

The effect of alternational code-switching on bilinguals' executive functions

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Research question: How do bilinguals' code-switching habits modulate their performance at tasks testing executive control?

independent variable:

socio-linguistic
code-switching habits

modulate



dependent variable:

non-linguistic
performance tasks testing
executive functions

language pair constant:

German-English bilinguals

Definition executive functions

umbrella term for processes orchestrating goal-oriented behaviour

Inhibitory control

- inhibit undesired task-schemata
 - global** versus **local**
- (Taomei & Kroll, 2011)



Monitoring

~**mental flexibility**

- ability to manage co-activated competing task-schemata
 - de & re-activation of inhibition
- (Botvinick et al., 2001)

Bilingual “advantages” / restructuring effects

- explanation: executive functions involved in bilingual language control processes
- > enhanced practice -> enhanced performance (Bialystok, 2009)
- recent suggestion: bilingual behaviour challenging language control processes, i.e. code-switching, at root of bilingual executive modulations (Costa et al., 2009, Soveri et al., 2011)

Code-switching

Definition

mixing co-activated languages within same utterance

Ich gebe dem Kinobesuch heute A MISS.

I give the cinema visit today A MISS.



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- bilingual optimisation strategy (Bhatt & Bolonyai, 2011)
- requires constant monitoring of appropriate language choice
- “juggling” of co-activated languages enhances mental flexibility
- executive control modulation depends on code-switching type

Code-switching types (Muysken, 2000; Treffers-Daller, 2009; Green & Li Wei, 2014)

(1) alternation (a)

structurally independent stretches of language A and B alternate

Ich kann heute nicht kommen BECAUSE I'M ILL.

I can't come today BECAUSE I'M ILL.

(2) insertion (i)

constituents from language B inserted into grammar of language A with partial co-activation at the lexical level, but inhibition of grammar B

Wir suchen noch VOLUNTEERS fuer das Projekt.

We are still looking for VOLUNTEERS for the project.

typical for 1st generation immigration settings

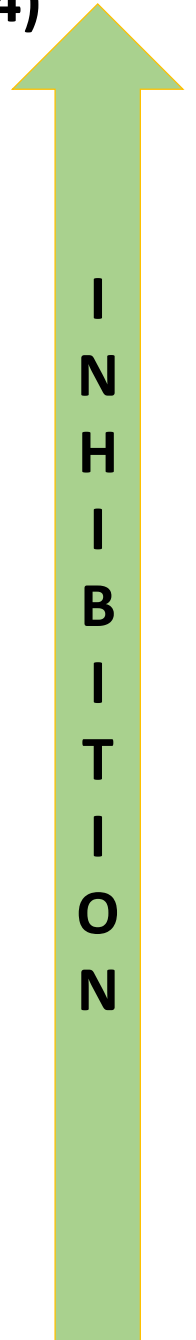
(3) congruent lexicalisation or dense code-switching (d)

co-activation of grammar and lexicon of languages A and B requiring little or no inhibition, but monitoring of co-activation

Wir haben FRIENDS gemacht mit'm SHOP OWNER.

We have FRIENDS made with th' SHOP OWNER.

associated with communities with several generations of language contact



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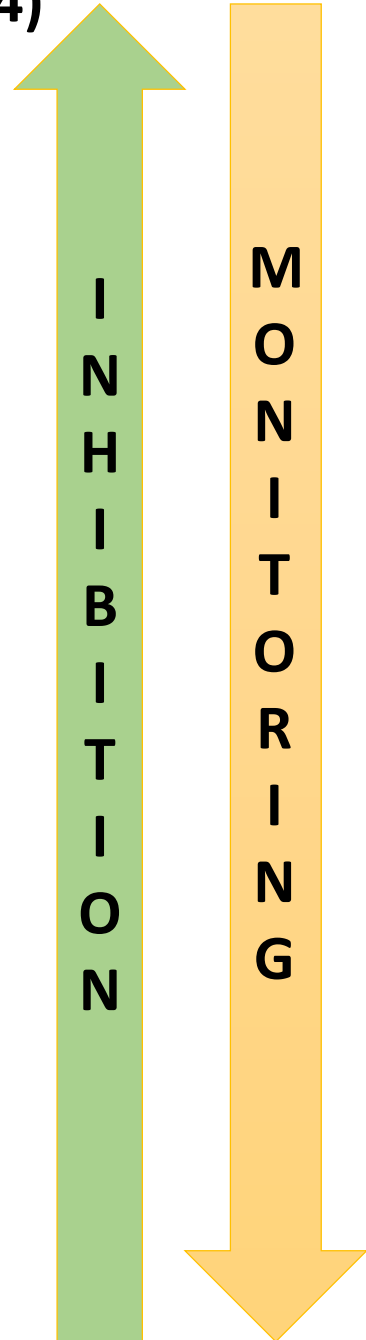
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Project hypotheses

Focus on the two “extreme ends” of the continuum,
i.e. alternation and dense code-switching.

- 1) Alternational code-switching frequency will correlate positively with inhibitory control performance.
- 2) Dense code-switching frequency will correlate positively with performance in tasks challenging monitoring.
- 3) Executive function modulations through code-switching will translate into bilingual advantages compared to monolinguals.

Participants

Bilinguals: L1 = German, L2 = English, immersed in UK L2-context, N=43

Monolinguals: control group, L1 = English, no active bilingualism, N=41

Variable	Group	Mean	Std. Dev.	P-value	N
Age	Monolinguals	33.83	11.80	0.47	41
	Bilinguals	32.14	9.56	0.47	43
Education	Monolinguals	4.12	0.87	0.69	41
	Bilinguals	4.20	1.10	0.69	43
Non-verbal IQ (Ravens Progressive Matrix)	Monolinguals	110.44	18.04	0.10	41
	Bilinguals	116.28	13.61	0.10	43
Short-term Memory (Digit span forward)	Monolinguals	6.21	1.07	0.38	41
	Bilinguals	6.40	0.80	0.38	43
Working Memory (Digit span backward)	Monolinguals	4.48	1.21	0.82	41
	Bilinguals	4.53	0.84	0.82	43

Methods
independent variable code-switching

Multi-method approach assessing language mixing profile

Code-switching typical of informal registers characterised by high levels of interlocutor familiarity -> hard to replicate in experimental settings (Gardner-Chloros, 2009)

- language history and dominance questionnaires
- **detailed language switching questionnaire**
(scores for CS attitude, CS frequency, CS frequency by type)
- monolinguals: dialect / register switching questionnaire
- **frequency judgement task indicating cognitive embedding (Backus, 2014)**
- email discourse completion task (Sweeney & Hua, 2010)
- authentic emails
- short elicited conversation (topic: work)

aim: treat code-switching as a continuous variable to take into account individual variation

Frequency judgement task measures code-switching as a continuous variable

instruction:

“How often do you come across this type of sentence when talking to other German-English bilinguals?”

rate from “1” = never ----- to ----- “7” = very frequently

Why “frequency” rather than “acceptability” judgement? Code-switching still stigmatised, so acceptability judgement might bring too much of an attitudinal element into the rating.

presentation in visual and audio format in pseudo-randomised order:

Ich gebe dem Kinobesuch heute a miss.

(I'll give the cinema visit a miss today.)



stimuli:

14 insertion German into English

14 insertion English into German

14 alternation

14 dense code-switching

14 monolingual control utterances

- **authentic utterances from existing corpora (Eppler, 2004, Clyne, 2003)**
- **classification using criteria catalogue (Deuchar, Muysken & Wang, 2008)**

Code-switching classification for stimulus creation and production task analysis

spreadsheet containing extensive list of criteria calculating a score for each code-switching instance for insertion, alternation and dense code-switching thus identifying a predominant pattern (Deuchar, Muysken & Wang, 2008)

insertion	alternation	dense code-switching
-matrix language identifiable	-several constituents switched	-matrix language not identifiable
-nested aba structure	-non-nested, periphery, adjuncts, discourse markers	-non-nested, cross-constituent mixing
-content words	-switch at major clause boundary	-mixed collocations, calque translations
-integration, complements	-flagging, hesitation (indicating increased inhibitory effort?)	-bidirectional mixing, frequent back and forth switching
-morphological integration	-no morphological integration	-morphological integration, structural equivalence, convergence

Methods
dependent variable executive control

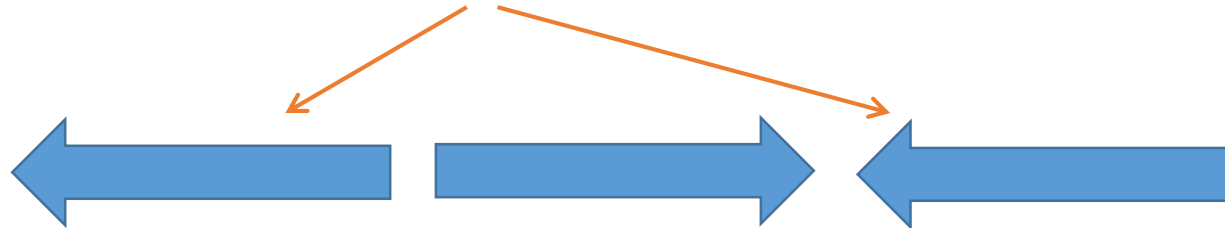
Flanker task: inhibitory control performance measurement

instruction: Does the central arrow face leftwards or rightwards?

congruent condition: faster RTs



incongruent condition: slower RTs
inhibition of distracting stimuli



measure of inhibition - conflict effect CE:

RT incongruent condition – RT congruent condition

The smaller your CE, the better you are at inhibition.

3 blocks of flanker trials varying in proportion of congruent to incongruent trial switching resulting in different cognitive load to EC (Costa et al., 2009)

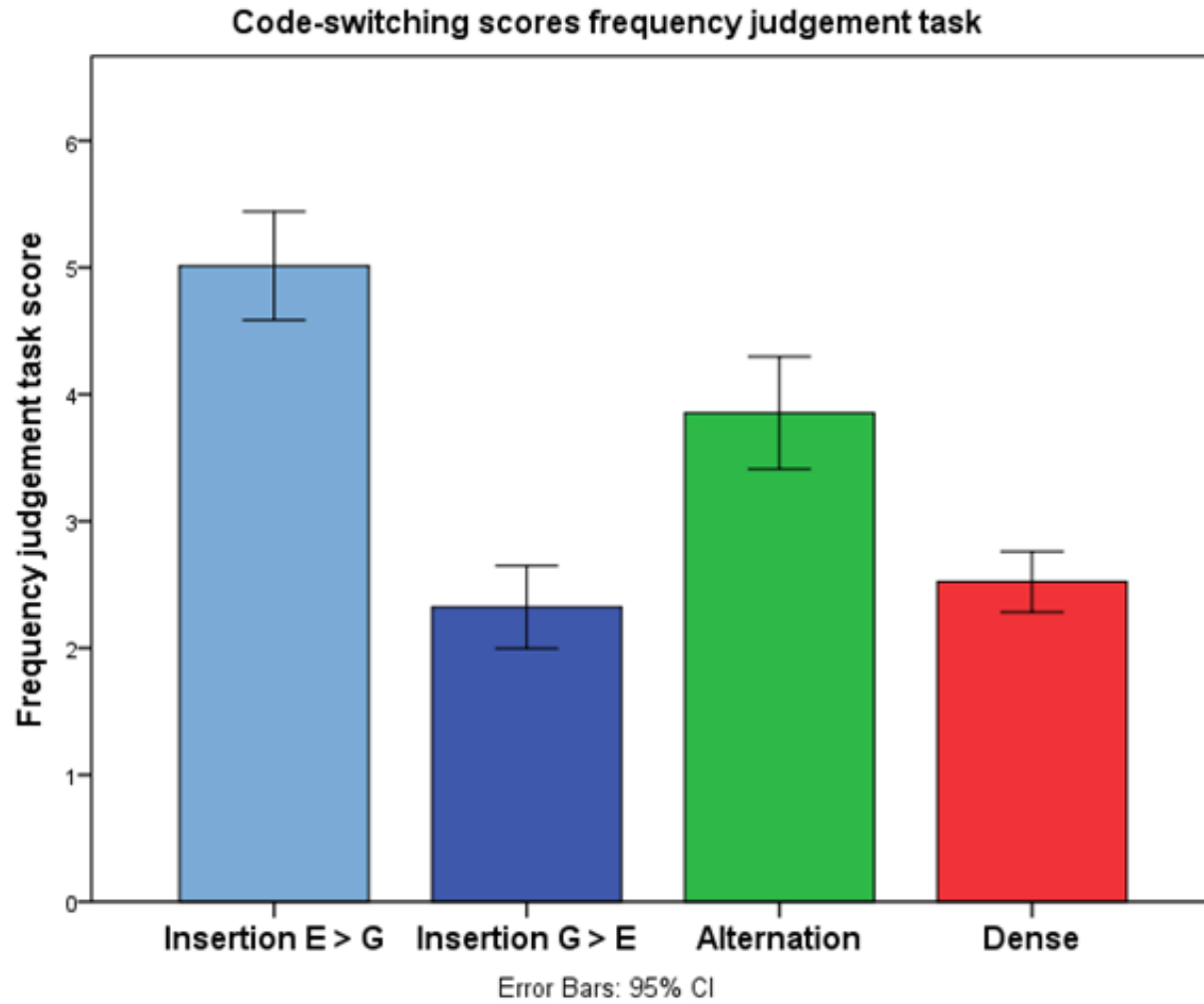
block label	congruent trials	incongruent trials	Monitoring cost	Inhibitory Load
92 low	92 %	8 %	Low	High
75 medium	75 %	25 %	Medium	Medium
50 high	50 %	50 %	High	Low

Monitoring Cost = RTs in 50 high Block – RTs in 92 low Block

The smaller your **monitoring cost MC**, the better you are at **monitoring**.

Results

Code-switching types used by German-English bilinguals



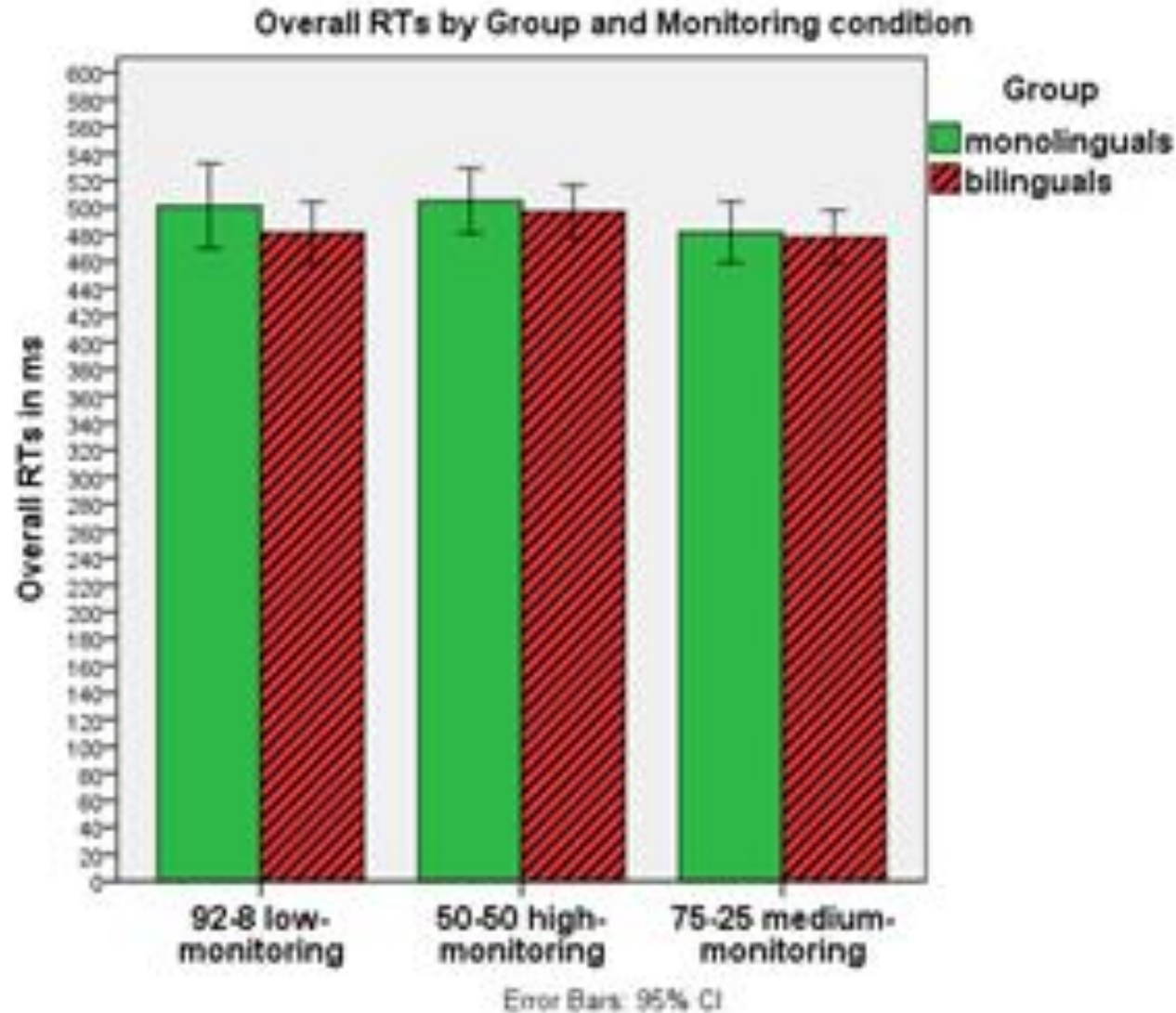
-all types of code-switching represented to some extent

-significantly more Insertion and Alternation

-low Dense code-switching scores

-dis-preference for Insertion English into German

Comparison monolinguals to bilinguals for Overall RTs / Monitoring



no interaction, no group difference

Multiple regression: Predictors of Overall RTs / Monitoring

Non-linguistic predictor variables:

Age, Education, IQ, Short-term memory, Working memory

Monolinguals: **Age** explains 33.7% and **IQ** explains 15.7% of Overall RTs variance ($p=0.001$)

Bilinguals: **Age** explains 39% of Overall RTs variance ($p=0.000$)

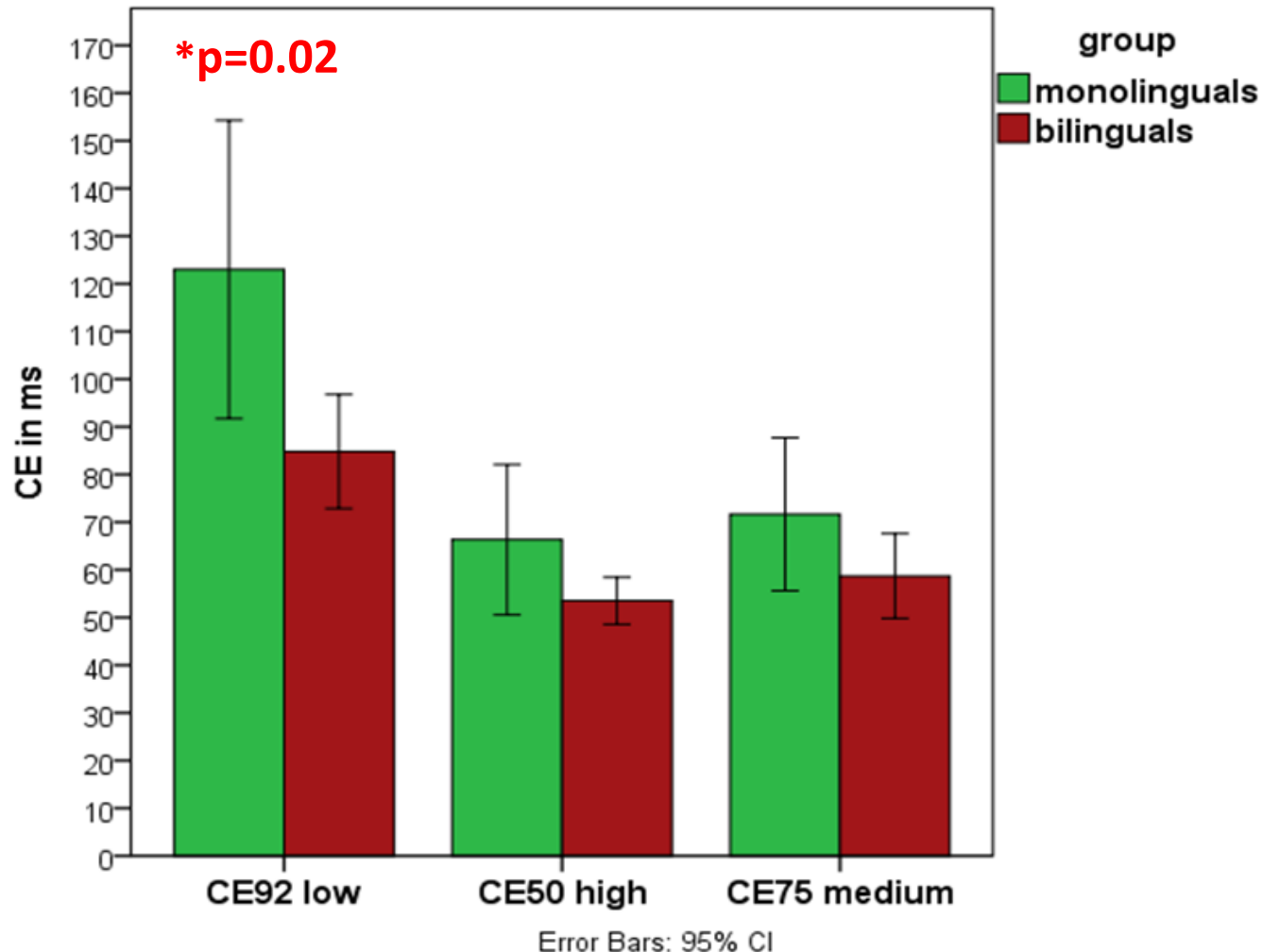
unsurprising: Age increases RTs & IQ correlates with cognitive abilities

Similar predictors of Overall RT performance for monolinguals and bilinguals.

Comparison monolinguals to bilinguals for Conflict effect

-interaction CE * Group ($p=0.046$)

Conflict effect by group and monitoring condition



-Bilinguals outperformed monolinguals at CE in 92low condition ($p=0.02$)

-CE in 92low greater than other conditions ($p=0.00$) suggesting greatest inhibitory control effort

-Bilinguals outperformed monolinguals at the condition posing greatest cognitive load to inhibition

Multiple regression: Predictors of Conflict effect in 92-8 condition

Non-linguistic predictor variables:

Age, Education, IQ, Short-term memory, Working memory

Monolinguals: **IQ** & **Age** explain 65% of inhibitory control performance variance ($p=0.016$); **unsurprising:** Age increases RTs & IQ correlates with cognitive abilities

Bilinguals: **None** of the non-linguistic variables explain performance! Different predictors?

Additional regression with linguistic predictors: Proficiency, English Age of Onset, Immersion, Proficiency balance, Code-switching frequencies (Insertion E $\rightarrow$ G, Insertion G $\rightarrow$ E, Alternation, Dense code-switching)

Multiple regression Conflict effect in 92-8 condition (bilinguals only)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.382 ^a	.146	.125	36.34842203	.146	7.005	1	41	.011
2	.487 ^b	.238	.199	34.76879068	.092	4.810	1	40	.034

a. Predictors: (Constant), alternation

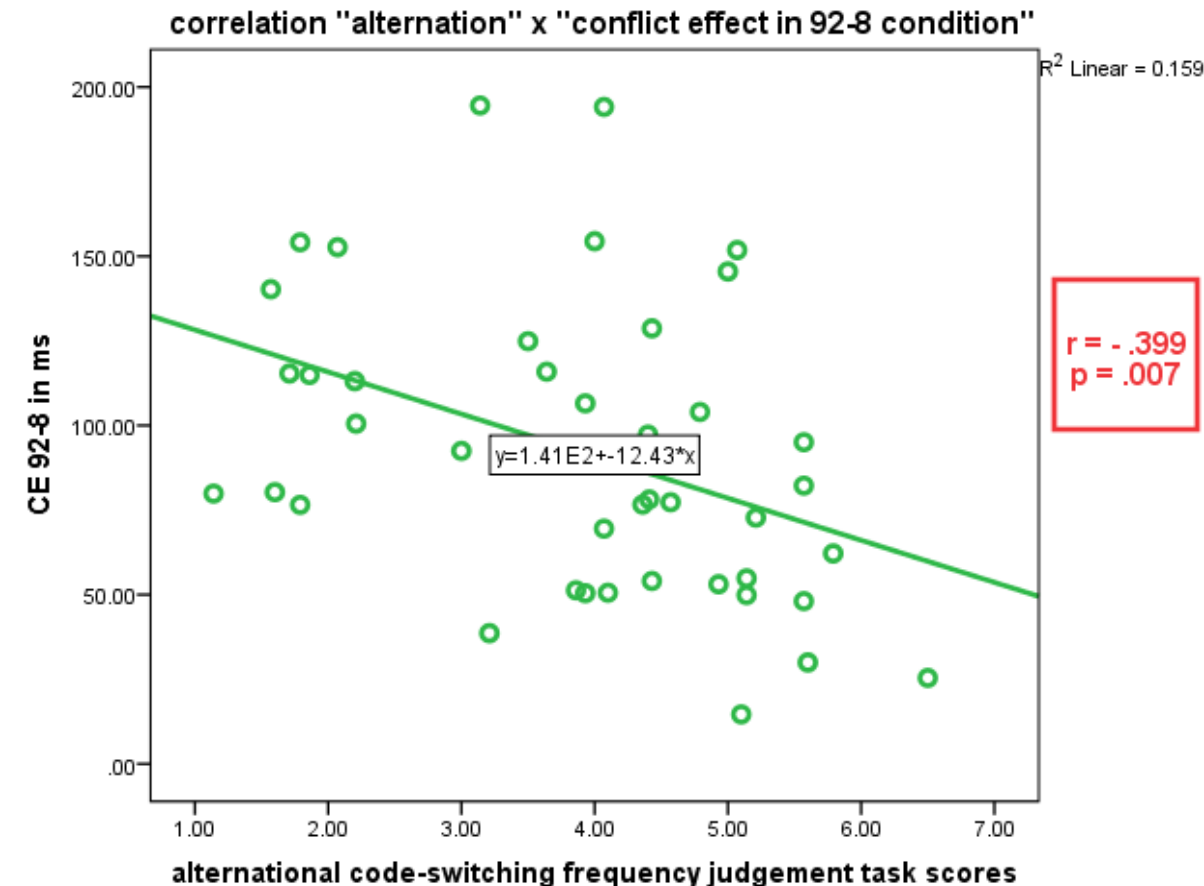
b. Predictors: (Constant), alternation, Immersion

-**Alternational code-switching** primary predictor

-**Immersion** (Time) second significant predictor

This “couple” of predictors suggests:

The more bilinguals engage in Alternation and the longer they do this (Immersion), the better they are at inhibition in the condition requiring the type of inhibition mirroring inhibitory processes during Alternation.



Converging evidence from questionnaire scores

Linguistic predictors: Proficiency, English Age of Onset, Immersion, Proficiency balance, Code-switching frequencies (Insertion E -> G, Insertion G -> E, Alternation, Dense code-switching)

+ controlling for Code-switching attitudes (Insertion E -> G, Insertion G -> E, Alternation, Dense code-switching)

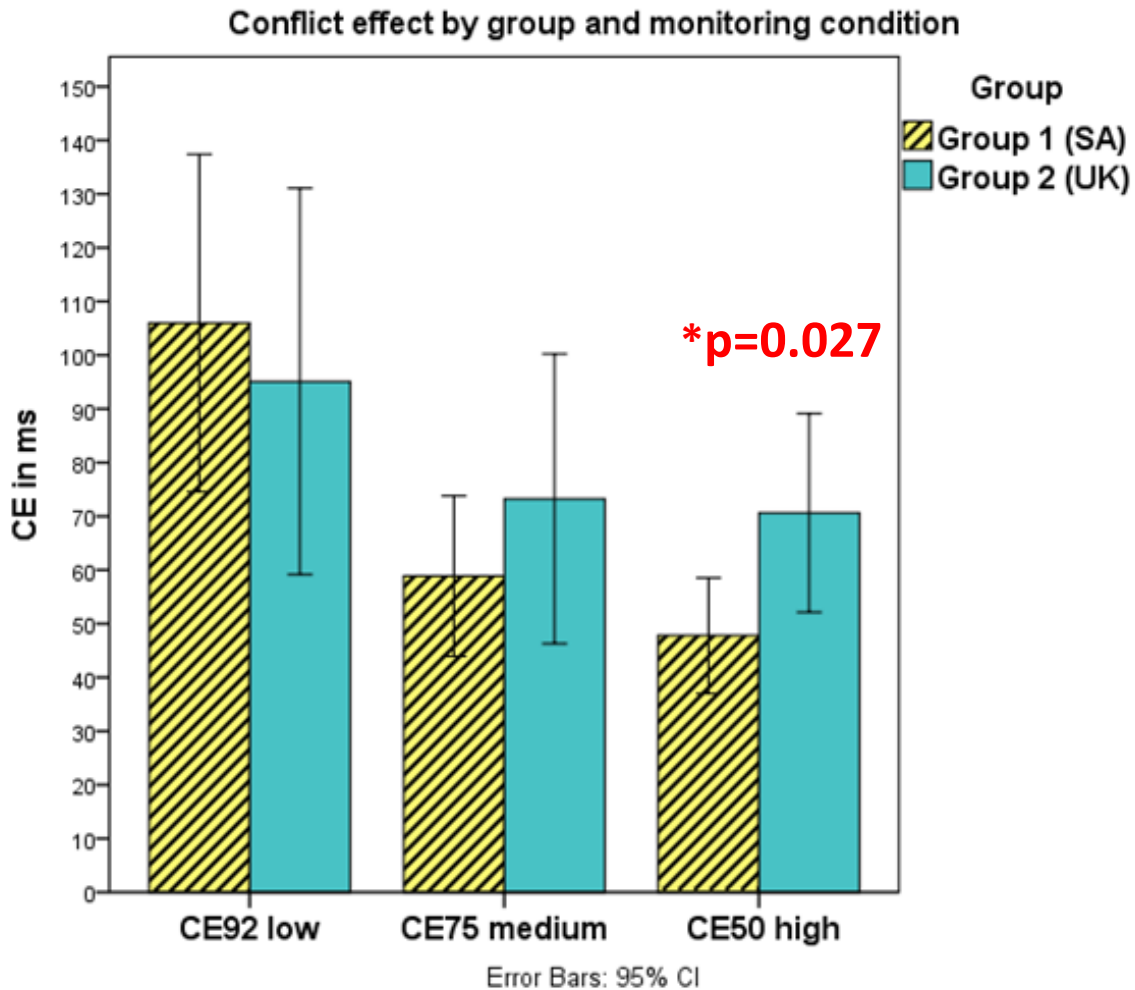
Alternational code-switching frequency only significant predictor of CE 92-8 explaining 20% of inhibitory performance variance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.441 ^a	.195	.175	35.29683593	.195	9.908	1	41	.003

a. Predictors: (Constant), QAlternationT2

Previous study : High frequency dense code-switchers showed advantages at CE 50-50 (Hofweber, Marinis & Treffers-Daller, 2016)



Group 1:

high dense code-switching frequency

Group 2:

low dense code-switching frequency

-Group 1 CE 50-50 < Group 2 CE 50-50
(p = 0.027)

-Group 1 outperforms Group 2 at
inhibition in high-monitoring condition

This study: Multiple regression Conflict effect 50-50

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.419 ^a	.176	.155	13.29878281	.176	8.528	1	40	.006	1.966

a. Predictors: (Constant), QDenseT2

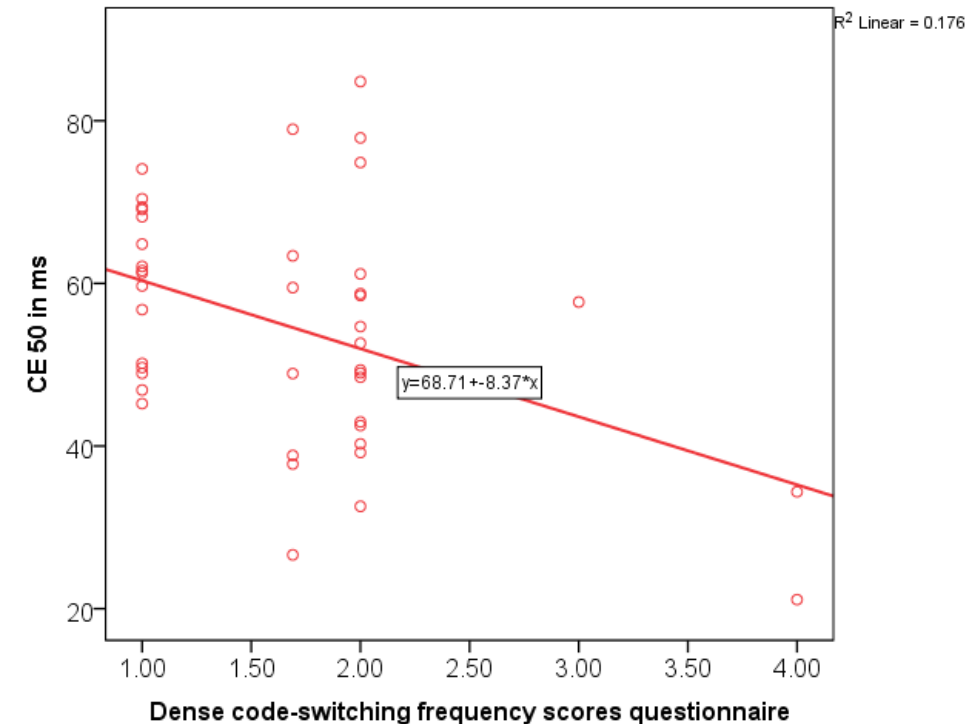
b. Dependent Variable: CE50

Dense code-switching only significant predictor of CE 50-50 explaining **17.5 %** of variance

Correlation “Dense * CE 50-50” medium effect size ($r = -0.31$, $p = 0.02$)

-> converging evidence for previous study

Correlation "dense code-switching frequency" * "CE 50 high-monitoring"



Conclusion 1

General trend in line with predictions derived from existing models (Treffers-Daller, 2009; Green & Li Wei, 2014):

When relationships are significant, then...

- a) Alternation correlates positively with inhibitory control performance.
- b) Dense code-switching correlates positively with performance in conditions challenging monitoring, i.e. mental flexibility.

Conclusion 2

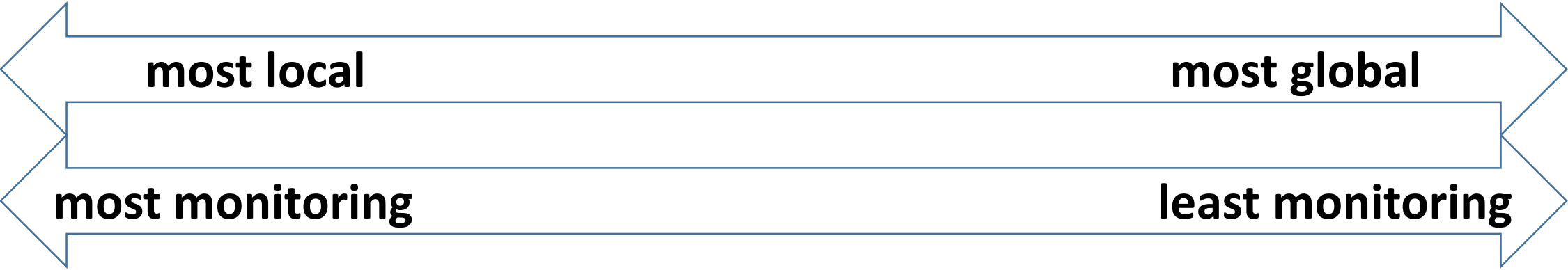
In this study, the modulations of executive functions potentially brought about by alternational code-switching coincide with “bilingual advantages” at inhibitory control in the condition mirroring inhibitory processes employed during alternation.

How does this fit in with studies showing that code-switching is not more effortful than monolingual modes?

(Gardner-Chloros & McEntee-Atalianis, 2012, Kleinmann & Gollan, 2016)

Conclusion 3: Does code-switching need to be more effortful in order for it to enhance executive functions?
Total “cognitive effort” may be the same, but different language modes may challenge different aspects of executive system.

dense code-switching	insertion	alternation	monolingual mode
Local inhibition of lexical items	Local inhibition of non-matrix lexical items	Temporary global inhibition	Prolonged Global inhibition
Local inhibition of grammatical features	Global inhibition of non-matrix grammar		



Conclusion 4

Dissociation of predictors of Overall RTs and Conflict effect in bilinguals supports inhibitory account of bilingual language production (Green, 1998).

Why?

a) Same variables predict Overall RT performance in monolinguals and bilinguals. It's inhibition-specific performance that is predicted by different variables in bilinguals as compared to monolinguals.

b) Within the bilingual group, Overall RTs are predicted by non-linguistic variables, but inhibition-specific performance predicted by bilingualism-related variables.

Conclusion 5

Chicken & Egg question:

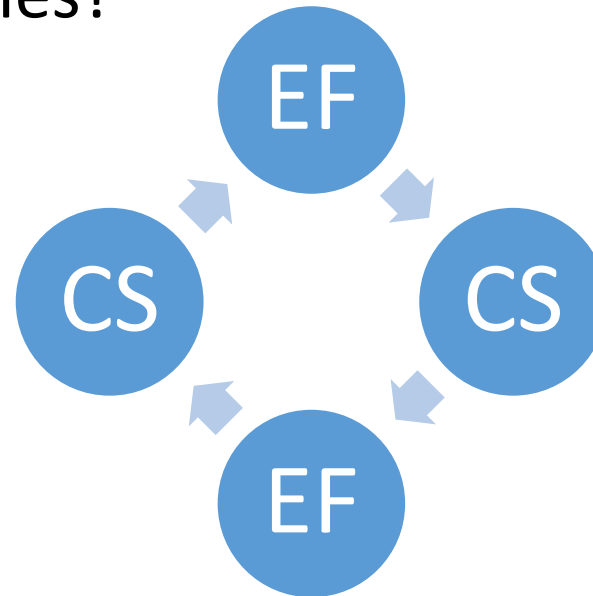
Does code-switching modulate executive functions?

Or

Do bilingual individuals with different executive abilities tend to choose different code-switching strategies?

Or

Mutual influence?



Conclusion 6

Add piece to the puzzle of understanding
which specific aspects of bilingualism modulate
which specific related aspects of the executive system



Why does this matter?

explain inconsistencies in bilingualism research (Paap & Greenberg, 2013)

If executive function tasks do not mirror the cognitive processes employed in bilinguals' sociolinguistic practices, then there may be no effects.

Bilinguals need to be assessed regarding their language practices to make predictions regarding performance at specifically matched executive tasks.

References

- Backus, A. (2014). A usage-based approach to codeswitching: The need for reconciling structure and function. in G. Stell, K. Yapko (forthcoming). *Code-switching at the crossroads between structural and sociolinguistic perspectives*. Mouton de Gruyter, Berlin
- Bhatt, R., Bolonyai, A. (2011). Code-switching and the optimal grammar of bilingual language use. *Bilingualism: Language and Cognition*. 14 (04), 522 – 546
- Bialystok, E. (2010). Global-Local and Trail-Making Tasks by Monolingual and Bilingual children: Beyond Inhibition. *Developmental Psychology*, 46, 93-105
- Botvinick, M., Carter, C.S., Braver, T.S., Barch, D.M., Cohen, J.D. (2001). Conflict-monitoring and Cognitive Control. *Psychological Review*, 108, 624-652.
- Deuchar, M., Muysken, P. & Wang, S. (2008). Structured Variation in Codeswitching: Towards an Empirically Based Typology of Bilingual Speech Patterns. *International Journal of Bilingual Education and Bilingualism*, 10 (3), 298-340
- Clyne, M. (2003). *Dynamics of Language Change*. Cambridge Approaches to Language Contact, Cambridge University Press, Cambridge, 2003
- Guo, T., Liu, H., Misra, M., Kroll, J.F. (2011). Local and global inhibition in bilingual word production: fMRI evidence from Chinese-English bilinguals. *Neuroimage*, 56, 2300-2309
- Hofweber, J., Marinis, T., Treffers-Daller, J. (2016). Effects of dense code-switching on executive control. *Linguistic Approaches to Bilingualism*
- Eppler, E. (2005). The Syntax of German-English code-switching. PhD Thesis, <http://discovery.ucl.ac.uk/1383656/>, download 18/03/2015
- Franke, K. (2008). “We call it Springbok German!”: Language Contact in the German Communities in South Africa. PhD Thesis, Monash University
- Green, D.W., Wei, L. (2014). A control process model of CS. *Language, Cognition and Neuroscience*, 24 (9), 499 – 511
- Franke (2008)
- Muysken, P. (2000). *Bilingual Speech: A Typology of Code-mixing*. Cambridge: Cambridge University Press, Cambridge, 2000
- Sweeney, E., Zhu H. (2010). Accommodating toward your audience. *Journal of Business Communication* 47(4): 477-504
- Treffers-Daller, J. (2009). CS and transfer: an exploration of similarities and differences. In: Bullock, B.E. and Almeida, J.T., eds. (2009) *The Cambridge Handbook of Linguistic Code-switching*. Cambridge University Press, p.58-74
- Wu, Y.J., Thierry, G. (2013). Fast Modulation of Executive Function by Language Context in Bilinguals. *The Journal of Neuroscience*, 33, 13533-14537