Multilingualism and Aging

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Language Processing and Aging

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Multilingualism and Aging

Cognitive and Linguistic Processing in the Bilingual Mind

E. Bialystok
F. Craik

Outline

- Bilingualism and the Executive Control System
- Linguistic Ability and Executive Control
- Mechanism for the bilingual advantage
- Bilingualism and Cognitive decline
- Bilingualism and its Neural Basis
- Further discussion

Experience shapes the brain

Is bilingualism an experience?

In what ways does it shape the brain?

Does speaking more than one language make you better at language in general?

The fun fact of the day

For many years people believed bilingualism lead to mental retardation and school failure due to language delay.

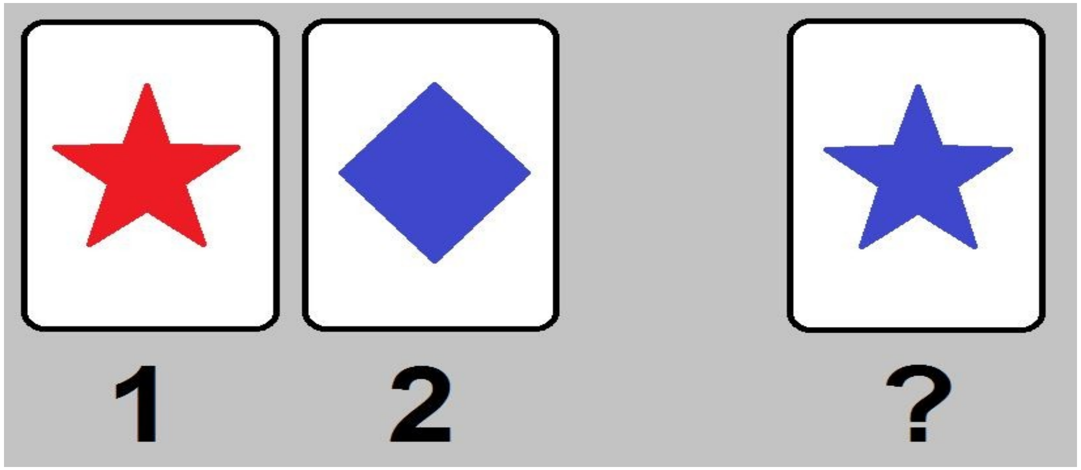
Bilingualism and the Executive Control System

- Ability to control attention, expand working memory, inhibit distraction

- Last cognitive skills to develop in childhood, first to decline with aging
- Compare monolinguals and bilinguals in similar tasks, where one condition requires executive control

Dimensional-change card-sort task (DCCS)
(Bialystok, 1999; Bialystok & Martin, 2004)

- 4- and 5-year olds
- Sort by colour or shape
- Children tend to persist sorting by the original dimension



Results DCCS

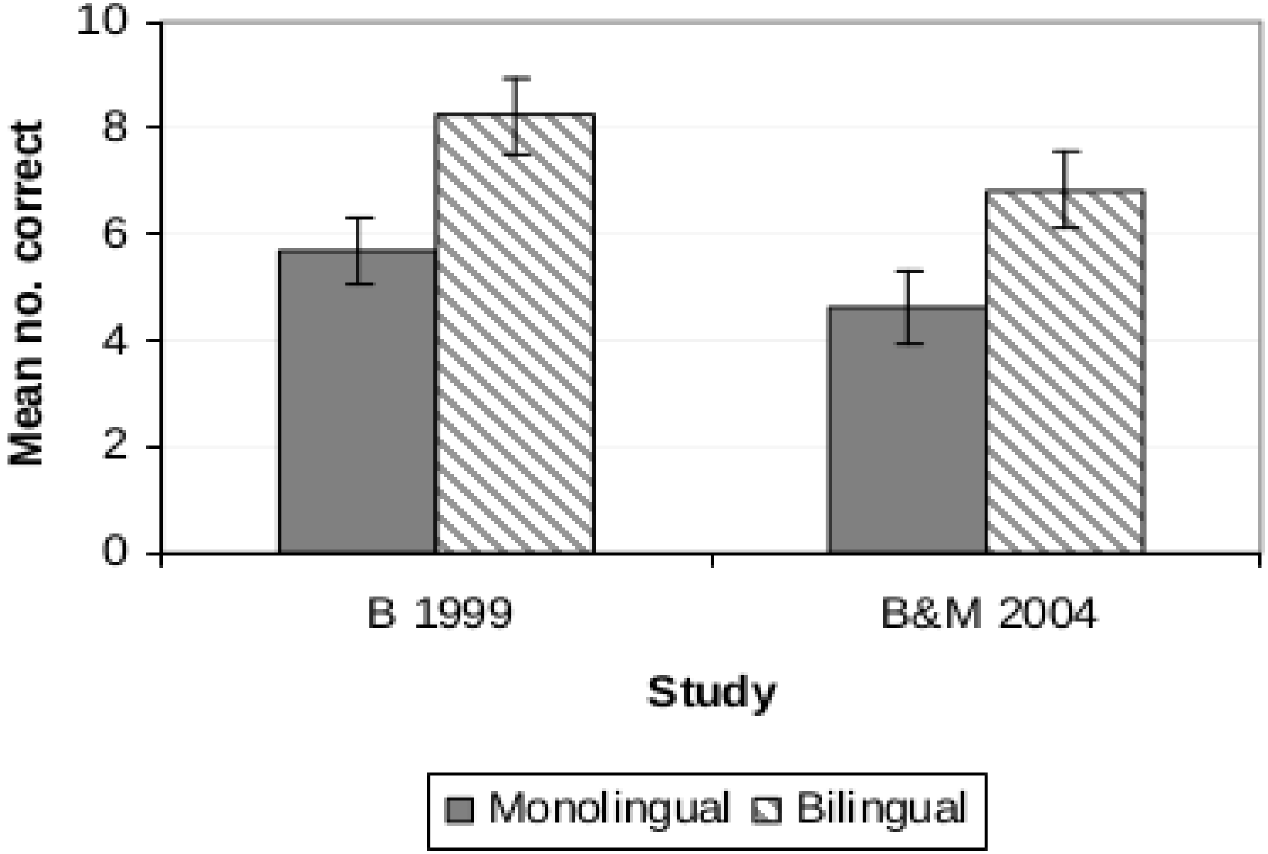
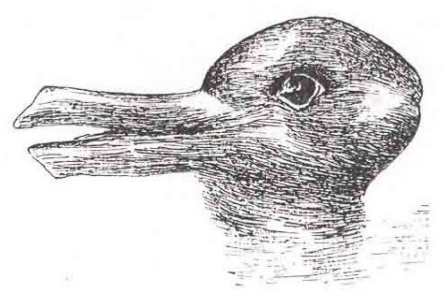


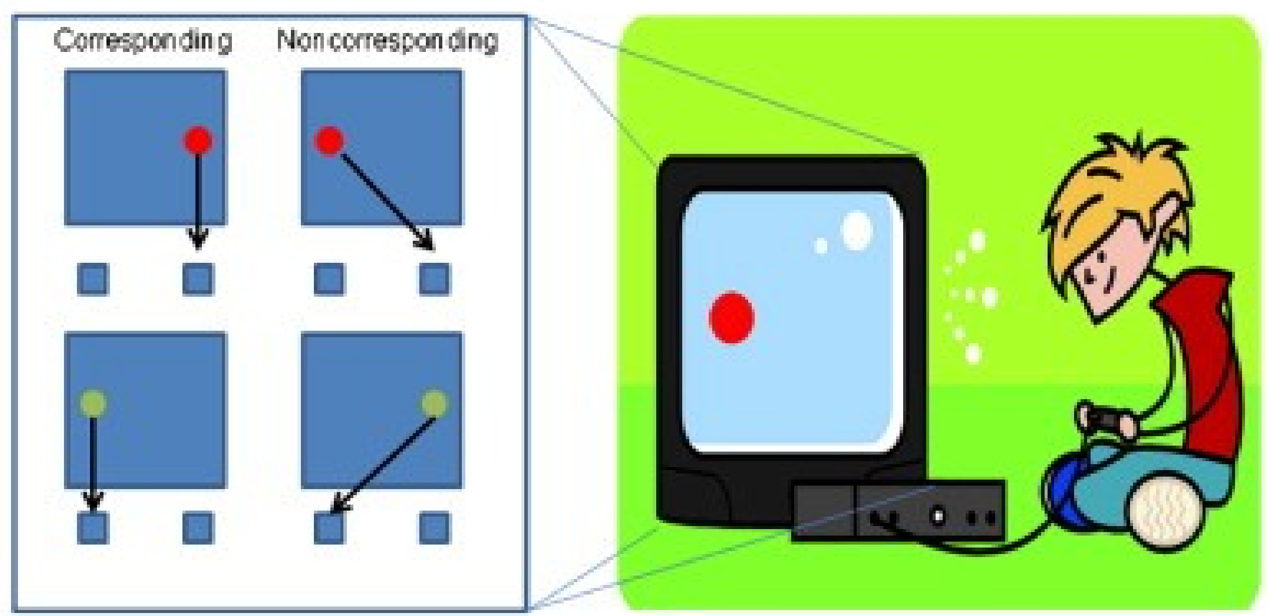
Fig. 1. Mean number correct (out of 10) and standard error by language group (monolingual or bilingual) in the post-switch condition of the dimension-change card-sort task in two studies. B 1999 = Bialystok (1999); B&M 2004 = Bialystok & Martin (2004).

Further studies on executive control



- 6- year old billinguals are more able to change their interpretation of an ambiguous figure
  (Bialystok & Shapero, 2005)
- 7-month old infants raised in bilingual housholds better switch responses after a rule shift
  (Kovacs & Mehler, 2009)
- Adult bilinguals are less dirupted by competing features of a stimulus; faster responces to conflict conditions in the Stroop and flanker task
  (Bialystok, Craik &Luk, 2008a and Costa, Hernandez & Sebastian-Galles, 2008)

Playing the Simon Game



Proctor R, 2010, Acta Psychologica

- Longer time needed to respond to the incongruent presentation
- Difficulty surpressing the irrelevant spatial information

The Simon effect

Bialystok, Craik, Klein, & Viswanathan (2004)

- Condition 1: center of screen
- Condition 2: congruent / incongruent
- Group A: 43.0 years (mean)
- Group B: 72.0 years (mean)

Results condition 1 (simple RT)

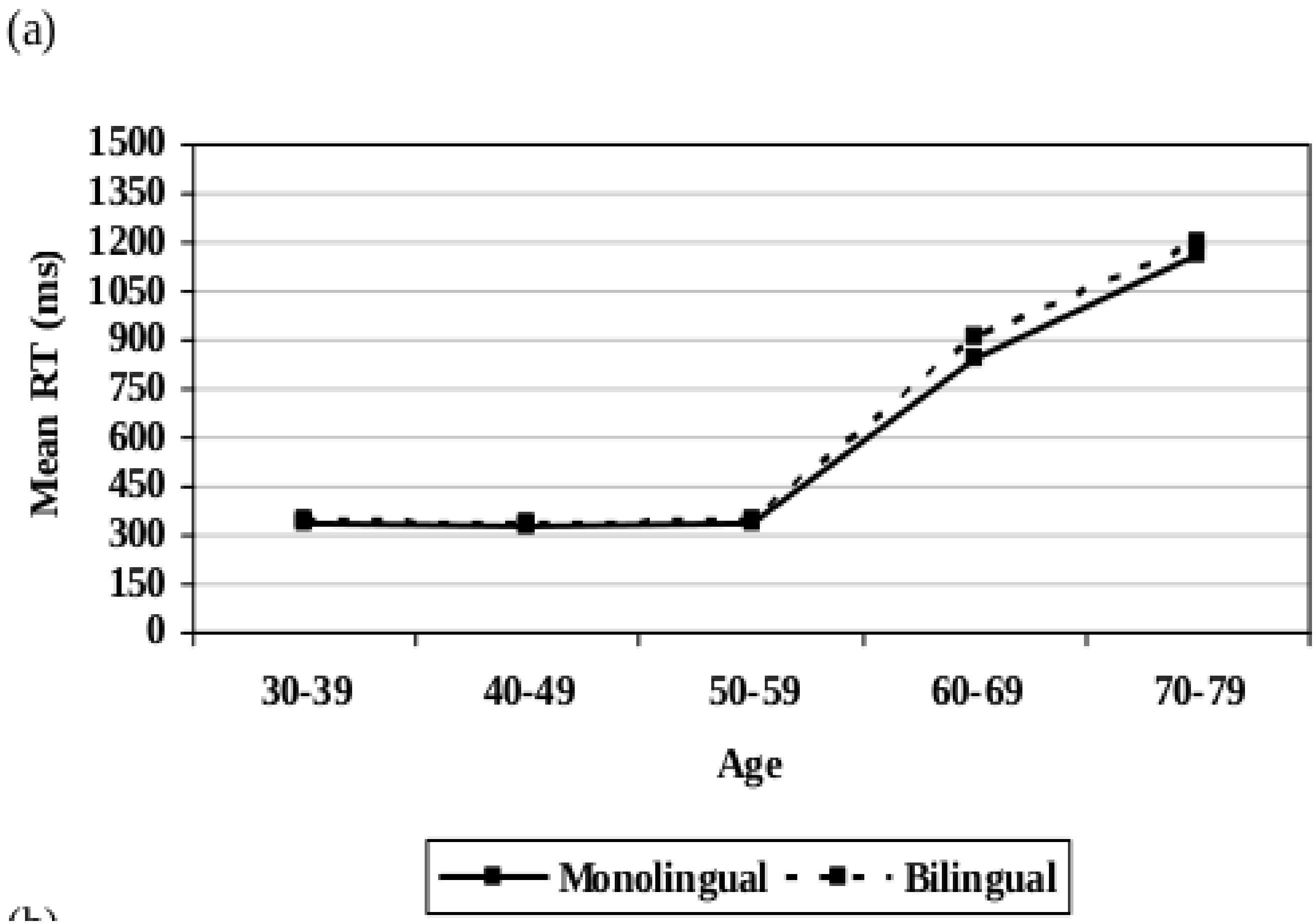


Fig. 2(a). Mean reaction time (RT) by decade for monolinguals and bilinguals. Mean RT for control condition.

Results condition 2 (Simon effect)

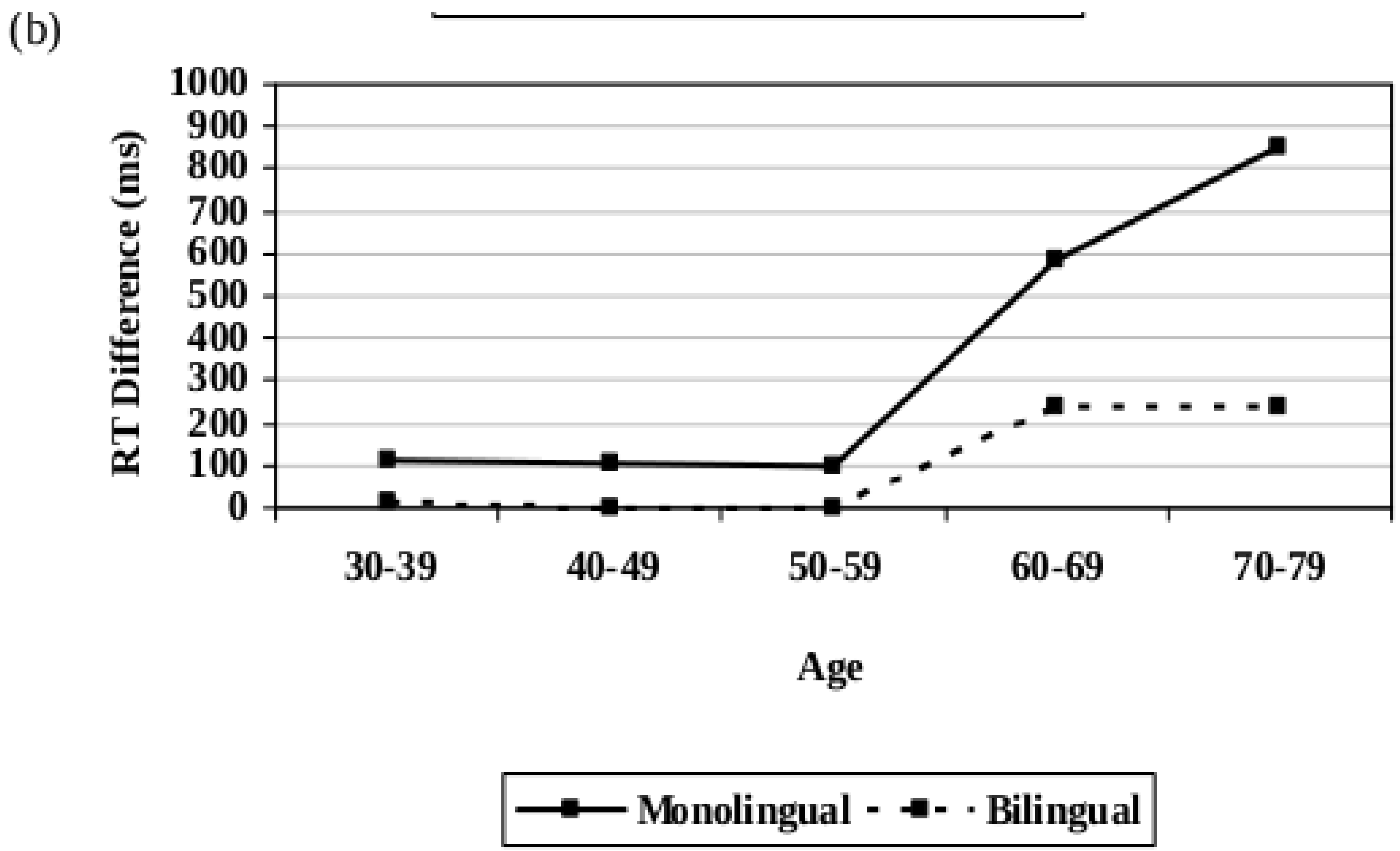


Fig 2.(b) Mean RT cost as the difference between congruent and incongruent trials (Simon effect).

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Linguistic Ability and Executive Control

- What's the effect of two language systems on linguistic performance?
- Do the conflicting influences co-exist?
- Independent or interactive effects?

Cognitive Control and Lexical Access in Younger and Older Bilinguals

(Bialystok et al., 2008a)

- 2x2 design:
  younger-older (20 vs 68 years)
  monolinguals-bilinguals

- Several tasks assesed:
  a) language proficiency & lexical access
  b) non-verbal executive functioning

Findings

- Monolinguals do better at lexical tasks
  Bilinguals at executive control tasks
- Younger do better than older, except in tasks tapping vocabulary knowledge (e.g. definitions)
- Large language-group differences in older adults; bilingualism might compensate for age-related decline in executive functions
- Lexical and executive functions are independent

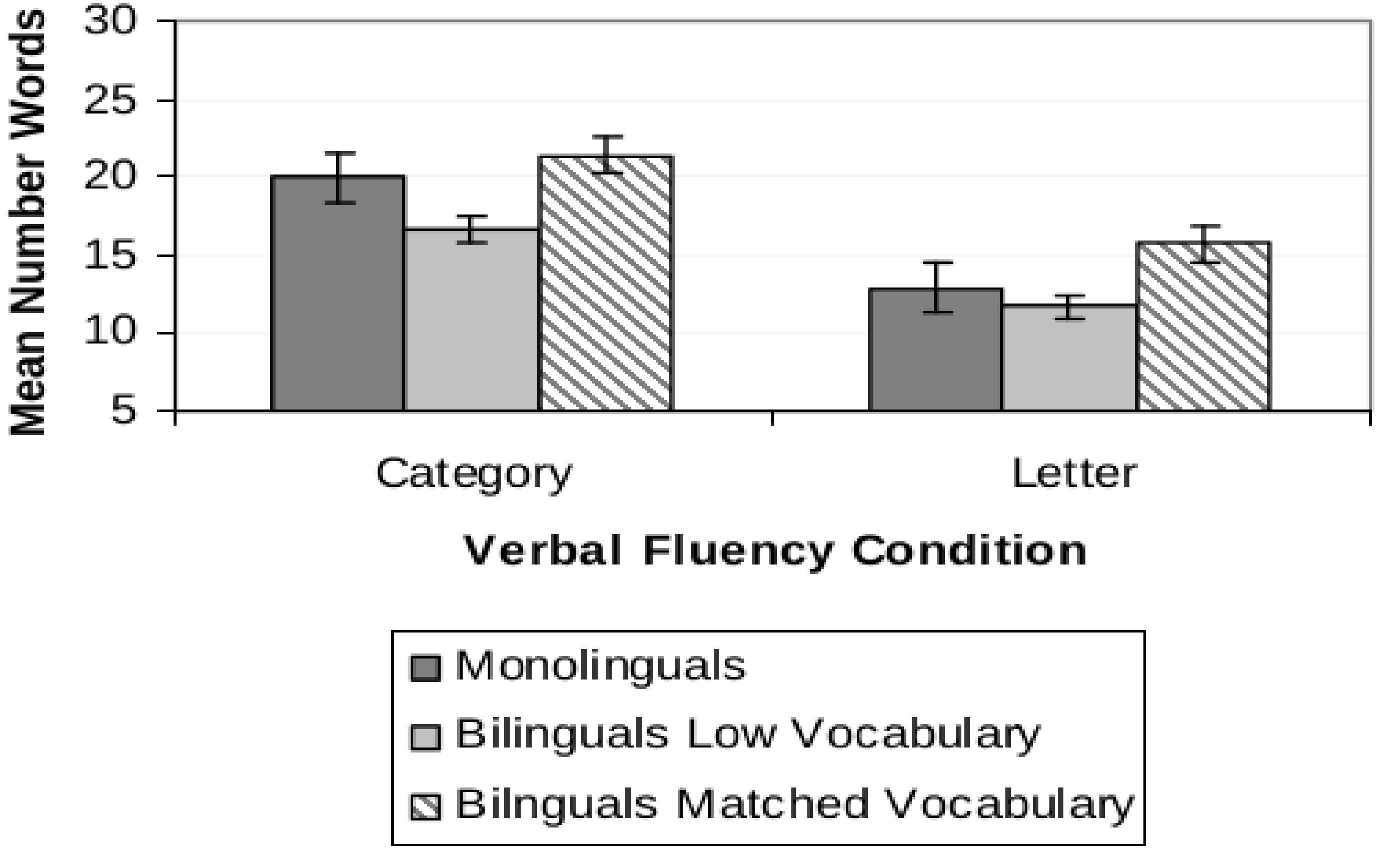
  BUT! Language processing often requires executive control

Verbal-Fluency task
(Bialystok, Craik & Luk, 2008b)

- 2 tasks:
  a) semantic fluency
  b) letter fluency

- **Letter fluency** assesses language proficiency and executive control
  (restrictions: no proper names, numbers or variations of the same word)

Results



- **Fig. 3.** Number of words generated on category-fluency and letter-fluency subtests of the verbal-fluency task for monolinguals, bilinguals with lower vocabulary, and bilinguals with vocabulary matched to monolinguals.

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Mechanism for the bilingual advantage

- Both languages active and available.
- Bilinguals need a system to resolve this conflict, possibly connected to the executive control system.
- Those effects were not found in speech-sign bilinguals, who can resolve conflict by producing both languages simultaneously.
(Emmorey, Luk, Pyers & Bialystok, 2008)

Billingualism and Cognitive decline

- “Cognitive reserve” against dementia
- Age of dementia for bilinguals was 4 years later than for monolinguals
  (Bialystok, Craik & Freedman, 2007)
- People who speak more than one language have twice as much brain damage as unilingual people before they exhibit symptoms of Alzheimer's disease (Schweizer et al., 2011)

Conclusions

- Bilingualism shows benefits on cognitive control
- Advances in development and maintenance of executive functions
- Negative effects only on verbal knowledge; smaller vocabularies, slower access

Is there also a direct evidence of a neural basis for the bilingual cognitive control boost in aging?

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Behavioral/Cognitive

Lifelong Bilingualism Maintains Neural Efficiency for Cognitive Control in Aging

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Assumed differences:

- Improved neural efficiency
- Successful neural compensation

➡ perceptual task-switching paradigm
➡ fMRT

Experiment I: Is there an advantage of bilingual over monolingual older adults?

Participants:

- N = 30 (15xbilingual, 15x monolingual, female)
- Mean age = 63.3 years (monolingual, SD = 3.8);

  64.1 years (bilingual, SD = 4.4)
- Lifelong bilingualism (10 years or younger, English + another language, proficiency in both languages)

Experiment II: Is it possible to replicate the bilingual advantage and is there an association to functional neuroanatomic variations?

Participants:

	monolingual	bilingual
younger	12♀+8♂ (32.3 mean age)	13♀+7♂(31.6 mean age)
older	10♀+10♂(64.4 mean age)	10♀+10♂(63.9 mean age)

- No significant difference for Education, IQ, Social position, Vocabulary,Digits backward/forwards, normal age related images

Method I: Perceptual task-switching paradigm

- Switching between task requires an increase of RT

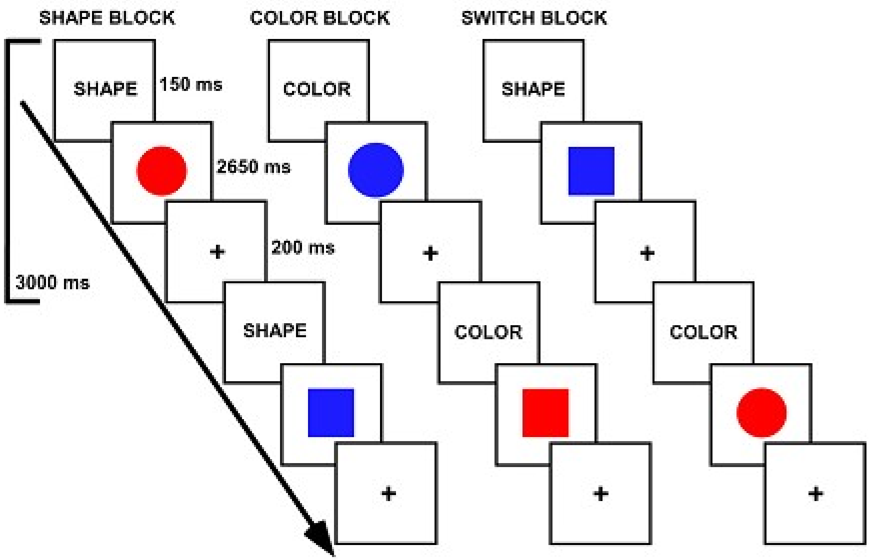


Figure 1. Task-switching paradigm (Gold et al. 2013)

<u>Procedures</u>:

- Block-design with 4 conditions
- Decision: shape or color via press a left/right button
- 3 runs with 4 conditions (total 80 trials)
- Measurement: Reaction time (RT)
  - Accuracy

→ Switch costs= $\text{Mean}_{\text{nonswitch}} - \text{Mean}_{\text{switch}}$

- Statistic analysis: ANOVA

Results: Experiment I

Accuracy *(ANOVA)*

- No main effect concerning the language group
  ➡ no significant differences between monolingual bilingual
- Main effect of condition
  ➡ more mistakes during switch-condition
- No condition X language group effect

Reaction time *(ANOVA)*

- No main effect concerning the language group
  ➡ no significant differences between monolingual bilingual
- Main effect of condition
  ➡ more mistakes during switch-Condition
- Sign. Effect condition X language
  ➡ Smaller switch costs for bilingual(M_{RT}=102ms) older adults than for monolingual older adults (M_{RT}= 152.1ms)

Method II: Functional neuroimaging studies.

- Brain activation of older people increases in switching task-related frontoparietal regions

- Older People use additional brain regions in switching task

Procedure:

- Same Perceptual task-switching paradigm during fMRT

- Control general age-related slowing → $(RT_{switch} - Rt_{nonswitch}) / (Rt_{nonswitch} x\ 100)$

- Statistic Analysis:
  - To **compare the efficacy of common task-switching regions**: they identified region of interest with conjunction analysis and tested with a 2(age) x2(language) ANOVA
  - To **figure out compensatory activation**: they do with all the other activated regions a cluster analysis.
  - To **identify neuronal correlates of behavioral switching advantage** by bilingual older adults: they measured the BOLD signal after stimulus onset and in each regions of interest. Correlation between neuronal switch costs and behavioral switch costs → Neuronal Switch costs = $Peak_{Bold.switch} - Peak_{Bold.nonswitch}$

Results: Experiment II (task-switching paradigm)

Accuracy *(ANOVA)*

- No main effect language group
- Main effect of condition
- No main effect of age (old/younger)
- No interactions

Reaction time *(ANOVA)*

- Main effect of condition
- No main effect of language group
- Sign. Main effect of age

➡ Older (M_{RTold}=890.8ms) need longer RT $M_{RTyoung}$=757.4ms)

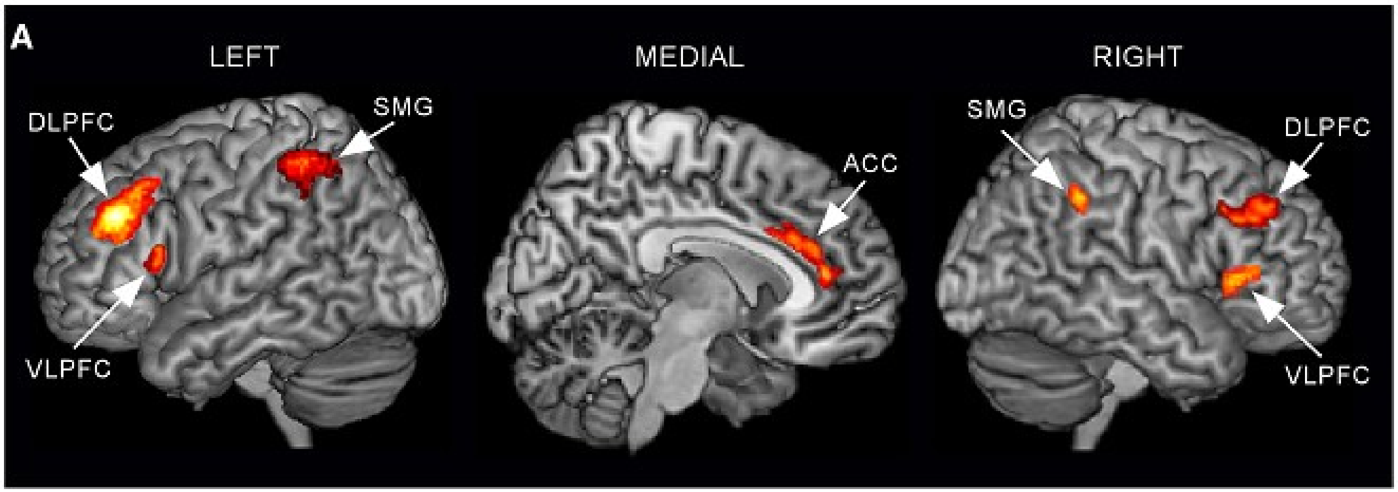
With the control for general age-related slowing:

- Tendency of Interaction age group X language group

  ➡ smaller RT switch costs of older bilinguals than older monolinguals, but no difference in younger participants

Results: Experiment II (fMRT)

Region of interest



DLPFC, BA (46/9): bilateral dorsolateral prefrontal cortex

VLPFC, BA (44/45): bilateral ventrolateral prefrontal cortex

ACC, BA24/32): anterior cingulate cortex

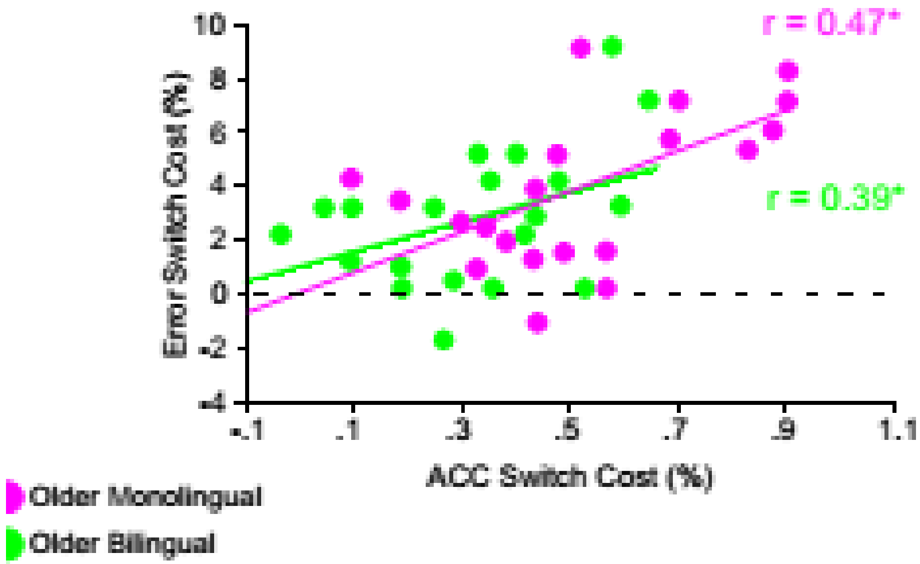
SMG BA 40:bilateral supramarginal gyrus

Comparison of the efficacy of common task-switching regions *(ANOVA)*

- Main effect of age in the frontal regions → older adults having increased activation.
- No main effect of language group at all
- Left site frontal regions and acc show a sign. age x language group Interaction
  → older (not younger) bilinguals have lower activation compared to old (not young) monolinguals
-
-

Results: Experiment II (fMRT)

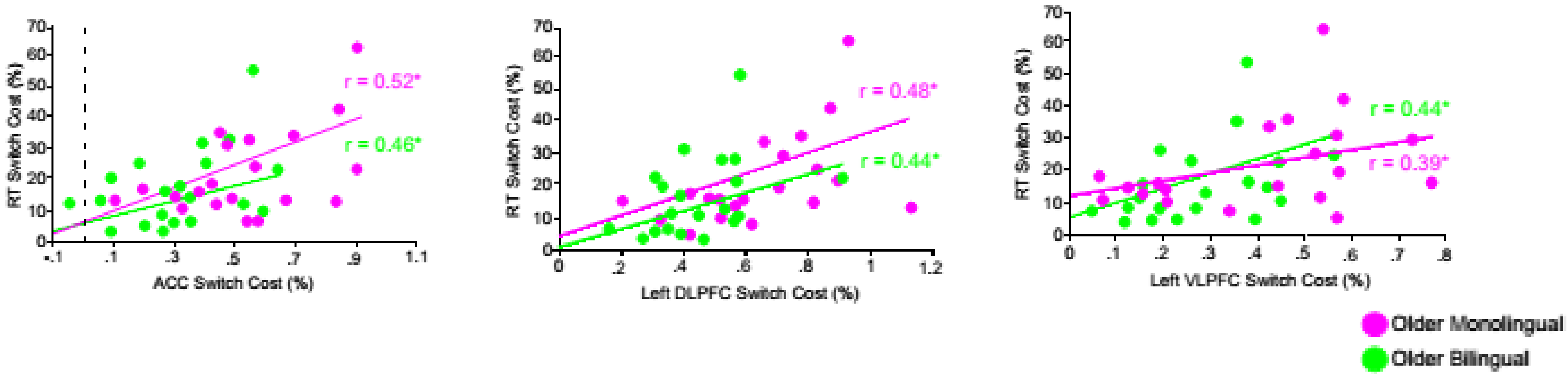
Relation between behavioral and neural switch cost *(Regression analysis)*
(Independent V: left site frontal regions and ACC ; dependent V: behavioral switch coast)



- Only for ACC switch costs and Error Switch Cost (not accuracy) is a significant relation.

Results: Experiment II (fMRT)

Relation between behavioral and neural switch cost *(Regression analysis)*
(Independent V: left site frontal regions and ACC ; dependent V: behavioral switch coast)



- Positive relation between reaction time and neuronal switch costs in all three regions.

Taken together and going a little further *(hierarchical regression)* :

- Significantly higher task-switching neuronal activation in older adult monolinguals than bilinguals.
- Positive correlation of neuronal activation and proportional RT switch coast in both adults group

Does neuronal response in these three regions mediate differences in reaction time?

Table 5. Effects of bilingualism and BOLD signal on proportional RT switch costs

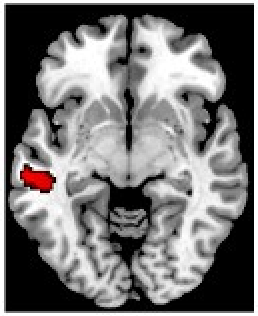
	r^2	Increment in r^2	F	% Attenuation
Model 1				
Language	0.092		3.86*	
Model 2				
BOLD	0.377		7.54***	
Language	0.394	0.017	0.46	81.52

BOLD reflects average neural switch cost in left DLPFC, VLPFC, and ACC. *p = 0.056, ***p < 0.001.

→after controlling neuronal response language group isn't a sign predictor anymore. **Neuronal response (BOLD) may explain 83% of language group related variance**

Results: Experiment II (fMRT)

Is there compensatory activation in other regions?



MTG: left middle temporal gyrus

- Difference of MTG activation in language group in each of the bilingual groups (→ no age effect, no interaction), but there was no correlation with RT.

What does all that tell us about bilingualism, aging and brain:

- First direct evidence of neuronal basis for bilingual cognitive control advantage in aging.
- ➔ Bilinguals switched between perceptual task sign. faster than monolingual peers
- ➔ Require less activation in three frontal brain regions older bilinguals show the same less effort full way of processing as younger people.
- ➔ Effects of bilingualism on task switching are lager in older adults.
- ➔ There were only findings for declines of neural efficiency not for compensatory activation
- ➔ Neuronal efficiency may be a core mechanism of bilingual task switching advantage in aging
- ➔ Maybe bilinguals have got a daily training so that task switching shifts from strategic to automatic processing which require less efforts.

Further questions

1) Speaking two languages shows beneficial effects on cognitive control. Three languages? Two-fold effects? What if languages are related (Mandarin-English or Spanish-Portuguese)?

1) Progressing from 2 to 3 languages, instead of staying bilingual, was associated with a 7-fold protection against CIND (Perquin et al., 2013).

Kave et al. (2008) found that knowledge of multiple languages might be a significant determinant of congitive state in old age, beyond the effects of other demographic factors.

Table 2

Mean Scores on Cognitive-Screening Tests, by Wave and Language Group

Language group	Wave 1 (Katzman)		Wave 2 Katzman		Wave 2 Folstein		Wave 3 (Katzman)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Bilingual	10.0	8.2	11.7	7.7	21.3	5.8	12.7	8.8
Trilingual	7.0	6.4	8.6	6.6	24.1	4.8	11.8	7.8
Multilingual	5.4	5.7	6.1	6.1	25.8	4.5	6.1	5.6
Total	7.1	6.9	8.1	7.0	24.3	5.3	9.5	7.7

Note. Katzman = the Katzman et al. (1983) test; Folstein = the Mini-Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975). Lower scores on the Katzman et al. test indicate better performance. Lower scores on the MMSE indicate poor performance.

Further questions

2) Multilingualism is usually a result of better education. Studies have shown that education contributes to cognitive reserve more than other demographic factors such as gender, occupational status, socio-economic class. Is multilingualism just a confound?

2) Kave et al. showed similar effects of multilingualism in uneducated adults.
In educated ones, both main effects of education and multilingualism are significant, but there is no interaction between them.

“Degree of bilingualism predicts age of diagnosis of Alzheimer's disease in low-education but not in highly educated Hispanics” (Gollan et al.)

Further questions

3) “Thus, the notion of cognitive reserve reflects either innate cognitive capabilities that lead to the attainment of higher education or lifelong cognitive activities that continue to accumulate over the years, or both” (Scarmeas & Stern, 2003)
Is multilingualism the cause or the result of better cognitive performance? What is your opinion?

4) Executive control is situated in the frontal lobes, which is the last brain area to mature. Does this mean that bilingualism can have an effect on executive control only during a critical period of development?

5) The delay of 4 years in the symptoms of dementia is an effect greater that those associated with drugs. Can educational and behavioural interventions substitute medical treatment? What are the implications for health care systems?

Further questions

6) Study results are contradictory between immigrant and non-immigrant groups of participants. Think of reasons why this might be the case.

7) Is it useful to start language studying in kindergarden, so that everybody shows great cognitive inhibition?

8) Can you imagine something else which has got probably the same effect as bilingualism?

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Спасибо
Gracias
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Спасибо
Dank U
Grazie
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