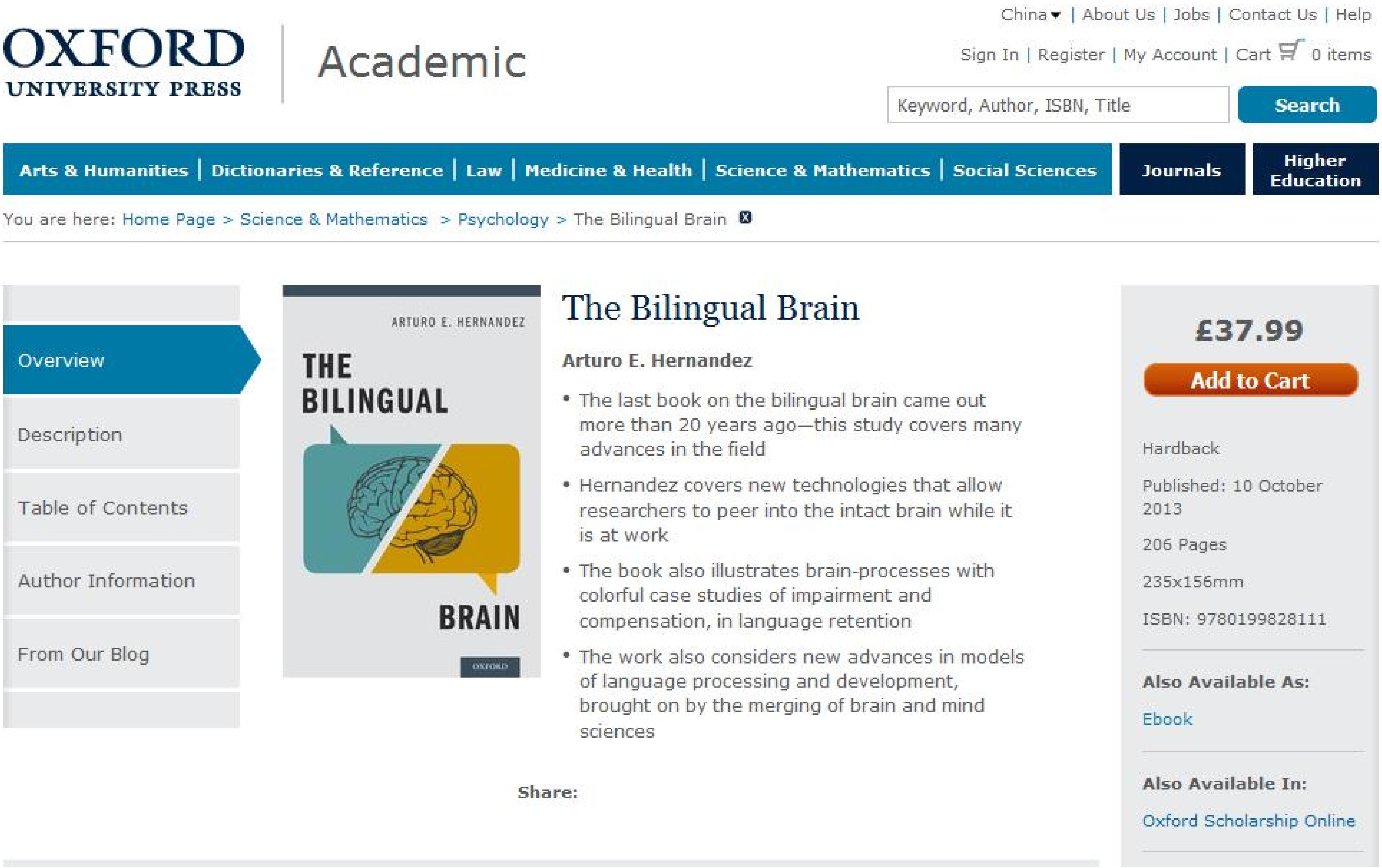
The bilingual brain

Online course and textbook



Online course and textbook

The Bilingual Brain

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关于此课程： This course explores the brain bases of bilingualism by discussing literature relevant to differences in age of initial learning, proficiency, and control in the nonverbal, single language and dual-language literature. Participants will learn about the latest research related to how humans learn one or two languages and other cognitive skills.

制作方： 休斯敦大学系统

UH SYSTEM

教学方： Arturo Hernandez, Professor
Psychology

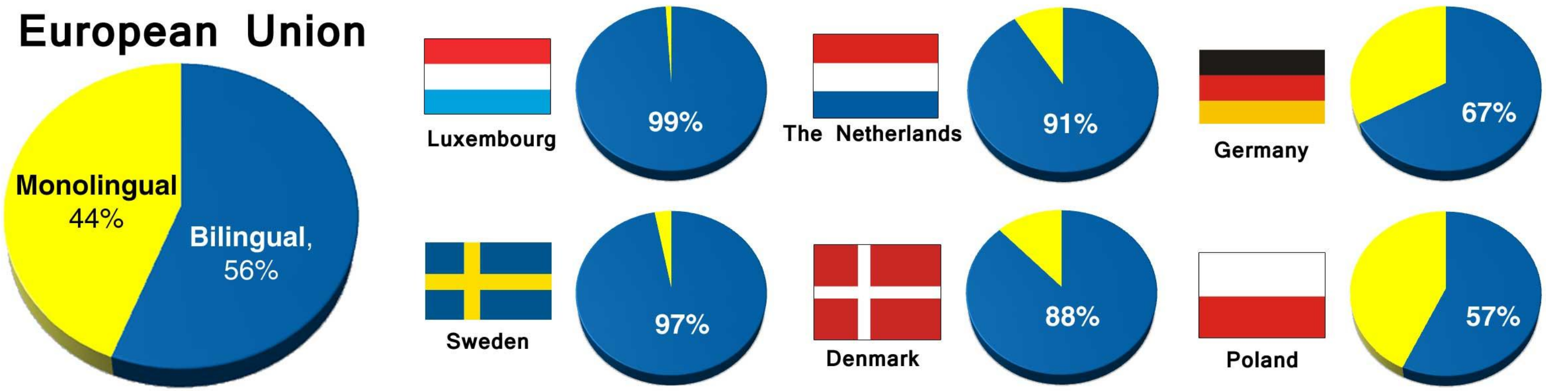
承诺学习时间	4-6 hours/week
语言	English, **字幕：** Russian
如何通过	通过所有计分作业以完成课程。
用户评分	★★★★★ Average User Rating 5.0 查看学生的留言

Outline

- Language representation
- Language control
- Second language learning
- Cognitive control advantage?

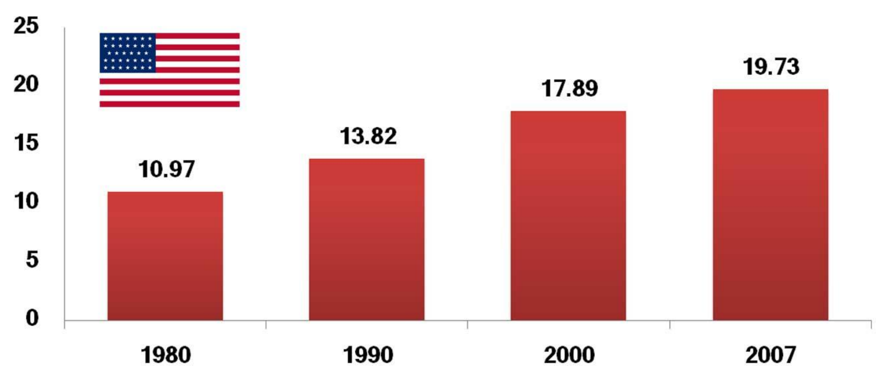
Bilingual speakers

Percentage of Bilingual Speakers in the World



Source: European Commission, "Europeans and their Languages," 2006

Percentage of US Population who spoke a language other than English at home by year

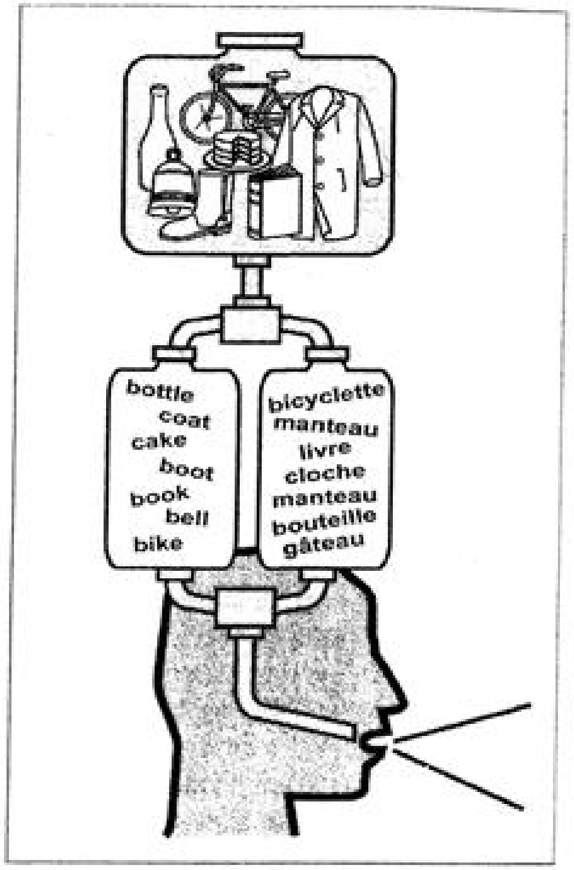


Source: U.S. Census Bureau, 2007 American Community Survey

Bilingual lexical access

- Selective (Costa, Miozzo, Caramazza, 1999; Rodriguez-Fornells et al., 2002)
- Non-selective (Dijkstra, Grainger, Van Heuven, 1999)

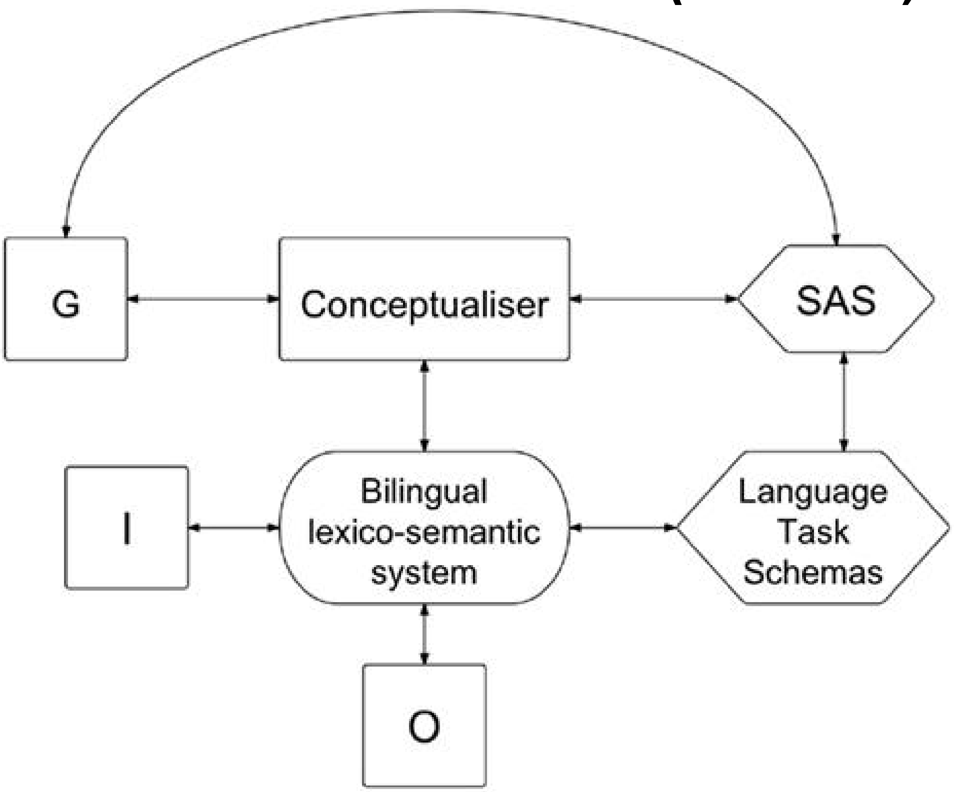
- Balanced proficient bilinguals-selective;
- Unbalanced less proficient bilinguals->non-selective (Costa & Santesteban, 2004)



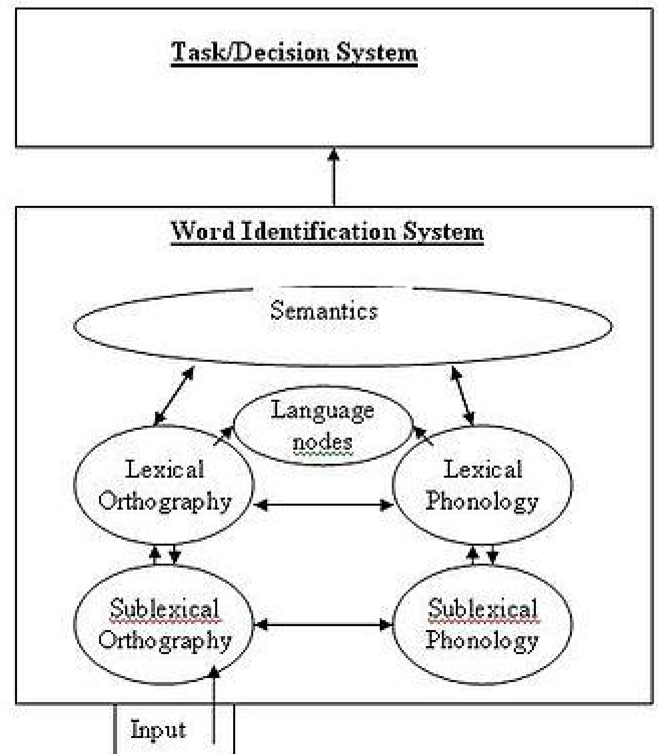
The Three-Store Hypothesis

Language control in bilinguals

- Inhibitory control model   Bilingual interactive   (Green, 1998)

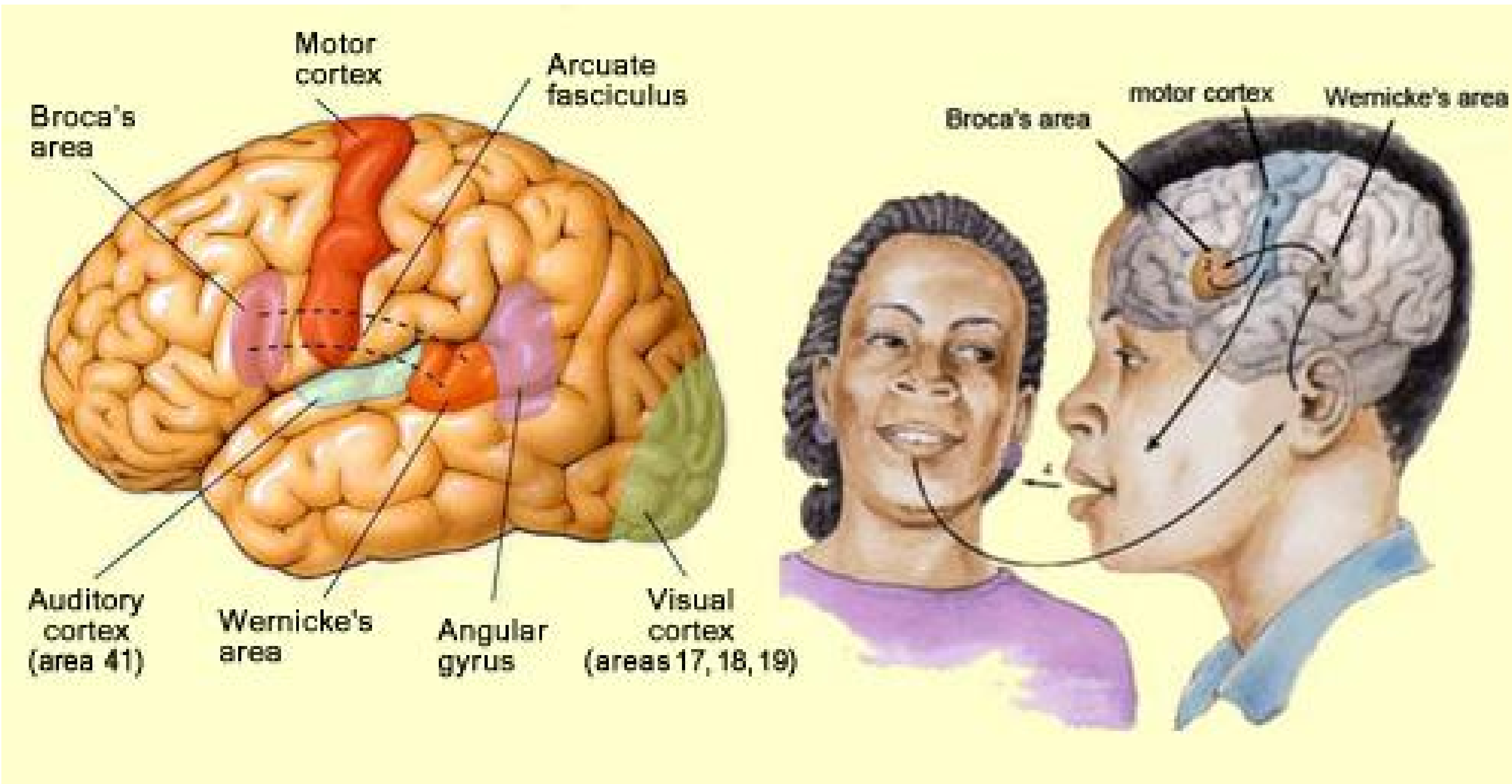


IC model

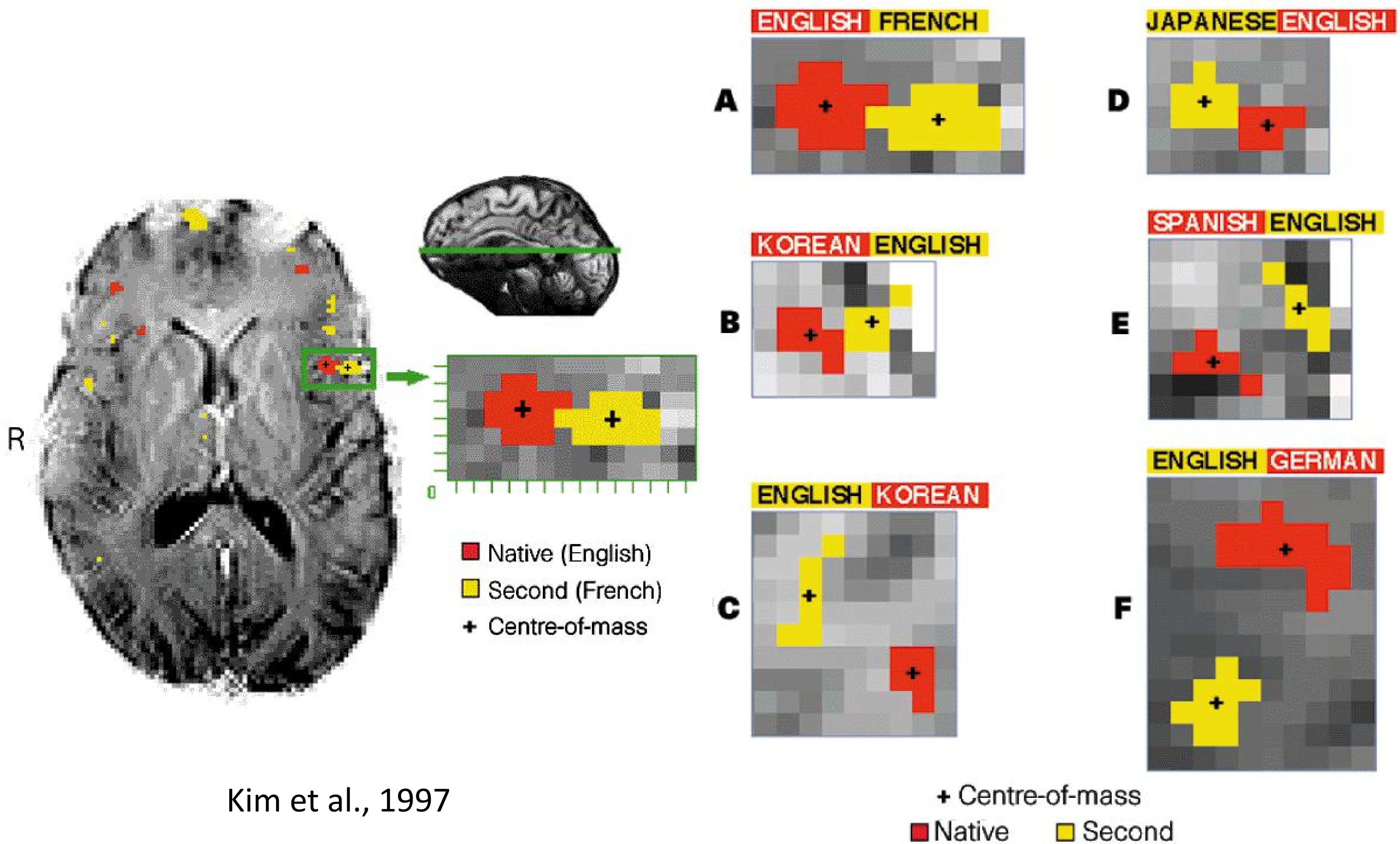


BIA + model

Brain areas for language processing

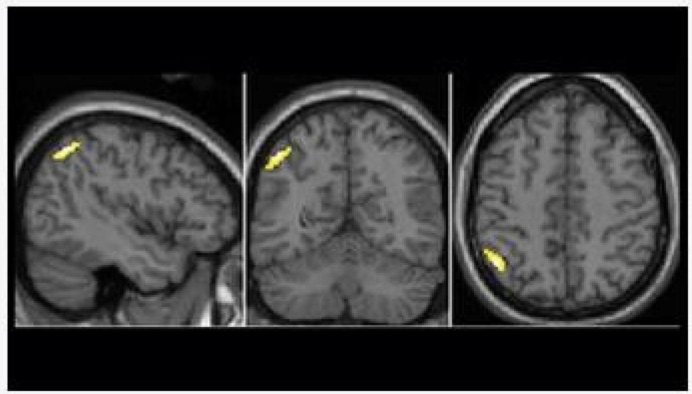


Bilinguals' sentence comprehension



Kim et al., 1997

Brain structure changes



- Brain scans of bilingual individuals found greater gray-matter density (yellow) in the inferior parietal cortex, an area in the brain's language-dominant left hemisphere. The density was most pronounced in people who were very proficient in a second language and in those who learned a second language before the age of five.

L1 and L2 processing in the bilingual brain: A meta-analysis of neuroimaging studies (Hengshuang Liu, Fan Cao)-Reading

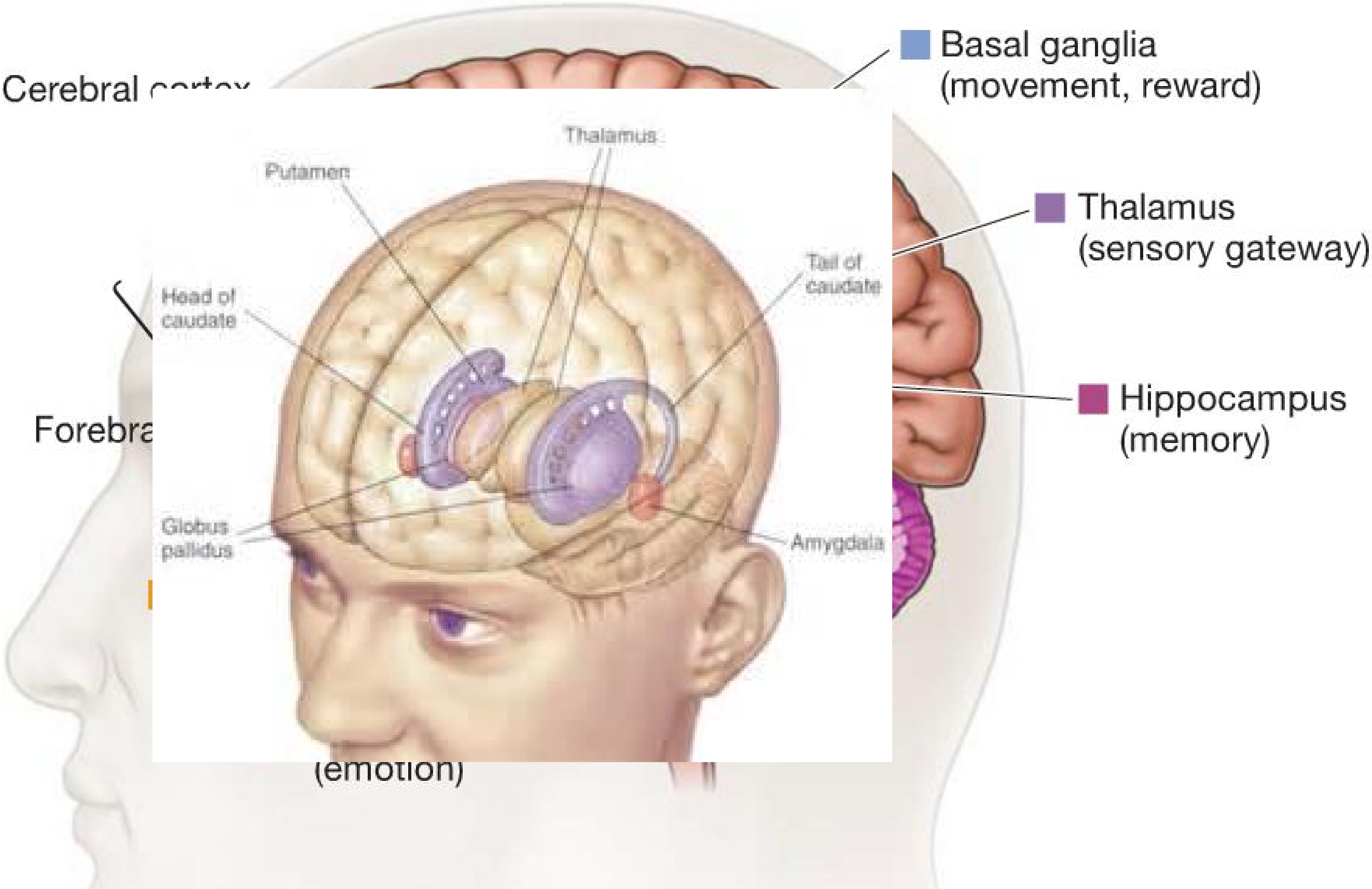
Highlights

- L1 and L2 networks were more divergent for late bilinguals than for early bilinguals.
- AOA of L2 influences brain activation of L1 even when L1 is exactly the same.
- L2 brain activation is partially determined by L1's orthographic transparency.

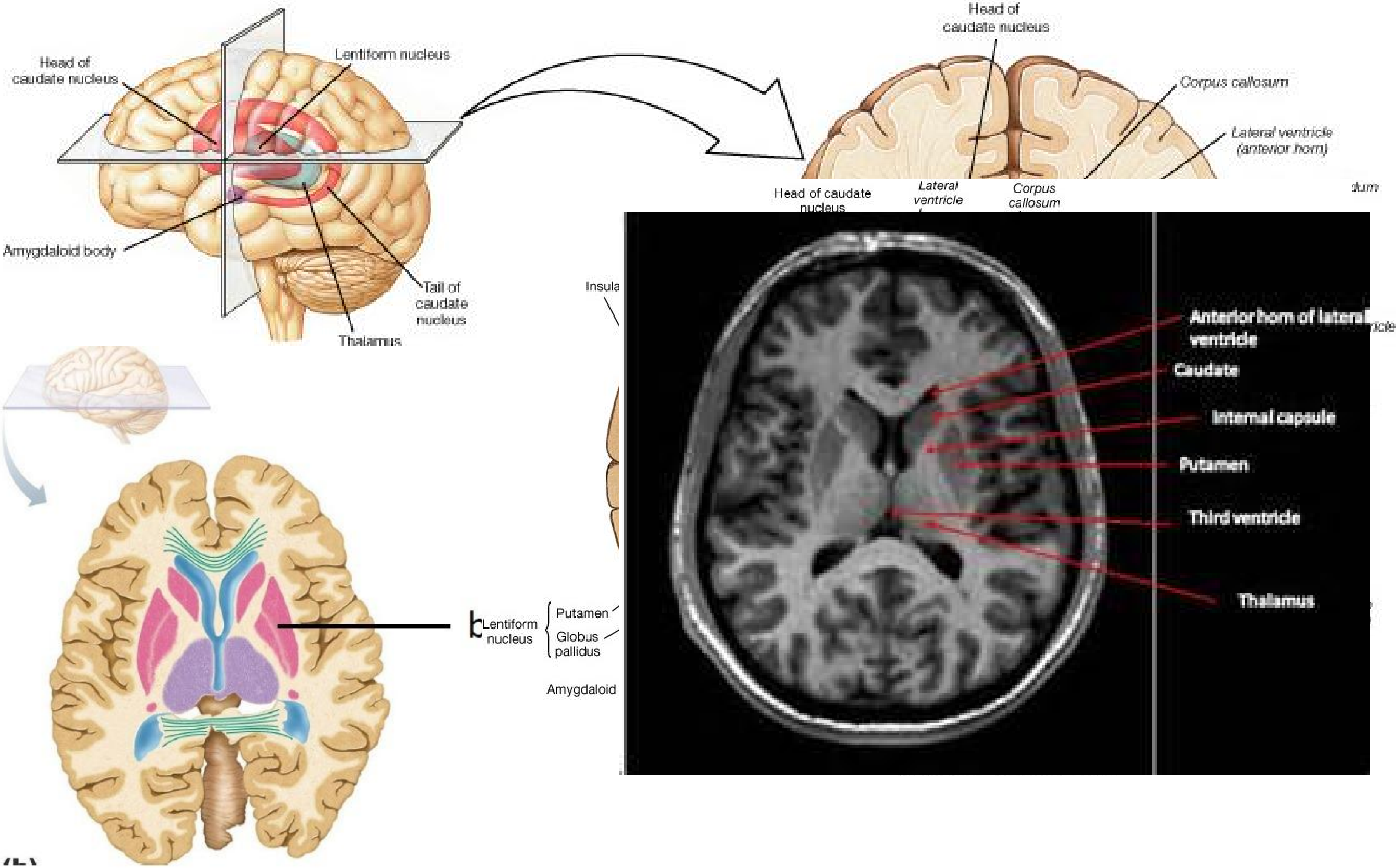
Brain networks underlying L2 processing

- L1 related brain areas, such as Broca's area (Abutalebi, 2008; Abutalebi & Green, 2007)
- Cognitive control areas, such as left prefrontal cortex, anterior cingulate cortex (ACC), left caudate (especially for low proficiency L2 speakers)

Basal Gangalia



Basal Gangalia



Cortical areas– language control

- Left prefrontal area
  - Bilingual aphasia (Fabbro, Skrap & Aglioti, 2000; Zatorre, 1989)
  - Spanish-English bilinguals (Hernandez, Depretto, Mazziotta, & Bookheimer, 2001)
  - Highly proficient Catalan-Spanish speakers (BAs 45, 9)(Rodriguez-Fornells et al., 2002)
  - German-Spanish bilinguals (go/no-go picture naming) –middle frontal gyrus (Rodriguez et al., 2005)
- Left inferior parietal lobe (supramarginal gyrus)
  - Bilingual aphasia (Herschmann & Pötzl, 1920)
  - German-Spanish bilinguals (go/no-go picture naming) –supramarginal gyrus (Rodriguez et al., 2005)
- Anterior cingulate cortex
  - German-French bilinguals (picture naming) (Abutalebi et al., 2008)
- Broca's area
  - Finnish-Norwegian bilinguals performed sentence translation judgment task (BA 47) (Lehtonen et al., 2005)

Subcortical areas– language control

- Left caudate nucleus
  - Motor control
  - Language control
    - Bilingual aphasia (Abutalebi, Miozzo, & Cappa, 2000; Aglioti & Fabbro, 1993)
    - Language switching (Abutalebi ., 2007, 2008; Crinion et al., 2006; Garbin et al., 2011; Wang, Kuhl, Chen, & Dong, 2009; Wang, Xue, Chen, Xu & Dong, 2007; Crinion et al., 2006)
    - Switching to the weaker language during language production tasks (Abutalebi & Green, 2008; Abutalebi et al., 2008; Crinion et al., 2006; Abutalebi et al., 2013)
    - Bilateral activity during language switching in a comprehension task (Abutalebi et al., 2007)
- Left putaman
  - Posterior part: articulation
    - Dysarthria (Wise et al., 1999)
    - Foreign Accent Syndrome (FAS) (Kurowski, Blumstein, & Alexander, 1996; Robles, Gatignol, Capelle, Mitchelle, & Duffau, 2005)
  - L1 vs. L2 (Klein et al., 1994; PET)
  - Dopamine release in the left putaman correlates with the reaction times of detecting phonological errors (Tettamani et al., 2005; PET)
  - Increased brain activation when moderate proficient multilinguals (14s vs. 14s) process their non-native language (L3);increased grey matter density in multilinguals (Abutalebi et al., 2013);

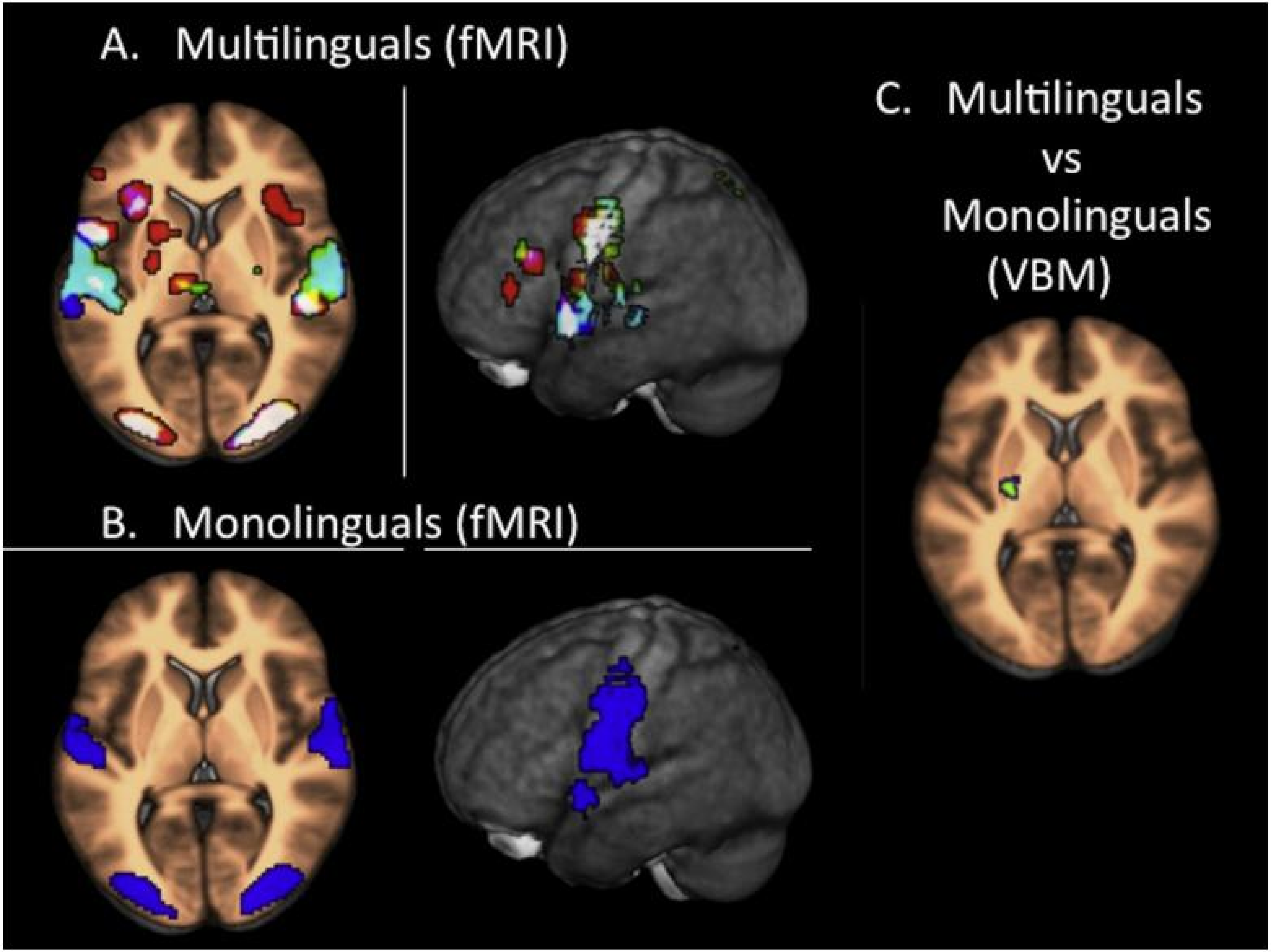
Abutalebi 2013-putaman

Subjects (All female psychology students):
- 14 Italian monolinguals
- 14 multilinguals (L1: German; L2: Italian; L3: English)

Task:
- Picture naming (L1: green; L2: blue; L3: Red)
- 32 pictures (Snodgrass & Vanderwart, 1980)x3

Condition:
- Con1: L1-L2
- Con2: L1-L3
- 48 switch trials & 48 non-switch trials

Trial
- Picture (2s)->ISI(1880, 3550, 4950)


A. Multilinguals (fMRI)
B. Monolinguals (fMRI)
C. Multilinguals
vs
Monolinguals
(VBM)

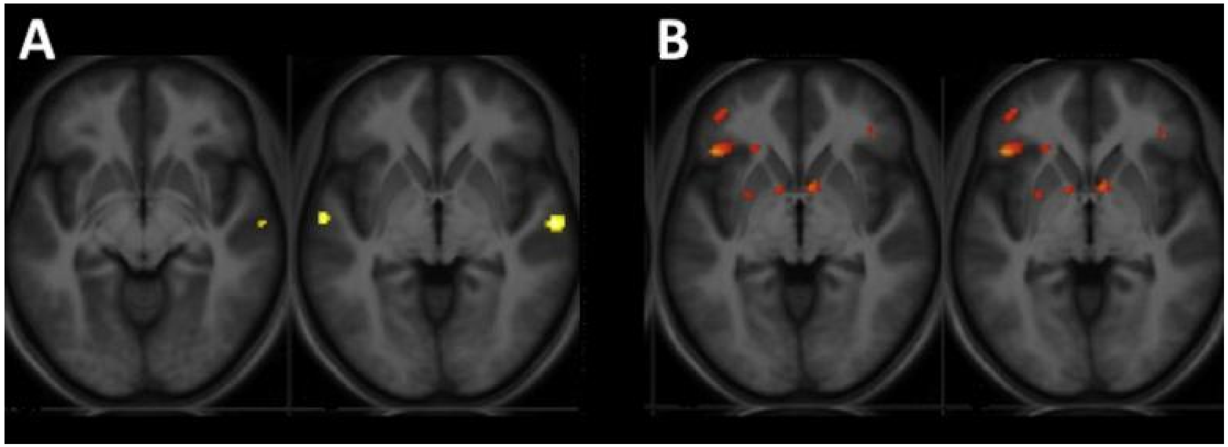
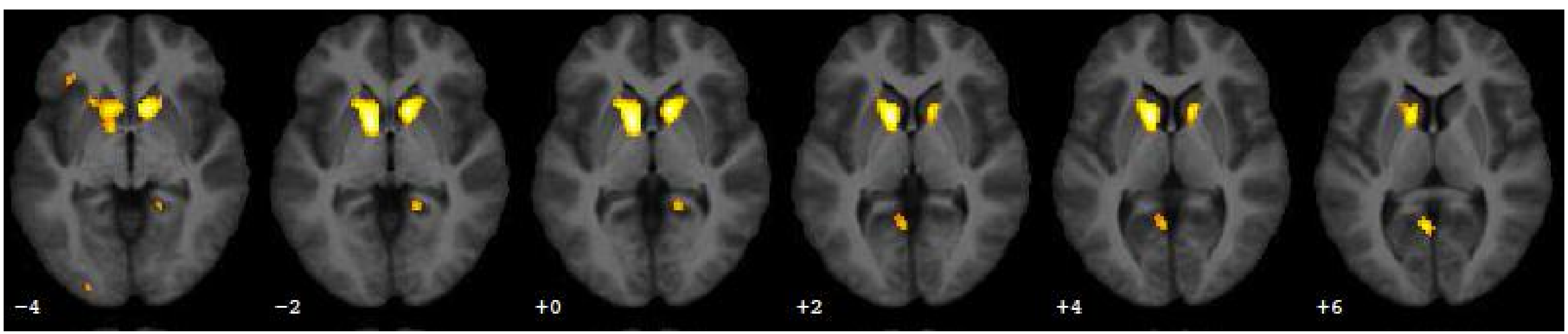


Fig. 2. Direct comparisons between L2 and L3 in multilinguals. In (A) L2 vs. L3 and in (B) L3 vs. L2. Only the latter contrast was associated to left putaminal activity.



Language control areas

- Left inferior frontal gyrus (Broca's area)
- Left inferior parietal lobe (supramarginal gyrus)
- Bilateral dorsal presental cortex
- Anterior cingulate cortex
- Caudate
- Putamen

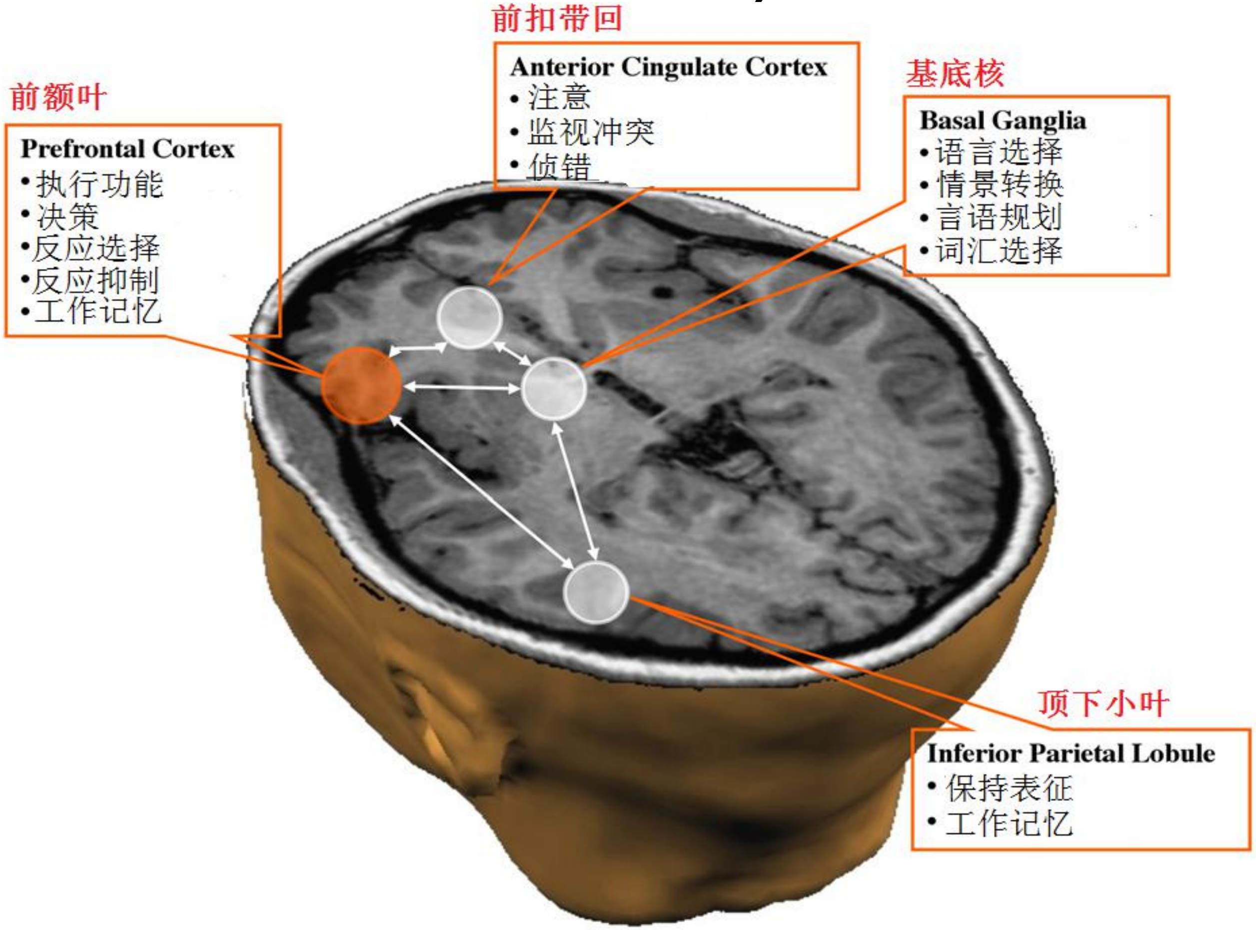
Luk, Green, Abutalebi & Grady, 2012 Meta-analysis

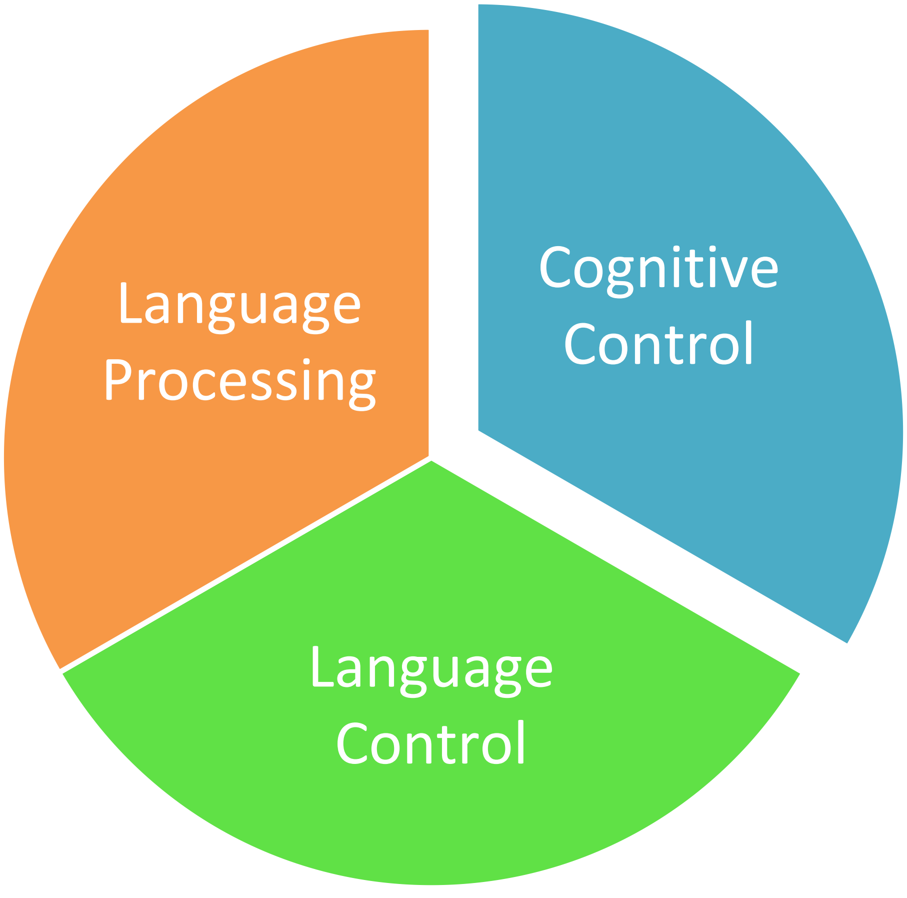
- Left inferior frontal gyrus (BAs 44/47)
- Left middle frontal areas (BA 9/46)
- Right precentral gyrus (BA 6)
- Left middle temporal gyrus (BA 37)
- Right superior temporal gyrus (BA 22)
- Premotor area (BA 6)
- Bilateral caudate

Caudate
Prefrontal gyrus

Language control network

- Abutalebi & Green, 2007




Cognitive Control
Language Processing
Language Control

Cognitive control

- Prefrontal area
  - Ventromedial prefrontal cortex-decision making
  - Dorsolateral prefrontal cortex-working memory
- Parietal lobe-task switching (Bunge et al., 2002)
- Anterior cingulate cortex (Duncan & Owen, 200)-monitor confliction

Cognitive control network (Cole & Schneider, 2007)

- ACC
- Dorsolateral prefrontal cortex
- Inferior frontal gyrus
- Insula
- Premotor area
- Parietal lobe

Second language experience modulates functional brain network for the native language production in bimodal bilinguals

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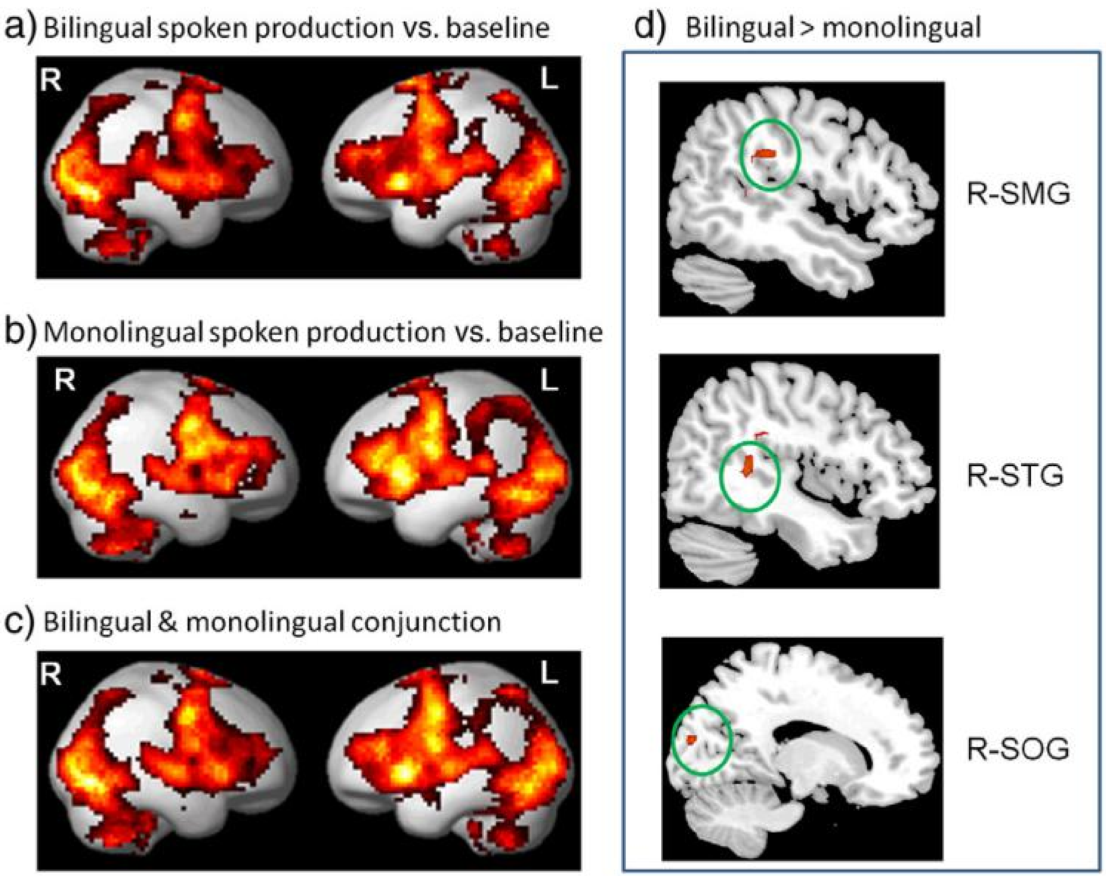
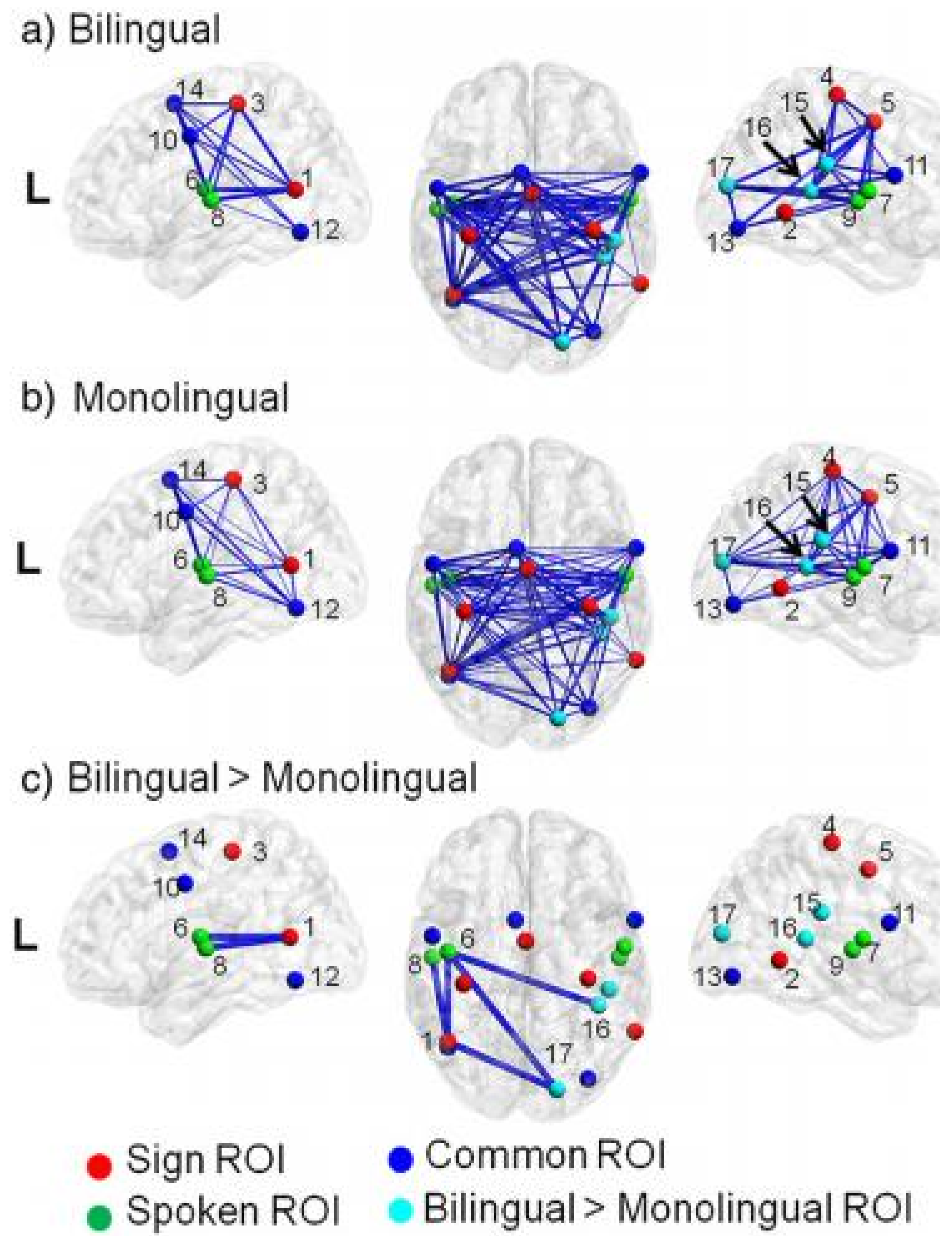


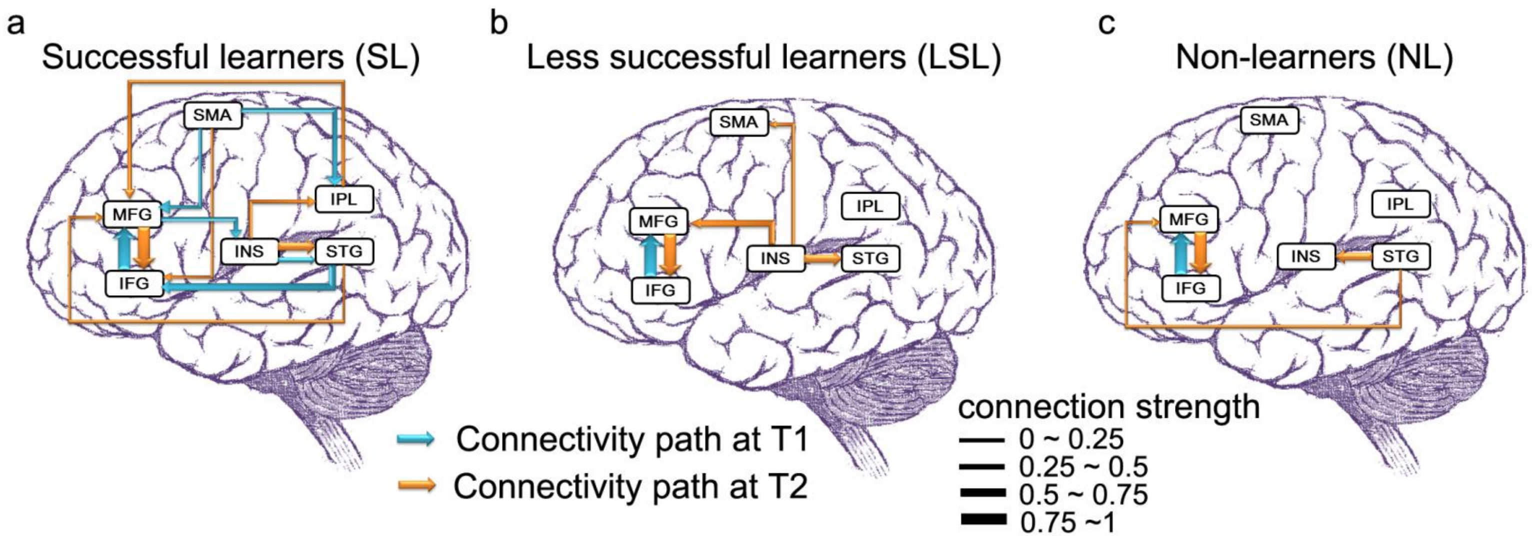
Table 2
ROIs used in functional connectivity analysis.

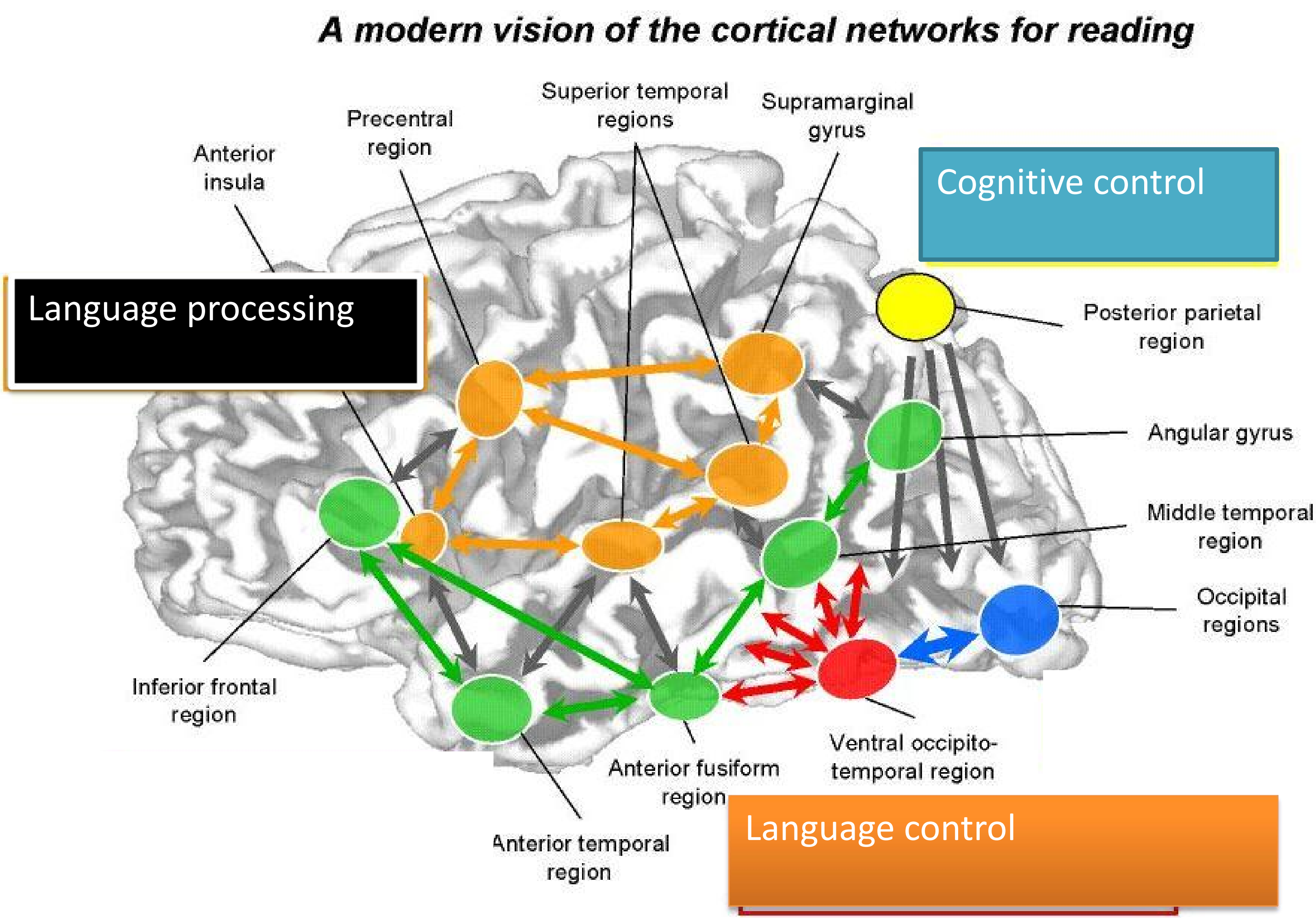
ROI number	Brain regions	ROI type	Type number	x	y
1	L-MTG	Sign ROIs	1	−45	−60
2	R-MTG	Sign ROIs	1	63	−54
3	L-Precentral	Sign ROIs	1	−36	−27
4	R-Precentral	Sign ROIs	1	36	−24
5	MCC	Sign ROIs	1	0	−3
6	L-Rolandic-Oper	Spoken ROIs	2	−45	−9
7	R-Rolandic-Oper	Spoken ROIs	2	57	−6
8	L-STG	Spoken ROIs	2	−54	−12
9	R-STG	Spoken ROIs	2	54	−12
10	L-Precentral	Common ROIs	3	−54	0
11	R-Precentral	Common ROIs	3	63	9
12	L-IOG	Common ROIs	3	−45	−63
13	R-IOG	Common ROIs	3	36	−81
14	L-SMA	Common ROIs	3	−6	9
15	RSMG	Bilingual-specific ROIs	4	48	−30
16	R-STG	Bilingual-specific ROIs	4	42	−39
17	RSOG	Bilingual-specific ROIs	4	18	−87

L: Left hemisphere; R: Right hemisphere; x, y, z = MNI Coordinate; MTG: middle temporal gyrus; Precentral: Precentral gyrus; MCC: middle cingulated cortex; Rol
Rolandic-Oper area; STG: superior, temporal gyrus; IOG: inferior occipital gyrus; SMA: supplementary motor area; SOG: superior occipital gyrus.


a) Bilingual
b) Monolingual
c) Bilingual > Monolingual
L
R
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Sign ROI
Spoken ROI
Common ROI
Bilingual > Monolingual ROI

Effective connectivity




A modern vision of the cortical networks for reading
Anterior insula
Precentral region
Superior temporal regions
Supramarginal gyrus
Cognitive control
Language processing
Posterior parietal region
Angular gyrus
Middle temporal region
Occipital regions
Inferior frontal region
Ventral occipito-temporal region
Anterior fusiform region
Anterior temporal region
Language control

Neurocognitive language control model (Green & Abutalebi, 2013)

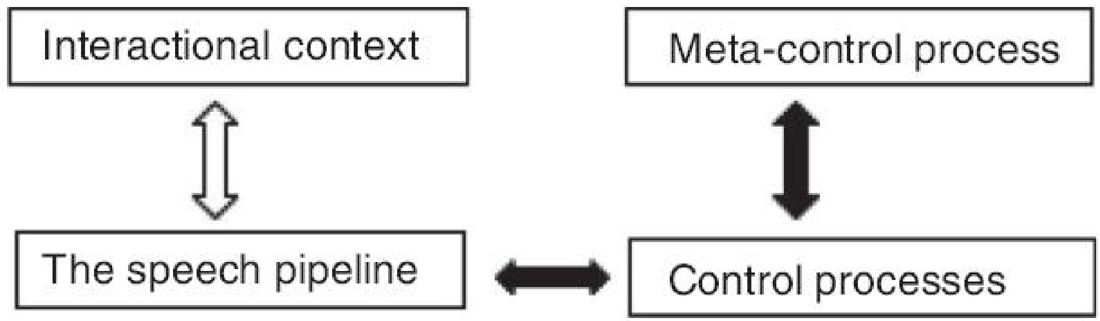


Figure 1. Architecture of the adaptive control hypothesis. Filled arrows depict internal processes of control.

TABLE 1
Demands on language control processes in bilingual speakers as a function of the interactional context relative to demands on the processes in monolingual speakers in a monolingual context

	Interactional contexts		
Control processes	*Single language*	*Dual language*	*Dense code-switching*
Goal maintenance	+	**+**	=
Interference control: conflict monitoring and interference suppression	+	**+**	=
Salient cue detection	=	+	=
Selective response inhibition	=	+	=
Task disengagement	=	+	=
Task engagement	=	+	=
Opportunistic planning	=	=	**+**

+ indicates the context increases the demand on that control process (more so if bolded); = indicates that the context is neutral in its effects. Please see main text for explanation of the control processes.

Adaptation results

- Bilingual speakers to become more proficient at handling linguistic interference but not to advantages in controlling other kinds of non-verbal interference.
- However, the control of language, as we have argued previously (Green, 1986; 1998; Abultalebi & Green, 2007), is likely to recruit evolutionary earlier systems that subserve the control of action in general (Green & Abultalebi , 2013).

Brain areas

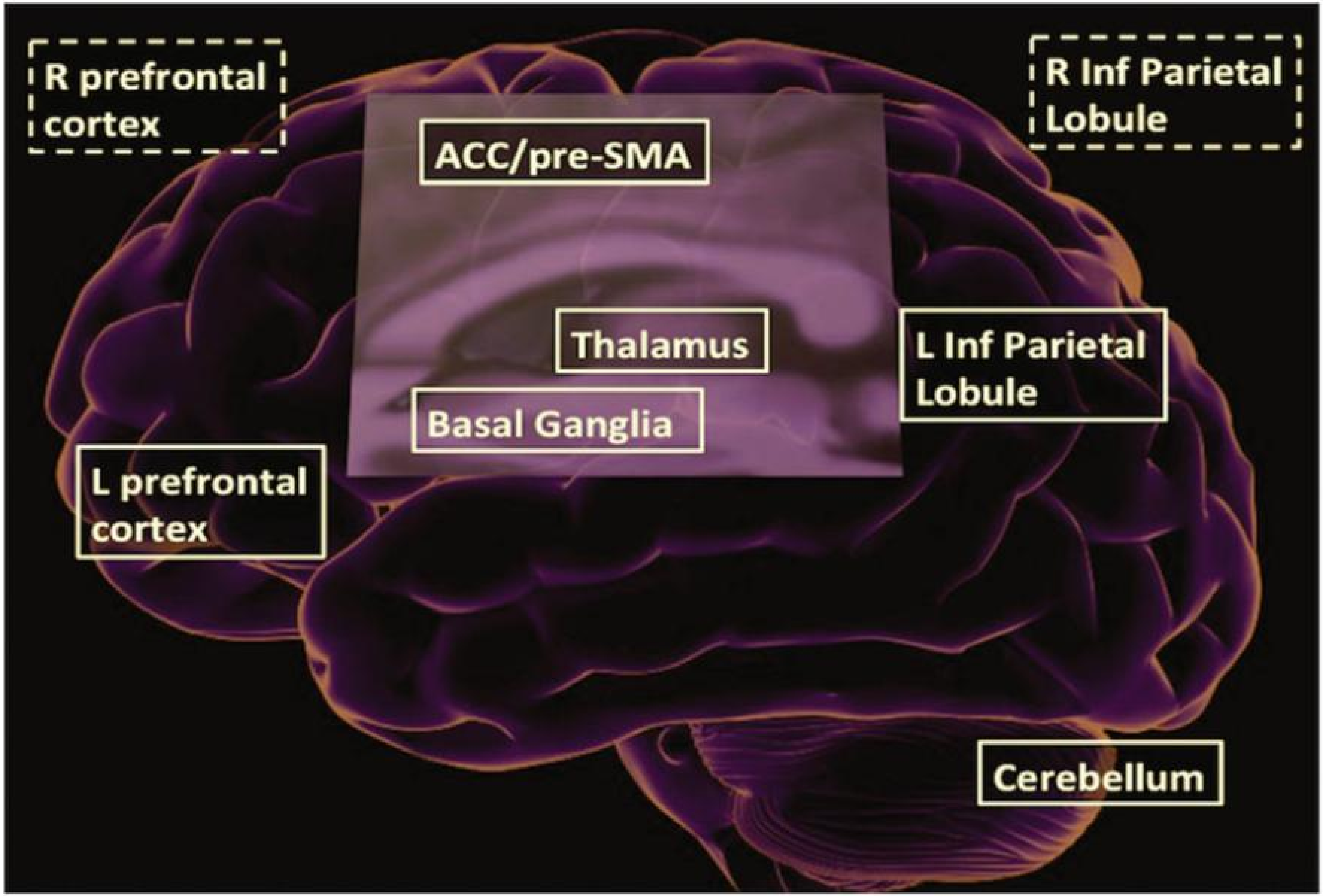
- The neural basis of language control
  - The dACC/pre-SMA complex
  - The left prefrontal cortex
  - The right inferior frontal cortex
  - The inferior parietal lobules
  - Subcortical structures: the left caudate, putamen and thalamus
  - Cerebellum
- Neural adaptation and neural reserve in bilinguals

Language control during speech

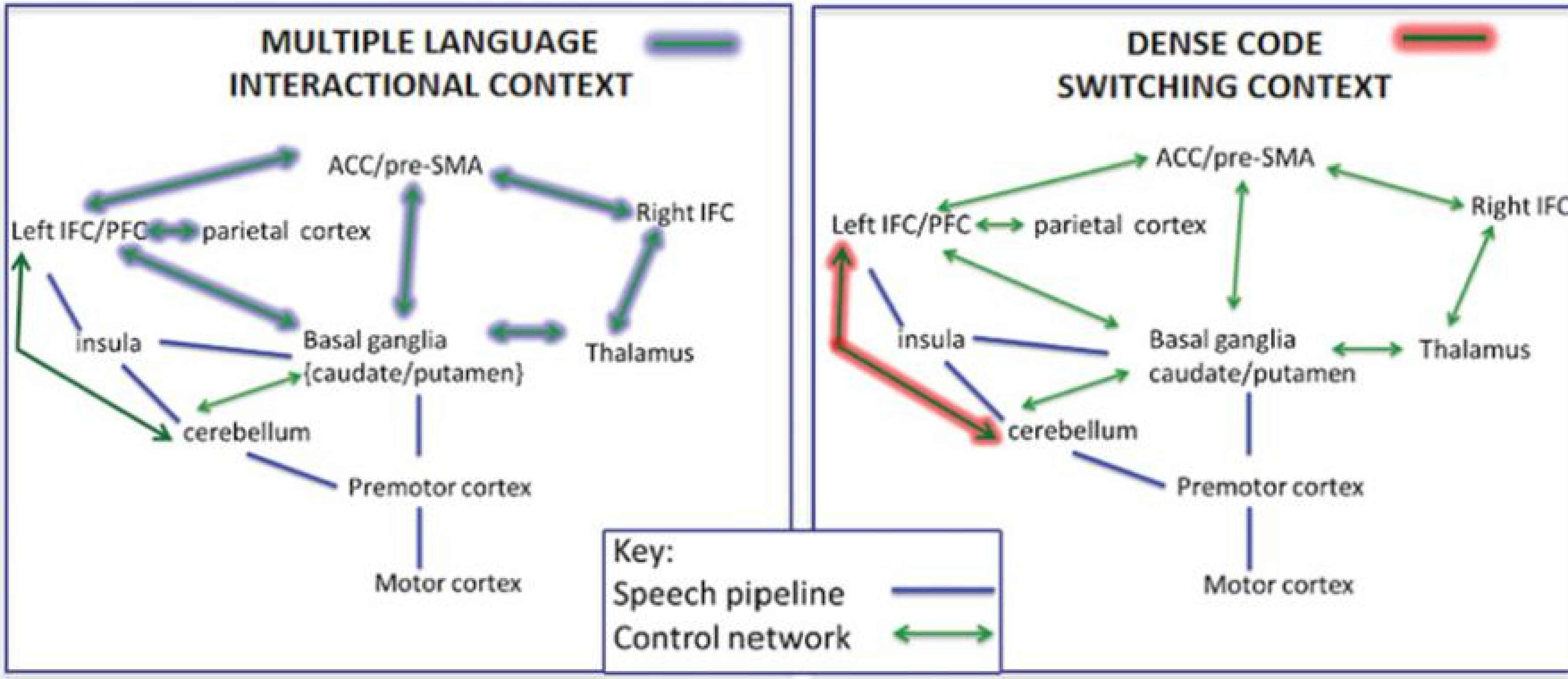
- The intention to speak in one language
- Selection of the target word in the language
- Inhibition of words from the non-target language
- Monitoring speech for potential intrusions
- Language disengagement and engagement (i.e., ceasing to speak in one language and switching to another).

Language control network

- dACC/pre-SMA complex (i.e., dorsal anterior cingulate cortex/pre-supplementary motor area)
- The left prefrontal cortex
- The left caudate (LC)
- The inferior parietal lobules bilaterally
- Right prefrontal cortex
- The thalamus
- The putamen of the basal ganglia
- The cerebellum



Green & Abutalebi, 2013



Green & Abutalebi, 2013

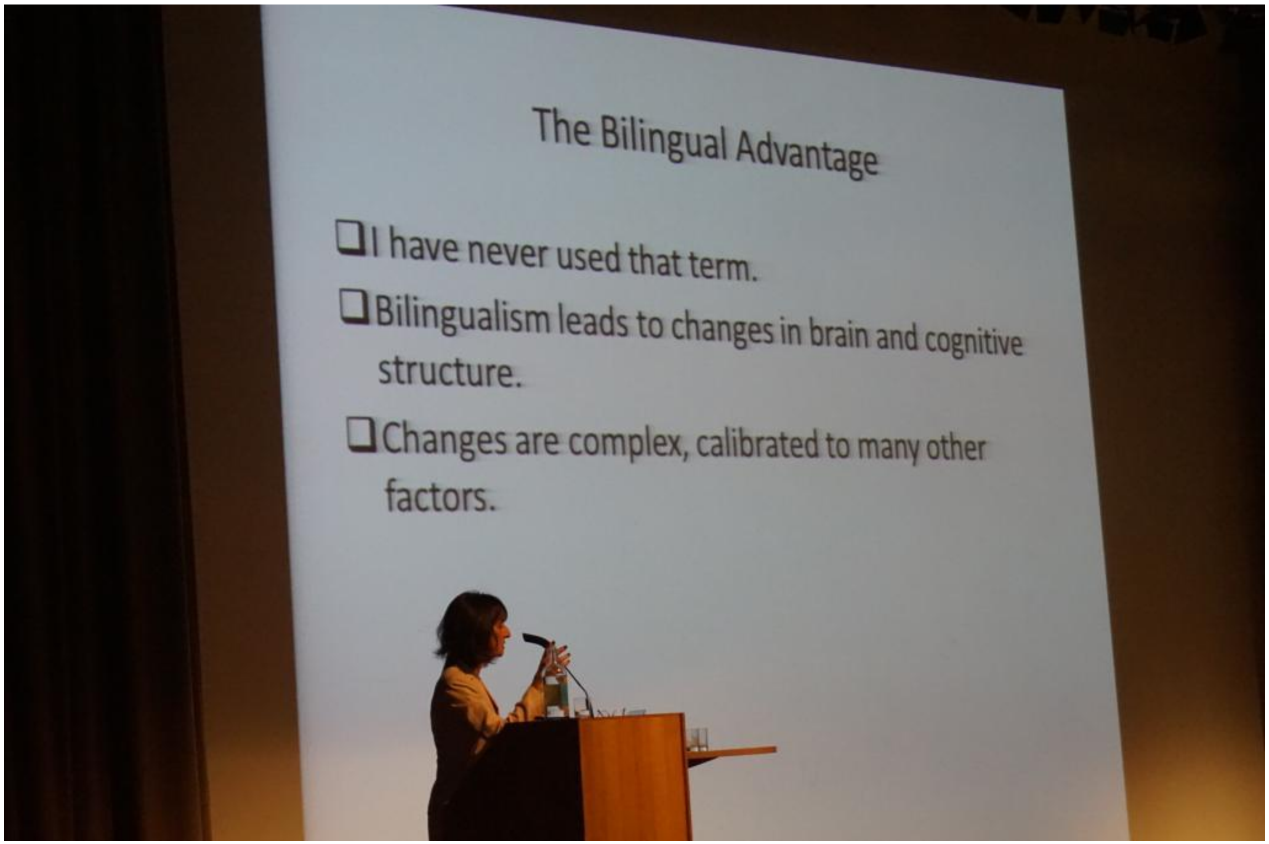
Neural adaptation and neural reserve in bilinguals.

- Bilinguals delays the onset of dementia by an average of 4 to 5 years.
- Luk et al. (2011): using DTI to investigate white matter connectivity in 14 bilingual and 14 monolingual senior adults matched. Higher FA values for bilinguals in corpus callosum.
- The study of Luk et al. (2011) show that bilingualism may delay the progressive loss of white matter and hence protects the aging brain against the effects of loss of white matter such as cognitive decline.

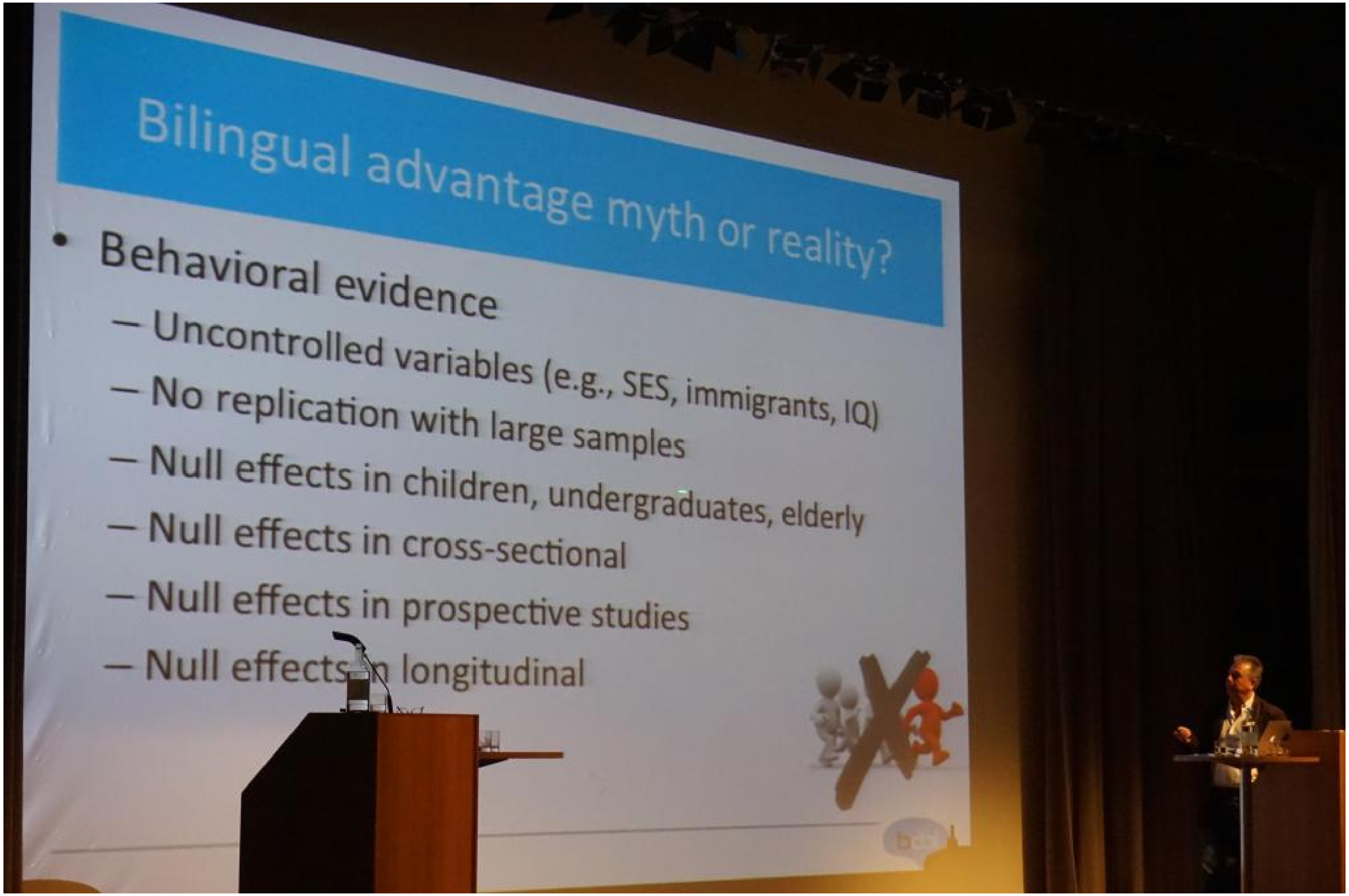
Neural adaptation and neural reserve in bilinguals.

- Abutalebi et al. 2015: Aging bilinguals compared to matched monolinguals have increased grey matter along the entire extension of the ACC. The ACC surrounds the corpus callosum and many of the cingulate projections pass through the corpus callosum.
- Abultalebi et al., 2014: aging bilinguals have increased gray matter in the temporal poles and the orbitofrontal cortex.
- Bilinguals fluent in their second language appeared to have the greatest neuroprotection.

Cognitive advantage in bilingual



Ellen Bialystok



Manuel Carreiras