



Neural Efficiency in Lifelong Bilinguals Studied by Functional MRI

Brian Gold, PhD
Associate Professor
Department of Neuroscience
University of Kentucky

DISCLOSURES



- None

Background

- Bilingualism has been associated with a 4-5 year delay in the diagnosis of clinical Alzheimer's disease.
- Bilingual older adults outperform their monolingual peers on tasks of executive function (EF).
- These findings suggests that bilingualism may build cognitive reserve.

Potential Functional Bases

- Efficiency: when high behavioral task performance is associated with low metabolic response in task-relevant regions.
 - Prediction: bilinguals will show better EF performance and lower brain activation in EF-related regions than monolinguals.
- Compensation: when high behavioral task performance is associated with high metabolic response in task-relevant regions or in other brain regions.
 - Prediction: bilinguals will show better EF performance and higher brain activation in EF-related regions, or other regions, than monolinguals.

Study 1

- Aim: To explore potential bilingual advantages in task switching and their fMRI correlates
 - 4 groups: older and younger bilingual and monolingual groups performed an fMRI of task switching paradigm.
 - fMRI data were acquired on a 3-T Siemens TIM scanner.

Groups

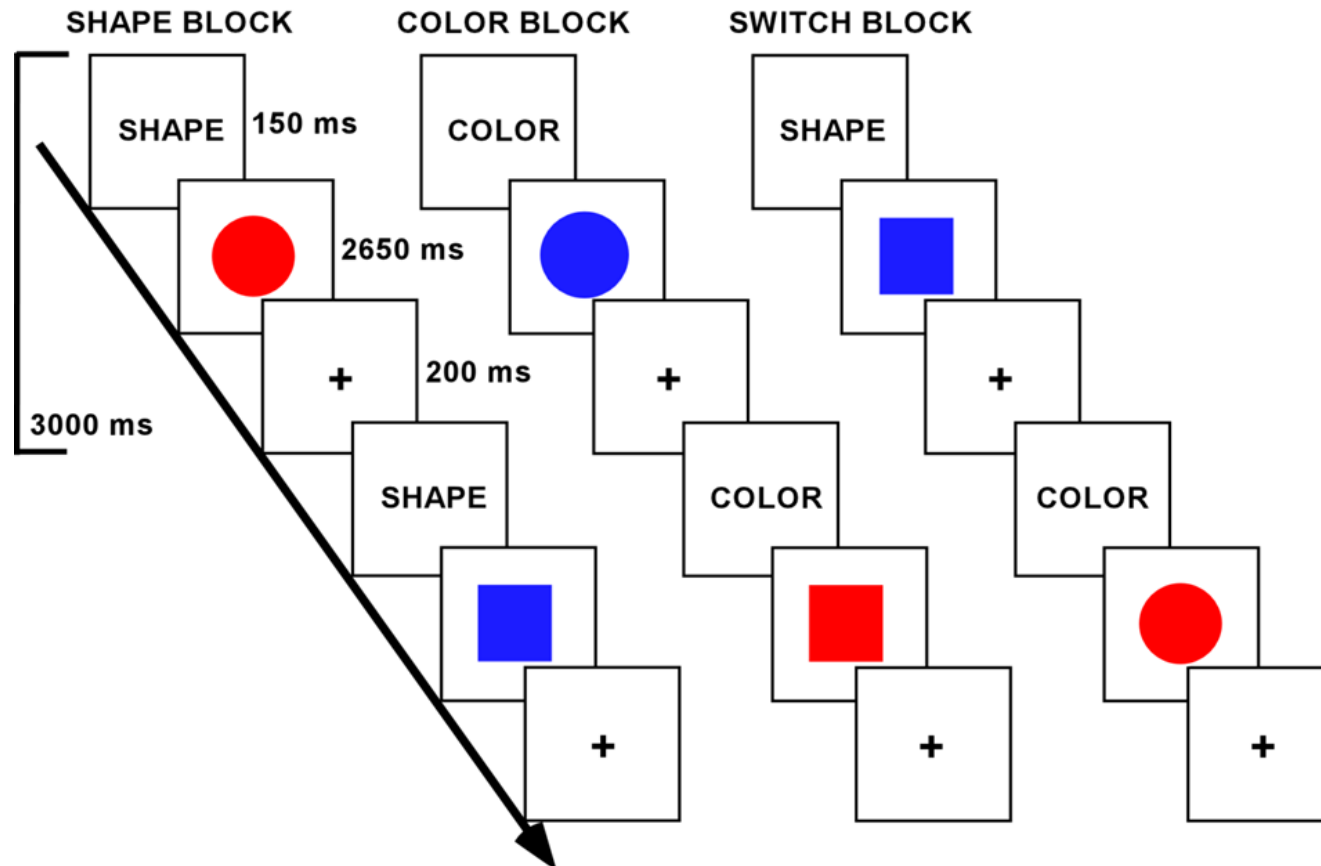
	Young Monolingual N = 20	Young Bilingual N = 20
Language(s) spoken	English	English + African language (Luo, Swahili), French, German, Indian language (Gujarati, Hindi), Greek, Spanish, Turkish, Mandarin

	Older Monolingual N = 20	Older Bilingual N = 20
Language(s) spoken	English	English + African language (Igbo, Swahili), Filipino, French, German, Indian language (Gujarati, Hindi, Konkani), Spanish

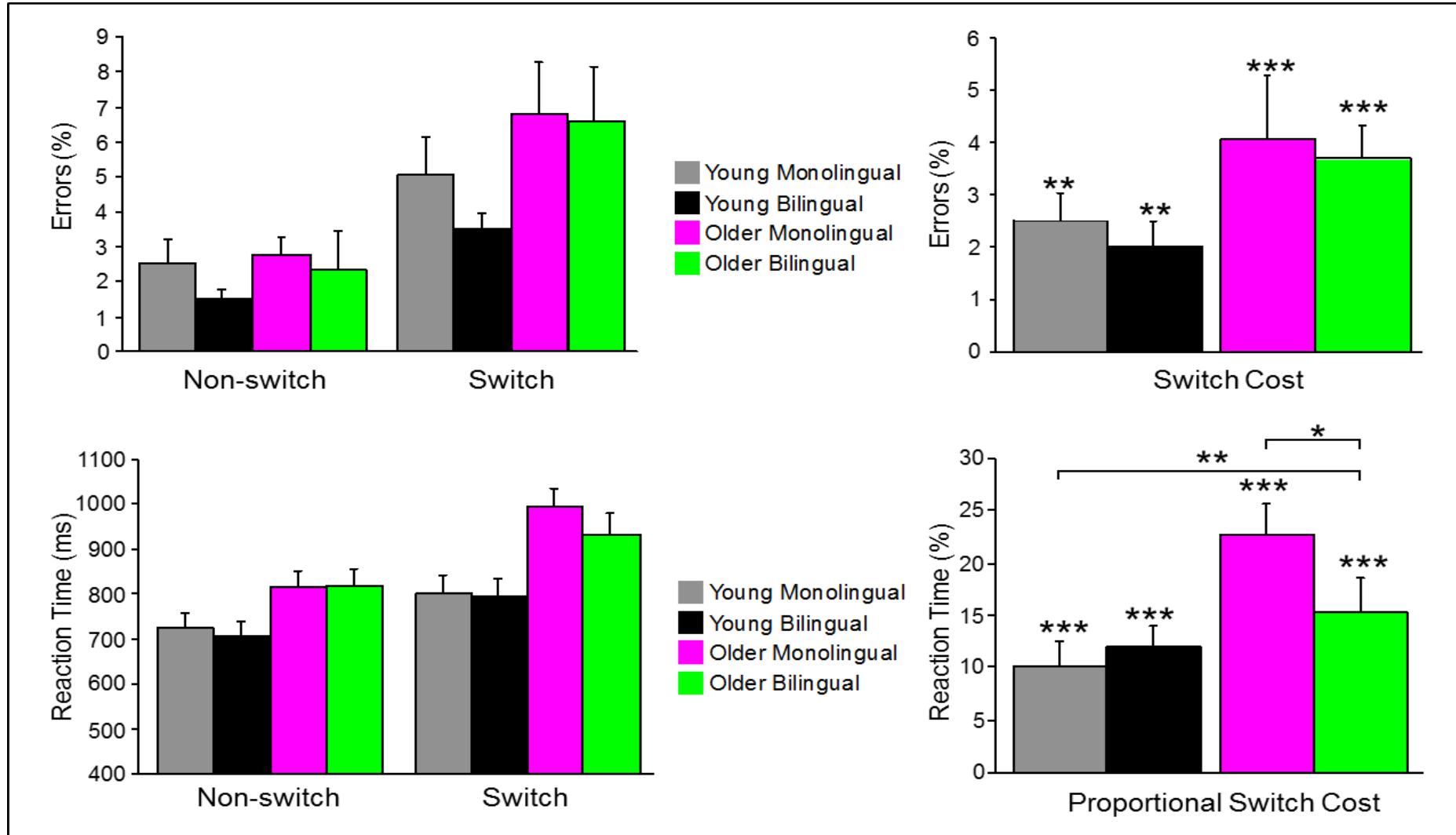
Participants

	Young Monolingual	Young Bilingual	Older Monolingual	Older Bilingual	P Values		
	12 Females 8 Males	13 Females 7 Males	10 Females 10 Males	10 Females 10 Males	Age Group	Language Group	Age × Language
Age	32.2 (3.3)	31.6 (4.3)	64.4 (5.1)	63.9 (4.0)	<0.001	0.92	0.74
Education	17.1 (2.6)	18.3 (2.5)	17.5 (2.6)	17.4 (2.2)	0.37	0.38	0.23
ISP	26.1 (5.3)	21.7 (10.1)	21.6 (7.0)	19.7 (8.7)	0.12	0.19	0.58
PPVT	107.2 (11.8)	102 (10.7)	110.1 (13.9)	106.3 (18.5)	0.28	0.13	0.85
IQ	126.6 (23.3)	121.3 (15.6)	124.6 (20.2)	127.6 (22.5)	0.64	0.80	0.38
DF	10.7 (2.5)	10.8 (2.4)	10.6 (2.0)	9.7 (2.1)	0.22	0.50	0.38
DB	10.4 (2.8)	10.3 (3.1)	10.5 (2.1)	10.5 (3.2)	0.83	0.96	0.93

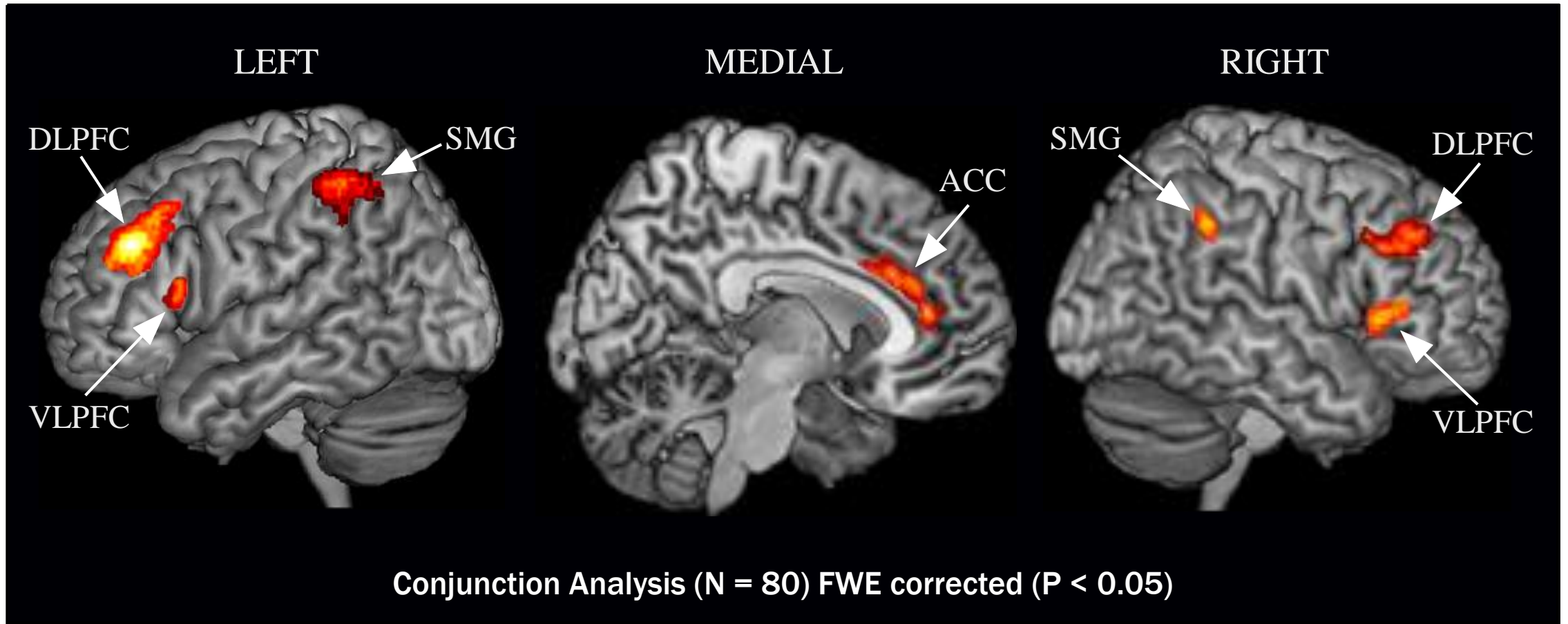
fMRI Task Switching Paradigm



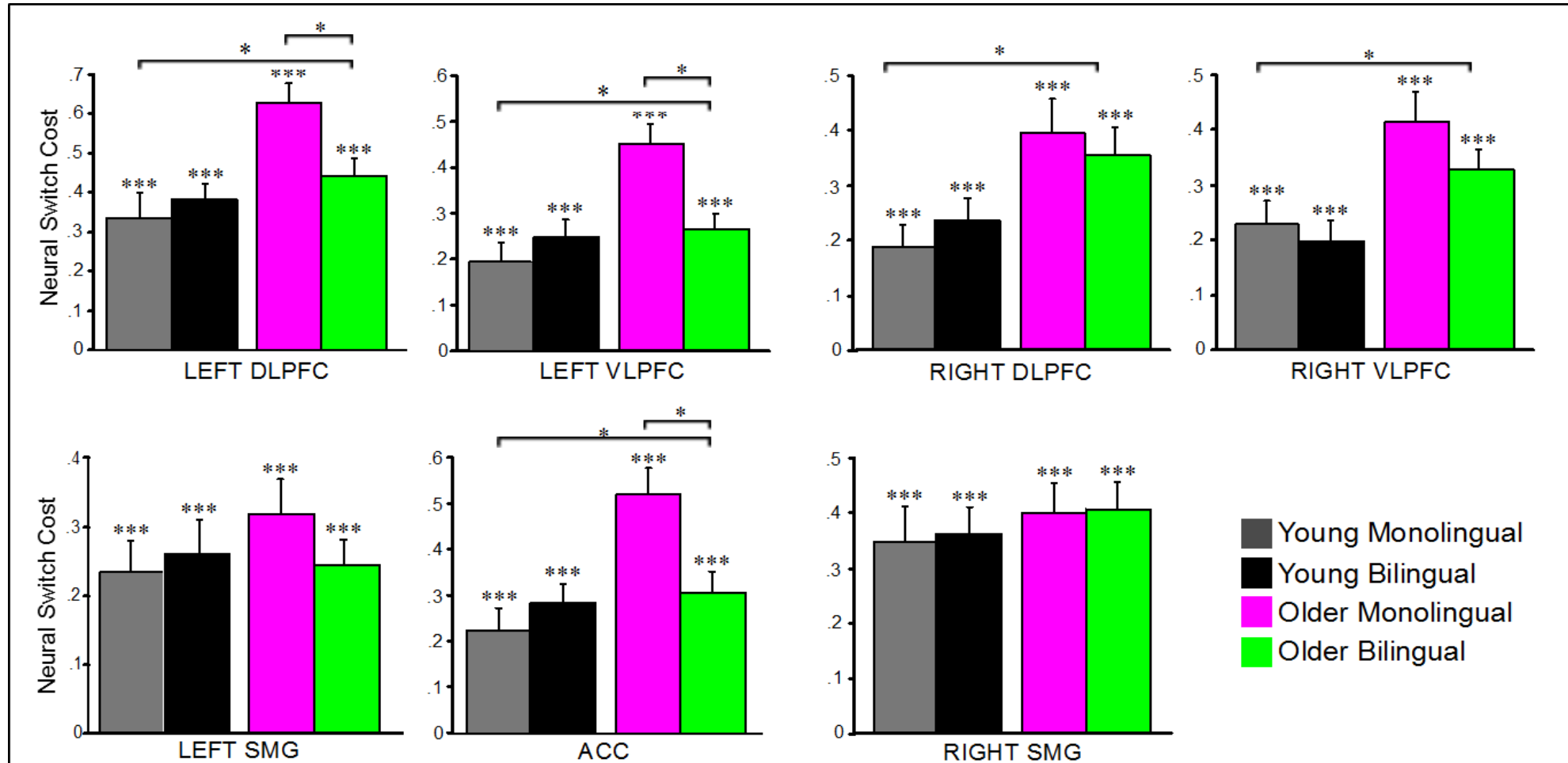
Older Bilinguals Outperform Older Monolinguals



Common Task Switching Network

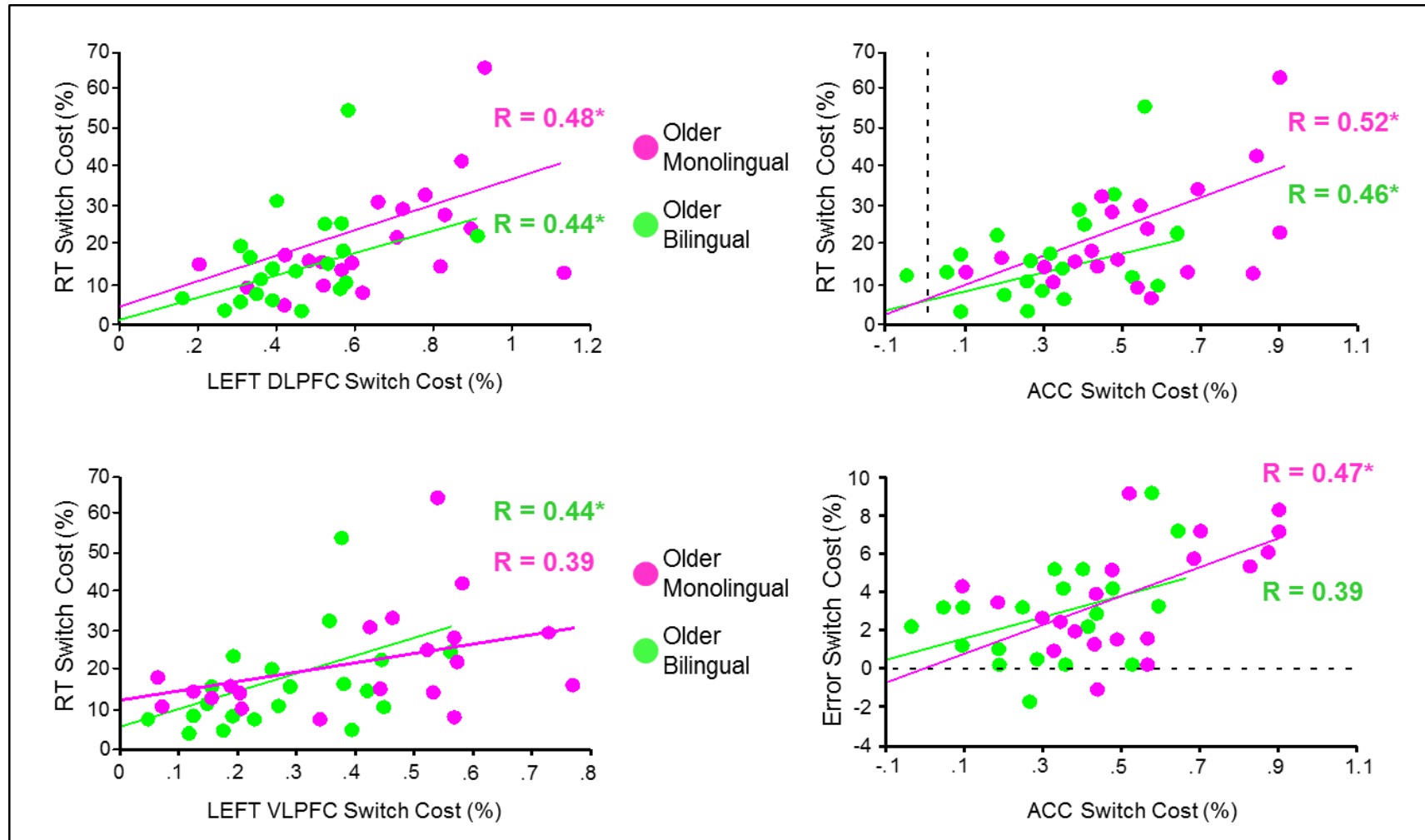


Older Bilinguals Show Lower fMRI Switch Costs



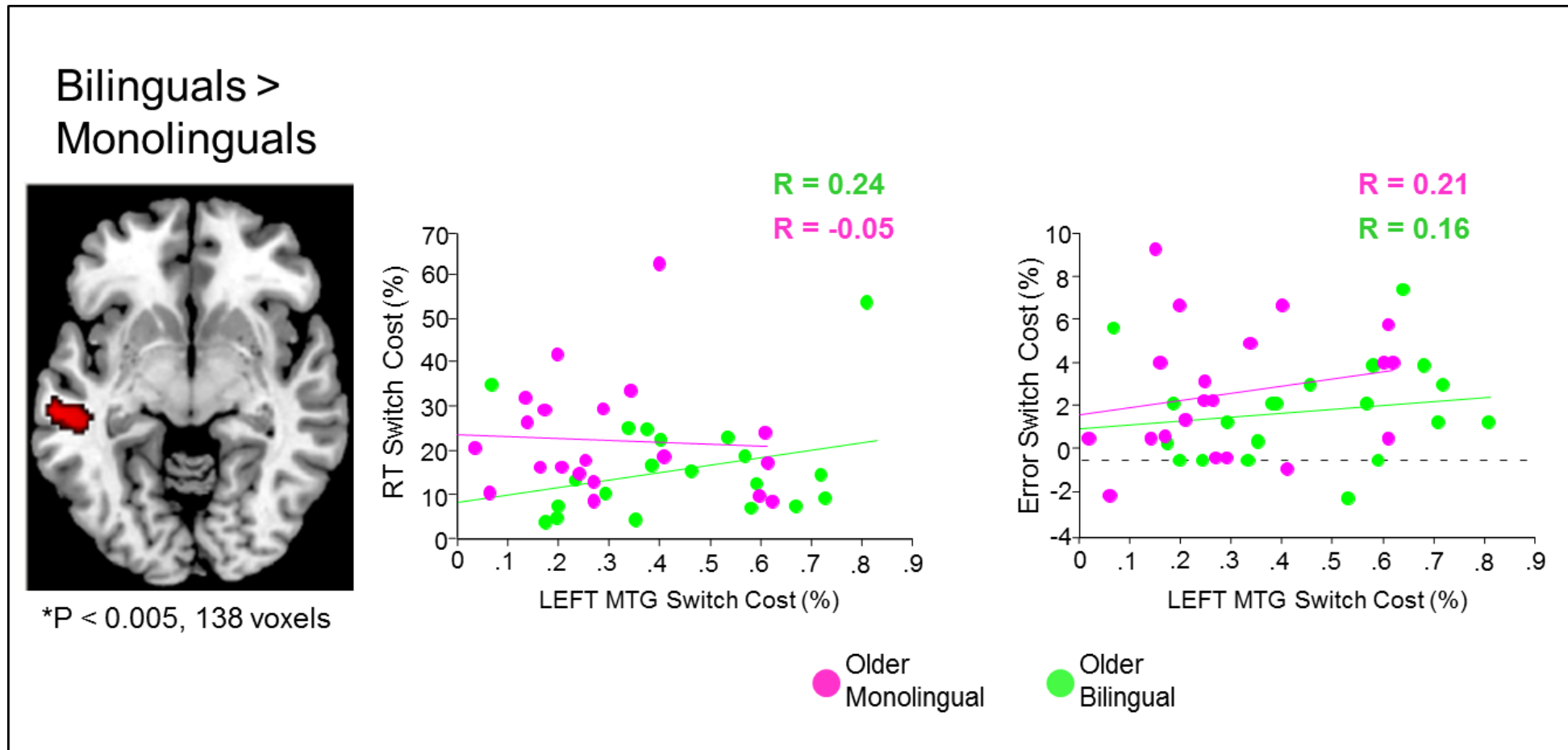
Note: * $P < 0.007$, * $P < 0.001$

Testing the Efficiency Hypothesis

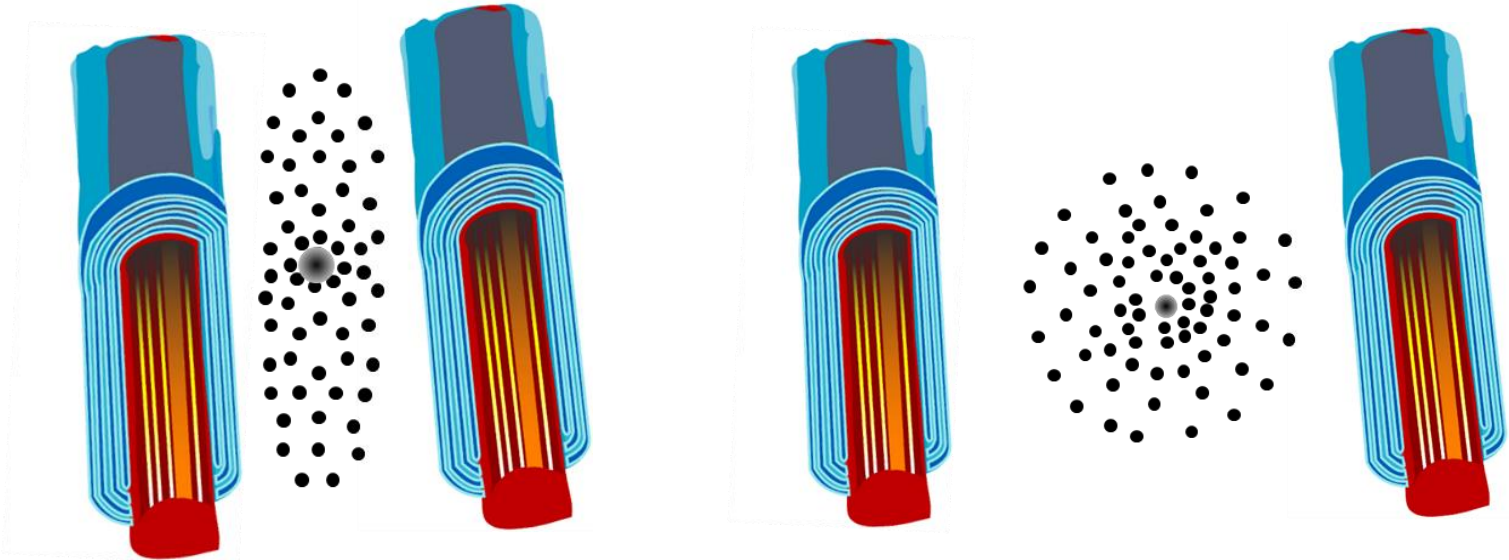
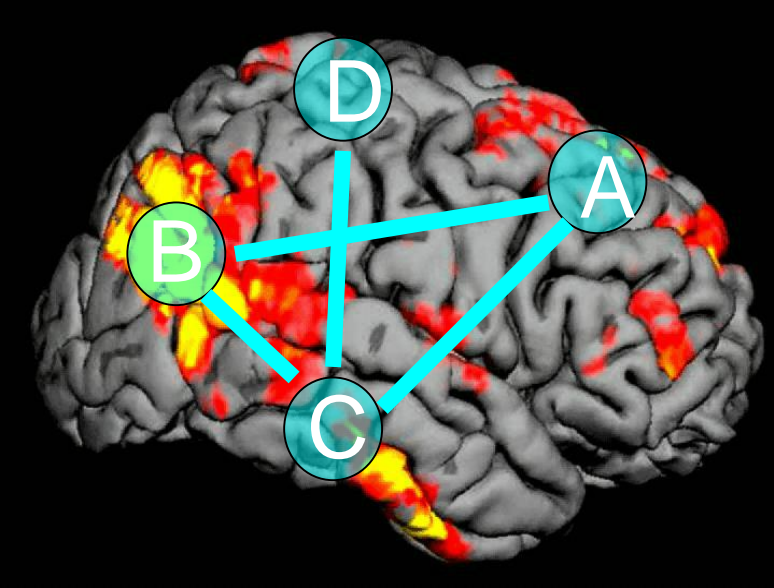


Note: *P < 0.05

Testing the Compensation Hypothesis



Efficiency: A Role for WM Microstructure?

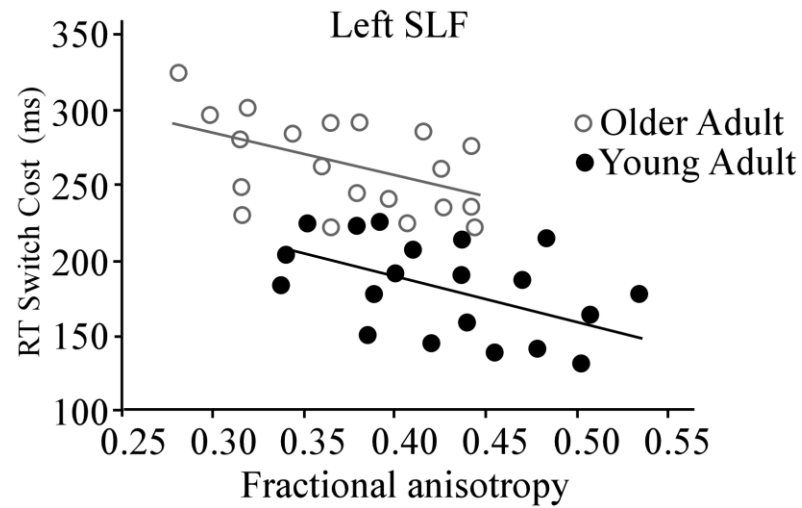


High fractional anisotropy (FA)

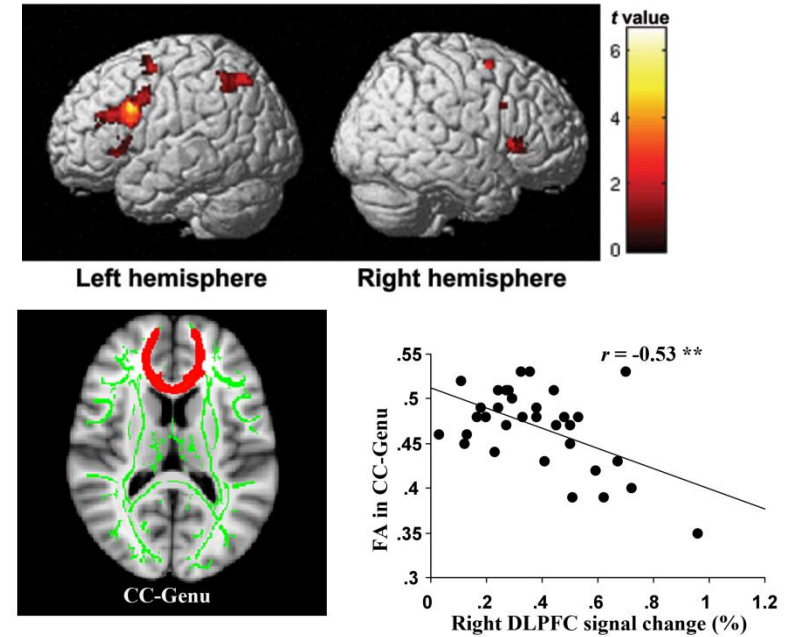
Low fractional anisotropy (FA)

WM Microstructure, RT and fMRI Magnitude

- Better WM microstructure has been associated with faster reaction time and lower fMRI response magnitude.



Gold et al. (2010) Neurobiol. Aging



Zhu et al. (2015) Cereb. Cortex

Study 2

Common Task Switching Network and Connecting WM Tracts

Age-Related WM Declines and Efficiency

Bilingualism and WM Microstructure

Efficiency

CONCLUSIONS



- Bilingualism may contribute to efficiency.
- The structural bases of efficiency are not yet fully understood but appear to include the quality of WM connections.
- Future research should assess the effects of second language learning on efficiency and WM microstructure.