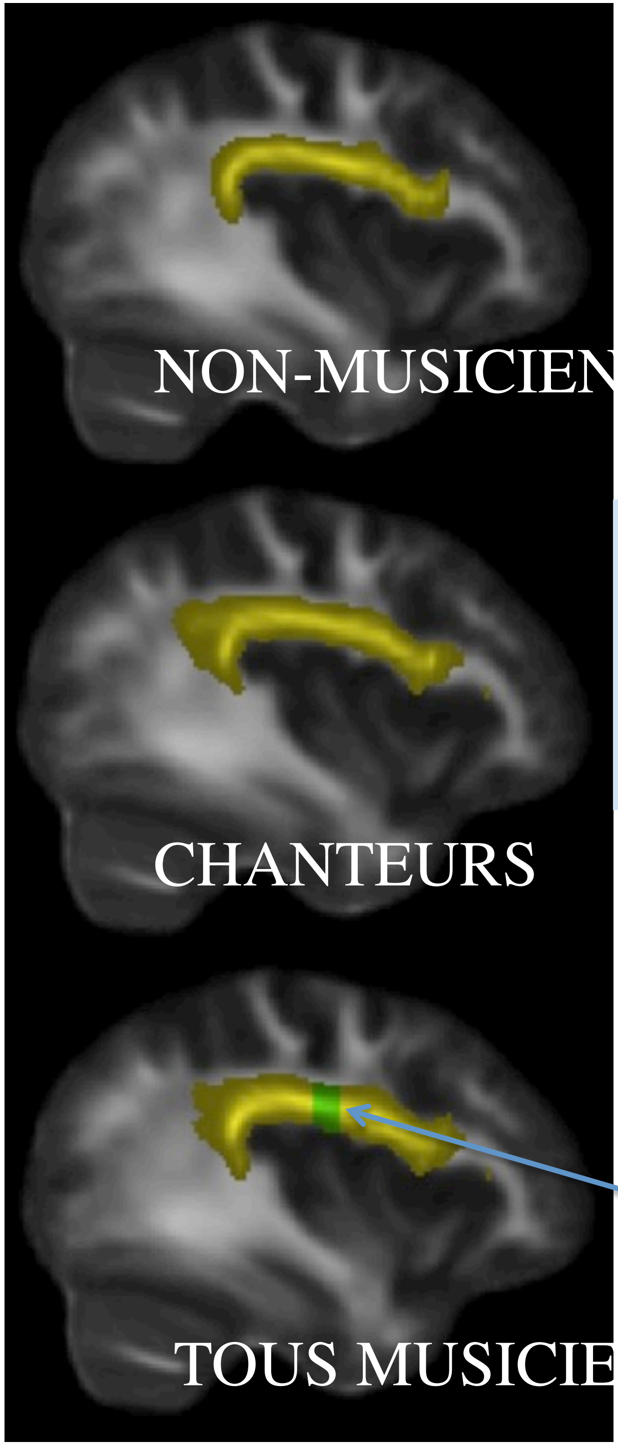
(B) the arcuate fasciculus of a healthy 63-year-old nonmusician, otherwise matched with regard to their handedness, gender, and overall IQ

8-year-old child without instrumental music training scanned twice (A and B) 2 years apart

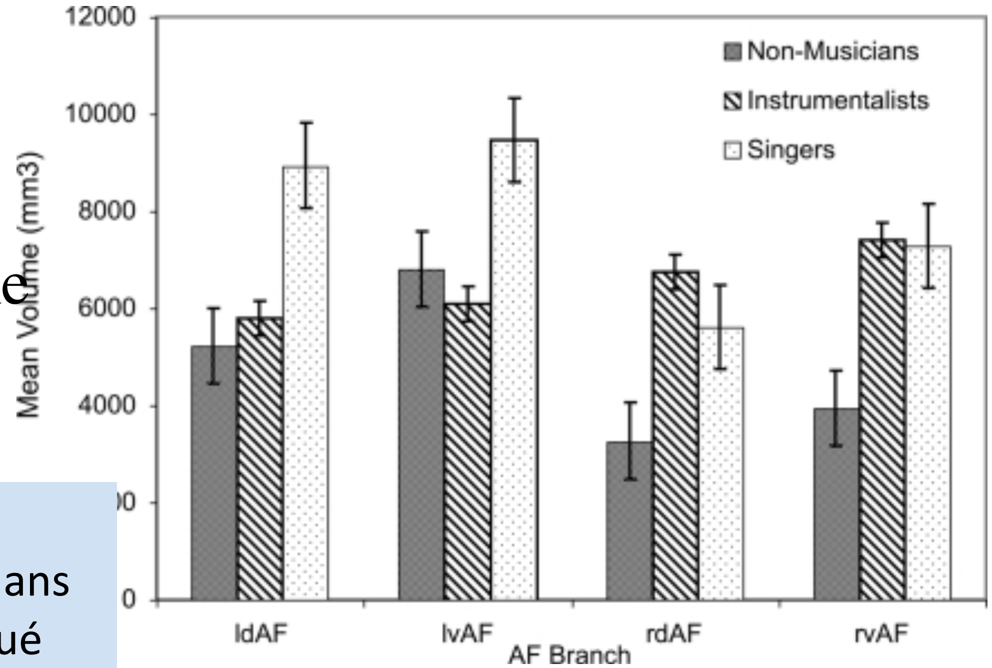


8-year-old child before (C) and 2 years after (D) instrumental music training involving a string instrument.

Changes in the arcuate fasciculus after instrumental music training



Volume



Différences prédominant dans le faisceau arqué gauche, partie dorsale

anisotropie

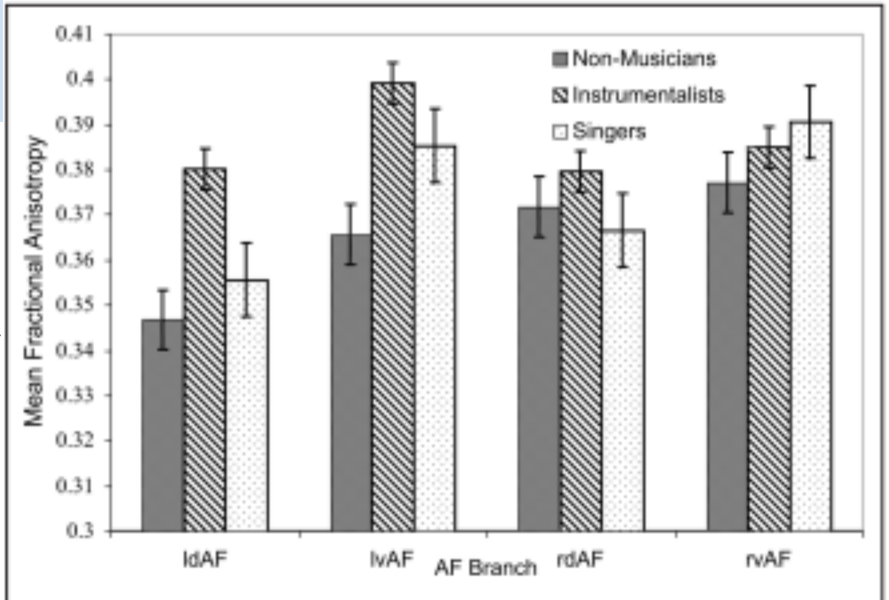


FIGURE 3 | Mean FA for all branches of the AF in both hemispheres for all groups (l = left, r = right, d = dorsal, v = ventral). Error bars represent SE of the mean.

Zone de différence d'anisotropie

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).*

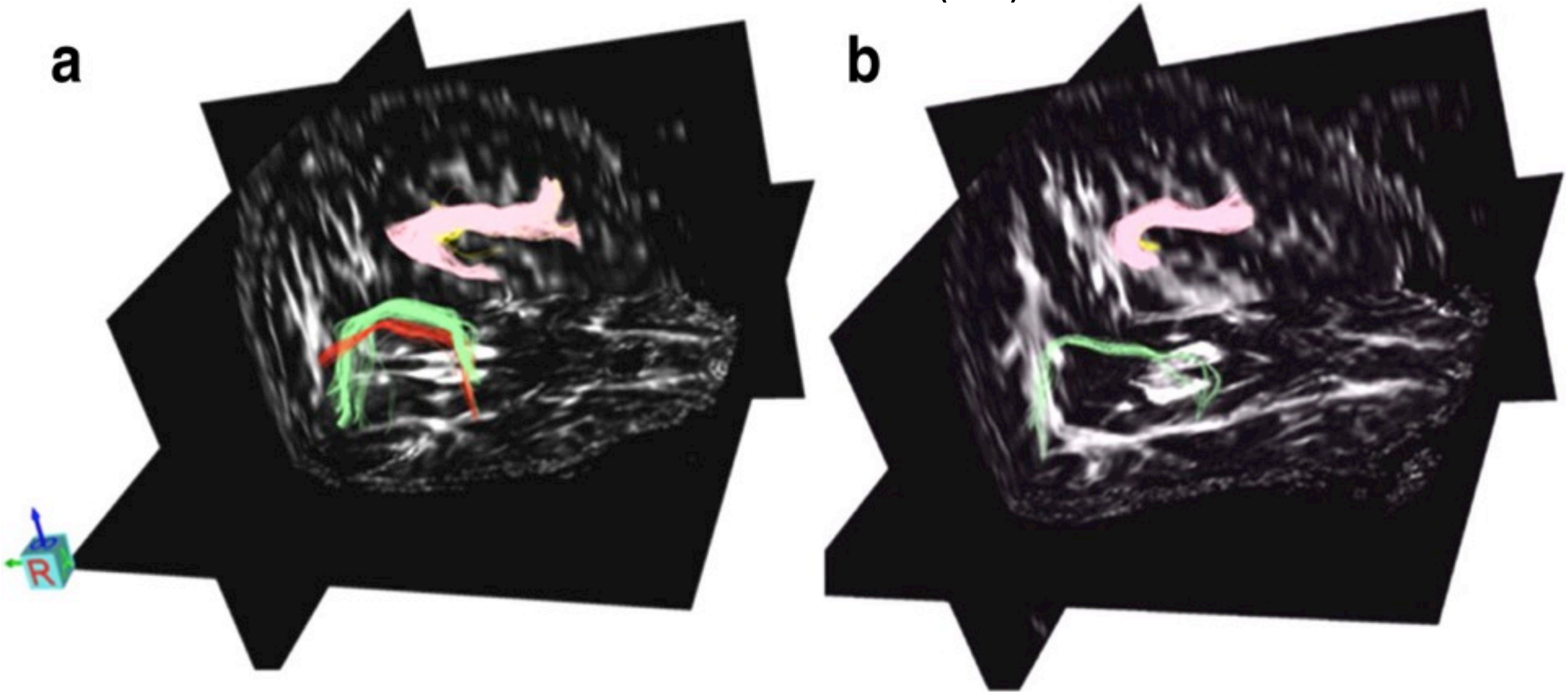
Peretz & Hyde (2003) *Trends in Cognitive Science*

Tone Deafness: A New Disconnection Syndrome?

Psyche Loui,[1] David Alsop,[2] and Gottfried Schlaug[1]
Departments of [1]Neurology and [2]Radiology, Beth Israel Deaconess Medical Center and Harvard Medical School, Boston, Massachusetts 02215

Tractography of a typical normal individual showing superior and inferior AFs bilaterally

Tractography of a typical tone-deaf individual showing hemispheric asymmetry in the AF. Right superior AF is lacking (red)



En résumé (1ere partie)

- Le cerveau du musicien est morphologiquement singulier : certaines zones, celles impliquées dans la perception auditive et celles impliquées dans la motricité sont plus développées
- De façon encore plus nette, les faisceaux de substance blanche connectant les zones sensorielles et motrices sont jusqu'à une fois et demi plus développées que sur un cerveau standard.
- Le faisceau arqué, qui unit des zones temporo-pariétales au cortex frontal inférieur, apparaît d'après les travaux les plus récents comme la cible principale de cet effet « sculptant » de la musique sur le cerveau.
- Ces particularités sont très probablement liées moins à une compétence innée qu'à l'effet de l'exercice de l'instrument, tout particulièrement la nécessité pour tout apprentissage musical de développer des connexions à distance entre différentes aires du cortex.

9632 • The Journal of Neuroscience, September 24, 2008 • 28(39):9632–9639

Behavioral/Systems/Cognitive

Cortical Plasticity Induced by Short-Term Unimodal and Multimodal Musical Training

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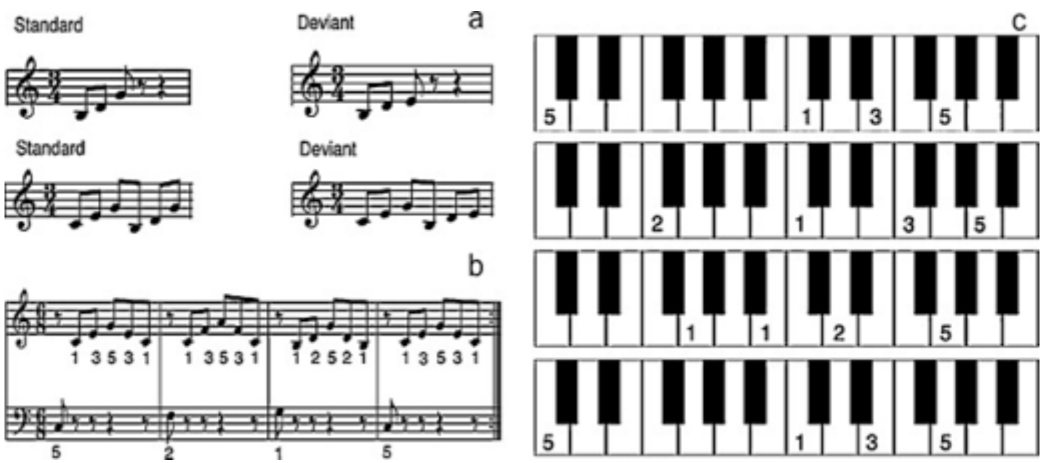
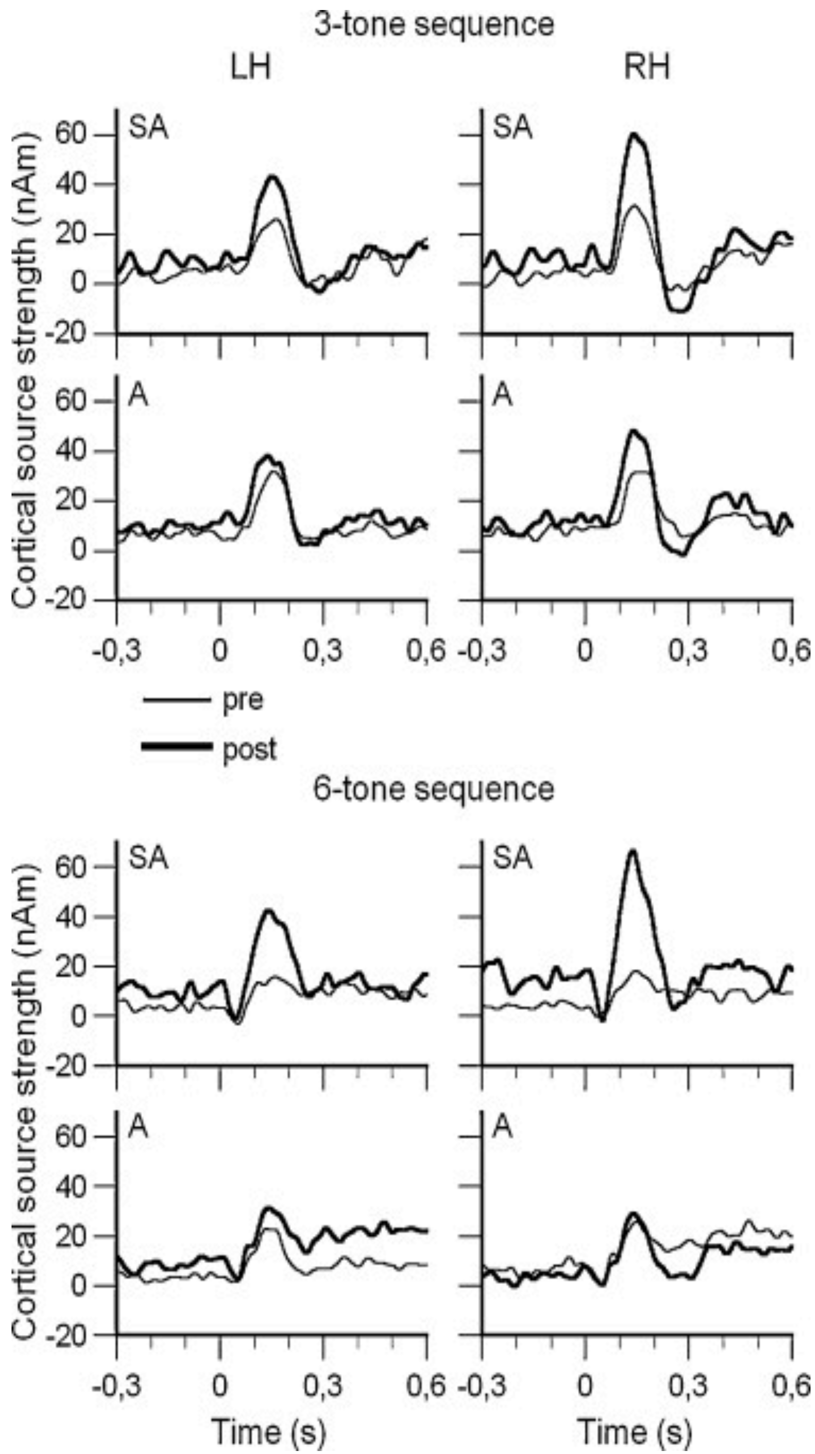
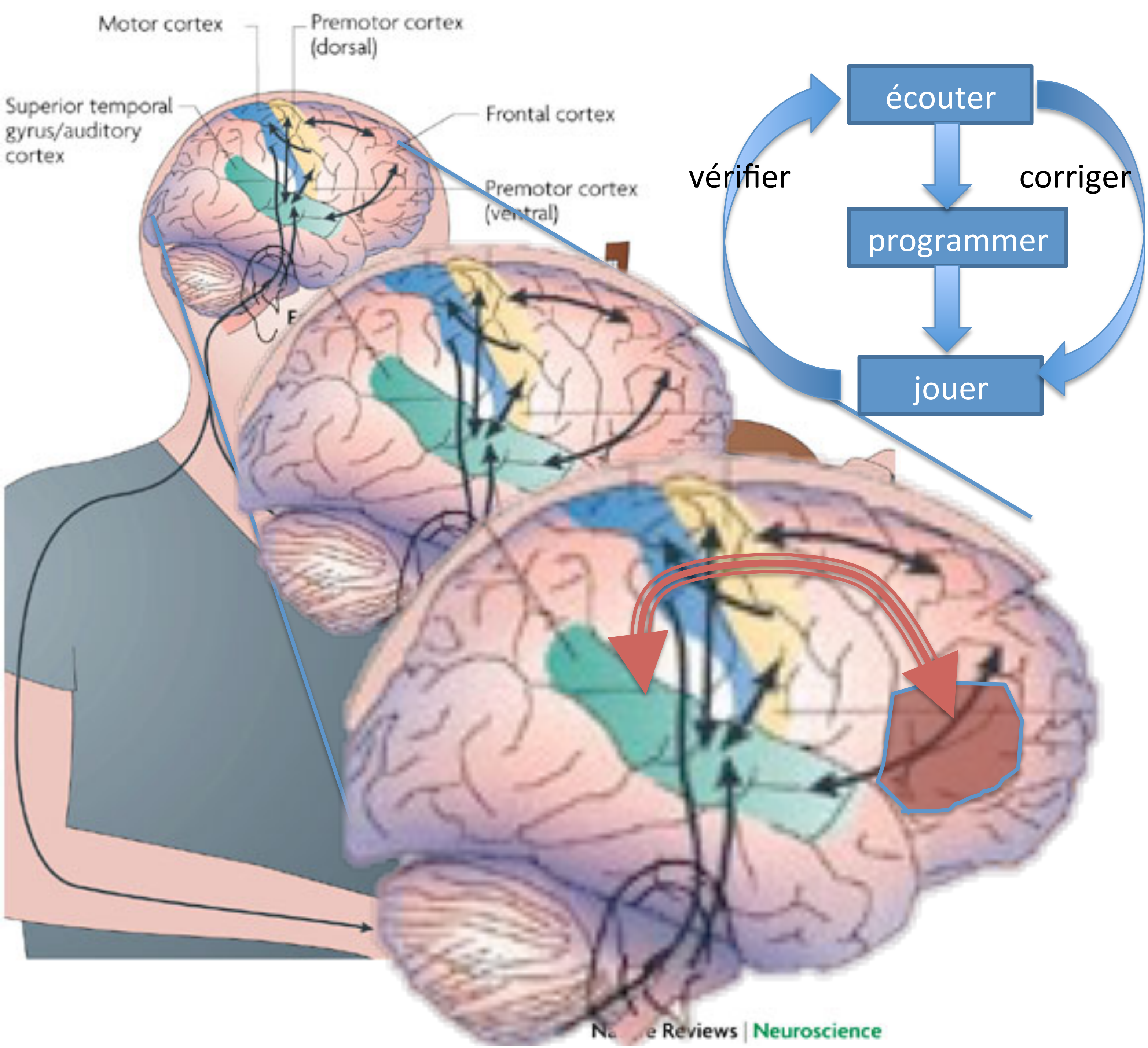
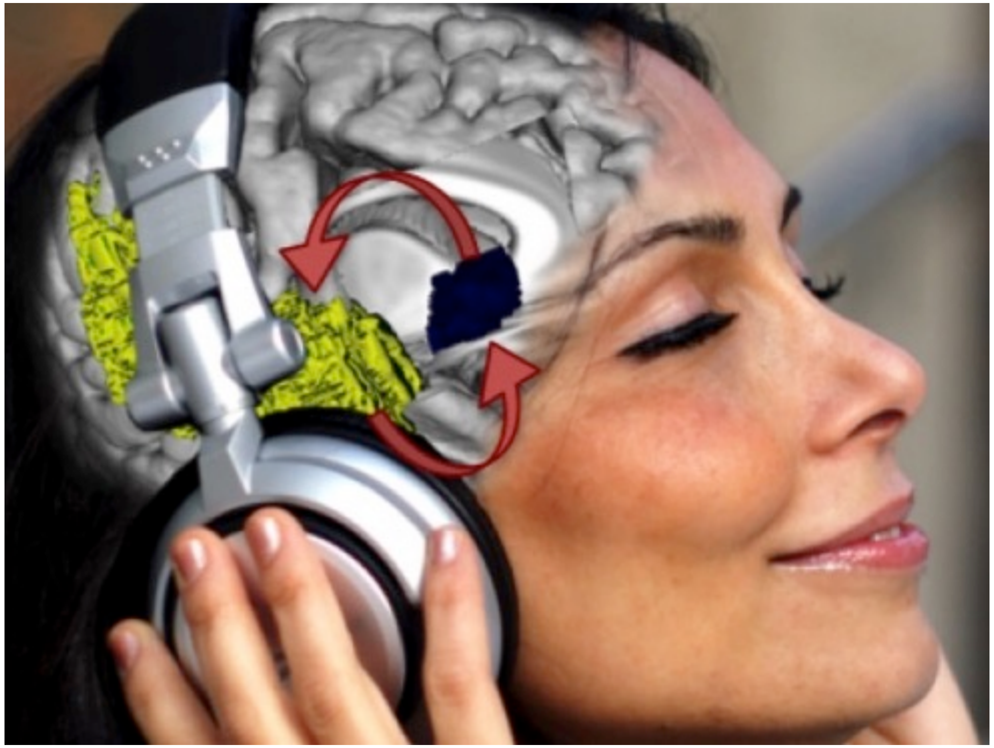




Enregistrement MEG avant et après 2semaines d'entraînement chez deux groupes de non-musiciens :SA sensori-moteur + auditif (clavier) & A auditif seul.

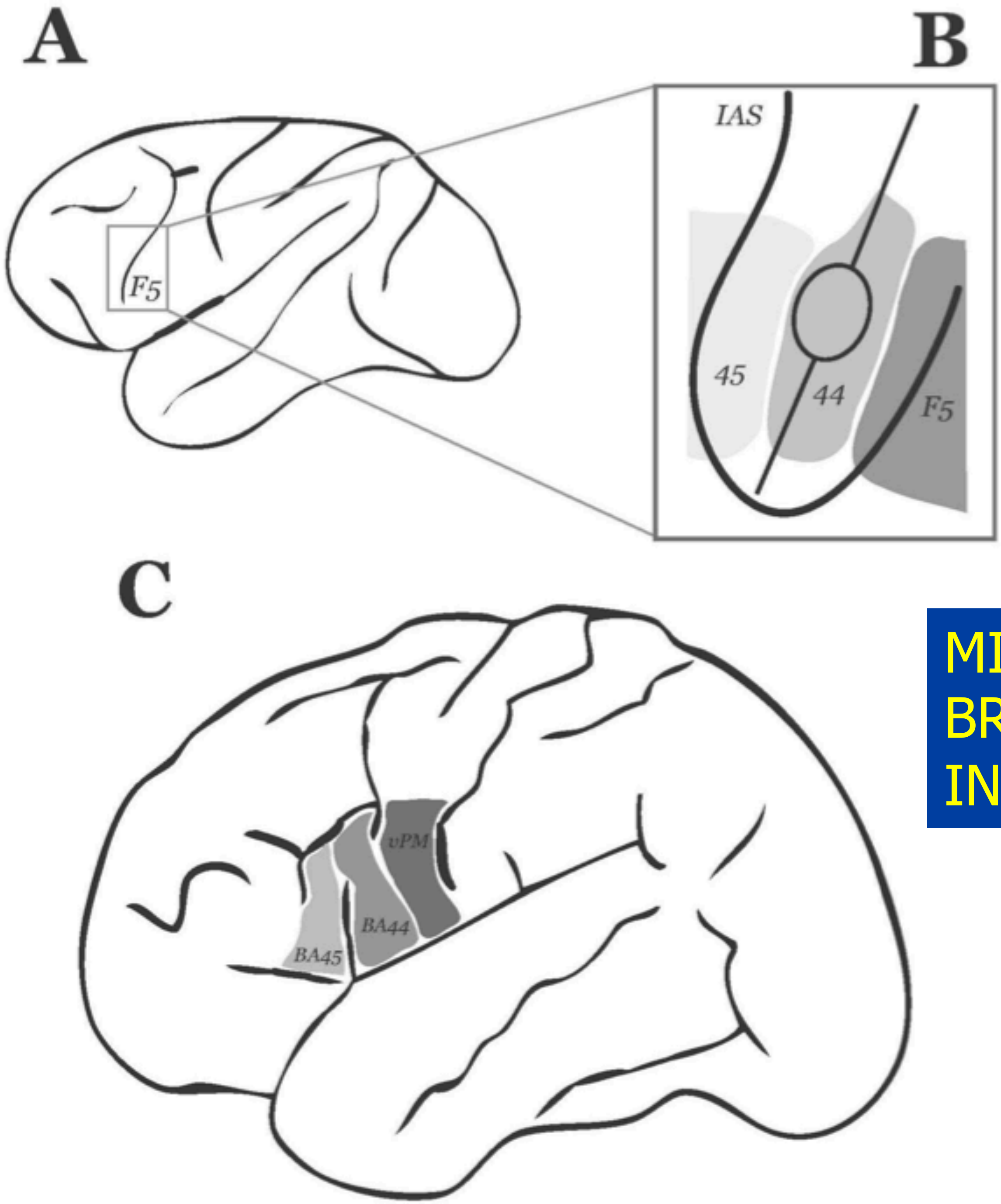
multimodal sensorimotor-auditory training in non-musicians results in greater plastic changes in auditory cortex than auditory-only training.


Motor cortex
Premotor cortex (dorsal)
Superior temporal gyrus/auditory cortex
Frontal cortex
Premotor cortex
écouter
vérifier
corriger
programmer
jouer
Reviews | Neuroscience



2eme partie

LES NEURONES MIROIRS : ÉCHANGE, PARTAGE ET EMOTION



MIRROR NEURONS / BRAIN LOCALIZATION IN MONKEY AND MAN

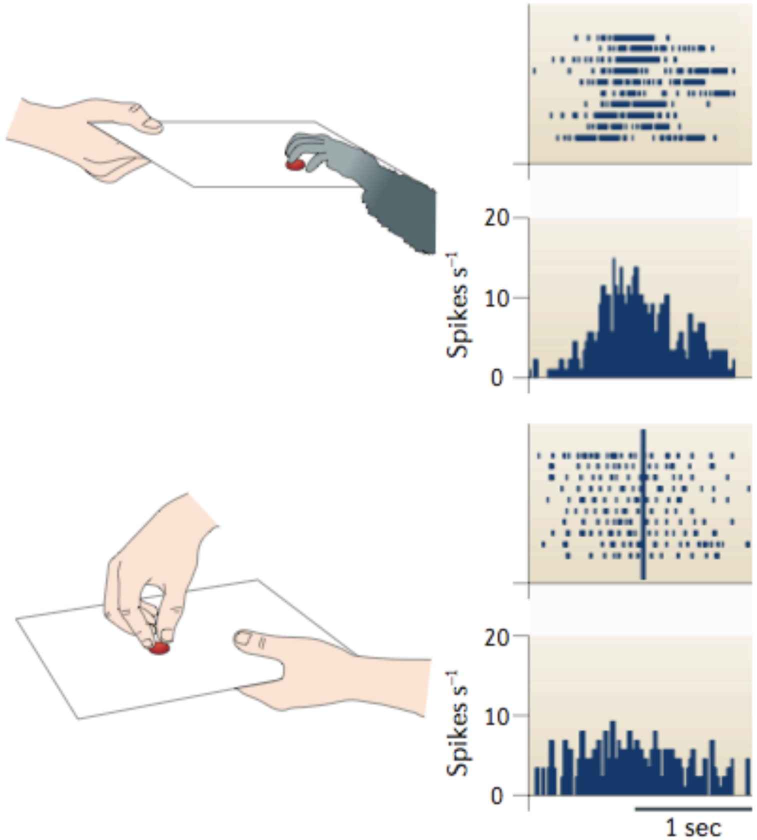


Figure 2 | **Mirror neurons in area F5.** The recordings show neural discharges of a mirror neuron in area F5 of the macaque inferior frontal cortex when the monkey grasps food (top) and when the monkey observes the experimenter grasping the food (bottom)[19]. Note that both tasks elicit strong neural responses in area F5. Modified, with permission, from REF. 115 © (2001) Macmillan Publishers Ltd.

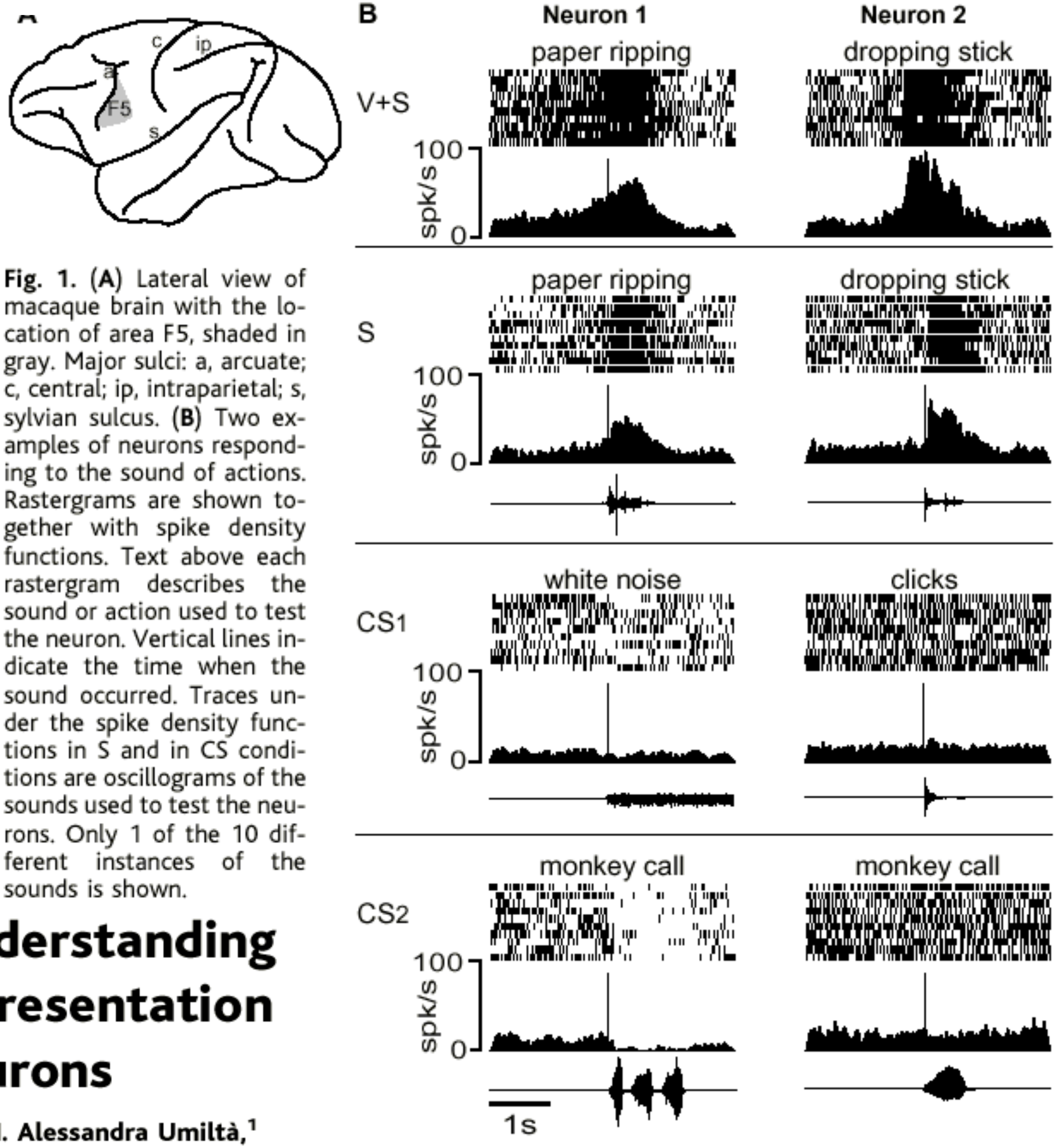


Fig. 1. (**A**) Lateral view of macaque brain with the location of area F5, shaded in gray. Major sulci: a, arcuate; c, central; ip, intraparietal; s, sylvian sulcus. (**B**) Two examples of neurons responding to the sound of actions. Rastergrams are shown together with spike density functions. Text above each rastergram describes the sound or action used to test the neuron. Vertical lines indicate the time when the sound occurred. Traces under the spike density functions in S and in CS conditions are oscillograms of the sounds used to test the neurons. Only 1 of the 10 different instances of the sounds is shown.

Hearing Sounds, Understanding Actions: Action Representation in Mirror Neurons

Evelyne Kohler,[1] Christian Keysers,[1] M. Alessandra Umiltà,[1] Leonardo Fogassi,[2] Vittorio Gallese,[1] Giacomo Rizzolatti[1]*

Rôles supposés des neurones miroir

- Comprendre les actions d'autrui
- Anticiper les intentions et états mentaux d'autrui (théorie de l'esprit)
- Apprentissage par imitation
- Contrôle (et apprentissage) du langage
- Mécanisme de l'empathie, compréhension des affects d'autrui
- Musique, danse +++

Behavioral/Systems/Cognitive

Action Representation of Sound: Audiomotor Recognition Network While Listening to Newly Acquired Actions

Amir Lahav,[1,2] Elliot Saltzman,[2,3] and Gottfried Schlaug[1]
[1]Department of Neurology, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, Massachusetts 02215, [2]Department of Rehabilitation Sciences, Boston University, Boston, Massachusetts 02215, and [3]Haskins Laboratories, New Haven, Connecticut 06511

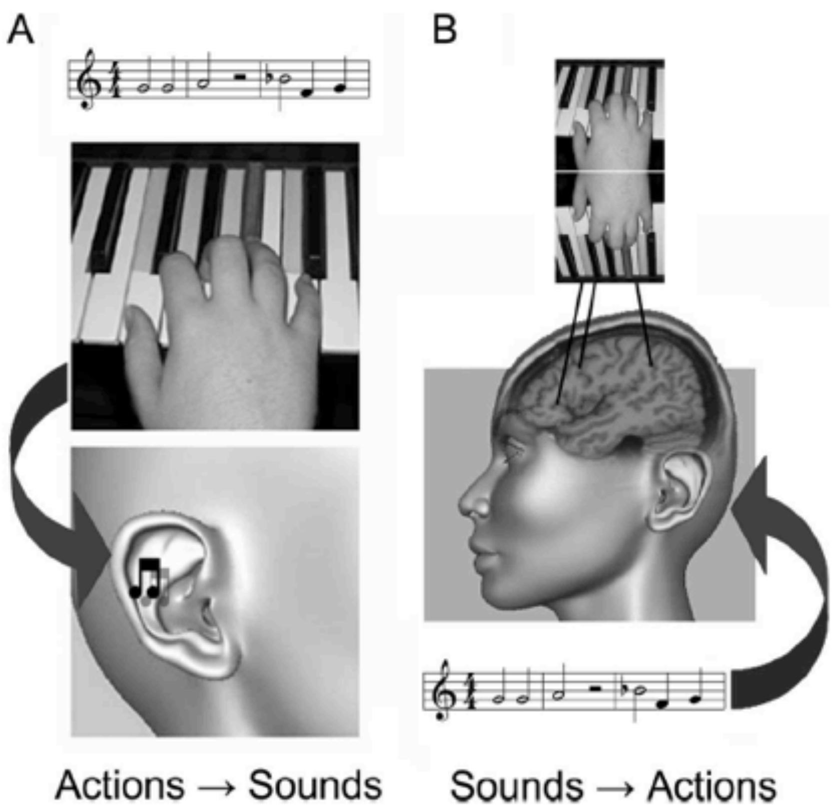


Figure 1. Action–listening illustration. ***A***, Music performance can be viewed as a complex sequence of both actions and sounds, in which sounds are made by actions. ***B***, The sound of music one knows how to play can be reflected, as if in a mirror, in the corresponding motor representations.

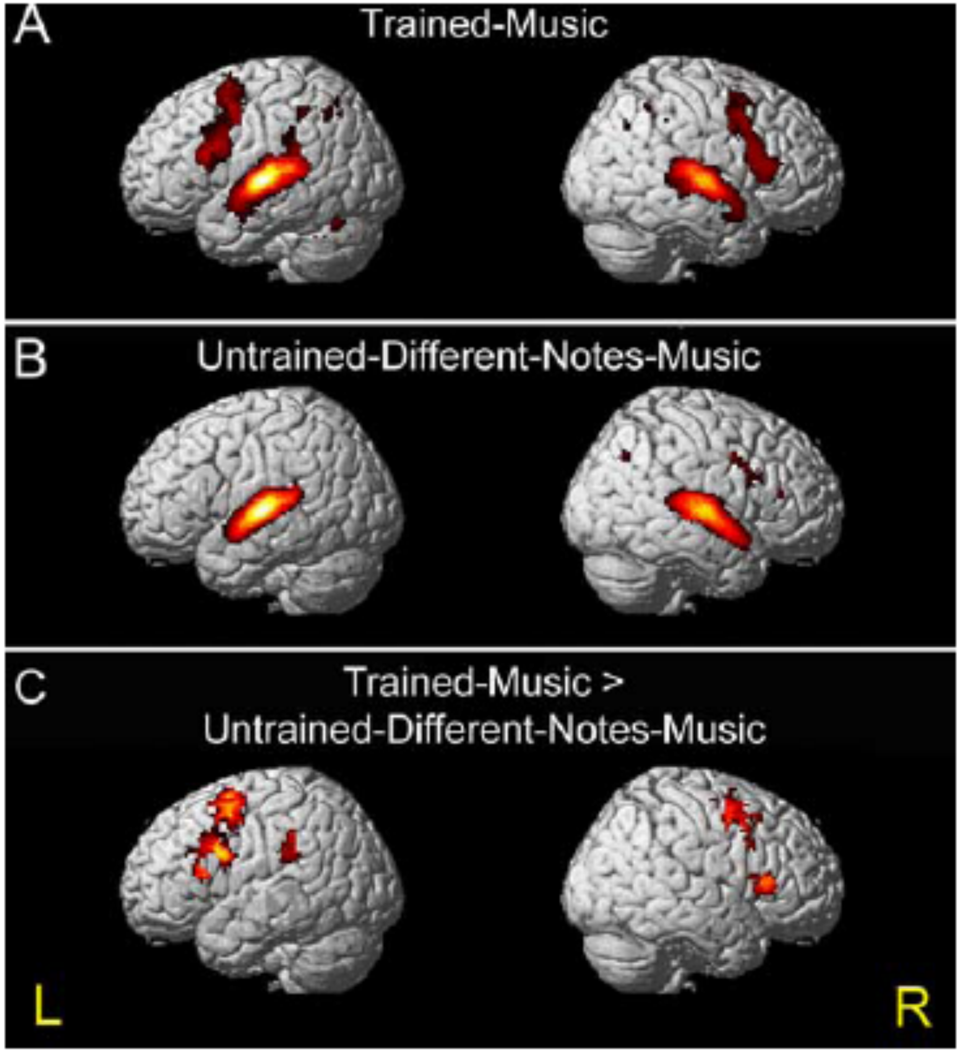
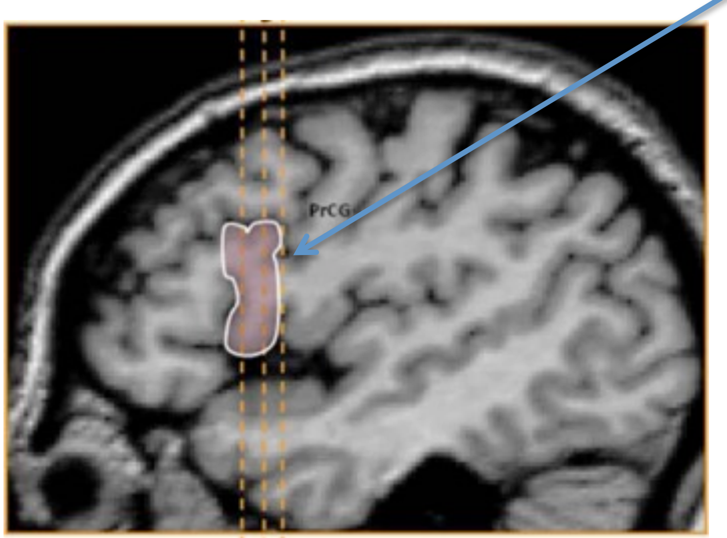
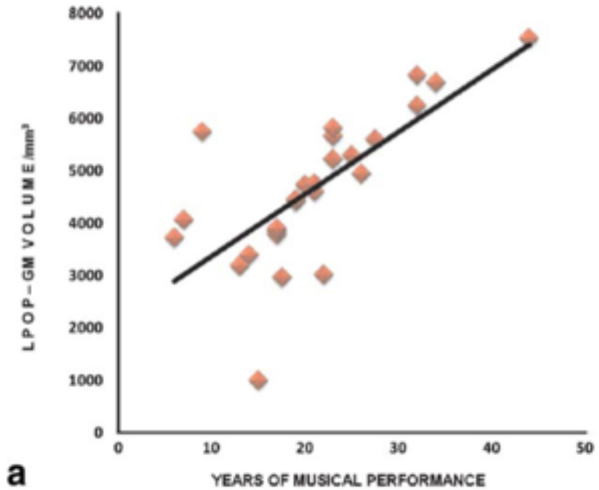


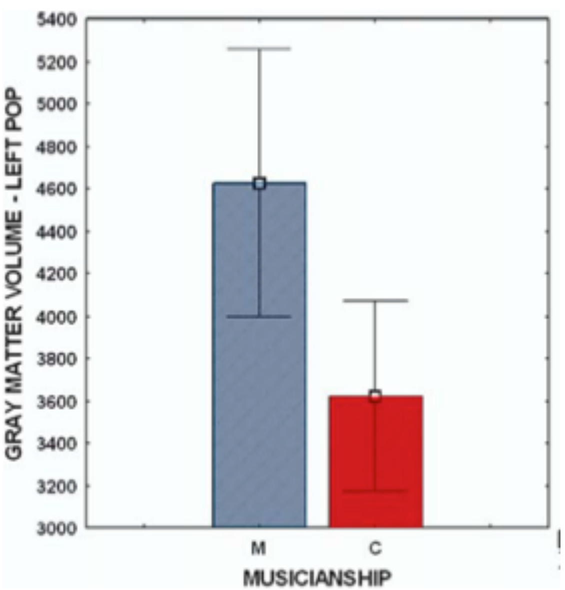
Figure 3. Action–listening activation. ***A***, ***B***, Extensive bilateral activation in the frontoparietal motor-related brain regions was observed when subjects listened to the trained-music they knew how to play (***A***), but not when they listened to the never-learned untrained-different-notes-music (***B***) (contrasted against rest baseline; $p < 0.05$, FDR corrected). ***C***, Activation maps are shown in areas that were significantly more active during listening to the trained-music versus the untrained-different-notes-music. Surface projection of group mean activation ($n = 9$) are rendered onto an individual standardized brain ($p < 0.05$, FDR corrected). L, Left; R, right.

Etude de l'aire de Broca (BA44) chez 26 musiciens d'orchestre (comparé à 26 témoins non musiciens)

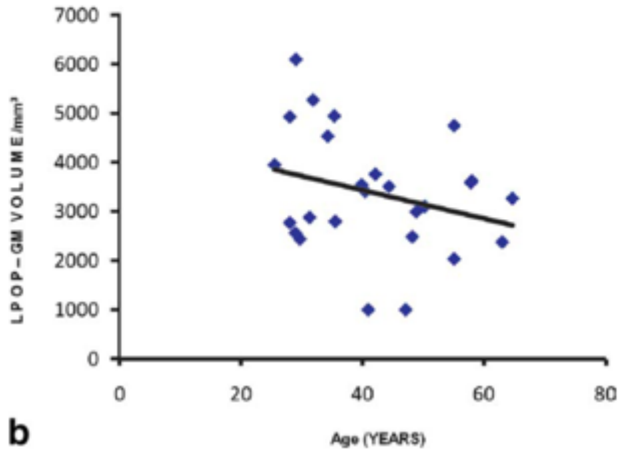


Corrélation avec le nombre d'années d'activité orchestrale





Aire 44 plus de deux fois plus développée en moyenne chez les musiciens



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Dynamic Emotional and Neural Responses to Music Depend on Performance Expression and Listener Experience

Heather Chapin[1], Kelly Jantzen[2], J. A. Scott Kelso[1,3], Fred Steinberg[4], Edward Large[1]*

Expressive vs "mechanical" performance

Frederic Chopin Etude in E major, Op.10, No. 3
(« tristesse »)

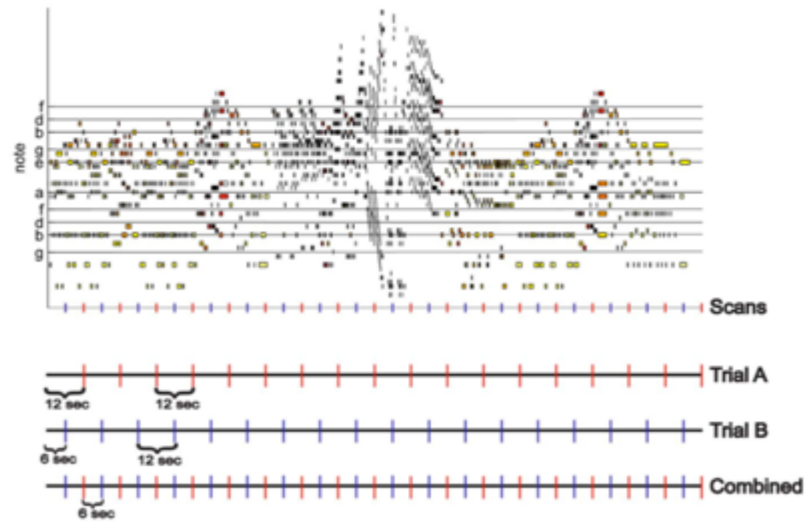
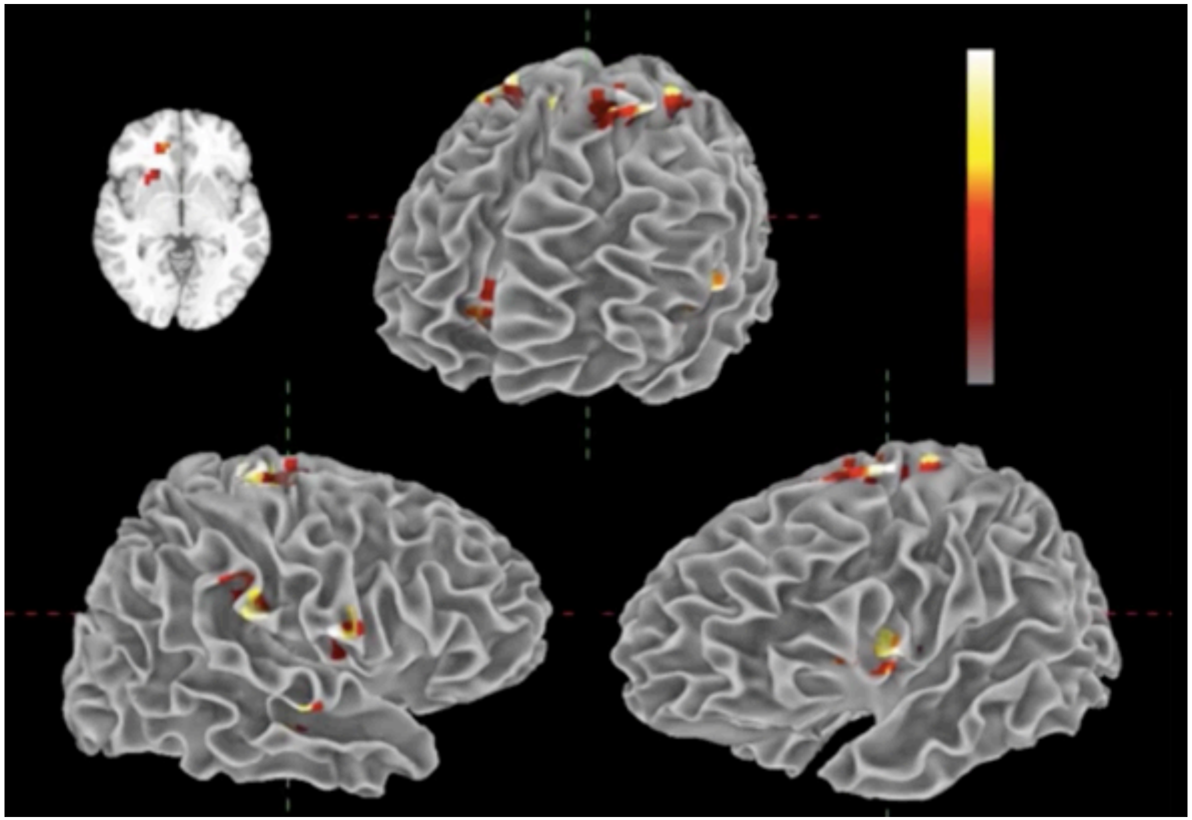


Figure 2. Piano roll notation and fMRI scan times. Piano roll notates Chopin's Etude in E major, opus 10, no .3.
doi:10.1371/journal.pone.0013812.g002



Neuron, Vol. 40, 655–664, October 30, 2003, Copyright ©2003 by Cell Press

Both of Us Disgusted in *My* Insula: The Common Neural Basis of Seeing and Feeling Disgust

Bruno Wicker,[1] Christian Keysers,[2,3]
Jane Plailly,[4] Jean-Pierre Royet,[4]
Vittorio Gallese,[2] and Giacomo Rizzolatti[2,*]
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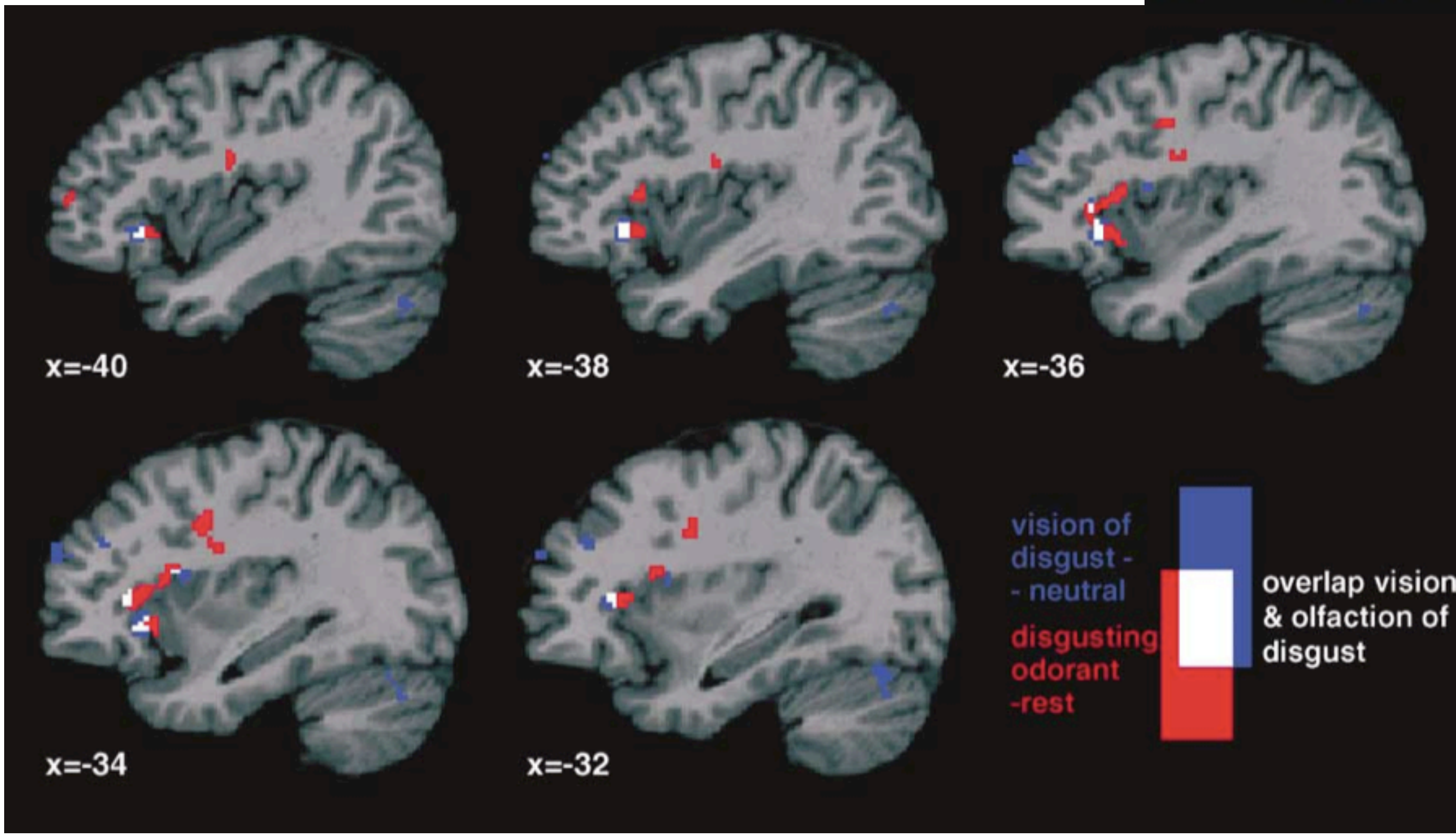
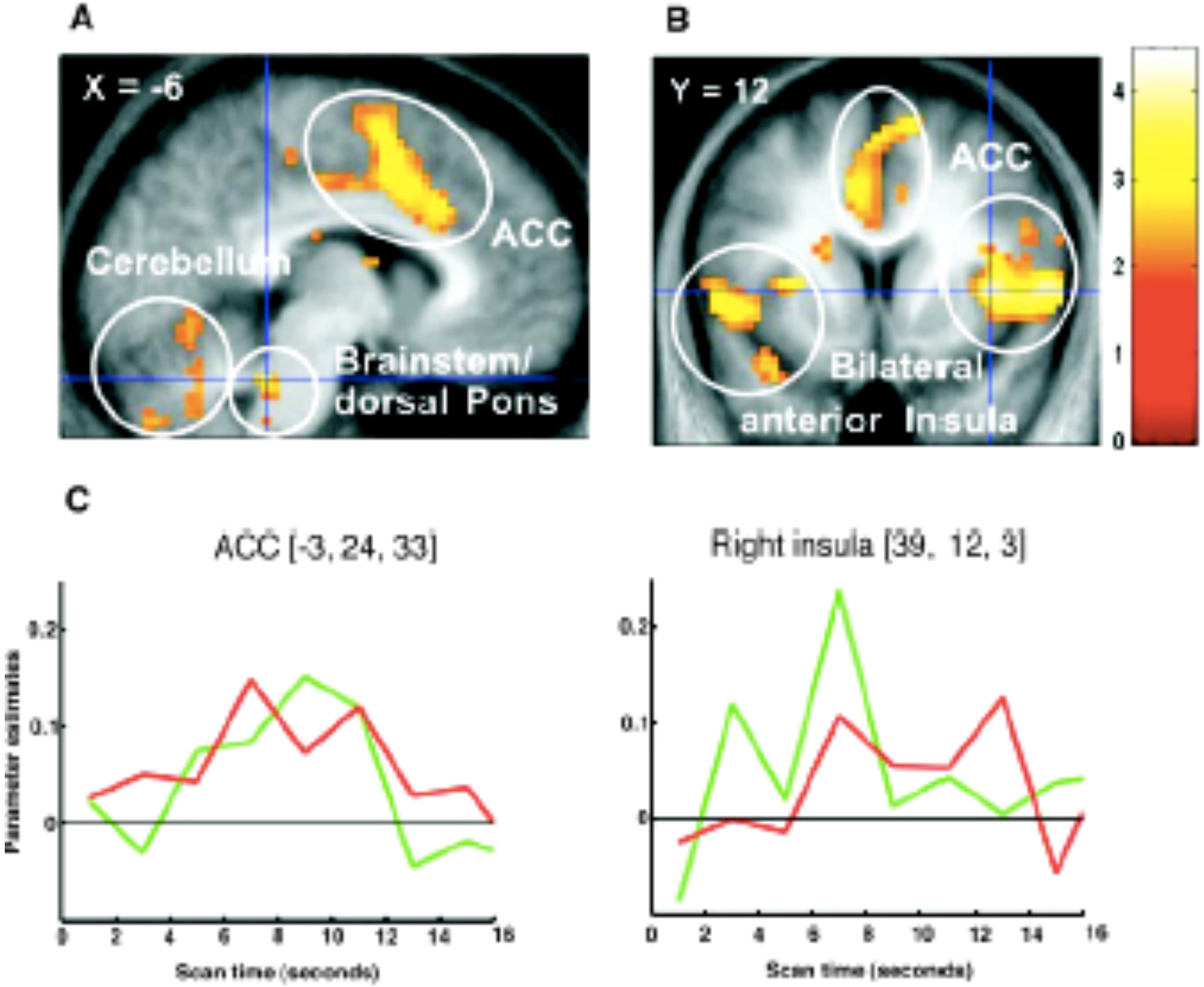


“Feeling” someone else’ s pain…

Own pain:

Significant other’ s pain:



Current Biology 16, 1905–1910, October 10, 2006 ©2006 Elsevier Ltd All rights reserv

Seeing or Doing? Influence of Visual and Motor Familiarity in Action Observation

Beatriz Calvo-Merino,[1,*] Julie Grèzes,[2]
Daniel E. Glaser,[1] Richard E. Passingham,[3,4]
and Patrick Haggard[1,*]
[1] Institute of Cognitive Neuroscience and
Department of Psychology
University College London

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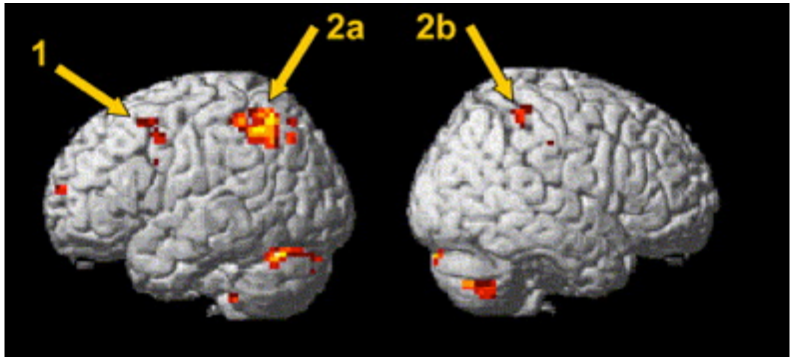
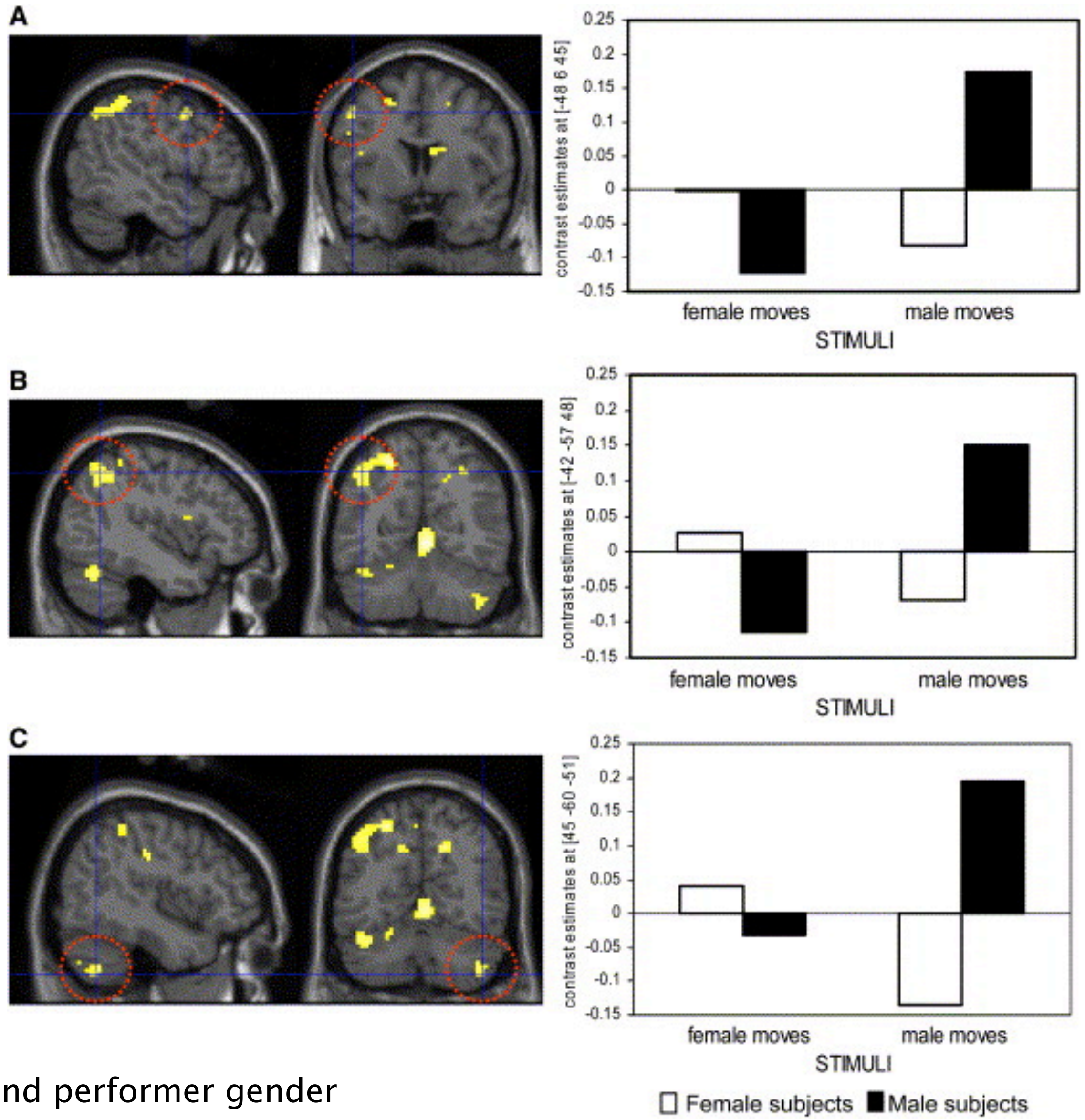
network

Results

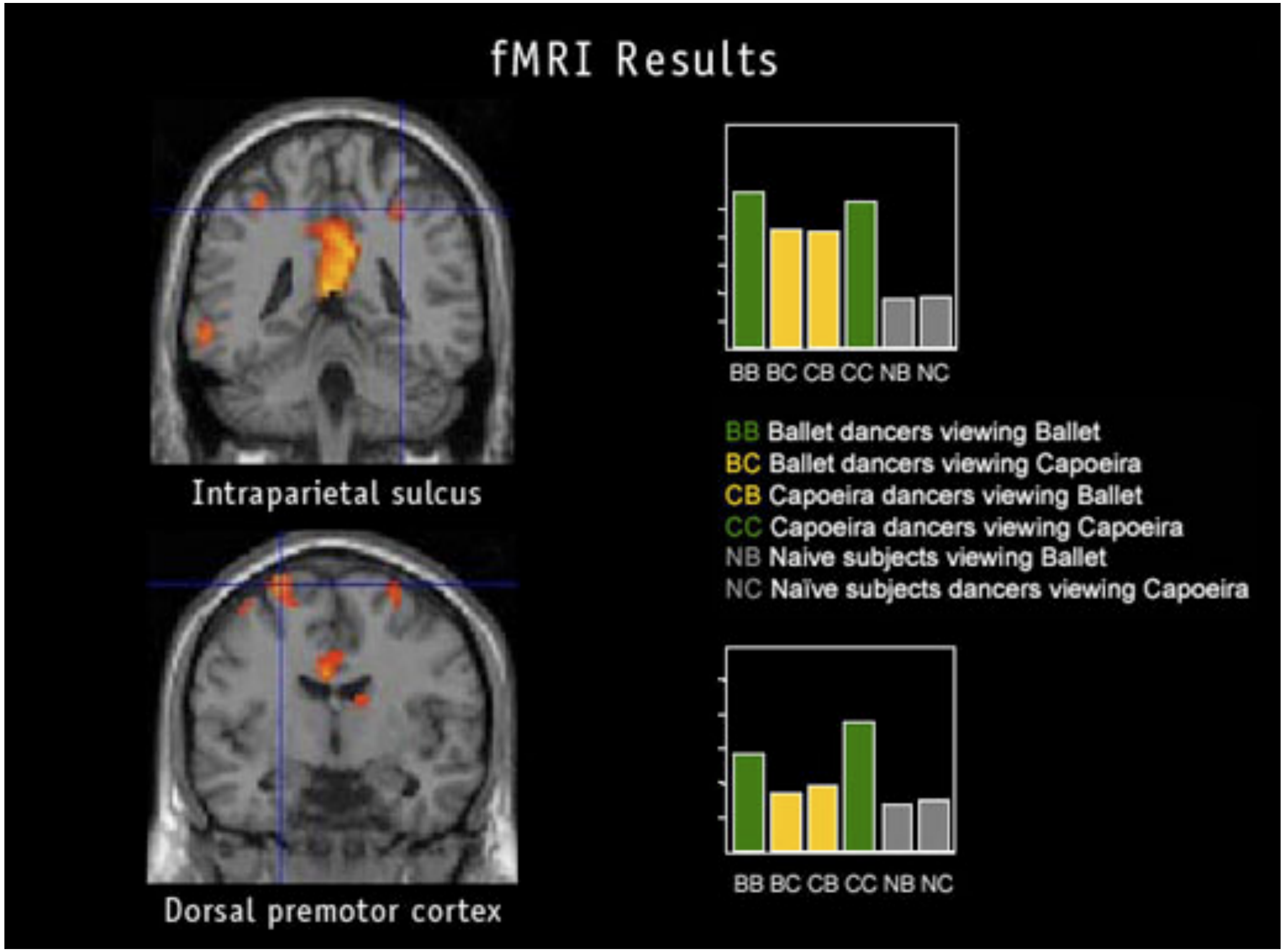
Observi





interaction between subject gender and performer gender

Daniel Glaser
University College London



Daniel Glaser
University College London

THE NEUROSCIENCE OF Dance

Recent brain-imaging studies reveal some of the complex neural choreography behind our ability to dance

By Steven Brown and Lawrence M. Parsons

KEY CONCEPTS

- Dance is a fundamental form of human expression that likely evolved together with music as a way of generating rhythm.
- It requires specialized mental skills. One brain area houses a representation of the body's orientation, helping to direct our movements through space; another serves as a synchronizer of sorts, enabling us to pace our actions to music.
- Unconscious entrainment—the process that causes us to absentmindedly tap our feet to a beat—reflects our instinct for dance. It occurs when certain subcortical brain regions converse, bypassing higher auditory areas.

—*The Editors*

So natural is our capacity for rhythm that most of us take it for granted: when we hear music, we tap our feet to the beat or rock and sway, often unaware that we are even moving. But this instinct is, for all intents and purposes, an evolutionary novelty among humans. Nothing comparable occurs in other mammals nor probably elsewhere in the animal kingdom. Our talent for unconscious entrainment lies at the core of dance, a confluence of movement, rhythm and gestural representation. By far the most synchronized group practice, dance demands a type of interpersonal coordination in space and time that is almost nonexistent in other social contexts.

Even though dance is a fundamental form of human expression, neuroscientists have given it relatively little consideration. Recently, however, researchers have conducted the first brain-imaging studies of both amateur and professional dancers. These investigations address such questions as, How do dancers navigate though space? How do they pace their steps? How do people learn complex series of patterned movements? The results offer an intriguing glimpse into the complicated mental coordination required to execute even the most basic dance steps.

I Got Rhythm

Neuroscientists have long studied isolated movements such as ankle rotations or finger tapping. From this work we know the basics of how the brain orchestrates simple actions. To hop on one foot—never mind patting your head at the same time—requires calculations relating to spatial awareness, balance, intention and timing, among other things, in the brain's sensorimotor system. In a simplified version of the story, a region called the posterior parietal cortex (toward the back of the brain) translates visual information into motor commands, sending signals forward to motion-planning areas in the premotor cortex and supplementary motor area. These

TANTALIZING TANGO FINDING

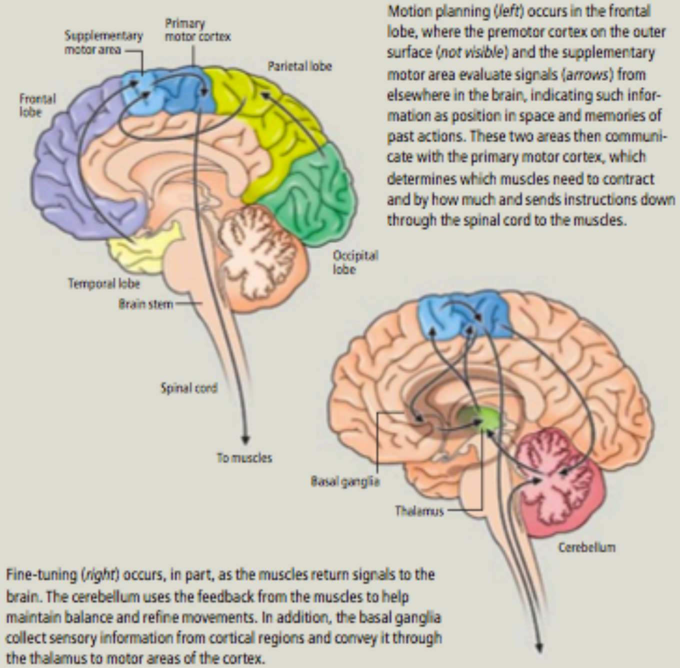
In a study published in December 2007, Gammon M. Earhart and Madeleine E. Hackney of the Washington University School of Medicine in St. Louis found that tango dancing improved mobility in patients with Parkinson's disease. The condition stems from a loss of neurons in the basal ganglia, a problem that interrupts messages meant for the motor cortex. As a result, patients experience tremors, rigidity and difficulty initiating movements they have planned.

The researchers found that after 20 tango classes, study subjects "froze" less often. Compared with subjects who attended an exercise class instead, the tango dancers also had better balance and higher scores on the Get Up and Go test, which identifies those at risk for falling.

[THE BASICS]

THE BRAIN'S MOVING PARTS

To identify the brain areas that control dance, researchers first need a sense of how the brain allows us to carry out voluntary movements in general. A highly simplified version is presented here.



Motion planning (*left*) occurs in the frontal lobe, where the premotor cortex on the outer surface (*not visible*) and the supplementary motor area evaluate signals (*arrows*) from elsewhere in the brain, indicating such information as position in space and memories of past actions. These two areas then communicate with the primary motor cortex, which determines which muscles need to contract and by how much and sends instructions down through the spinal cord to the muscles.

Fine-tuning (*right*) occurs, in part, as the muscles return signals to the brain. The cerebellum uses the feedback from the muscles to help maintain balance and refine movements. In addition, the basal ganglia collect sensory information from cortical regions and convey it through the thalamus to motor areas of the cortex.

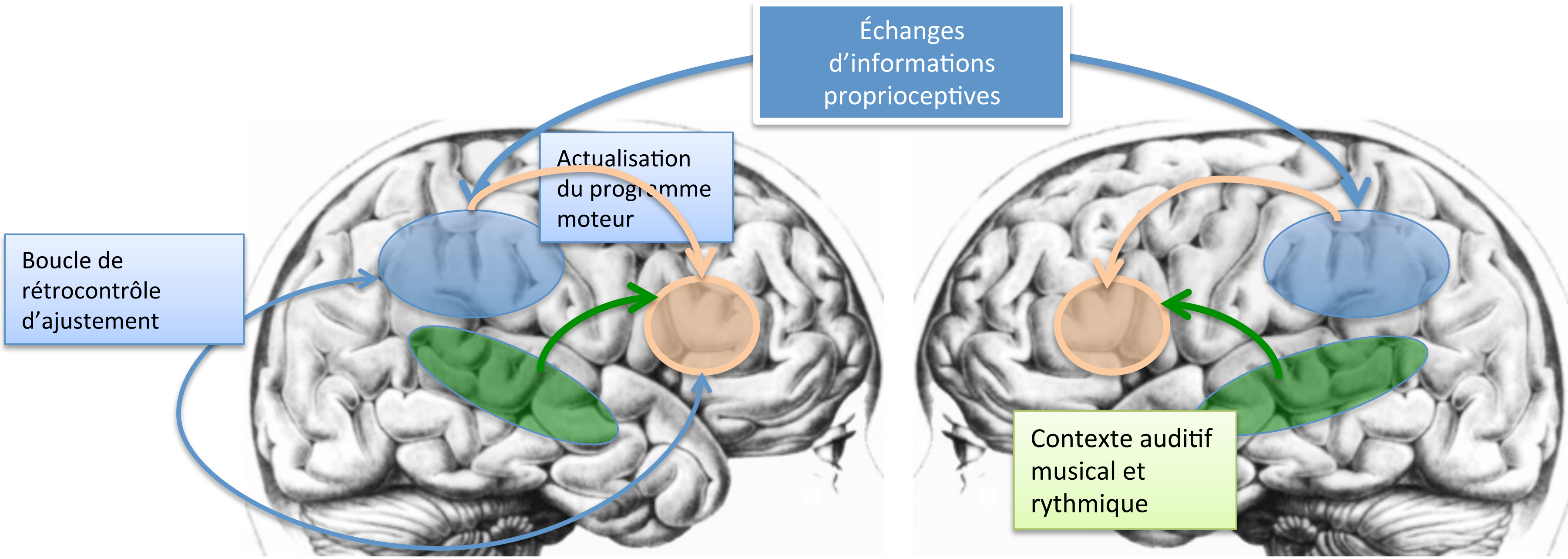
As anticipated, this comparison eliminated many of the basic motor areas of the brain. What remained, though, was a part of the parietal lobe, which contributes to spatial perception and orientation in both humans and other mammals. In dance, spatial cognition is primarily kinesthetic: you sense the positioning of your torso and limbs at all times, even with your eyes shut, thanks to the muscles' sensory organs. These organs index the rotation of each joint and the tension in each muscle and relay that information to the brain, which generates an articulated body representation in response. Specifically, we saw activation in the precuneus, a parietal lobe region very close to where the kinesthetic representation of the legs resides. We believe that the precuneus contains a kinesthetic map that permits an awareness of body positioning in space while people navigate through their surroundings. Whether you are waltzing or simply walking a straight line, the precuneus helps to plot your path and does so from a body-centered or "egocentric" perspective.

Next we compared our dance scans to those taken while our subjects performed tango steps in the absence of music. By eliminating brain regions that the two tasks activated in common, we hoped to reveal areas critical for the synchronization of movement to music. Again this subtraction removed virtually all the brain's motor areas. The principal difference occurred in a part of the cerebellum that receives input from the spinal cord. Although both conditions engaged this area—the anterior vermis—dance steps synchronized to music generated significantly more blood flow there than self-paced dancing did.

Albeit preliminary, our result lends credence

TAMI TOLPA; PETER MUELLER/Aurora Photos (dancers)

[redacted]


Échanges d'informations proprioceptives
Actualisation du programme moteur
Boucle de rétrocontrôle d'ajustement
Contexte auditif musical et rythmique

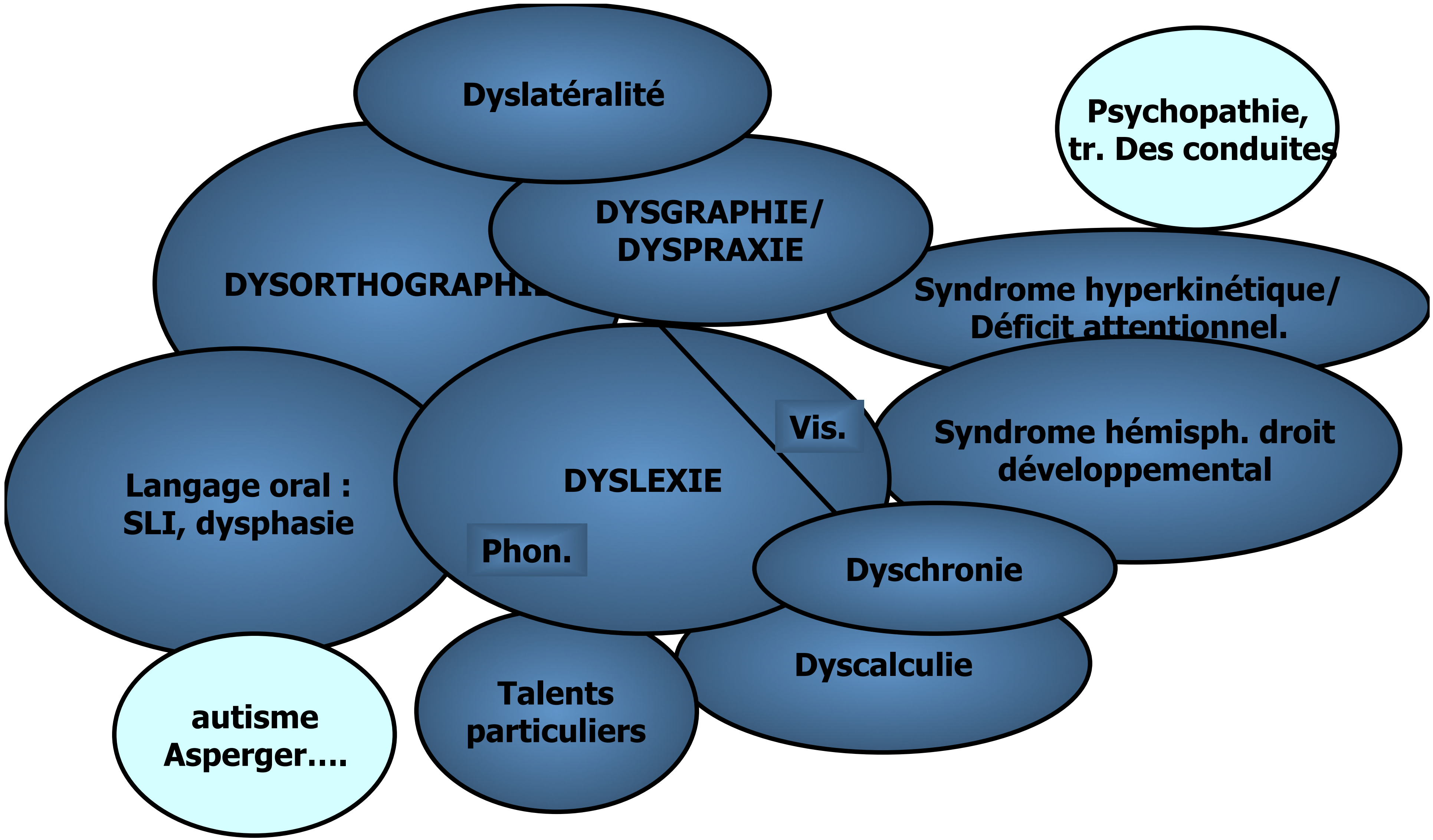

1
2
3
4

En résumé (2eme partie)

- Il existe un ensemble croissant et convergent d'arguments montrant que la perception de la musique mais aussi la capacité à jouer (et sans doute à apprendre à jouer) d'un instrument de musique fait appel de manière singulière au fonctionnement du système des neurones miroir (idéalement placé pour établir la jonction audio-motrice entre perception et production)
- Des expériences isolant l'aspect esthétique et le plaisir musicaux convergent vers l'activation spécifique de parties du SNM, en particulier l'insula et le gyrus frontal inférieur ("Broca"), deux zones dont la proximité anatomique suggère leur rôle conjoint mais distinct dans la façon dont l'humain partage, perçoit et "vit" la musique
- Ainsi, perception, production et émotion musicales semblent étroitement liées par l'anatomie comme par la fonction.
- La danse, comme la musique, utilisent les propriétés du système des neurones miroirs, sans doute par la nécessité qu'elles partagent d'une interaction étroite entre toutes les dimensions du message artistique : sensoriel, moteur et émotionnel, message ayant vocation à être <u>partagé</u> entre différents cerveaux : l'orchestre ou le couple de danseurs, mais aussi l'artiste ou les artistes et leur public.

3eme partie

LA MUSIQUE COMME OUTIL DE RÉÉDUCATION : UNE NOUVELLE VOIE POUR TRAITER LES ENFANTS DYSLEXIQUES



La « constellation dys » : un complexe symptomatique suggérant des mécanismes communs

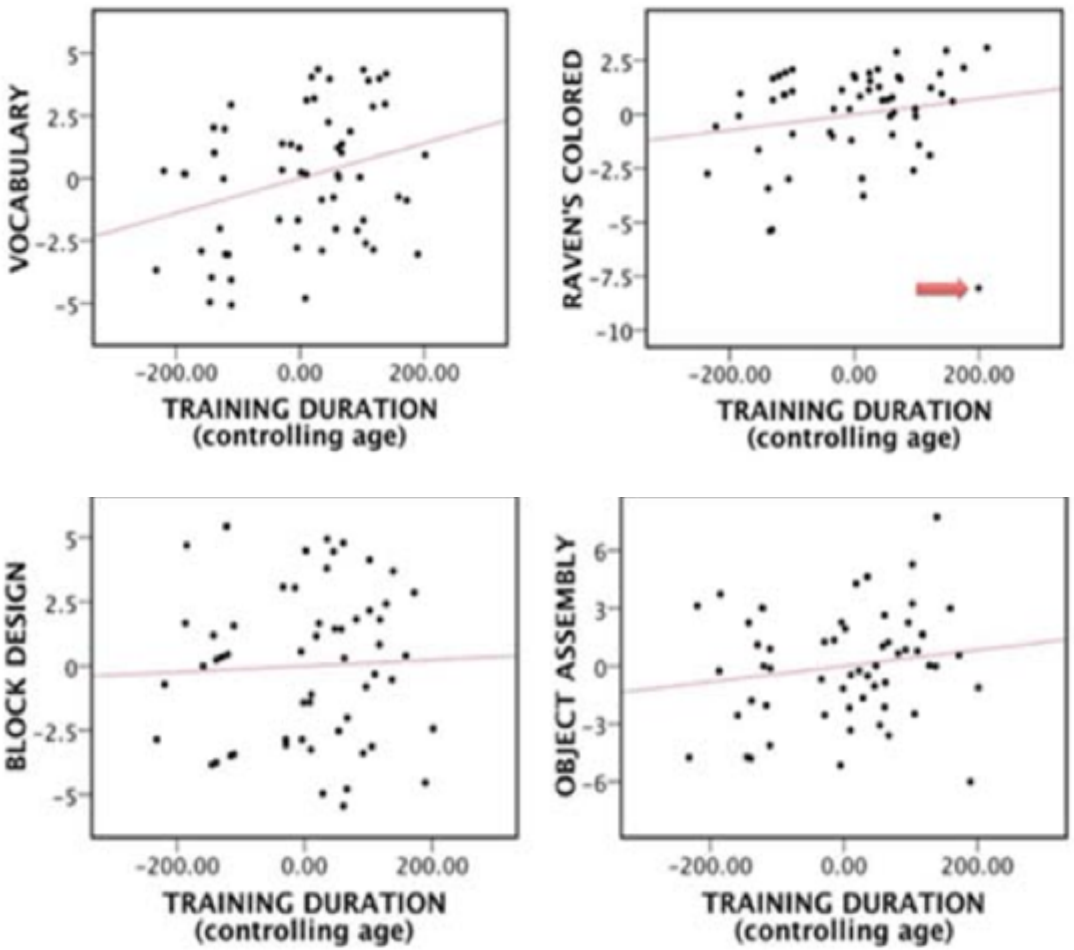
Transfer effect between music and non-musical abilities in children

- Literacy (Anvari et al., 2002; Moreno & Besson, 2007)
- Verbal memory (Chan et al., 1998; Ho et al., 2003)
- Vocabulary and non-verbal reasoning (Forgeard et al., 2008)
- Visuo-spatial processing (Costa-Giomi, 1999)
- Mathematics (Cheek & Smith, 1999)
- IQ (Schellenberg, 2004)
- Second language learning (White et al., 2013; Yang et al., 2014)
- Executive function & frontal activation during task-switching (Zuk et al., 2014)

Practicing a Musical Instrument in Childhood is Associated with Enhanced Verbal Ability and Nonverbal Reasoning

Marie Forgeard[1], Ellen Winner[2,3]*, Andrea Norton[1], Gottfried Schlaug[1]

1 Department of Neurology, Beth Israel Deaconess Medical Center and Harvard Medical School, Boston, Massachusetts, United States of America, 2 Department of Psychology, Boston College, Chestnut Hill, Massachusetts, United States of America, 3 Project Zero, Harvard Graduate School of Education, Cambridge, Massachusetts, United States of America



Signif.

Non-signif.

Short-Term Music Training Enhances Verbal Intelligence and Executive Function

Psychological Science
22(11) 1425–1433

DOI: 10.1177/0956797611416999
http://pss.sagepub.com
SAGE

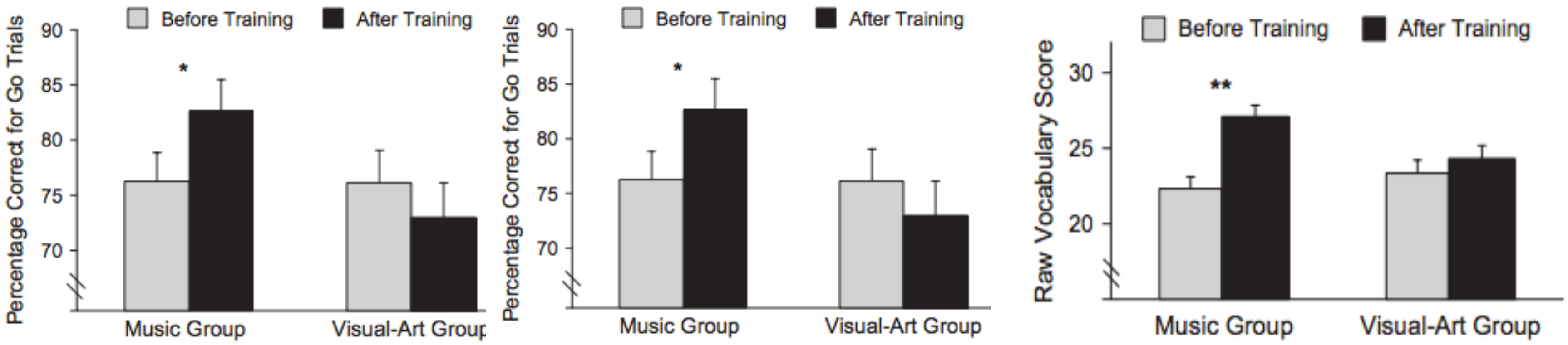
Sylvain Moreno[1], Ellen Bialystok[2], Raluca Barac[2],
E. Glenn Schellenberg[3], Nicholas J. Cepeda[2,4],
and Tom Chau[3,5]
[1]Rotman Research Institute, Toronto, Ontario, Canada; [2]Department of Psychology, York University;

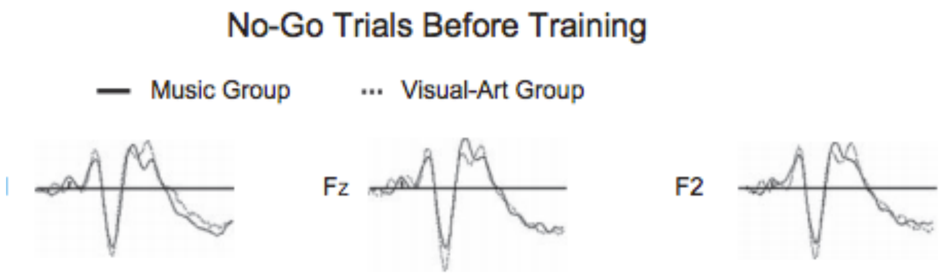
Un entraînement musical d'à peine 20 jours est capable de modifier durablement les capacités de flexibilité mentale et d'intelligence verbale

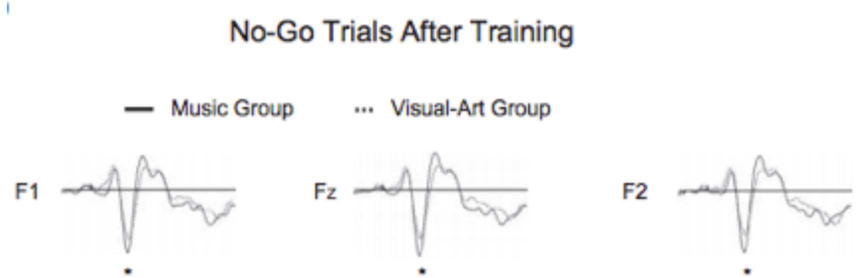
48 enfants 4-6 ans:

- 24 music group
- 24 : visual-art group

(2 programmes informatisés conçus pour l'occasion, parfaitement similaires en temps, nombre de sessions, difficulté attentionnelle)
20 jours d'entraînement 45 mn/j.
Tâche go-nogo : appuyer pour les figures mauves, ne pas appuyer pour les blanches : deux mauves (carré triangle) deux blanches (carré, triangle)







CHAPTER 8

Music Training for the Development of Reading Skills

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[1]Corresponding author: Phone: +847-491-3181, e-mail address: nkraus@northwestern.edu

Table 2 Summary of longitudinal studies of the effect of music training on reading ability and phonological awareness

Study	Subjects	Music training	Control group	Improvements relative to control group
Without random assignment				
Hurwitz et al. (1975)	20 7-year-olds	Experimenter-designed	No training	Reading
Standley (1997)	32 4–5-year-olds	Experimenter-designed	No training	Pre-reading skills
Overy (2000, 2003)	9 dyslexic 9-year-olds	Experimenter-designed	None	Phonological awareness and spelling
Register (2004)	86 5–7-year-olds	Experimenter-designed to teach language skills	Literacy-training television show	None
Gromko (2005)	103 5-year-olds	Experimenter-designed	No training	Phoneme segmentation fluency
Rauscher and Hinton (2011)	75 5-year-olds	Private Suzuki violin instruction	Swimming lessons or no training	Word naming and phonemic awareness
Moritz et al. (2012)	30 5-year-olds	Preexisting school music classes	Less frequent music classes	Phonological awareness
Tierney et al. (2013)	43 adolescents	Preexisting school music classes	Fitness training	Earlier neural timing
With random assignment				
Roskam (1979)	36 learning-disabled 6–9-year-olds	Experimenter-designed	Learning disability rehabilitation	None
Douglas and Willatts (1994)	12 reading-disabled 9-year-olds	Experimenter-designed	No training	Reading
Fisher (2001)	80 5-year-olds	Experimenter-designed to teach language skills	Language skill teaching without music	Phoneme segmentation and oral skills
Costa-Giomi (2004)	80 fourth-graders	Private piano instruction	No training	None
Register et al. (2007)	33 second-graders, 6 reading-disabled	Experimenter-designed to teach reading skills	No training	Word knowledge
Forgeard et al. (2008)	44 6-year-olds	Unclear	No training	Word reading
Moreno et al. (2009)	32 8-year-olds	Computer-based	Painting or no training	Reading
Degé and Schwarzer (2011)	41 5–6-year-olds	Experimenter-designed	Phonological skill training	Phonological awareness
Herrera et al. (2010)	97 4-year-olds	Experimenter-designed to teach phonological skills	Phonological skill training or no training	Phonological awareness
Taub and Lazarus (2012)	280 students, age unclear	Synchronization to metronome	No training	Reading
Bhide et al. (2013)	19 poor readers, 6–7 years old	Computer-based rhythm training	Reading intervention	None
Cogo-Moreira et al. (2013)	240 poor readers, 9 years old	Experimenter-designed	No training	Reading and phonological awareness
Rautenberg (2013)	159 7-year-olds	Experimenter-designed	Visual arts training or no training	Word reading
Slater et al. (2013)	42 6–9-year-olds	Previously existing music program	No training	Reading

« we would argue for the inclusion of musical training as a part of a balanced school curriculum, including reading, foreign language instruction, mathematics, science, athletics, etc. »
(Tierney & Kraus, 2013).

Neuropsychologia 54 (2014) 28–40

The enigma of dyslexic musicians

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[d] Department of Musicology, Hebrew University, Mt. Scopus, Jerusalem 91905, Is

24 musiciens dyslexiques comparés
à 24 dyslexiques non musiciens et
24 musiciens non dyslexiques

Table 1
Means and STDs of cognitive and reading related measures for the four groups of participants.

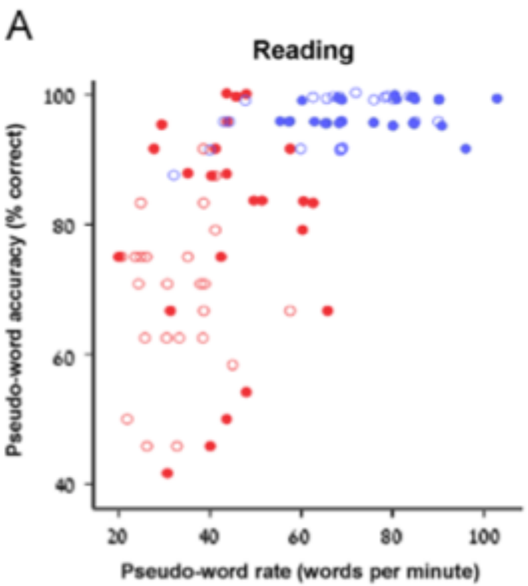
	Musicians			Non-musicians			Scheffé post-hoc comparison	
	Controls	Dyslexics	t	Controls	Dyslexics	t	Control groups	Dyslexic groups
	$n=28$	$n=24$		$n=23$s	$n=24$			
	19F	9F		12F	18F			
Age (years)	23.5 (2.1)	23.7 (2.7)	−0.3	24.8 (3.7)	25.6 (2.5)	1.2	$p=.487$	$p=.998$
Cognitive tests (scaled WAIS scores)								
Block design	12.9 (2.0)	12.2 (2.6)	1.2	12.2 (2.8)	11.1 (2.5)	1.4	$p=.798$	$p=.519$
Digit span	11.6 (2.9)	9.7 (2.1)	2.6*	11.7 (2.4)	8.0 (1.8)	5.9***	$p=.999$	$p=.101$
Reading accuracy (% correct)								
Words	98.9 (1.8)	94.1 (6.0)	4.1***	99.3 (1.6)	92.0 (6.5)	5.2***	$p=.996$	$p=.478$
Pseudo words	97.3 (2.3)	79.8 (17.3)	5.3***	96.4 (4.0)	69.4 (11.9)	10.1***	$p=.992$	**$p=.012$***
Reading rate (words/min)								
Paragraph	130.8 (13.4)	109.3 (25.3)	3.9**	–	–	–	–	–
Words	122.2 (21.2)	88.8 (28.5)	4.8***	114.3 (34.7)	69.4 (20.9)	5.5***	$p=.772$	$p=.096$
Pseudo-words	76.6 (12.4)	44.1 (11.7)	9.6***	65.9 (15.2)	33.1 (8.8)	9.0***	**P=.025***	**P=.026***
Visual word recognition (words/min)								
	70.1 (11.7)	53.4 (12.6)	4.8***	–	–	–	–	–
Phonological awareness (spoonerism)								
Accuracy (% correct)	95.1 (5.0)	81.6 (17.4)	3.9***	95.4 (5.6)	72.7 (21.7)	4.9***	$p=1.0$	$p=.152$
Rate (items/min)	12.3 (3.7)	9.1 (3.8)	2.9**	12.7 (3.8)	7.5 (3.2)	5.0***	$p=.983$	$p=.505$

> à En lecture de pseudomots

+ à un moindre degré en phonologie

Les meilleurs lecteurs, parmi les dyslexiques musiciens, sont ceux qui ont la meilleure MDT

A



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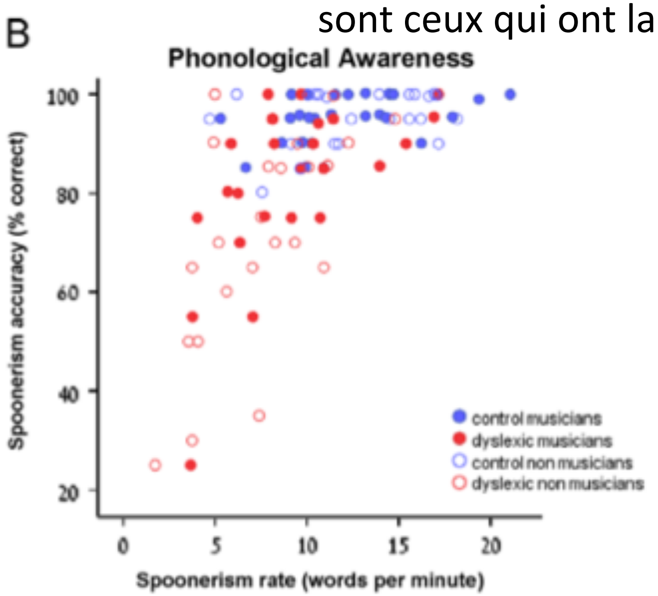

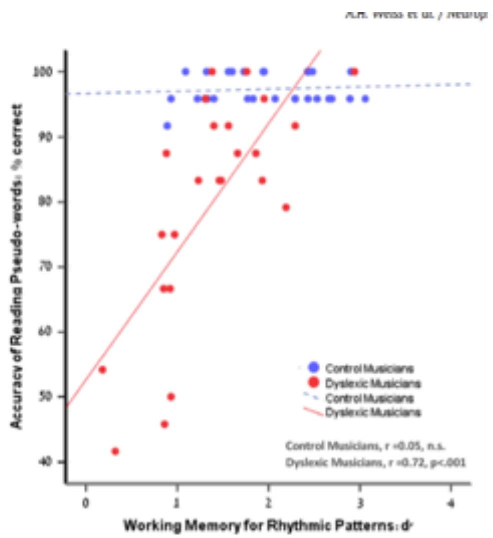

frontiers in NEUROSCIENCE

REVIEW ARTICLE
published: 20 January 2014
doi: 10.3389/fnins.2013.00279

How musical training affects cognitive development: rhythm, reward and other modulating variables

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[2] Swiss Centre of Affective Sciences, University of Geneva, Geneva, Switzerland

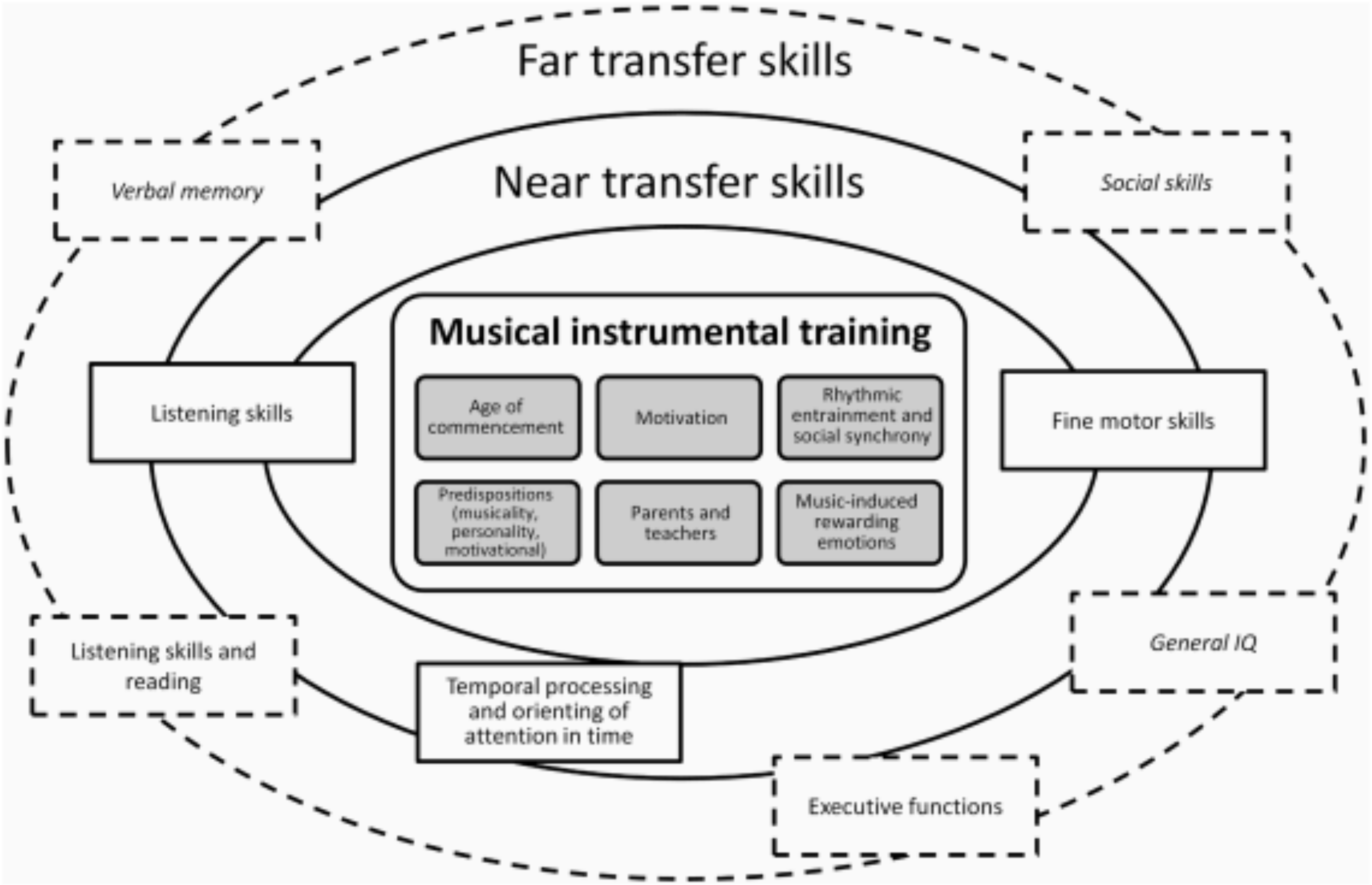

FIGURE 1 | Schematic representation of near and far transfer skills that benefit from musical instrumental training. In the inner rectangle variables modulating the influence of musical training on cognitive development are listed (see main text, in particular section Variables Modulating Brain Plasticity via Musical Training). Near transfer skills are marked in solid rectangles and far transfer skills are marked in dashed rectangles (described in detail in section Effects on Cognitive Functions). Terms in italic indicate results inconclusive in the present state of the literature.

McGurk effect : an auditory /ba/ presented with a visual /ga/ is typically “heard” as /da/ (the reverse, i.e., auditory /ga/ and visual /ba/, tends to yield /bga/).

frontiers in
PSYCHOLOGY
ORIGINAL RESEARCH ARTICLE
published: 02 March 2012
doi: 10.3389/fpsyg.2012.00060

Mapping symbols to sounds: electrophysiological correlates of the impaired reading process in dyslexia

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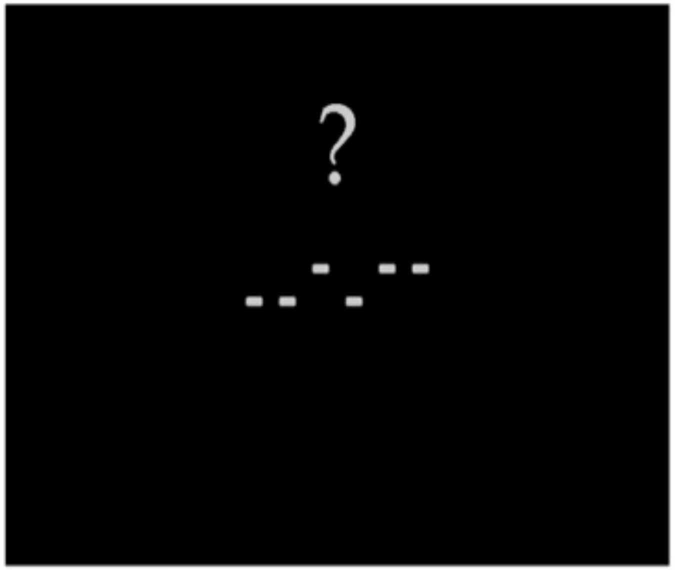
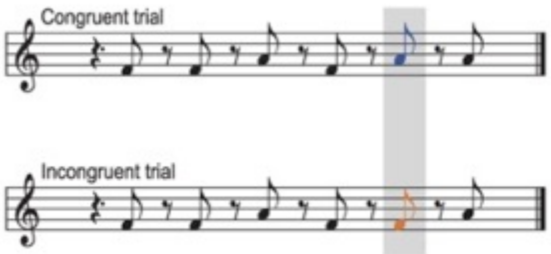




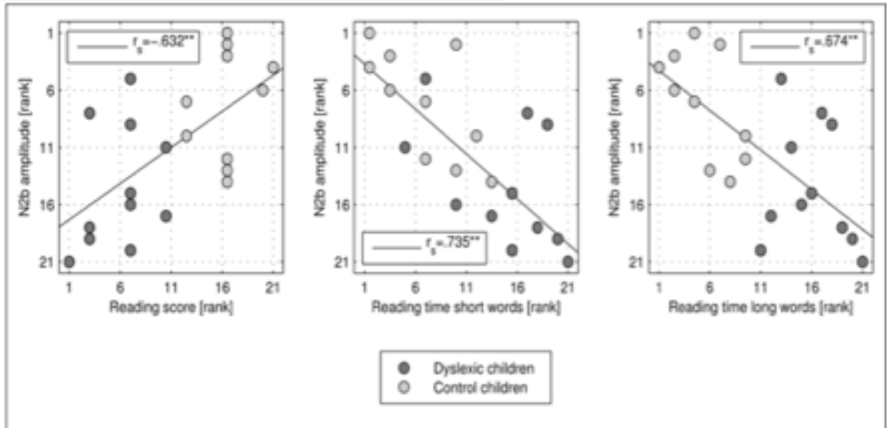
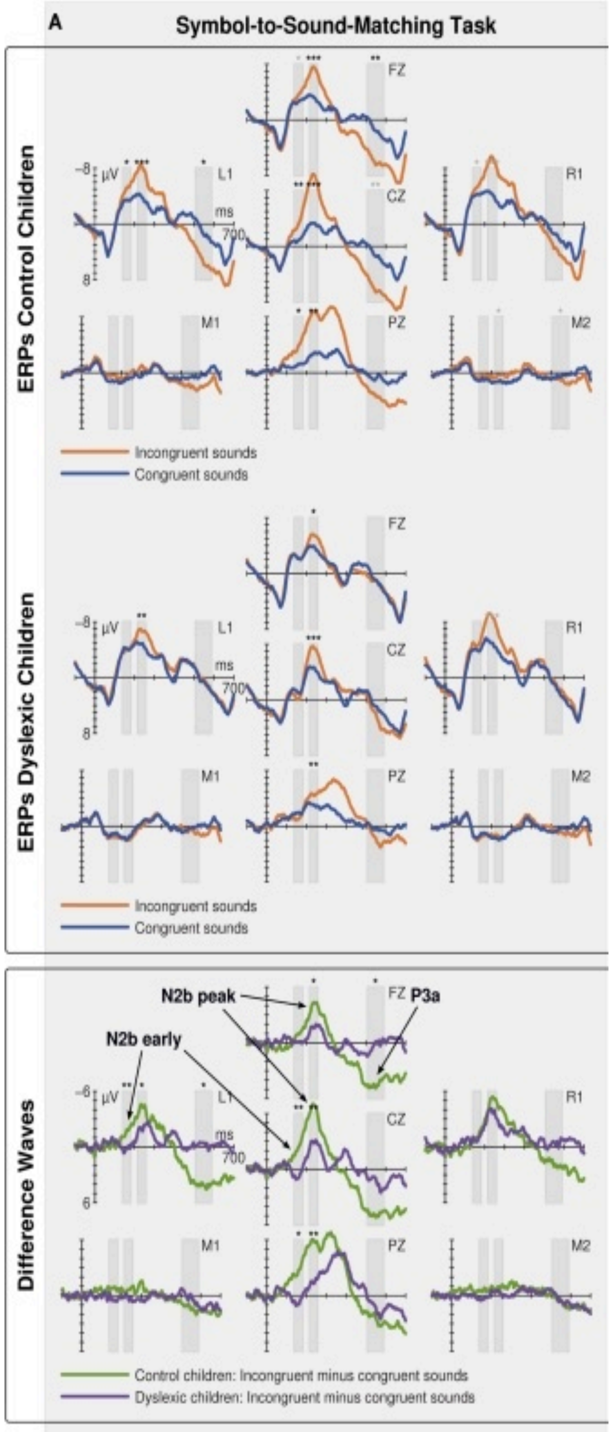


FIGURE 3 | Scatter plot and correlation of N2b amplitude rank (negative up) at electrode location Cz and rank of reading score, and reading time of short and long words, respectively.



doi:10.1093/brain/awr363 Brain 2012: 135; 935–948 | 935

BRAIN
A JOURNAL OF NEUROLOGY

A tractography study in dyslexia: neuroanatomic correlates of orthographic, phonological and speech processing

Maaike Vandermosten,[1,2,3] Bart Boets,[1,2,4] Hanne Poelmans,[1,2] Stefan Sunaert,[3] Jan Wouters[2] and Pol Ghesquière[1]

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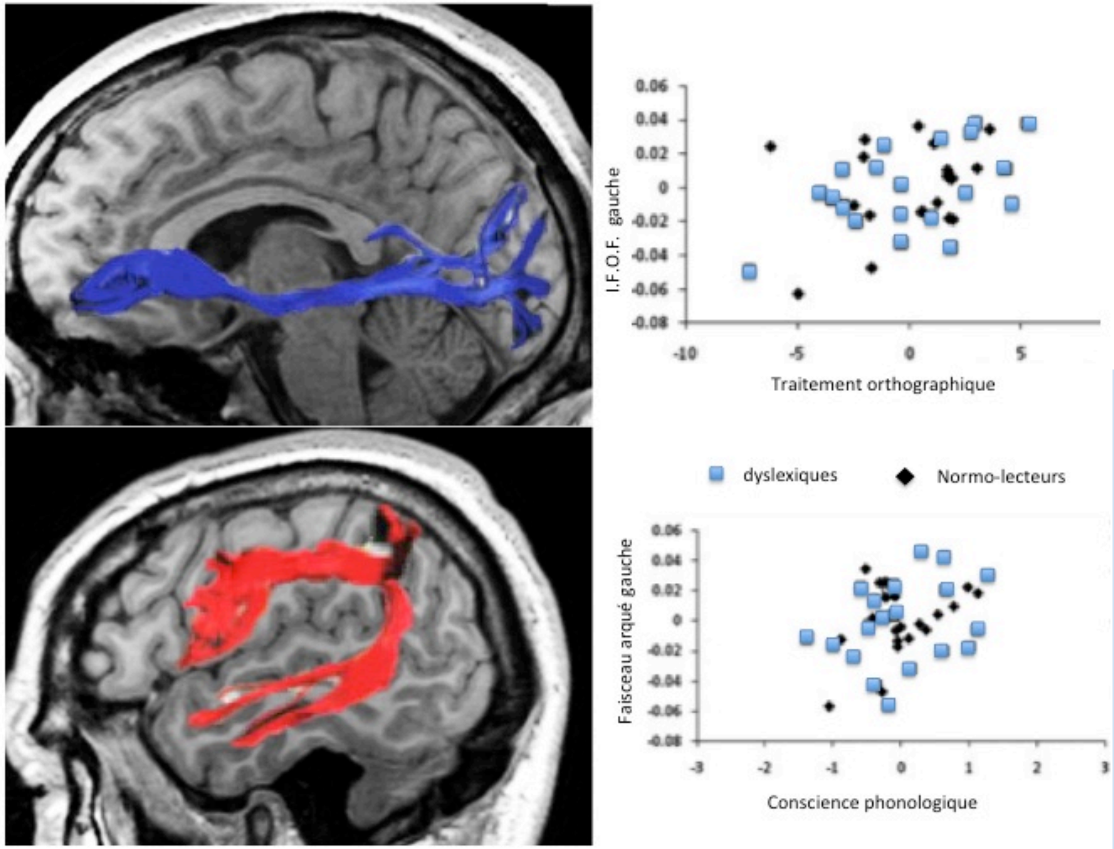


Etude en tractographie des déficits auditif et orthographique chez les dyslexiques ; dissociation entre une voie inférieure (orthographique) et une voie dorsale (phonologique et perception de la parole)

Dyscalculie : défaut de connectivité entre
les zones du traitement analogique (aire du « sens des nombres ») et les zones du langage oral et écrit

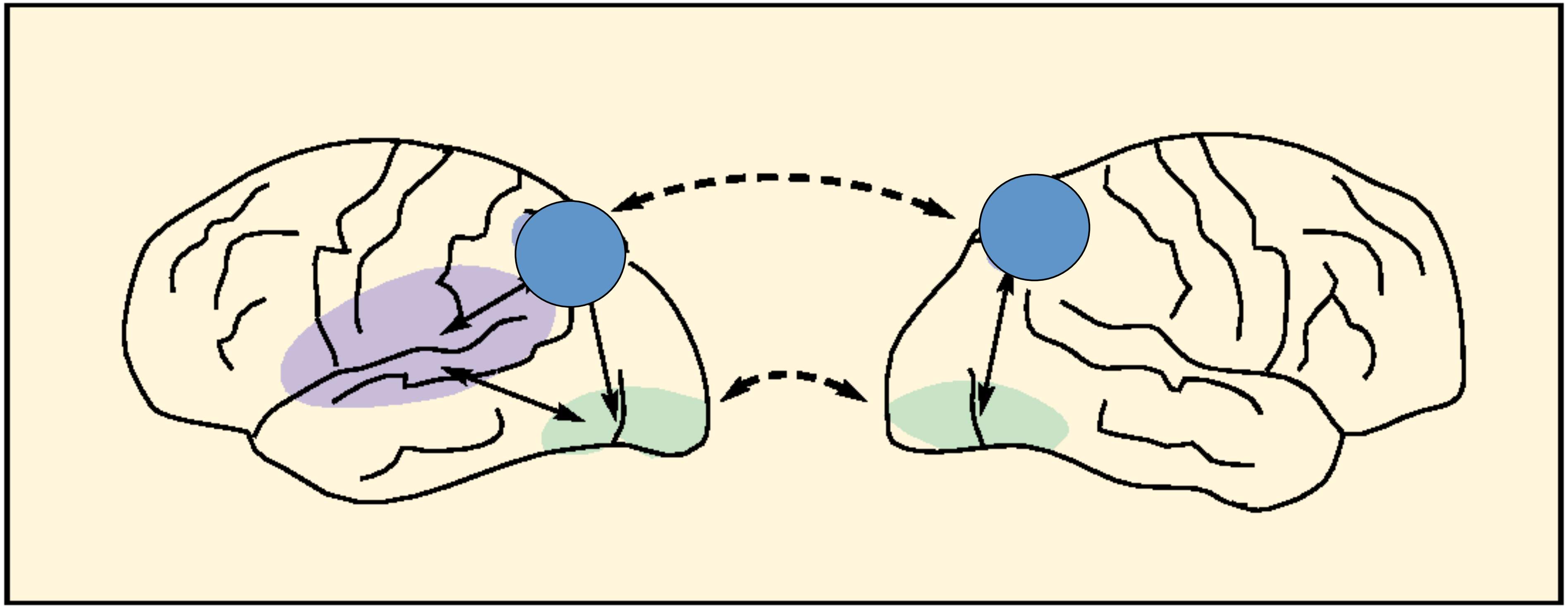


Figure 3 - Implémentation anatomique du triple code (traitement visuel arabe en vert, traitement analogique en bleu et traitement langagier en violet).

En résumé,

- Les troubles « DYS » pourraient fort bien s'expliquer par un trouble de la connectivité inter-modalitaire (défaut dans les connexions à longue distance intra-cérébrales)
- Or, la pratique d'un instrument de musique ou du chant est capable de modifier durablement la morphologie de ces connexions
- Un entraînement musical, et plus particulièrement l'apprentissage d'un instrument de musique ou du chant, serait-il capable de modifier les connexions dysfonctionnelles chez les enfants souffrant de troubles DYS?

Auteurs :

Michel Habib est neurologue au CHU de Marseille, où il a exercé dans le domaine des troubles cognitifs de l'adulte et de l'enfant avant de se spécialiser progressivement dans les troubles d'apprentissage. Il enseigne la neuropsychologie dans plusieurs universités françaises et outre-Atlantique. Fondateur de la Revue de neuropsychologie, co-responsable de la revue *Développements*, et auteur de plusieurs ouvrages et articles, il a consacré ces dix dernières années à mettre en place un réseau de professionnels (Résodys) autour de la dyslexie et des autres troubles d'apprentissage.

Orthophoniste, Céline Commeiras est responsable du pôle orthophonie au CPA-Provence et travaille en collaboration avec Résodys depuis de nombreuses années. Maîtresse de stage d'étudiants en orthophonie de la faculté de Marseille, elle a également codirigé des mémoires de recherche sur la dyscalculie et le rôle de la musique dans la remédiation des enfants Dys.

www.deboeck.fr

La **rééducation par la musique** des personnes présentant des difficultés d'apprentissage n'est pas une idée nouvelle : depuis l'Antiquité, la musique fascine les observateurs par ses effets psychoaffectifs et le bien-être général qu'elle procure aux personnes qui l'écoutent.

La méthode présentée dans cet ouvrage ne se réclame pas de la musicothérapie, mais plutôt de la **rééducation fonctionnelle** : contrairement à la première, largement basée sur des constatations empiriques où le cerveau n'a qu'une place secondaire, le présent travail suit la démarche inverse, partant des données acquises par la **recherche en neurosciences** pour déboucher sur la construction d'outils de remédiation. Les auteurs proposent donc une véritable théorie du fonctionnement cérébral qui explique l'efficacité de la musique dans la rééducation.

Fondée sur du matériel musical, la méthode répond aux critères habituels de la **rééducation orthophonique**. Elle est, de ce fait, principalement destinée aux orthophonistes qui y trouveront une mine d'informations et d'idées pour leur tâche de rééducateur. Les thérapeutes et enseignants de diverses disciplines pourront également puiser dans ces pages des pistes et des outils transposables à leur pratique.

Public :

- Orthophonistes
- Neuropsychologues
- Psychomotriciens
- Ergothérapeutes
- Rééducateurs
- Professeurs de musique

REORMU
ISBN : 9 782353 272884

Michel Habib - Céline Commeiras

Mélodys

Mélodys

Remédiation cognitivo-musicale des troubles d'apprentissage

Michel Habib
Céline Commeiras

de boeck solal

Les ateliers « musique et rééducation »

- Petits groupes, stage de 3 à 5 jours durant les vacances scolaires
- Piano – percussions – danse – orthophonie musicale, toujours sous un angle participatif et multisensoriel
- Effectuer des bilans avant et après les stages pour mesurer l'évolution des aptitudes du langage.

PIANO	•Découverte de l'instrument – pulsation - reproduction mélodique, rythmique, invention – morceau appris collectivement joué sur accompagnement rythmique enregistré – lecture, écriture des hauteurs, des durées – chant
PERCUSSIONS	•frappés sur le métronome – pratique rythmique collective sur percussions diverses
DANSE	•Groupe de 12 enfants + personnel encadrant dans un apprentissage collectif de pas de danses rythmées (rondes, en ligne, en couples) sur des musiques traditionnelles ou actuelles.
ORTHOPHONIE	•exercices collectifs (groupes de 4) basés sur des tâches musicales multimodalitaires : tâches visuelles, d'écoute, verbales, motrices.

Atelier rééducation cognitivo-musicale

Une double finalité

- Elaborer un outil de rééducation en complément de la rééducation classique
  - Vise principalement la dyslexie, mais peut aussi être efficace sur les autres troubles (calcul, attention, mémoire…)
  - De conception similaire aux matériels utilisés en rééducation orthophonique (mais avec des matériels musicaux)
- Développer une pédagogie spécifique pour enfants dyslexiques
  - A partir de l'observation de difficultés particulières rencontrées par les dyslexiques dans l'apprentissage de la musique et/ou d'un instrument
  - Construction d'outils pédagogiques spécialement conçus pour compenser le trouble
  - Objectif apprentissage d'un instrument (au delà d'écouter, chanter et lire la musique)

État des lieux: l'apprentissage de la musique chez les enfants "dys"

- des déficits significatifs dans 3 domaines particuliers :
  - **des difficultés de nature perceptive** (soit auditive soit visuelle soit dans l'intégration des deux types d'information)
  - **des difficultés de nature motrice et ou rythmique** (se manifestant dans des tâches de reproduction de rythme et tout particulièrement dans l'apprentissage des gestes relatifs à l'exécution instrumentale)
  - **des troubles non spécifiques** (de la concentration, de la mémoire et plus généralement des fonctions dites exécutives)

Etude préliminaire d'un entraînement musical intensif

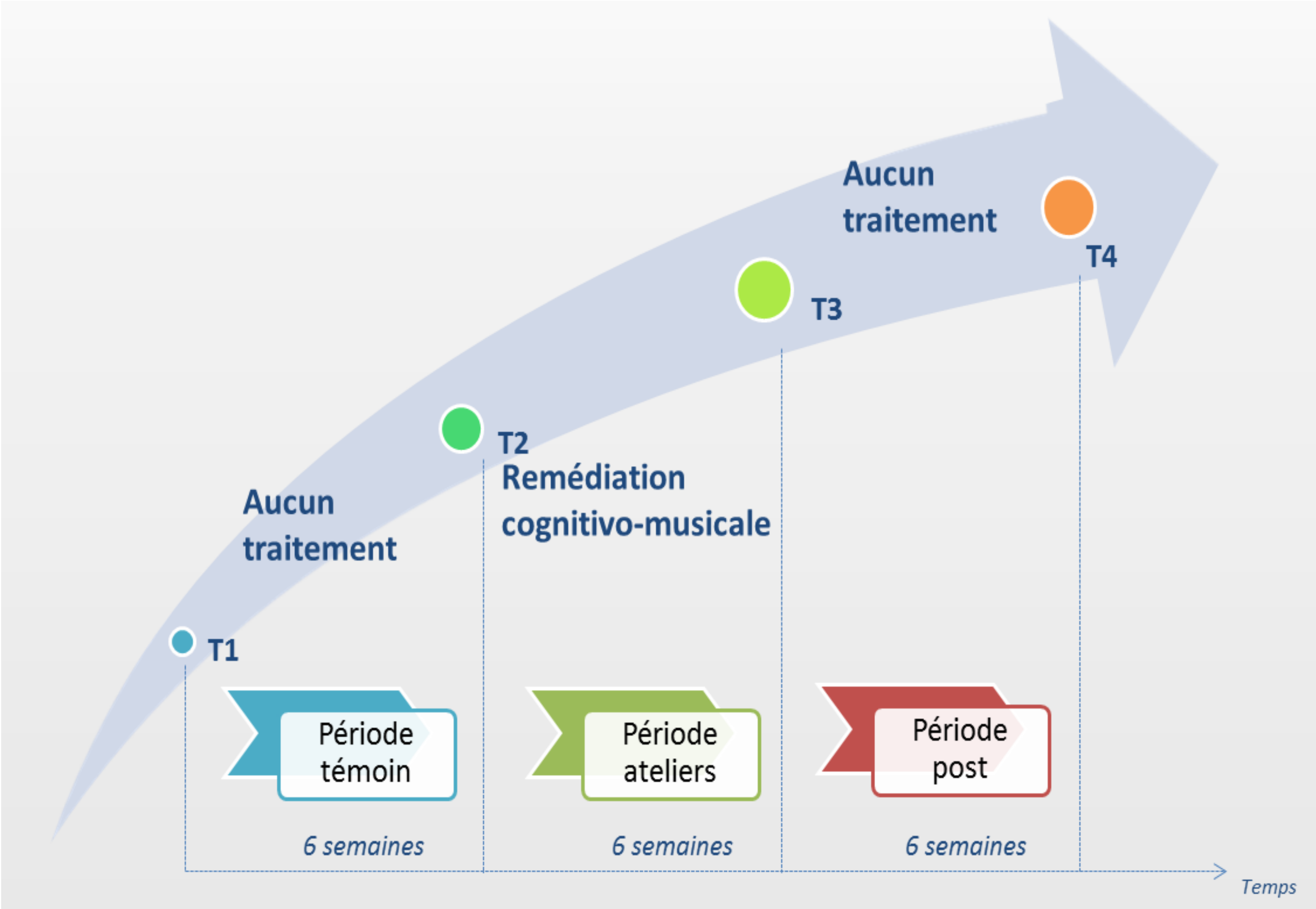
- 12 enfants dyslexie sévère (multi-dys)
- 3 jours, 6 heures/jour 3 ateliers tournants (de 4)
  - Pédagogique : initiation au piano
  - Orthophonique : exercices auditifs (hauteur, durée, timbres, rythme)
  - Psychomoteur : percussions (rythme, tempo, motricité); danse folklorique de groupe

Avec la participation de : Céline Commeiras (orthophoniste), Alice Dormoy (enseignante musique), Tristan Desiles (doctorant), Muriel Coulon (enseignante spécialisée), Elodie Dourver (psychomotricienne), Anne-Cendrine Segond (éducatrice), Lalaina Rasolo (orthophoniste).

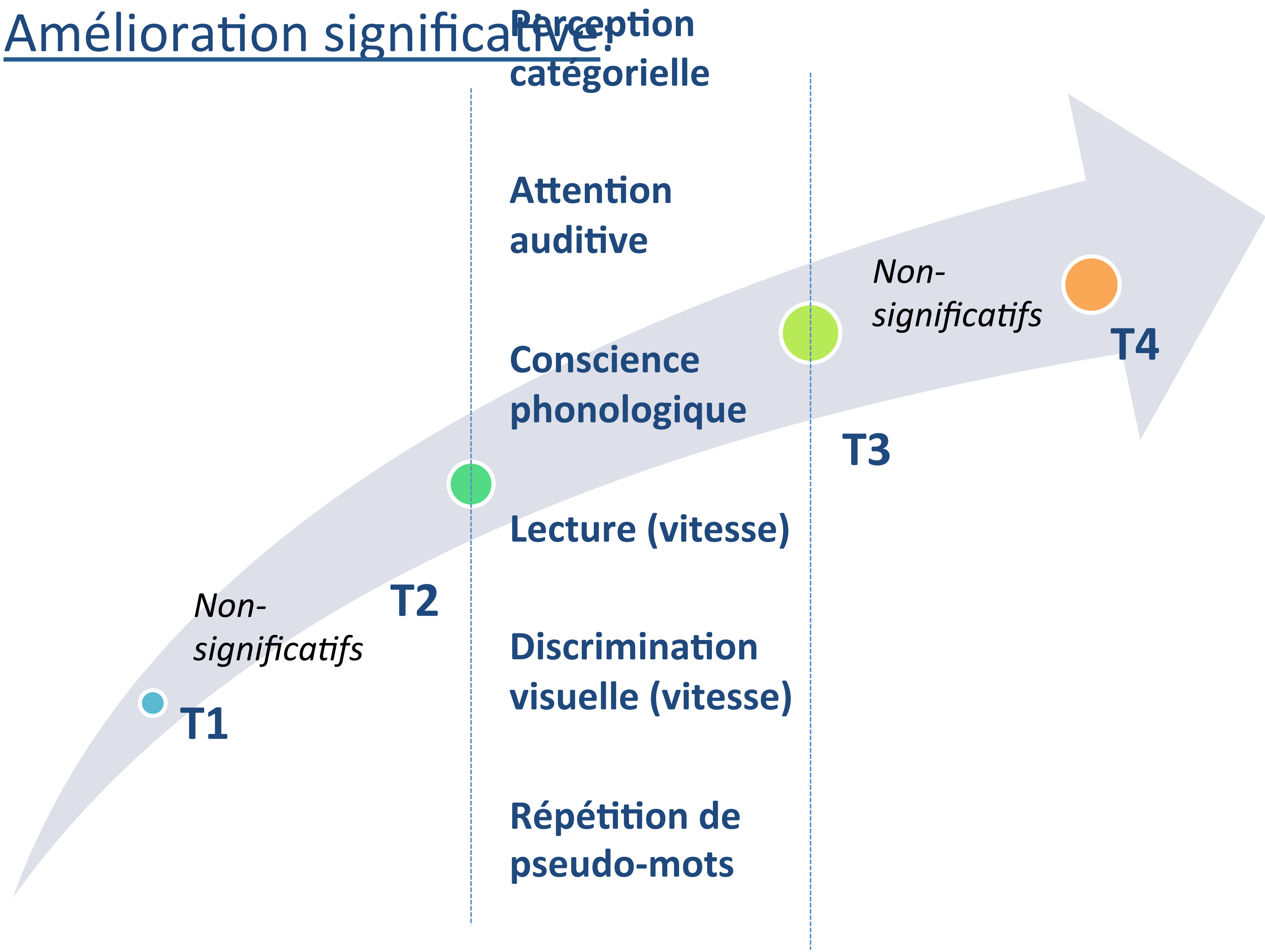
Etude n°2 : dyslexiques en CLIS

- 12 enfants âgés de 7 à 12 ans, tous atteints d'un trouble spécifique du langage et/ou de la parole
- 4 filles 8 garçons
- Sur 6 semaines : deux séances d''orthophonie ou remédiation cognitivo-musicale d'une heure chacune en classe entière (12 enfants) puis deux ateliers musicaux d'une demi-heure : piano et percussion par groupe de quatre enfants.
- 4 mesures T1, T2, T3, T4 : entraînement entre T2 et T3 + deux périodes contrôles

Chloé Lardy, mémoire d'orthophonie, juin 2014


Aucun traitement
T4
T3
T2
Remédiation cognitivo-musicale
Aucun traitement
T1
Période témoin
Période ateliers
Période post
6 semaines
6 semaines
6 semaines
Temps

Amélioration significative!

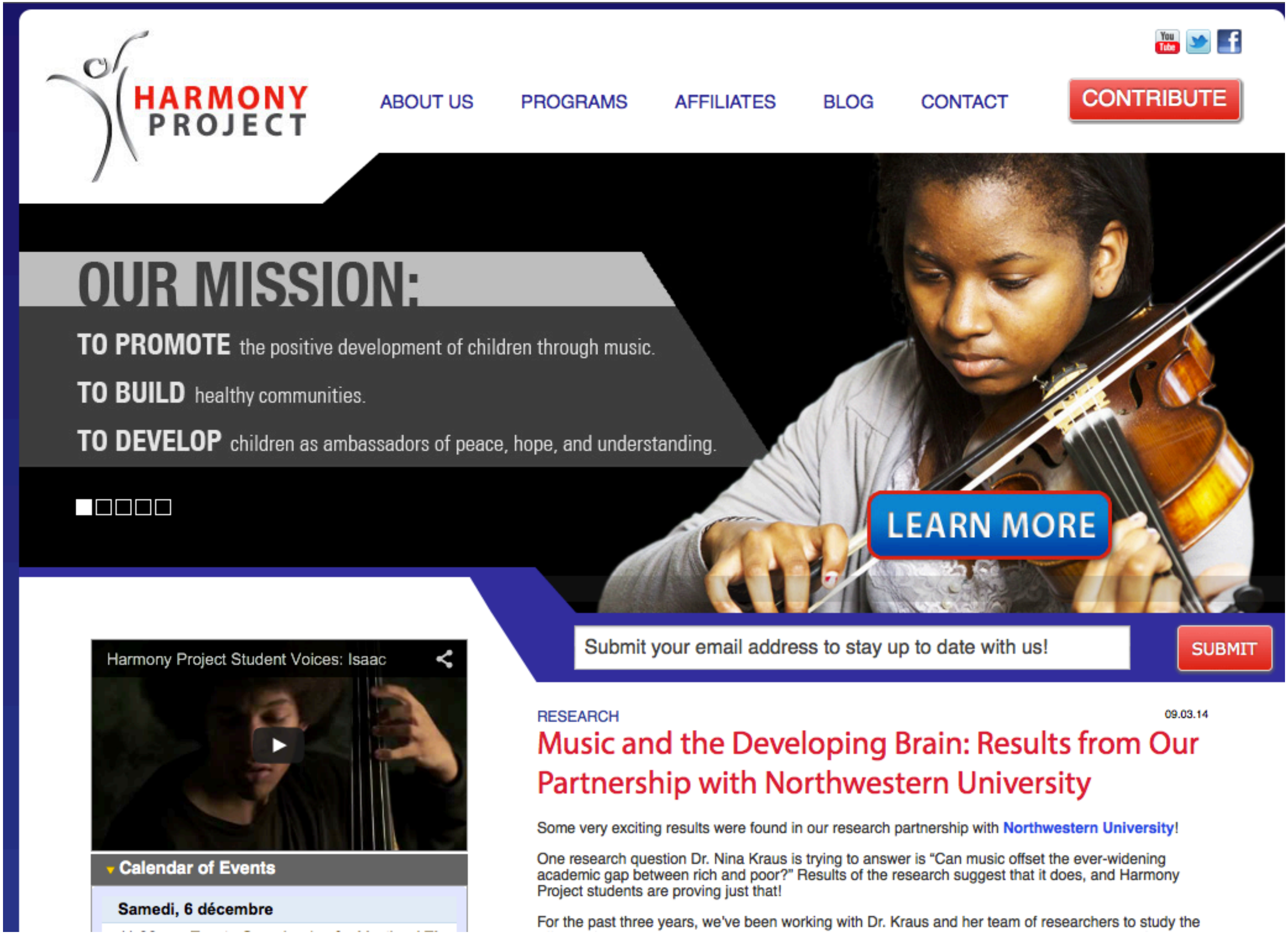


En résumé

- Il existe un ensemble croissant et convergent d'arguments montrant que les troubles d’apprentissage sont associés du point de vue anatomique à des anomalies de connectivité entre des zones fonctionnelles de modalités différentes
- …et que l’entraînement rééducatif (en particulier phonologique) s’accompagne de remise en place des circuits anormalement connectés
- Par ailleurs, l’entraînement musical, et tout particulièrement l’apprentissage d’un instrument de musique, s’accompagne d’une modification de ces mêmes circuits, un effet qui semble plus net lorsque les composantes motrice et sensorielle sont activées simultanément

Gustavo Dudamel

'El Sistema'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OUR MISSION:
TO PROMOTE the positive development of children through music.
TO BUILD healthy communities.
TO DEVELOP children as ambassadors of peace, hope, and understanding.
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Harmony Project Student Voices: Isaac
Calendar of Events
Samedi, 6 décembre
RESEARCH
09.03.14
Music and the Developing Brain: Results from Our Partnership with Northwestern University
Some very exciting results were found in our research partnership with Northwestern University!
One research question Dr. Nina Kraus is trying to answer is “Can music offset the ever-widening academic gap between rich and poor?” Results of the research suggest that it does, and Harmony Project students are proving just that!
For the past three years, we've been working with Dr. Kraus and her team of researchers to study the

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Longitudinal Effects of Group Music Instruction on Literacy Skills in Low-Income Children

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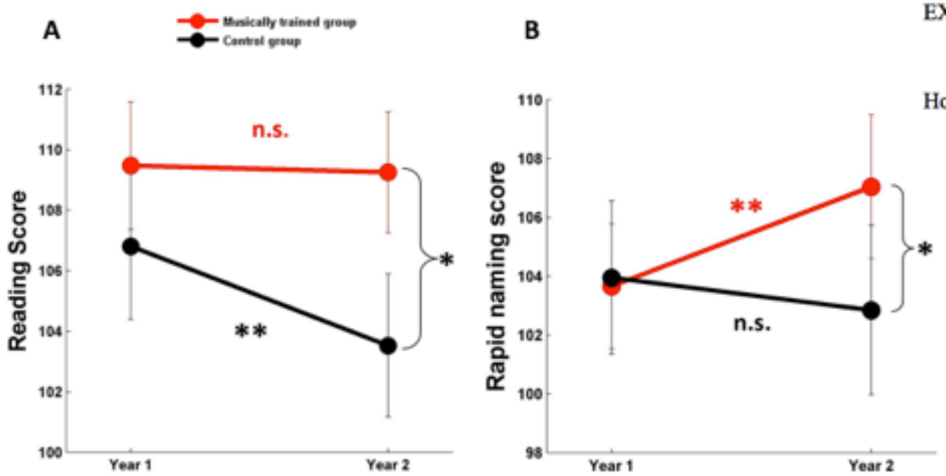

Figure 1. Music training supports reading abilities and rapid naming. (A) The children who received music training (n = 23) maintained their

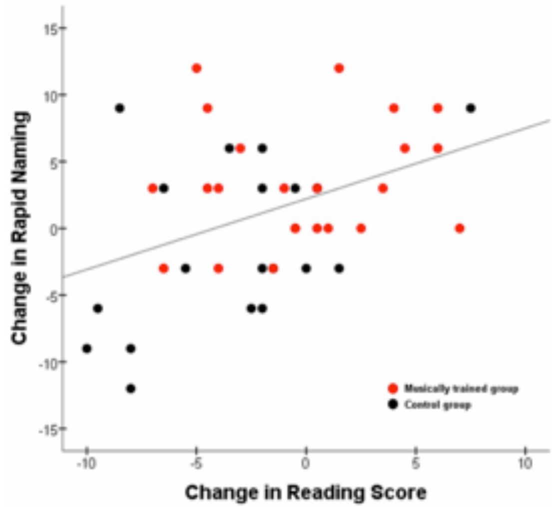

Figure 2. Improvement in rapid naming relates to reading improvement. Year-over-year improvement in rapid naming was correlated with

Harmony Project Program	Typical class participation	Number of children
Alexandria Elementary School	One-hour instrumental classes twice a week plus a two hour string ensemble rehearsal each week	3
Beyond the Bell	Twice-weekly two-hour ensemble rehearsals. These include pull-out sectional rehearsals, which are similar to large instrumental classes at other sites.	9
EXPO Center (YOLA)	One-hour instrumental music classes each week and a three hour ensemble rehearsal each week.	3
Hollywood	One-hour instrumental classes twice a week plus a three-hour ensemble rehearsal (concert band) each week.	4
		19

42 Spanish-English bilingual elementary school children (mean age 8.3 years)

The training group (n=23) began music classes with the Harmony Project after the initial assessment, while the control children (n=19) remained on the organization's waiting list to begin music classes the following year.