An introduction to the cognitive neuroscience of bilingualism and L2 learning

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Overview

- What does it mean to be bilingual
- Linguistic effects of bilingualism
- Cognitive and environmental factors affecting L2 learning
- Cognitive effects of bilingualism
- Neural correlates of L2 learning

What does it mean to be bilingual?

Bilingualism: a widespread phenomenon

- 6912 official languages in 160 Countries
- More than 50% of the world's population speaks at least two languages (de Hower, 1998; Tucker, 1998; Grosjean, 1982, 1994)

There are different ways to be bilingual

Age of Acquisition of an L2

- Simultaneous bilinguals
- Early sequential bilinguals
- Late sequential bilinguals

How about proficiency ?

- Balanced bilinguals
- Dominant bilinguals

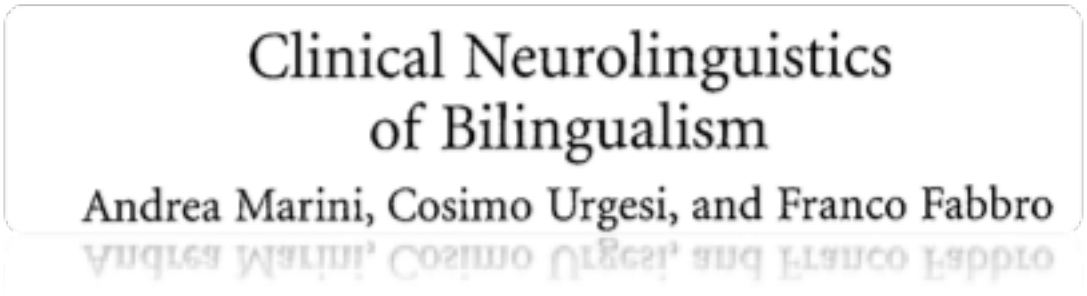
(Peal and Lambert, 1962)

Effect exerted by the L2 on L1

- Additive bilinguals
- Subtractive bilinguals

(Lambert 1974)

An operational definition of bilingual competence



Knowledge and use of two or more languages/ dialects independently from the age of acquisition and the level proficiency

Linguistic effects of bilingualism

- Side effects of bilingualism on linguistic structures
- Code switching/mixing "Pappa, vuoi come here a casa lunchen?"
- Linguistic interference (e.g., borrowings vs. calchs)
- Crosslinguistic factors (e.g., positive vs. negative transfer)
- Interlanguage

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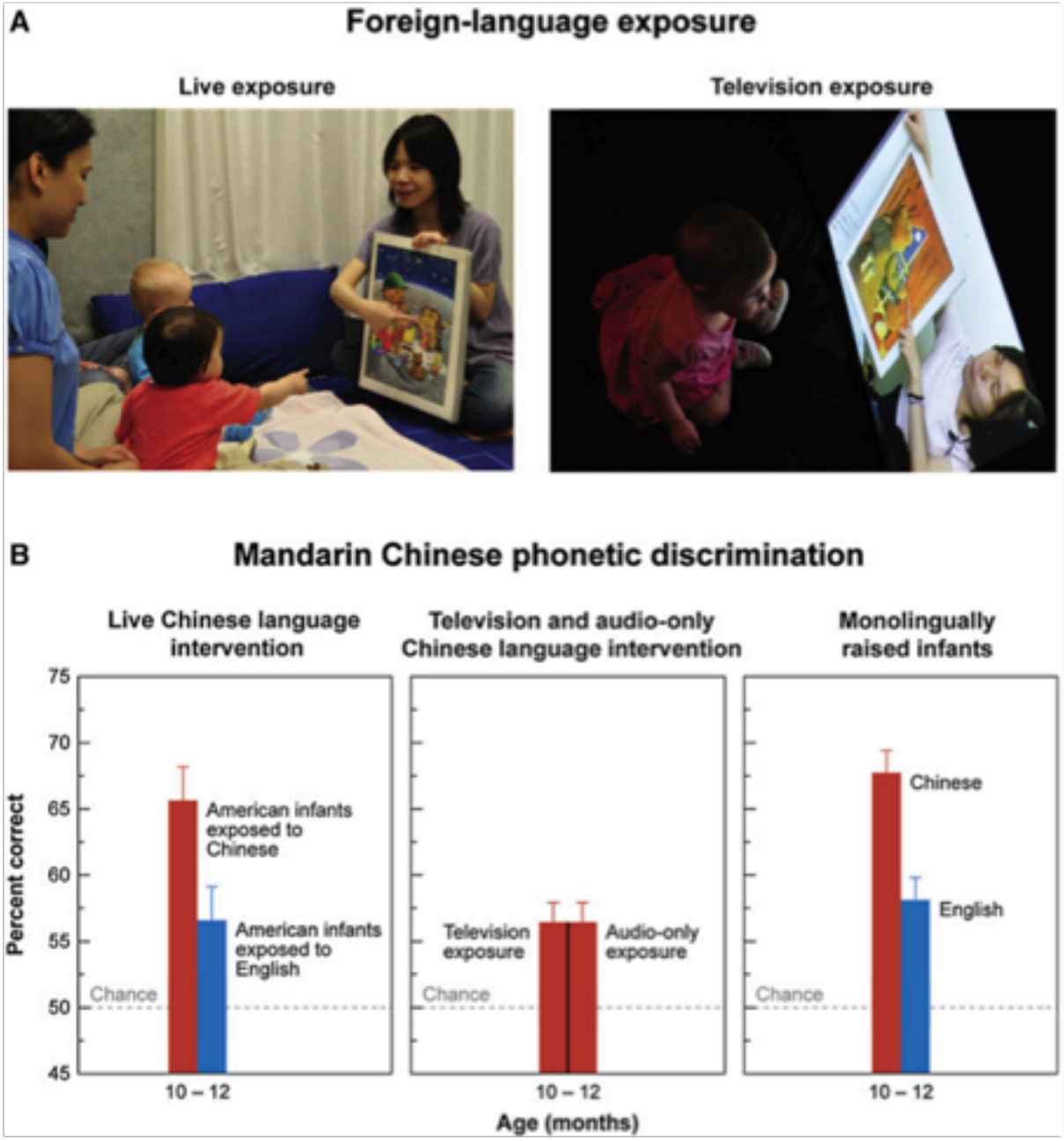
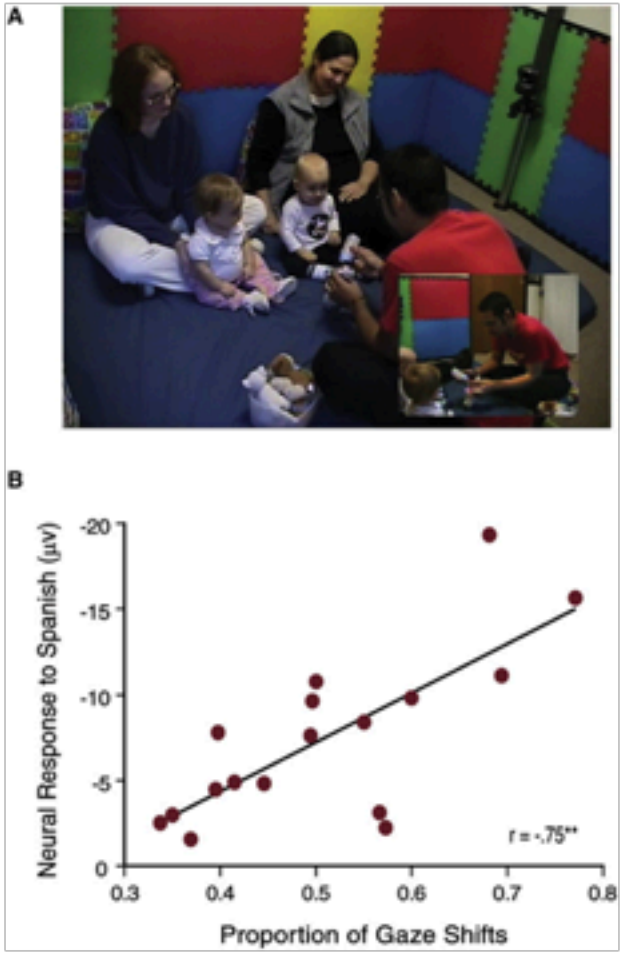
Cognitive and environmental factors affecting second language learning

Social and interactional factors affect L2 processing and learning



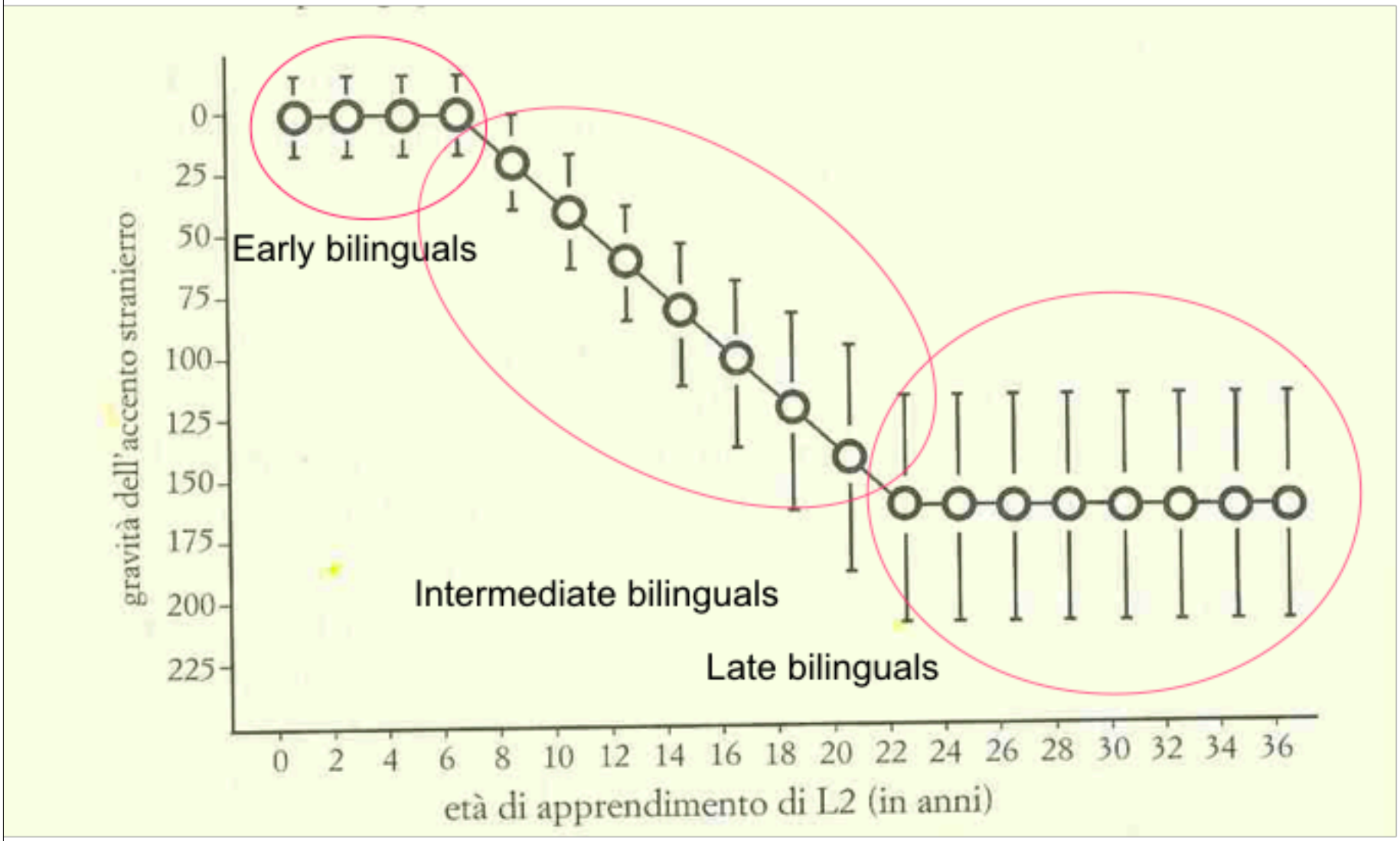
(Kuhl et al., 2003)

- American infants (9 months)
- Exposed to Spanish native speakers in 12 Spanish sessions
- After 12 sessions → amplitude of MMN while hearing spanish phonemic contrasts (/d/ - /t/) correlates with the children's eye shifts from the eyes of the spanish speaker to the toys used in the interaction



(Conboy et al., 2008)

Age of Acquisition affects L2 processing and learning


gravità dell'accento straniero
0
25
50
75
100
125
150
175
200
225
Early bilinguals
Intermediate bilinguals
Late bilinguals
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36
età di apprendimento di L2 (in anni)

(Flege, 1999)

Cognitive effects of bilingualism

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Better skills in auditory discrimination

Subcortical encoding of sound is enhanced in bilinguals and relates to executive function advantages

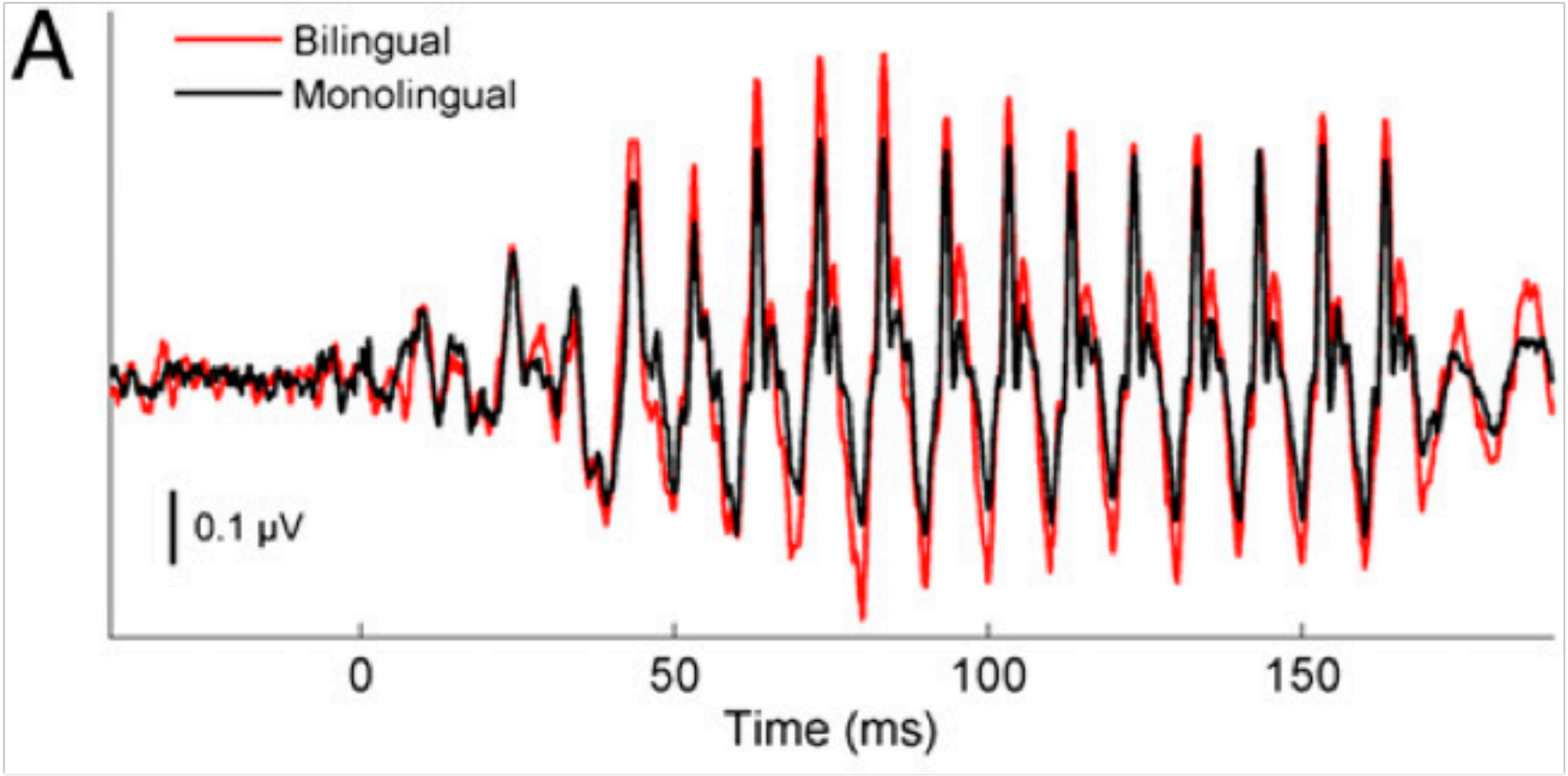
Jennifer Krizman[a,b,c], Viorica Marian[b,c], Anthony Shook[b,c], Erika Skoe[a,c], and Nina Kraus[a,c,d,e,f,1]

- Type of study → EEG (auditory brainstem response to complex sounds - cABR) and behavioral

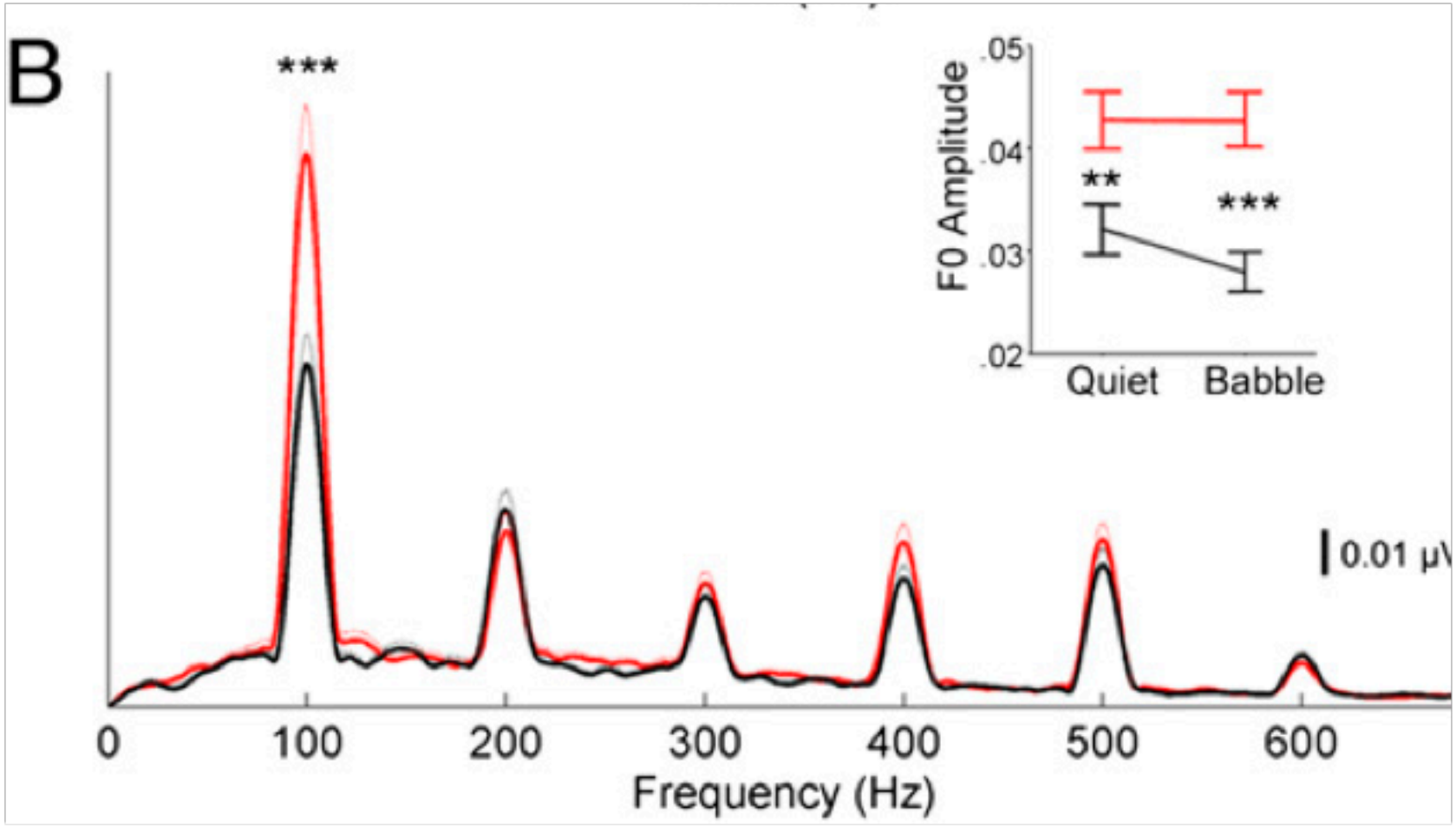
- Participants→ 48 freshmen (High School, Chicago)
  - 25 Monolinguals(52% fem.)
  - 23 Bilinguals Spanish-English (56.5% fem.)
  - Balanced for age (14 y.o.) and SES

PNAS Early Edition

Bilinguals→ Intense brainstem response



Higher response to /da/ (F_0=100Hz)



Better skills in learning from mixed inputs and in generalizing rules

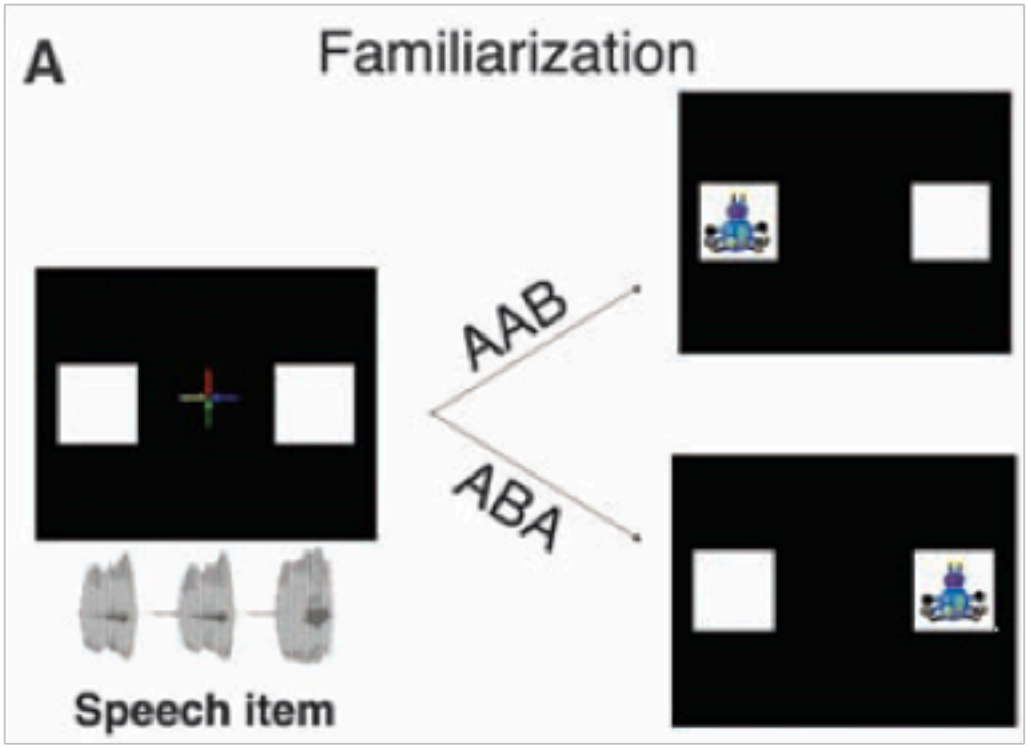
Flexible Learning of Multiple Speech Structures in Bilingual Infants

Ágnes Melinda Kovács* and Jacques Mehler

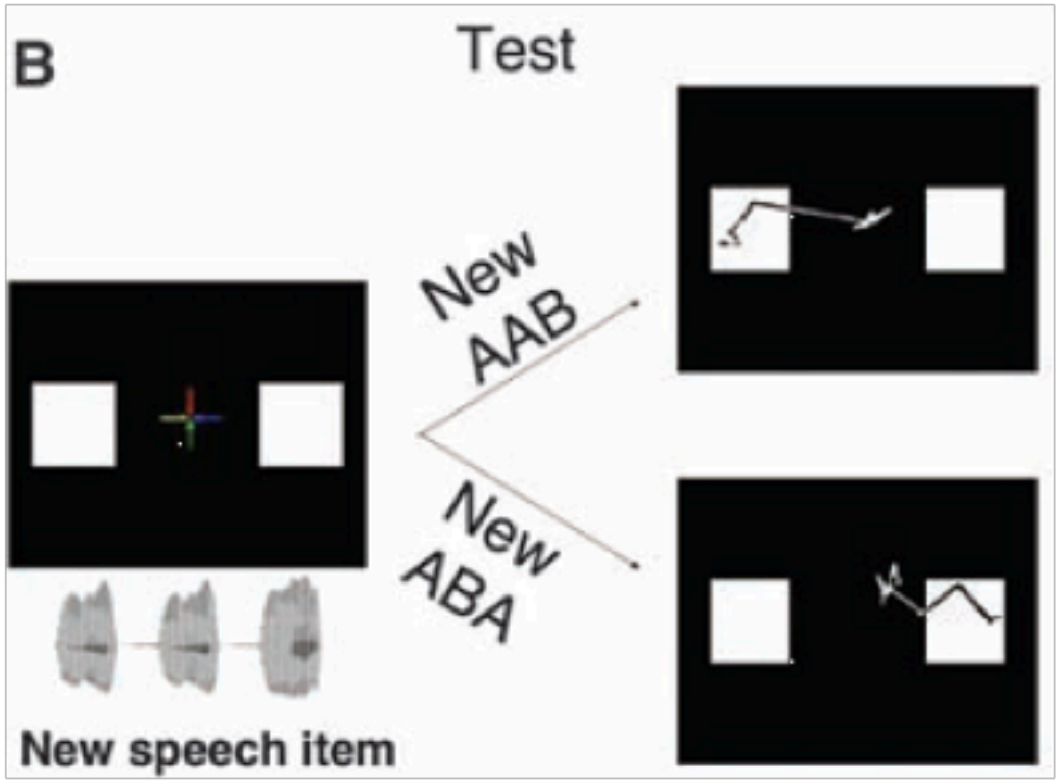
SCIENCE VOL 325 31 JULY 2009

- Study→ Eye-tracking
- Subjects→ Preverbal infants (12 months): bilinguals vs. monolinguals
- Task→ Listen to novel trisillabic sequences while staring at a monitor
- Stimuli→ Trisillabic clusters of two kinds: ABA vs. AAB
- Note → AAB perceptually easier

Familiarization

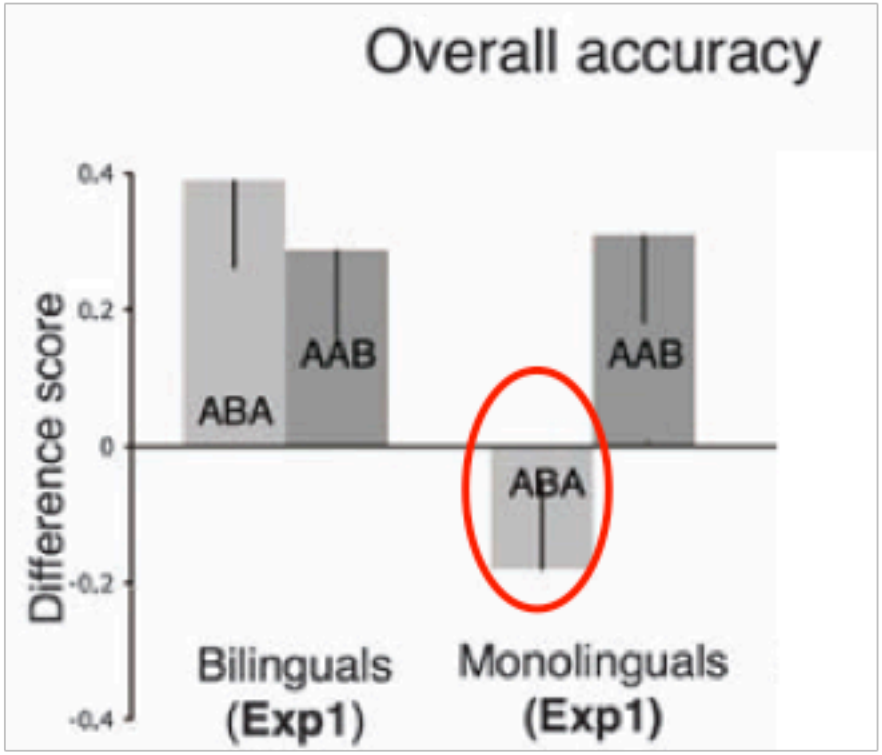


Experiment



Note→ stimuli are different from the familiariazion condition

Results



- Conclusions→ Advantage for bilinguals in learning new auditve-visual associations

Better Cognitive Flexibility

Bridging language and attention: Brain basis of the impact of bilingualism on cognitive control

G. Garbin et al. / NeuroImage 53 (2010) 1272–1278

- Type of study → fMRI
- Participants
  - 19 bilinguals (spanish-catalan)
  - 21 monolingual (spanish)
- Tasks→ non verbal switching paradigm

Bridging language and attention: Brain basis of the impact of bilingualism on cognitive control

G. Garbin et al. / NeuroImage 53 (2010) 1272–1278

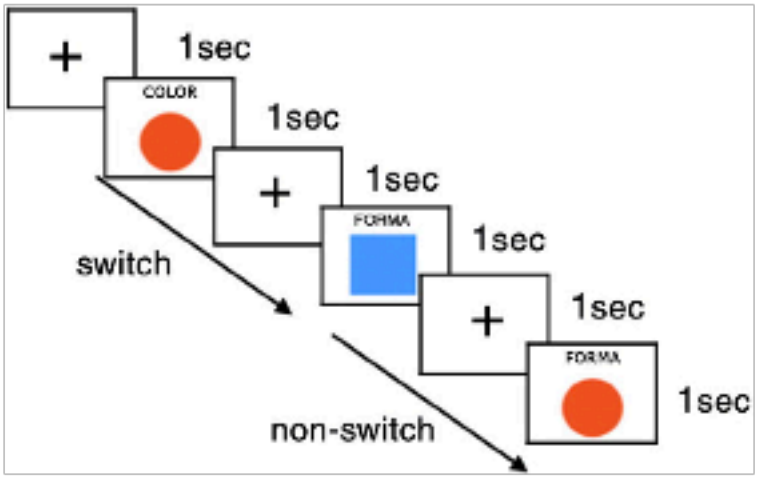


Fig. 1. Stimuli and task Conditions. Switching and Non-switch conditions: a "switch" event was defined as the condition of changing the set to be used in order to answer the upcoming stimulus in relation to the previous one (shape–color or color–shape trials). Coherently, a "non-switch" event was assumed to happen when the subject answered the upcoming stimulus with the same set as the previous one (shape–shape or color–color).

Bridging language and attention: Brain basis of the impact of bilingualism on cognitive control

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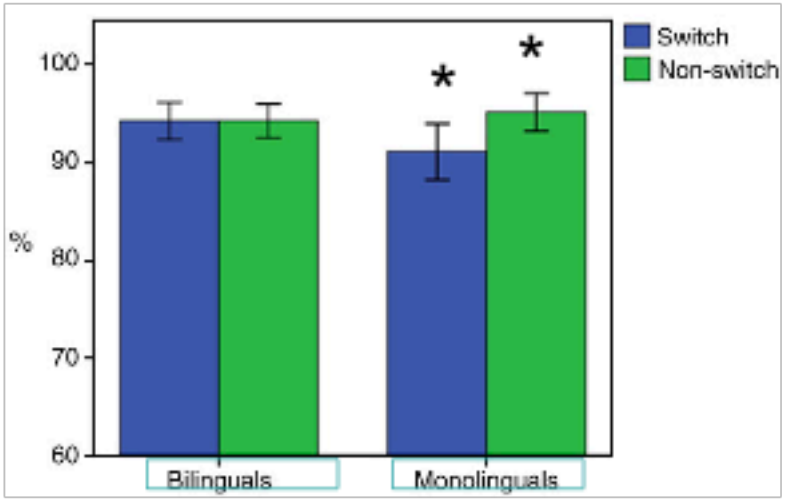
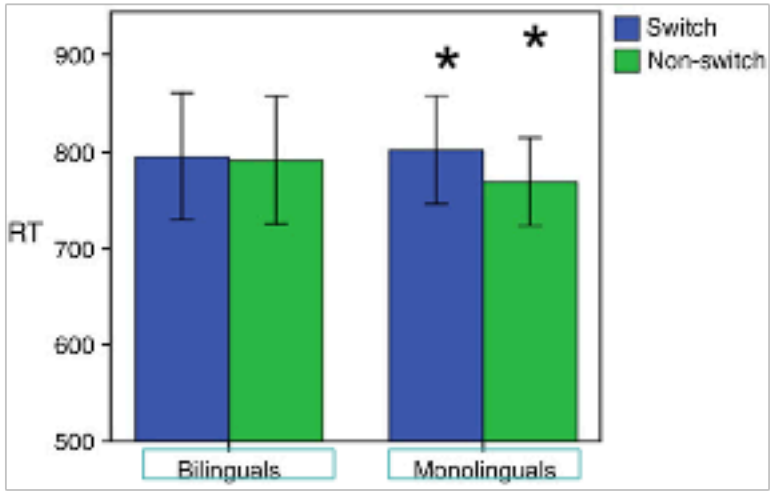




Longer protection from neurodegeneration

Delaying the onset of Alzheimer disease

Bilingualism as a form of cognitive reserve

Fergus I.M. Craik, PhD
Ellen Bialystok, PhD
Morris Freedman, MD

Table Mean value (SD) for descriptors for each language group

Language group	No.	Age at onset, y[a]	Age at first appointment, y[b]	Duration, y[c]	MMSE[d] at first appointment	Years of education	Occupation status[e]
Monolingual	109	72.6 (10.0)	76.5 (10.0)	3.8 (2.9)	21.5 (5.7)	12.6 (4.1)	2.8 (1.3)
Men	49	73.3 (9.4)	77.3 (8.9)	3.9 (2.9)	22.1 (5.7)	13.2 (4.4)	3.2 (1.0)
Women	60	72.1 (10.4)	75.9 (10.8)	3.7 (2.9)	21.0 (5.7)	12.0 (3.8)	2.5 (1.3)
Bilingual	102	77.7 (7.9)	80.8 (7.7)	3.1 (1.9)	20.4 (5.6)	10.6 (5.1)	2.5 (1.1)
Men	42	77.6 (7.8)	80.4 (7.8)	2.8 (1.8)	21.0 (4.8)	11.1 (6.1)	3.0 (0.9)
Women	60	77.8 (8.1)	81.1 (7.6)	3.3 (1.9)	20.0 (6.0)	10.3 (4.3)	2.2 (1.2)

Abbreviation: MMSE = Mini-Mental State Examination.
[a] Age at which symptoms were first reported by family.
[b] Age at first visit to clinic.
[c] Duration of elapsed time between [a] and [b].
[d] Scores out of 30.
[e] Based on 4-point scale developed by Human Resources and Skills Development, Canada, in which higher numbers signify higher status.

Neurology 75 November 9, 2010

Neural underpinnings of L2 processing and learning

Early Setting of Grammatical Processing in the Bilingual Brain

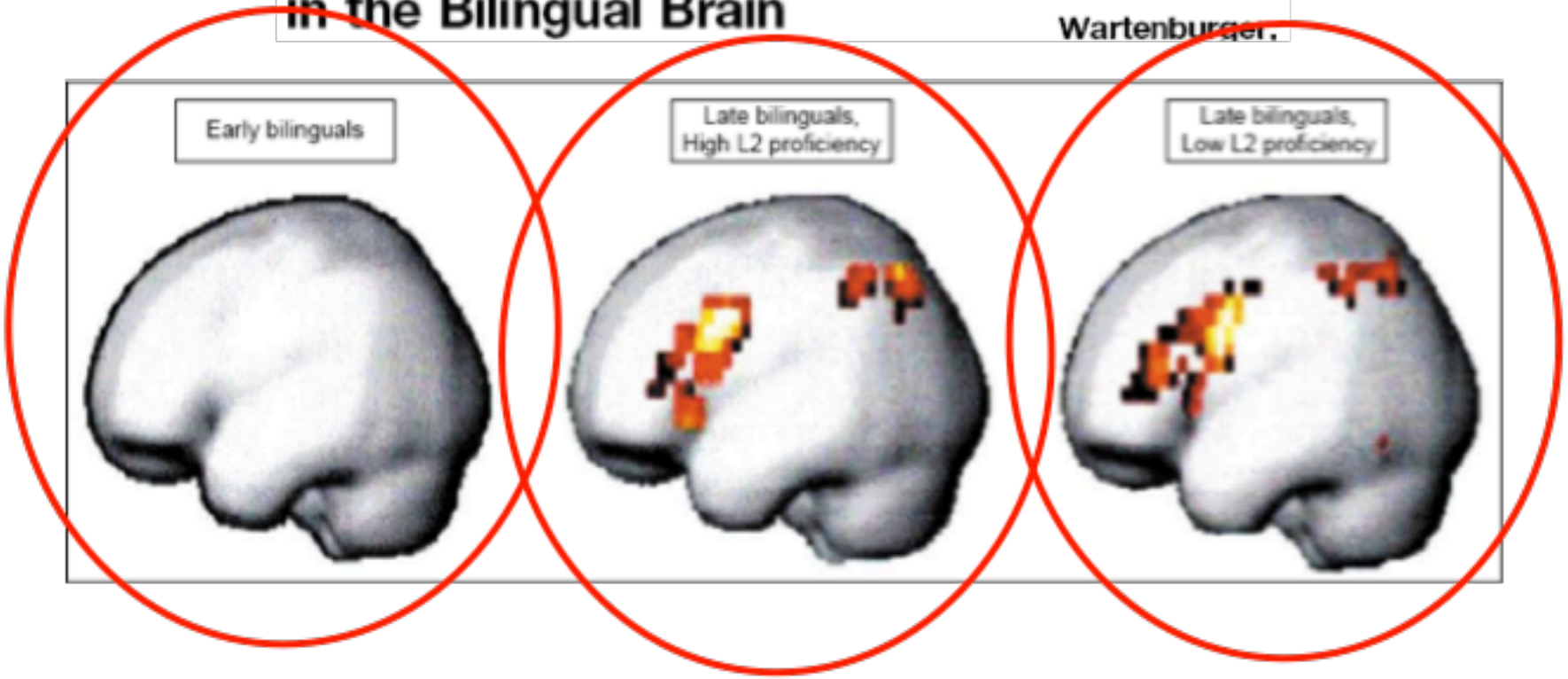
Wartenburger.

- Study: fMRI
- Subjects: 32 bilinguals (L1 Italian; L2 German)
  - 11 EAHP (exposed to L1 and L2 since birth)
  - 12 LAHP (L2 > 6 y.o.)
  - 9 LALP (L2 > 6 y.o.)
- Tasks
  - Grammatical judgement
  - Semantic judgement

Neuron, Vol. 37, 159–170, January 9, 2003,

Early Setting of Grammatical Processing in the Bilingual Brain

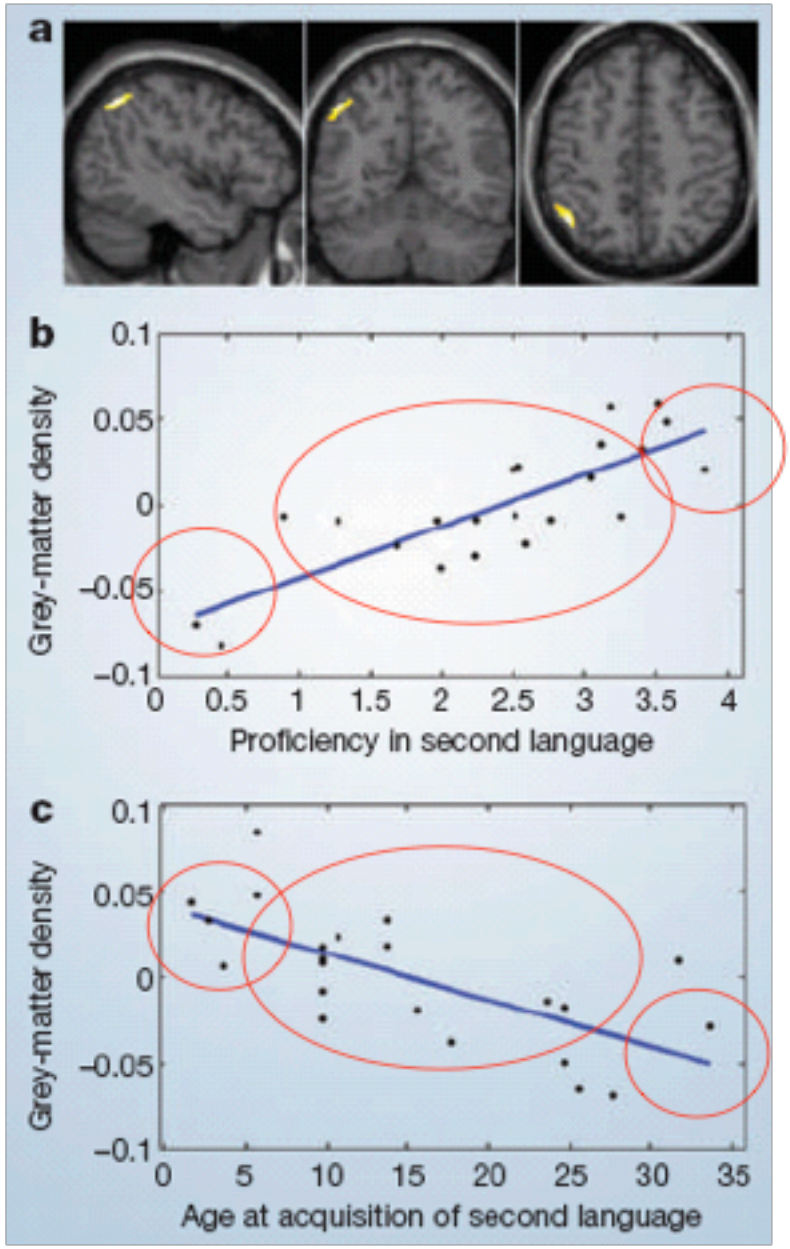
Wartenburger,



- Early bilinguals→ use for both languages the same areas
- Late Bilinguals → for grammatical tasks in L2 they us wider areas in Left Inferior Frontal Gyrus and in Le Parietal lobe

Neuron, Vol. 37, 159–170, January 9, 2003,

Structural plasticity in the bilingual brain



(Mechelli et al., 2004)

Structural plasticity in the language system related to increased second language proficiency

Maria Stein [a,1], *Andrea Federspiel* [a,1,*], *Thomas Koenig* [a], *Miranka Wirth* [a], *Werner Strik* [a], *Roland Wiest* [b], *Daniel Brandeis* [c,d] *and Thomas Dierks* [a]

- Study: MRI
- Subjects: 10 L2 Learners (native English-speaking exchange students learning German L2 in Switzerland)
- Tasks
  - German proficiency & MRI at T1 (beginning of their stay)
  - German proficiency & MRI at T2 (5 months later)

CORTEX 48 (2012) 458–465

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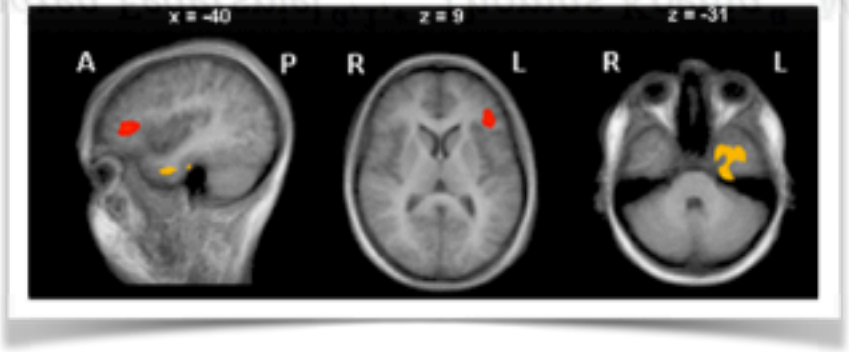
Maria Stein [a,1], *Andrea Federspiel* [a,1,*], *Thomas Koenig* [a], *Miranka Wirth* [a], *Werner Strik* [a], *Roland Wiest* [b], *Daniel Brandeis* [c,d] *and Thomas Dierks* [a]



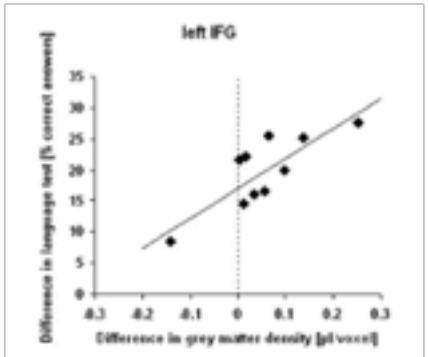


Fig. 2 – Grey matter difference in the left IFG cluster (mean of grey matter density over voxels belonging to the cluster on day 2 minus mean over same voxels on day 1) plotted against the difference in the language test (test core on day 2 minus test score on day 1). The linear regression line is overlaid ($r = .79$, $r^2 = .63$, $p = .0039$).

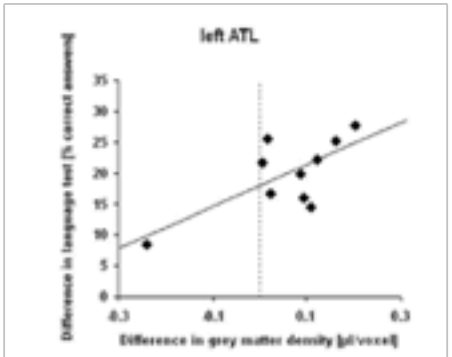


Fig. 3 – Grey matter difference in the left ATL cluster (mean of grey matter density over voxels belonging to the cluster on day 2 minus mean over same voxels on day 1) plotted against the difference in the language test (test core on day 2 minus test score on day 1). The linear regression line is overlaid ($r = .71$, $r^2 = .5$, $p = .02$).

CORTEX 48 (2012) 458–465

This structural plasticity may represent a general principle of experience-based brain reorganization

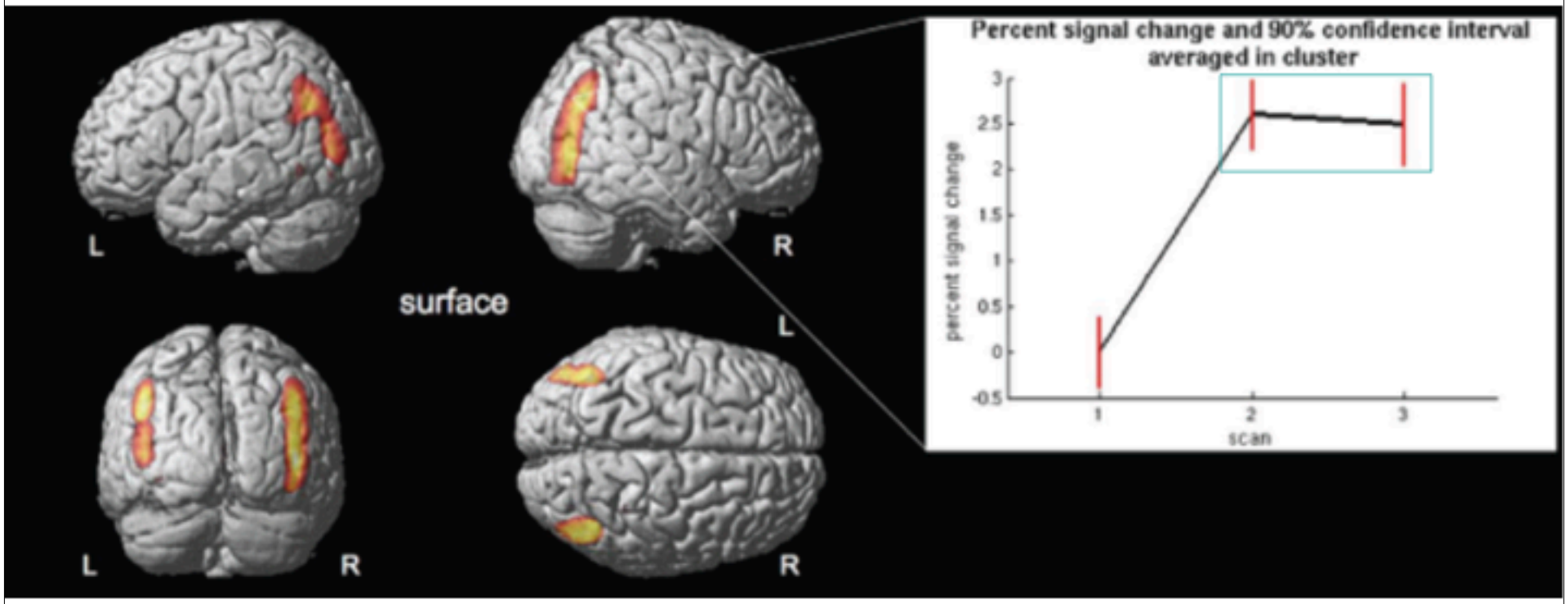
Temporal and Spatial Dynamics of Brain Structure Changes during Extensive Learning

Bogdan Draganski,[1] Christian Gaser,[2] Gerd Kempermann,[3] H. Georg Kuhn,[4] Jürgen Winkler,[1] Christian Büchel,[5] and Arne May[1,5]

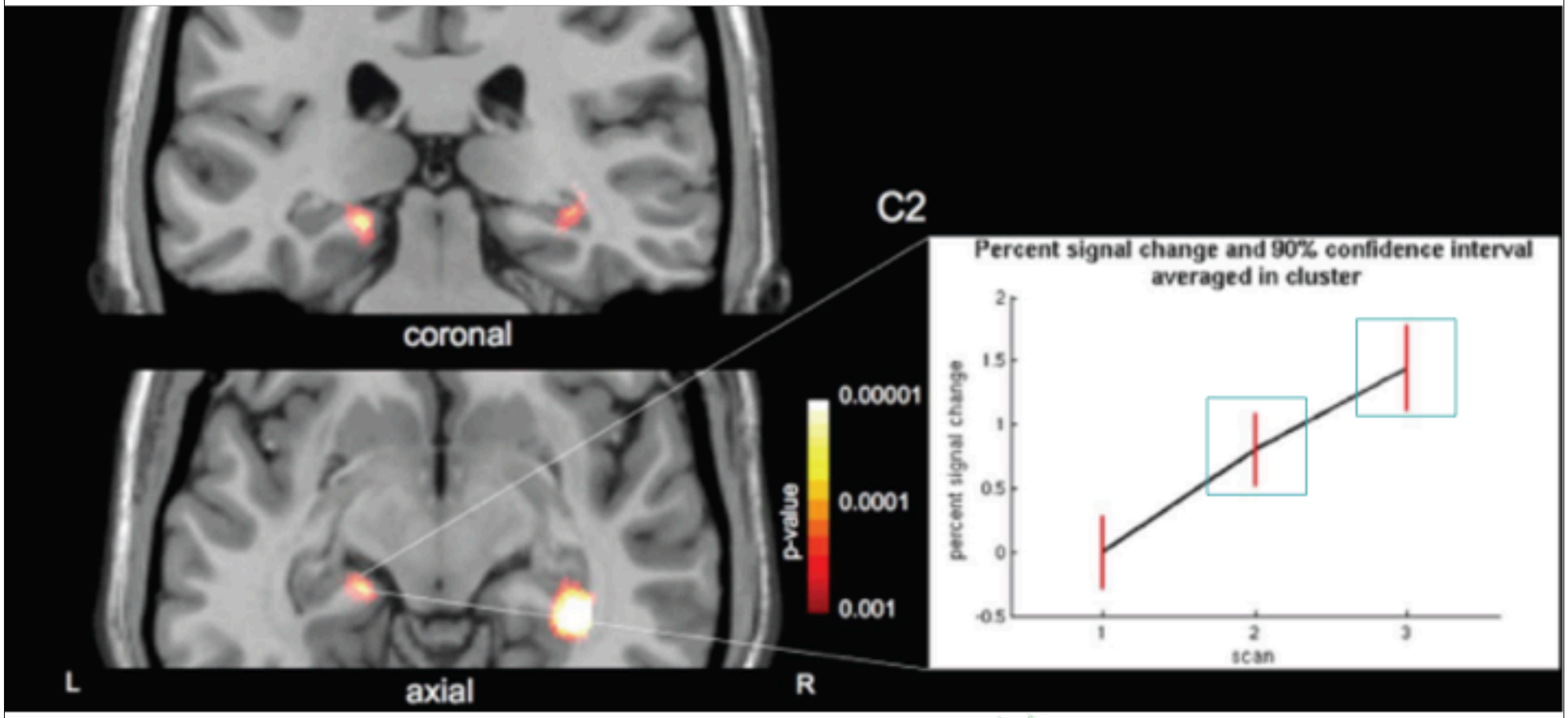
- Type of study → fMRI
- Participants
  - 38 german medical students studying for the Physikum preliminary medical exam (21 females; age: 24)
  - 12 controls (8 females; age: 22)
- 3 scans→ T1: 3 months before the medical exam; T2: 1-2 days after the exam; T3: 3months later

The Journal of Neuroscience, June 7, 2006 • 26(23):6314 – 6317

Grey-matter volume increase in temporo-parietal areas



Grey-matter volume increase in the Hippocampus



Feature Review

Bilingualism: consequences for mind and brain

Ellen Bialystok[1,2], Fergus I.M. Craik[2] and Gigi Luk[3]

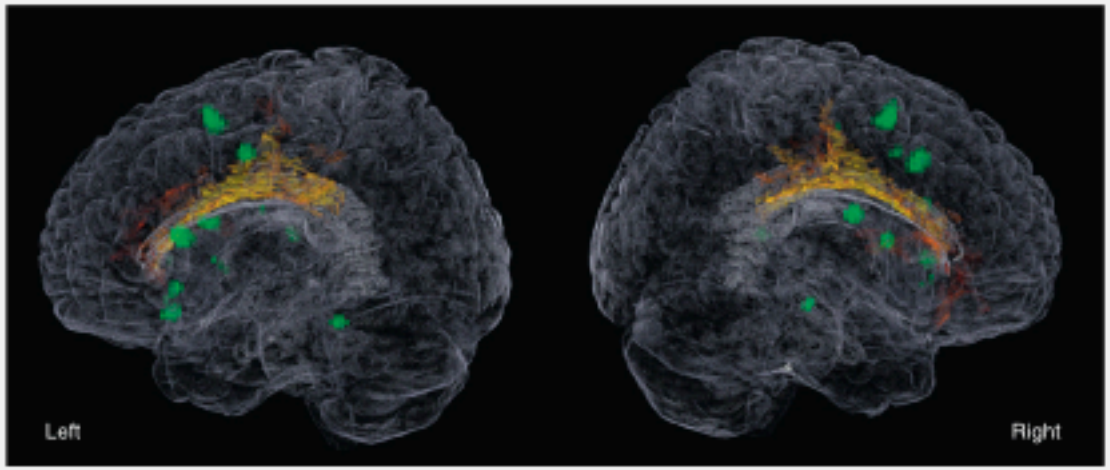
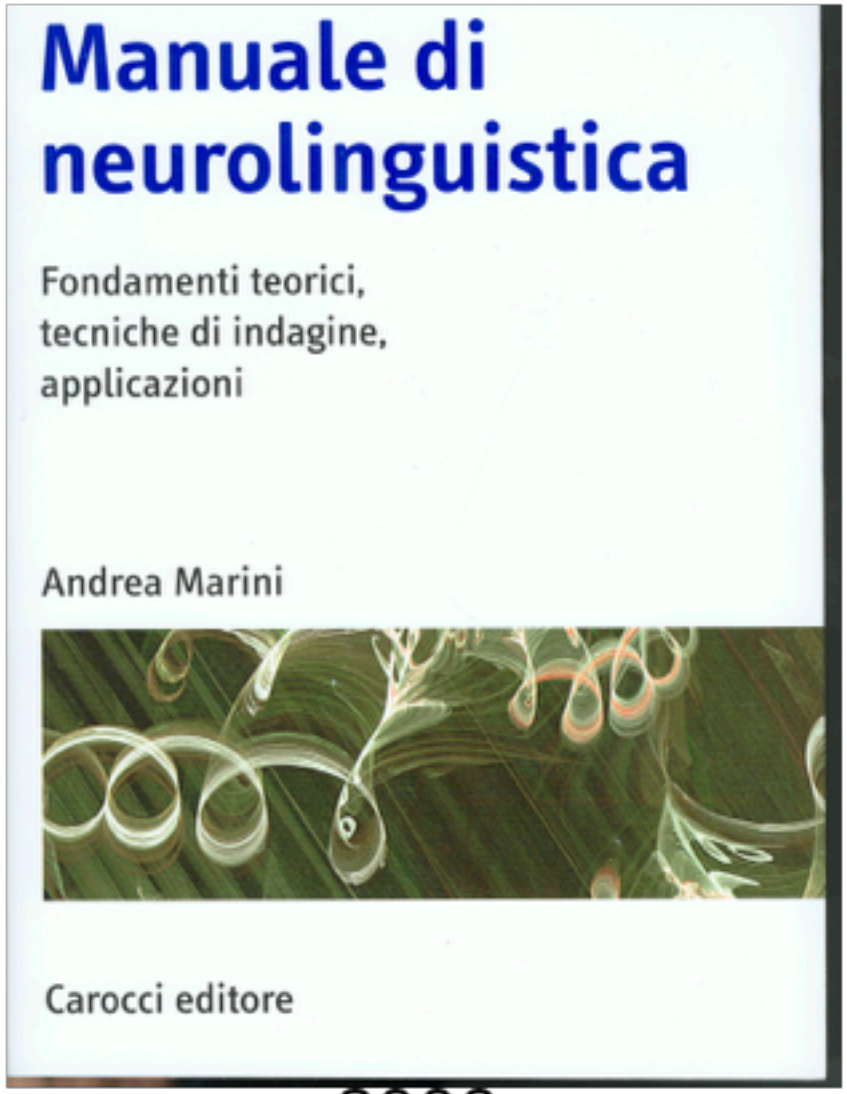


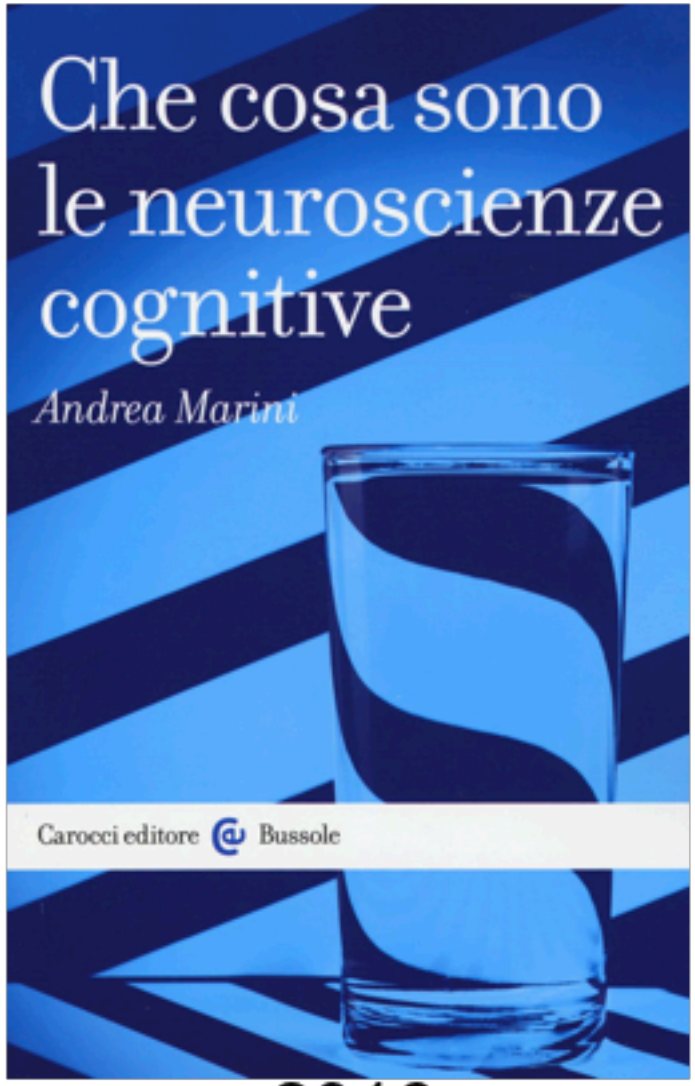
Figure 1. Bilingual influence on brain function and structure. Transparent brains showing the left and right hemispheres. Green voxels depict grey matter regions showing high activation during bilingual language switching in a meta-analysis [90]. Red–yellow voxels indicate regions of higher white matter integrity in bilingual older adults relative to monolinguals [107]. Together, the functional and structural data indicate that neural correlates of bilingualism are observed in the frontal lobes, generally responsible for higher cognition such as executive functions.

Trends in Cognitive Sciences April 2012, Vol. 16, No. 4

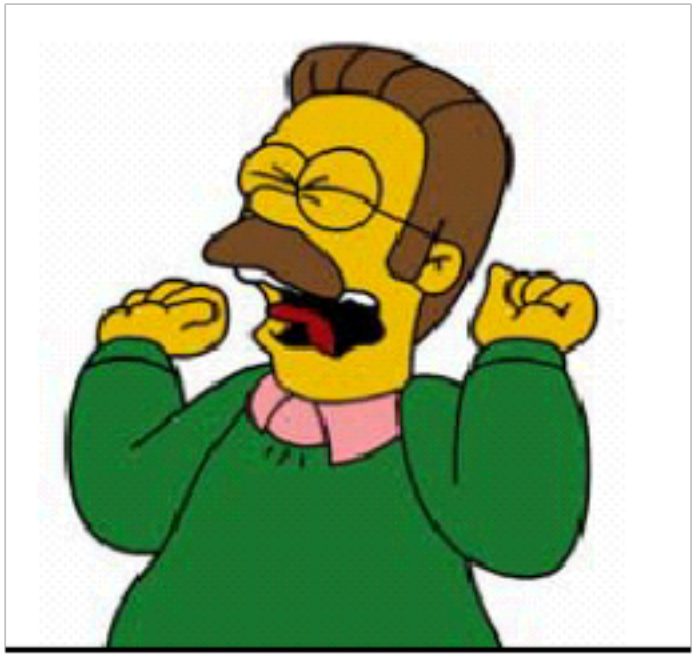
Ne volete sapere di più?



2008



2016



Thanks for your attention!!!

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