Lexical Access and Executive Control in Monolinguals and Bilinguals

Bilingualism Research Group
School of Psychology
University of Nottingham
Nottingham, NG7 2RD
United Kingdom
http://www.psychology.nottingham.ac.uk/research/cal/brg

Emily Coderre, Walter van Heuven & Kathy Conklin
University of Nottingham, UK
lpxec1@nottingham.ac.uk, walter.vanheuven@nottingham.ac.uk, kathy.conklin@nottingham.ac.uk

INTRODUCTION

It has been reported that bilinguals exhibit a performance advantage (i.e. experience less interference effects) on tasks of cognitive control and executive function, both linguistic (e.g. Stroop) and non-linguistic (e.g. flanker and Simon) compared to monolinguals (Bialystok, Craik & Luk, 2008). Research with bilinguals has shown that both languages are activated in parallel, even in completely monolingual contexts, and it is not possible to completely 'turn off' one language (van Heuven et al. 2008). The **bilingual advantage hypothesis** states that this *non-selective access* of the bilingual lexicon requires constant control over languages, which is thought to enhance executive control abilities globally (Bialystok, 2001).

Conversely, bilinguals exhibit a performance disadvantage (i.e. respond more slowly) on tasks of picture naming and lexical decision compared to monolinguals. This is explained by the **weaker links hypothesis**, which states that relative to monolinguals, bilinguals use each of their two languages less often, leading to weaker ties between the language and related concepts, both in bilinguals' L1 vs. monolinguals and in the L2 vs. the L1 (Gollan et al. 2005). The weaker links hypothesis is closely related to the **temporal delay assumption** of the BIA+ model, which states that between bilinguals' languages, the L2 experiences slower lexical access than the L1 due to lower proficiency (Dijkstra & van Heuven, 2002).

Both theories predict a bilingual advantage on the Stroop task, but focus on different levels of the cognitive system:

- Do bilinguals outperform monolinguals on the Stroop task because they have *enhanced cognitive control*? → bilingual advantage hypothesis
- Or is the word causing less interference because of *differences in language proficiency* in bilinguals as compared to monolinguals? → weaker links hypothesis

PREDICTIONS

We use a Stroop task with varying stimulus onset asynchrony (SOA; Glaser & Glaser, 1982) to manipulate the amount and timing of interference in order to investigate the contributions of executive control and speed of lexical access in Stroop performance.

Bilingual advantage hypothesis:

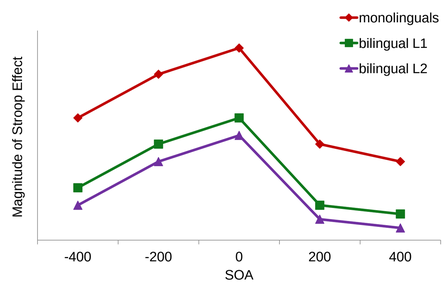
- Bilinguals experience enhanced cognitive control but no differences in speed of lexical access vs. monolinguals*
  →Overall reduction in interference effects but peak interference at same SOA

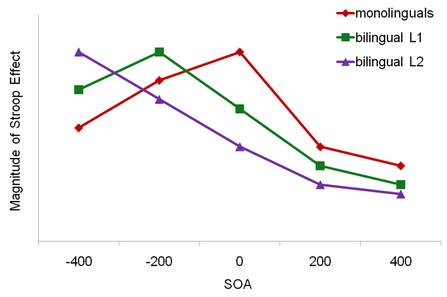
Weaker links hypothesis and temporal delay assumption:

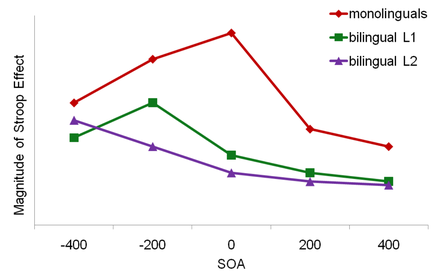
- Bilinguals experience weaker language ties and slower lexical access in L1 vs. monolinguals and in L2 vs. L1
  →Negative shift in interference effects with decreasing proficiency but same magnitude of interference

Combination hypothesis:

- Bilinguals experience slower lexical access but also enhanced cognitive control
  → Negative shift and overall decrease in interference effects





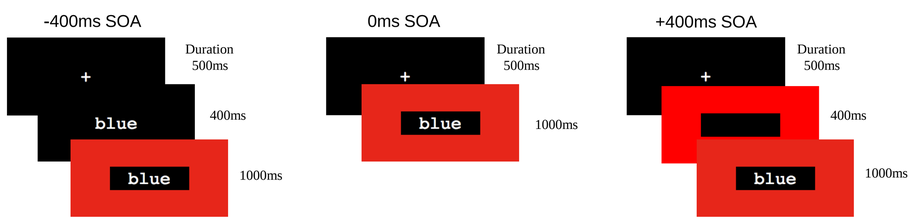


* Monolingual curves based on data from Glaser & Glaser (1982)

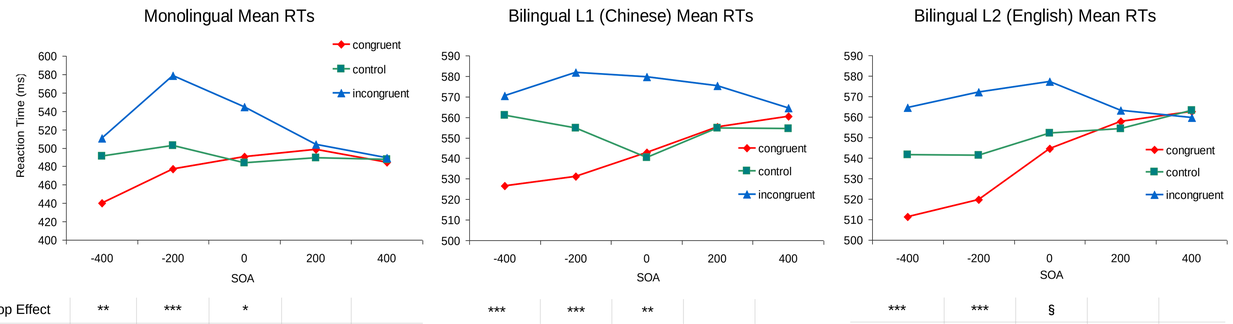
METHODS

Materials and Design:

- **Experiment 1:** 12 monolingual English speakers, 7 female, mean age 25 (SD 4.6), performed an English SOA Stroop task on one session.
- **Experiment 2:** 24 high-proficiency Mandarin - English bilinguals, 20 female, mean age 21 (SD 1.5), performed Chinese and English SOA Stroop tasks in two sessions on two consecutive days. Average self-reported proficiency in English was 7.3 on a 10-point scale.
- Five SOAs presented in blocks: -400ms, -200 ms, 0ms, +200 ms, +400ms
- Manual responses using 3 buttons on the right hand.
- Within each block, 36 congruent, incongruent and control ('%%%%' or '%') trials presented randomly using colours red, green, blue, English words 'red', 'green' and 'blue' and Chinese characters 红, 绿, and 蓝.



RESULTS

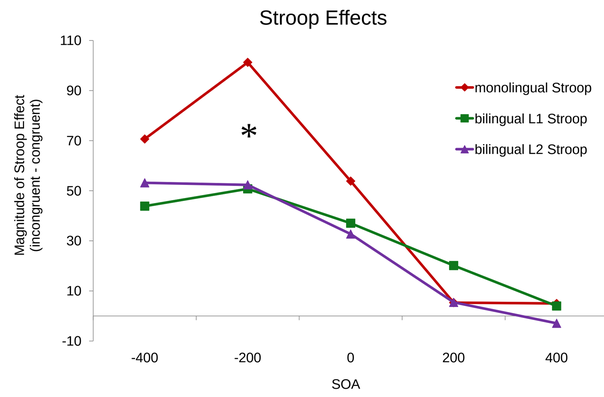


	Monolingual Mean RTs					Bilingual L1 (Chinese) Mean RTs					Bilingual L2 (English) Mean RTs				
Stroop Effect	**	***	*			***	***	**			***	***	§		
Inhibition Effect		***	*				*	*				*			
Facilitation Effect	*						**	***					*		

*** = $p < 0.001$, Bonferroni corrected; ** = $p < 0.01$, corrected; * = $p < 0.05$, corrected; § = trend, corrected
NB: Stroop Effect = incongruent – congruent; Inhibition effect = incongruent – control; Facilitation effect = control – congruent

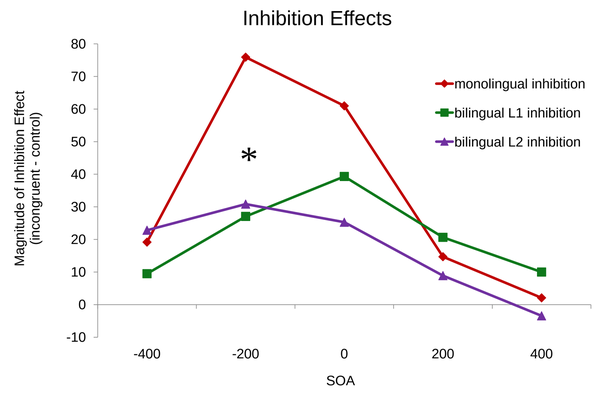
Monolinguals vs. Bilingual L1:

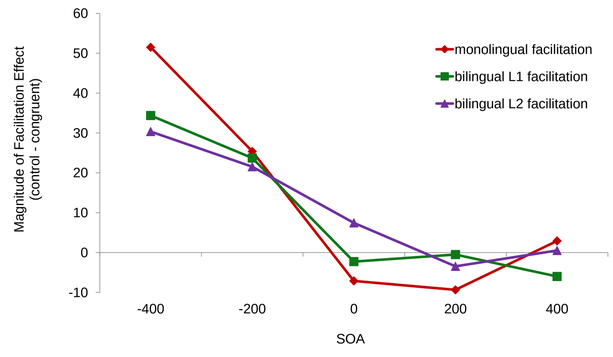
- Peak interference at -200 ms SOA for monolinguals due to the manual response modality producing faster RTs (vs. predicted peak at 0 ms based on vocal RTs by Glaser & Glaser).
- Monolinguals experienced significantly larger interference effects at the -200 ms SOA only (all $p<0.05$, corrected) → *support for bilingual advantage hypothesis*.
- Differences in peak inhibition effects were not in the directions predicted: monolingual peak -200ms; bilingual L1 peak 0ms → *does not support predictions of weaker links hypothesis*.
- Orthographic differences between English and Chinese may play a role: e.g. Chinese may experience a more direct route to phonology (Saalbach & Stern, 2004), leading to shifted interference effects.



Bilinguals' L1 vs. L2:

- Repeated-measures ANOVAs showed no main effects of language at any SOA.
- But patterns of inhibition effects suggest subtle differences between L1 and L2.
  Post-hoc ANOVAs comparing overall SOA direction (negative vs. positive) showed a main effect of SOA direction in all comparisons (negative vs. positive, all $p<0.05$) and a trend towards an interaction of language*SOA direction in inhibition effects ($p=0.064$).
- The L2 experiences a negative shift in inhibition effects compared to L1 → *support for weaker links hypothesis and temporal delay assumption*.





CONCLUSIONS

❖ It is a combination of executive control abilities and speed of lexical access that determines Stoop performance in bilinguals.

❖ The bilingual advantage is only manifested in situations of maximal interference (Costa et al., 2009), which in manual tasks is *not* at the 0 ms SOA. Those who report no bilingual advantage may not be looking at the correct time window, and may benefit from a larger temporal scale of interference effects.

❖ Factors such as response modality, orthographic language differences and subject proficiency level have an impact on when and where the bilingual advantage appears, and should be explicitly mentioned in literature addressing the bilingual advantage on the Stroop task.

REFERENCES

- Bialystok, E. (2001). *Bilingualism in Development: Language, Literacy and Cognition.* New York: Cambridge University Press.
- Bialystok, E., Craik, F. & Luk, G. (2008). Cognitive Control and Lexical Access in Younger and Older Bilinguals. *Journal of Experimental Psychology: Learning, Memory and Cognition, 34*(4), 859-873.
- Costa, A., Hernández, M., Costa-Faidella, J. & Sebastián-Gallés, N. (2009). On the bilingual advantage in conflict processing: Now you see it, now you don't. *Cognition, 113*, 135-149.
- Dijkstra, T. & van Heuven, W.J.B. (2002). The architecture of the bilingual word recognition system: From identification to decision. *Bilingualism: Language and Cognition, 5*(3), 175-197.
- Glaser, M.O. & Glaser, W.R. (1982). Time Course Analysis of the Stroop Phenomenon. *Journal of Experimental Psychology: Human Perception and Performance, 8*(6), 875-894.
- Gollan, T.H., Montoya, R.I., Fennema-Notestine, C. & Morris, S.K. (2005). Bilingualism affects picture naming but not picture classification. *Memory and Cognition, 33*(7), 1220-1234.
- Saalbach, H. & Stern, E. (2004). Differences between Chinese morphosyllabic and German alphabetic readers in the Stroop interference effect. *Psychonomic Bulletin & Review, 11*(4), 709-715.