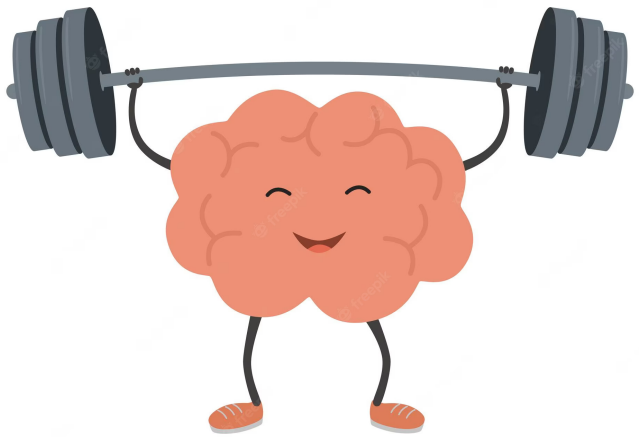
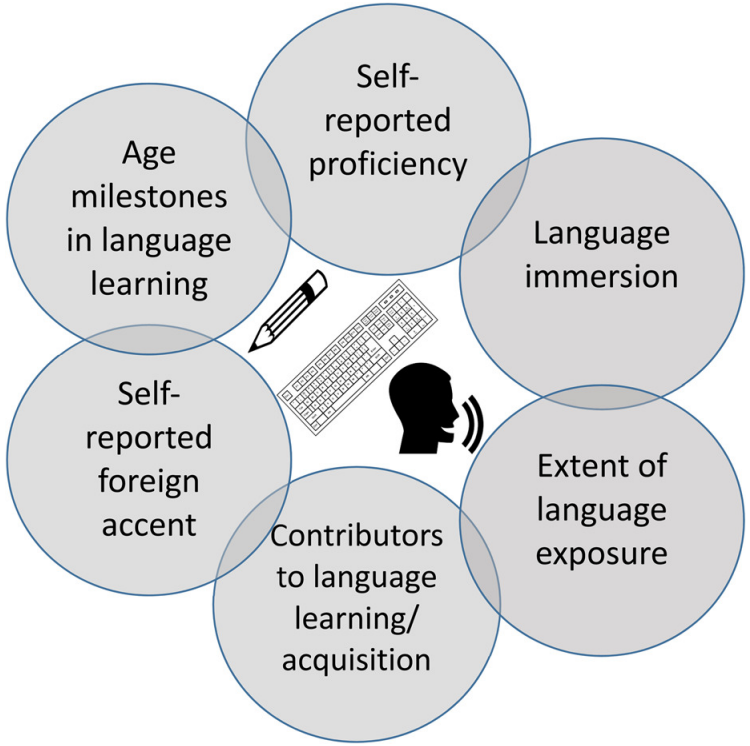
Cognitive consequences of bilingualism

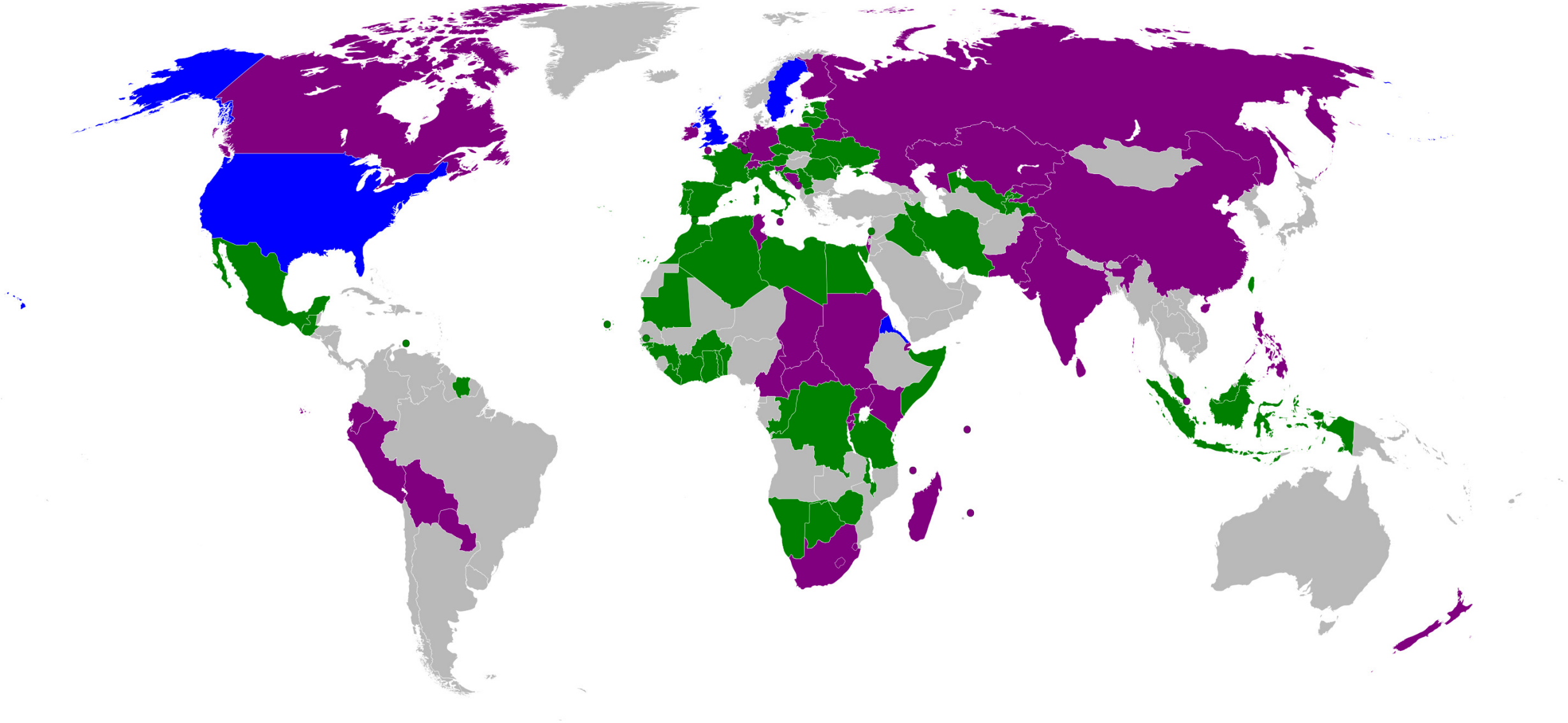




Language Experience and Proficiency Questionnaire (LEAP-Q):
https://bilingualism.soc.northwestern.edu/wp-content/uploads/2012/02/MarianBlumenfeldKaushanskaya.pdf (English version)
https://bilingualism.soc.northwestern.edu/wp-content/uploads/2012/08/LEAP-Q-Mandarin-Pencil-and-Paper.pdf (Mandarin)

Bilingual and Multilingual Countries/Regions

43% of the global population is bilingual



Purple: multiple official languages. Green: single official language. Blue: no official language, functionally multilingual.

Which languages are spoken in China?

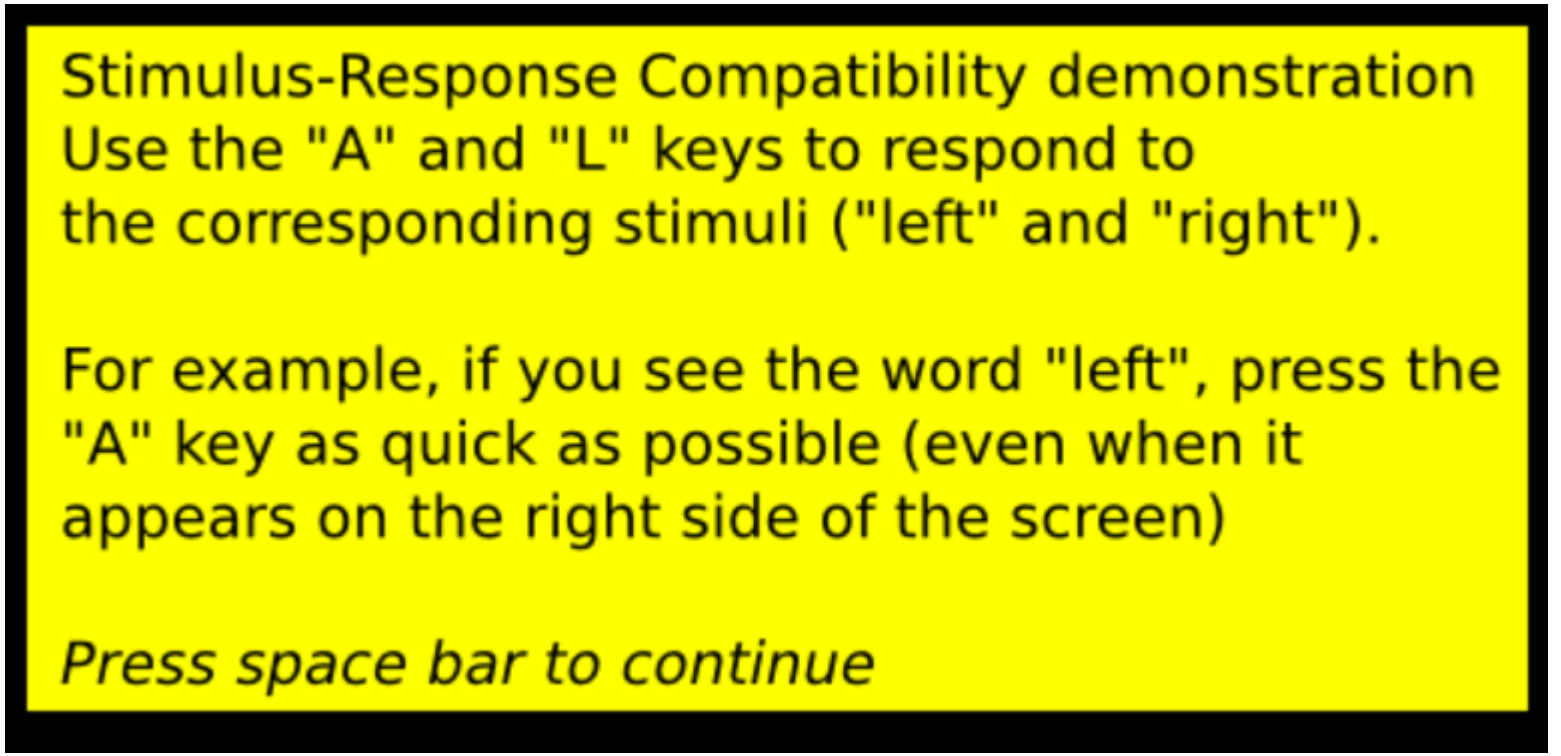
Consequences of co-activation

- Executive/Inhibitory control
- Memory
- Language learning
- Neural function
- Creativity
- Decision making

Bilingualism and inhibitory control

Evidence for better inhibitory control

- **Simon task** (Simon & Wolf, 1963)



Bialystok et al. (2004): study 1

- The first study to demonstrate the difference bt. younger adults and older adults via Simon tasks.
- Tasks:
  - Language background questionnaire
  - Peabody Picture Vocabulary Test—Revised (PPVT–R; Dunn & Dunn, 1981): a standardized test of receptive vocabulary.
  - Raven’ s Standard Progressive Matrices (Raven, 1958): an untimed test that measures abstract nonverbal reasoning ability.
  - **Simon tasks**
- Participants :
  - Study 1: 20 younger adults (M=43.0 yrs) + 20 older adults (M=71.9)
    - Half English monolinguals and half Tamil-English bilinguals in each group

Bialystok et al. (2004): study 1

- The first study to demonstrate the difference bt. younger adults and older adults via Simon tasks.

- Findings:
  - Simon effect was smaller in the bilingual samples
  - Larger Simon effect in older adults than younger adults

  Conclusions:
  - Bilingualism is associated with enhanced cognitive control
  - Executive control declines with age
  - but this decline was less severe in the older bilingual group

Bilingualism may therefore be one factor that mitigates the negative effects of aging

Bialystok et al. (2008)

Results (for the Corsi block task):

- a sig. main effect of age,
- no sig. ME of language group,
- sig. interaction of age and language group

Mean Score (and Standard Deviation) for the Working Memory Tasks by Age Group and Language Group

Group	Self-ordered pointing mean errors	Corsi block span	
		Forward	Backward
Young monolinguals	5.0 (2.8)	3.3 (0.9)	2.8 (1.2)
Young bilinguals	5.4 (2.5)	3.8 (1.2)	3.5 (0.7)
Older monolinguals	8.4 (2.8)	3.5 (0.8)	2.5 (0.7)
Older bilinguals	8.5 (2.4)	3.5 (0.8)	2.3 (0.7)

Working Memory Tasks

The results for the working memory tasks are shown in Table 1. For the Corsi block task, the younger participants recalled longer strings of blocks than older participants, $F(1, 92) = 6.49$, $MSE = 1.1$, $p < .01$, with no significant difference between participants in the two language groups, $F(1, 92) = 2.10$, *ns*, but an interaction of language group and age, $F(1, 92) = 5.16$, $MSE = 1.1$, $p < .03$. For the younger participants, the bilinguals recalled more items than the monolinguals, $F(1, 46) = 5.64$, $MSE = 1.2$, $p < .02$, but the performance of monolinguals and bilinguals did not differ in the older group ($MSE = 0.9$, $F < 1$). The forward span condition was easier than the backward span, $F(1, 92) = 50.70$, $MSE = 0.5$, $p < .0001$, and this difference interacted with age, $F(1, 92) = 13.77$, $MSE = 0.5$, $p < .0004$, reflecting the fact that the discrepancy was larger for the older participants, $F(1, 46) = 105.45$, $MSE = 0.3$, $p < .0001$, than for younger ones, $F(1, 46) = 4.03$, $MSE = 0.7$, $p < .05$. The difference between forward and backward span did not interact with language or with the interaction of age and language (both Fs < 1).

The dependent variable for the self-ordered pointing task was the number of repetition errors participants made across the trials. These data are also reported in Table 1. A two-way analysis of variance (ANOVA) for age and language group indicated only a difference for age group, $F(1, 92) = 35.58$, $MSE = 6.9$, $p < .0001$, in which older participants made more errors than younger ones. There was no effect of language group or the interaction of age and language group (both Fs < 1).

Bialystok et al. (2008)

- Simon arrow task and Stroop task
- Younger and older monolinguals and bilinguals

Findings:

- Older bilinguals showed greater facilitation and less cost than older monolinguals;
- Youngers: no difference in facilitation, a small one in cost

Conclusions:

- Bilingualism is associated with greater degrees of EC
- The bilingual advantage may be greater in older adults

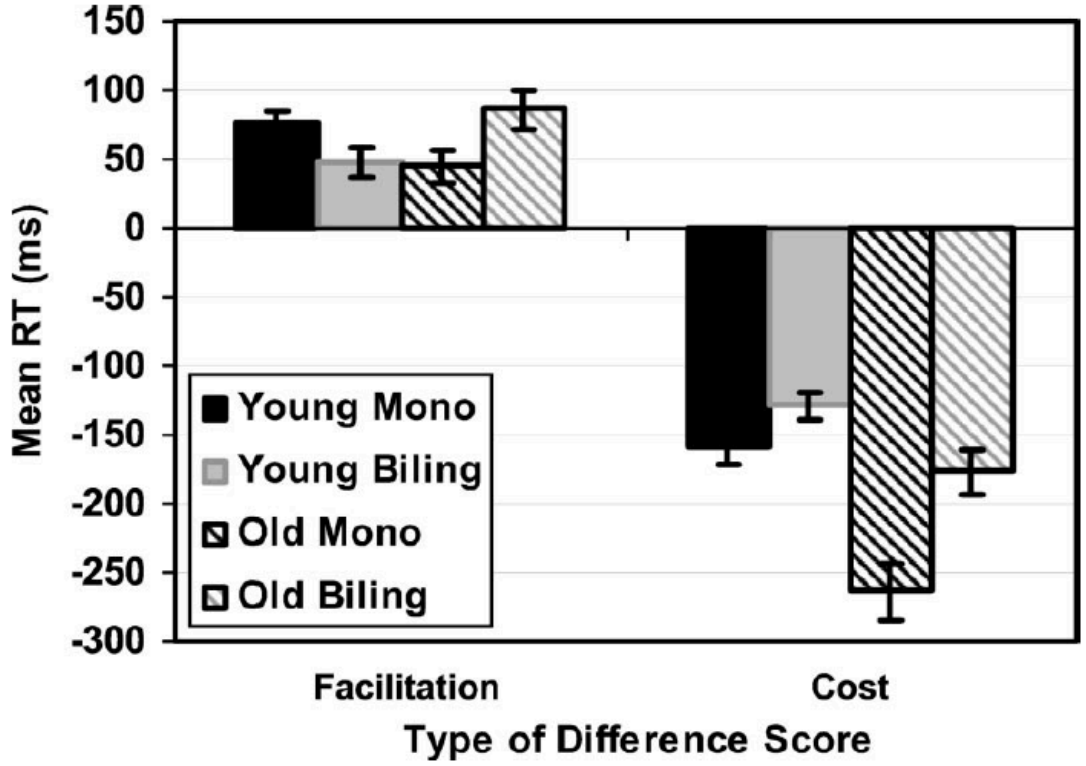


Figure 3. Mean reaction time (RT) and standard error for facilitation and cost in the Stroop task. The values are mean differences from baseline (0 ms) calculated as the average time to name colors from neutral stimuli (*X*s). Mono = monolinguals; biling = bilinguals.

Bilingualism and memory (or memory loss?)

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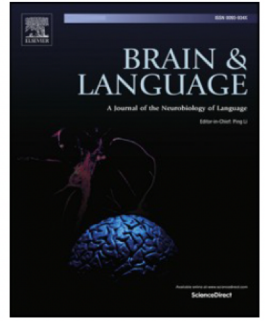

Memory after visual search: Overlapping phonology, shared meaning, and bilingual experience influence what we remember

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ARTICLE INFO

Keywords:
Bilingualism
Individual differences
Language experience
Visual memory
Visual world paradigm
Phonological overlap
Semantic overlap
Visual search
Object memory

ABSTRACT

How we remember the things that we see can be shaped by our prior experiences. Here, we examine how linguistic and sensory experiences interact to influence visual memory. Objects in a visual search that shared phonology (cat-cast) or semantics (dog-fox) with a target were later remembered better than unrelated items. Phonological overlap had a greater influence on memory when targets were cued by spoken words, while semantic overlap had a greater effect when targets were cued by characteristic sounds. The influence of overlap on memory varied as a function of individual differences in language experience – greater bilingual experience was associated with decreased impact of overlap on memory. We conclude that phonological and semantic features of objects influence memory differently depending on individual differences in language experience, guiding not only what we initially look at, but also what we later remember.

Phonological sets: e.g. *a cat, a cast, an iron*

Semantic sets: e.g. *a dog, a fox, a flashlight*

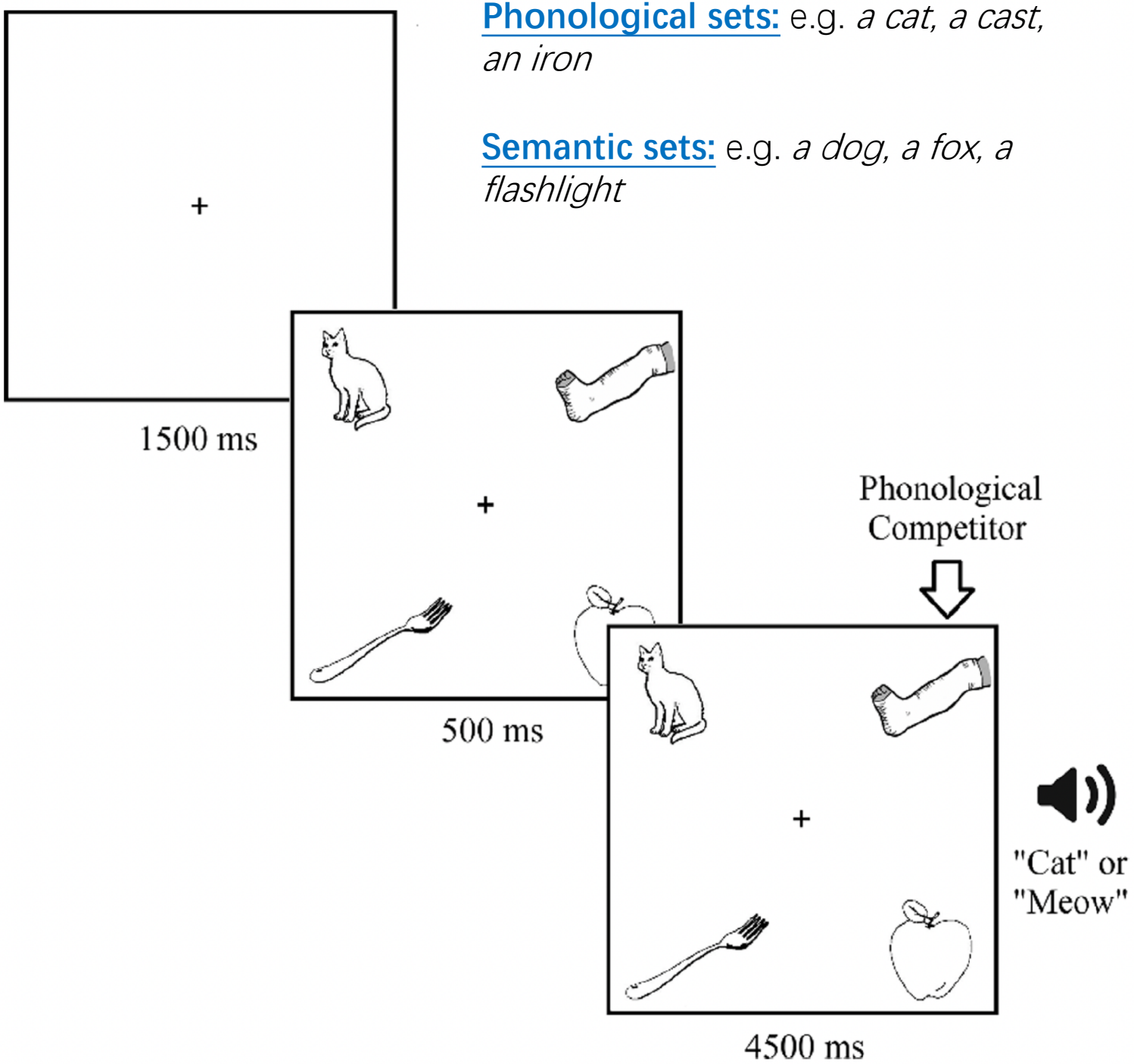

Fig. 2. Example timeline for a Target-Present/Competitor-Present visual search trial completed during the encoding phase. Participants were presented with a fixation cross for 1500 ms, followed by a four-object search display. An auditory target cue (either a spoken word or environmental sound) was presented 500 ms following the onset of the search display and participants were instructed to click on the target if it was present or the central fixation cross if it was absent. The search display remained on screen for a total of 5000 ms regardless of when a response was made.

Participants: 52 participants with varying degree of English and Spanish

Procedures: encoding phase + retrieval phase

Tasks: surprise recognition memory test

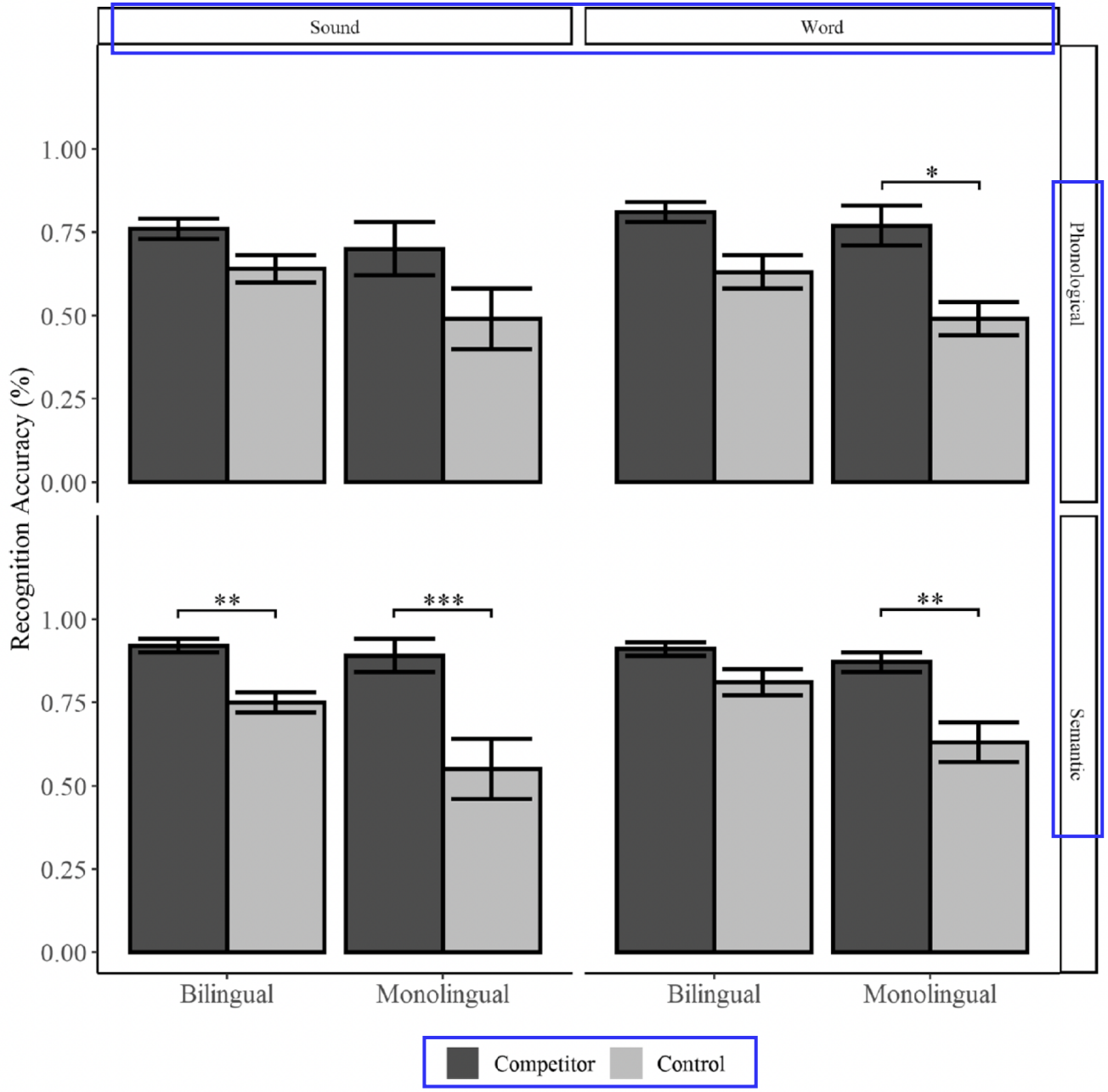

Fig. 3. Effects of Input (Sound, Word), Competition Type (Phonological, Semantic), and Language Group (Bilingual, Monolingual) on recognition accuracy (%) for competitor (black) and control objects (gray). Memory of competitors exceeded that of controls, with larger effects of competition for monolinguals than bilinguals and larger effects of phonological competition on memory in the word than sound condition. Error bars represent standard errors. Simple effects were Tukey-corrected for multiple comparisons. *<0.05, **<0.01, ***<0.001.

Results:

- Objects that shared phonology (*cat-cast*) or semantics (*dog-fox*) with a target were remembered better than unrelated/control items.
- **Phonological overlap** had a greater influence on memory when targets were cued by spoken words, while **semantic overlap** had a greater effect when targets were cued by characteristic sounds.
- Greater bilingual experience was associated with decreased impact of overlap on memory.

Bilingualism and memory

-variables that mediate co-activation
e.g., age, task…

What are age-related memory function losses?

- **Age-sensitive:**
  - Free recall
  - Paired-associate learning
  - Working memory
- **Not age-sensitive:**
  - Memory for procedures
  - Recognition memory
  - Implicit memory

- **Paired-associates cued-recall task**

The participants studied 40 unrelated word pairs (e.g., DOCTOR–LOBSTER) presented on the computer screen at a 5-sec rate.

During the recall phase, the cues (e.g., DOCTOR) were presented in the same order as during encoding, and the participants typed in the correct response (e.g., LOBSTER).

- **Free recall**

A list of 20 words appeared individually on-screen at a 5-sec rate. The participants immediately recalled the words in any order.

(Bailey et al., 2008)

- Luo et al. (2013): bilinguals better than monolinguals on a WM span task based on non-verbal spatial information, but not verbal ones
  - Why?

  - **A bilingual disadvantage**: lower vocabulary levels (Bialystok et al., 2010; Bialystok & Luk, 2012)

General conclusion: extensive practice managing two languages may lead to improved attentional control, which is related to enhanced retrieval in non-verbal memory tasks

Meta-Analysis Reveals a Bilingual Advantage That Is Dependent on Task and Age

Debate continues on whether a bilingual advantage exists with respect to executive functioning. This report synthesized the results of 170 studies to test whether the bilingual advantage is dependent on the task used to assess executive functioning and the age of the participants. The results of the meta-analyses indicated that the bilingual advantage was both task- and age-specific. Bilinguals were significantly faster than monolinguals (Hedges' *g* values ranged from 0.23 to 0.34), and significantly more accurate than monolinguals (Hedges' *g* values ranged between 0.18 and 0.49) on four out of seven tasks. Also, an effect of age was found whereby the bilingual advantage was larger for studies comprising samples aged 50-years and over (Hedges' $g = 0.49$), compared to those undertaken with participants aged between 18 and 29 years (Hedges' $g = 0.12$). The extent to which the bilingual advantage might be due to publication bias was assessed using multiple methods. These were Egger's Test of Asymmetry, Duval and Tweedie's Trim and Fill, Classic Fail-Safe *N*, and PET-PEESE. Publication bias was only found when using Egger's Test of Asymmetry and PET-PEESE method, but not when using the other methods. This review indicates that if bilingualism does enhance executive functioning, the effects are modulated by task and age. This may arise because using multiple languages has a highly specific effect on executive functioning which is only observable in older, relative to younger, adults. The finding that publication bias was not uniformly detected across the different methods raises questions about the impact that unpublished (or undetected) studies have on meta-analyses of this literature.

Ware, A. T., Kirkovski, M., & Lum, J. A. (2020). Meta-analysis reveals a bilingual advantage that is dependent on task and age. *Frontiers in psychology*, *11*, 1458.

Bilingualism and language learning

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Language Learning and Control in Monolinguals and Bilinguals

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Received 19 March 2011; received in revised form 3 November 2011; accepted 5 November 2011

Abstract

Parallel language activation in bilinguals leads to competition between languages. Experience managing this interference may aid novel language learning by improving the ability to suppress competition from known languages. To investigate the effect of bilingualism on the ability to control native-language interference, monolinguals and bilinguals were taught an artificial language designed to elicit between-language competition. Partial activation of interlingual competitors was assessed with eye-tracking and mouse-tracking during a word recognition task in the novel language. Eye-tracking results showed that monolinguals looked at competitors more than bilinguals, and for a longer duration of time. Mouse-tracking results showed that monolinguals' mouse movements were attracted to native-language competitors, whereas bilinguals overcame competitor interference by increasing the activation of target items. Results suggest that bilinguals manage cross-linguistic interference more effectively than monolinguals. We conclude that language interference can affect lexical retrieval, but bilingualism may reduce this interference by facilitating access to a newly learned language.

Participants: monolingual and bilingual

Tasks: a word recognition task with eye-tracking and mouse-tracking in an artificial language

Results:

- Eye-tracking results showed that monolinguals looked at competitors more than bilinguals, and for a longer duration of time.
- Mouse-tracking results showed the monolinguals' mouse movements were attracted to native-language competitors, whereas bilinguals overcame competitor interference by increasing the activation of target items.

Implication: language interference can affect lexical retrieval, but bilingualism may reduce this interference by facilitating access to a newly learned language.

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Learning and Instruction

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Bilingual advantages in early foreign language learning: Effects of the minority and the majority language

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ARTICLE INFO

Keywords:
Bilingualism
Foreign language learning
Proficiency
Achievement

ABSTRACT

This longitudinal study tests effects of minority and majority-language proficiency in the early foreign language learning of English in German primary schools. In a study with monolingual German and bilingual students who speak a minority language at home (N = 200), we find that the bilingual group scores lower than the monolingual group overall, yet bilingual students outperform monolingual German students in vocabulary and grammar in early foreign language learning, once socio-economic factors are controlled for. Vocabulary in the minority language acts as a significant predictor for early achievement in the foreign language for bilingual students. However, positive effects of bilingualism abate from grades 3 to 4, and proficiency in the majority language emerges as a significant predictor of English vocabulary. This change suggests that bilingual advantages wither unless they are explicitly fostered by teachers and educators.

Participants: monolingual and bilingual primary-school children with developmental language disorder (DLD)

Tasks: a vocabulary task, a grammar test, a grammaticality judgement task, the Litmus Sentence Repetition Task, and the Peabody Picture Vocabulary Test, semi-spontaneous speech task, a questionnaire measuring English exposure

Language group:
bilingual vs. monolingual

Bilingual advantages in foreign language learning: evidence from primary-school pupils with developmental language disorder

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Introduction: One of the bilingual advantages often reported in the literature on typically-developing children involves advantages in foreign language learning at school. However, it is unknown whether similar advantages hold for bilingual pupils with learning disabilities. In this study, we compare the performance of monolingual and bilingual primary-school children with developmental language disorder (DLD) learning English as a school subject in special education schools in the Netherlands.

Methods: The participants were monolingual (N = 49) and bilingual (N = 22) children with DLD attending Grade 4–6 of special education (age 9–12). The bilingual participants spoke a variety of home languages. The English tests included a vocabulary task, a grammar test and a grammaticality judgement task. The Litmus Sentence Repetition Task and the Peabody Picture Vocabulary Test were used as measures of, respectively, grammatical ability and vocabulary size in Dutch (majority/school language). In addition, samples of semi-spontaneous speech were elicited in both English and Dutch using the Multilingual Assessment Instrument for Narratives. The narratives were analysed for fluency, grammatical accuracy, lexical diversity, and syntactic complexity. A questionnaire was used to measure amount of exposure to English outside of the classroom.

One brain, two tongues, two systems?

- What goes on in the brains of people who know multiple languages?

- Are all of the languages you know always active or if your brain shutting off and sectioning things?

  - switching between languages?
  - Are different languages represented in different parts of the brain? E.g. a place for English? a place for Chinese? …

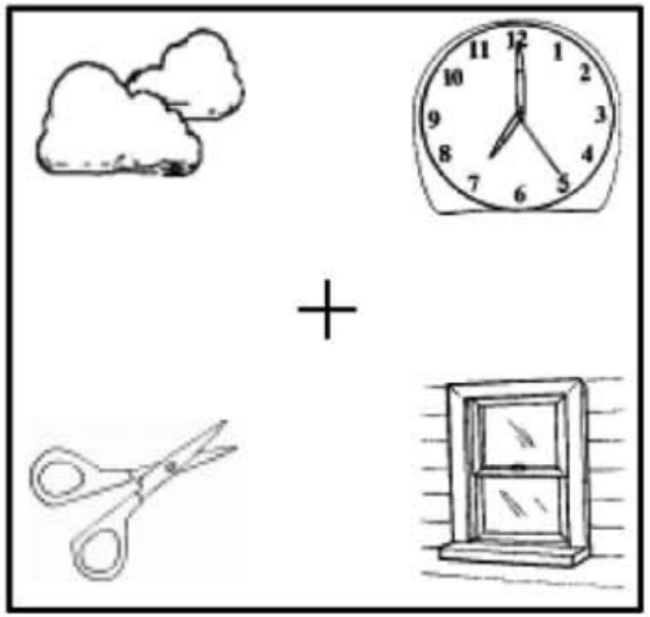
- We **NOW KNOW** that is not the case.

  - Language is distributed through out multiple areas of the brain. It is a network.
  - We don’ t ever really switch off our languages. They are constantly co-activated and running in parallel.

Evidence from bilingual eye-tracking experiments

The finding has been replicated with:

- Spanish-English (Ju & Luce, 2004; Chabal & Marian, 2015; Shook & Marian, 2019)
- Dutch-English (Weber & Cutler, 2004; Lagrou et al., 2012, 2013)
- Japanese-English (Cutler et al., 2006)
- German-English (Blumenfeld & Marian, 2007)
- Hindi-English (Kapiley & Mishra, 2018; Prasad et al., 2019)
- Finish-French-English (Veivo et al., 2018)
- …



Sample layout for English overlap condition

Variables that mediate co-activation:

- **Presence of within-language overlap** (Spivey & Marian, 2003)
- **Degree of phonological overlap** (Blumenfeld & Marian, 2007; Martinez Garcia, 2018)
- **Lexical status: cognate/non-cognate** (Blumenfeld & Marian, 2007)
- **Sentence context** (Lagrou et al., 2012; Shook et al., 2014)
- **Culture-specific cues** (Kapiley & Mishra, 2018)
- **Language history & experience: proficiency, native status, exposure**…
- **Cognitive load** (Prasad et al., 2019)

Target item: ***clock***

- English speakers: clock-cloud

- Spanish speakers:

clock (reloj) - gift (regalo)

- Spanish-English bilinguals

(Chabal & Marian, 2015)

Code-switching

“Can you get me *un café con leche y azúcar* [a coffee with milk and sugar]?”
“ Can you get me *einen Kaffee mit Milch und Zucker*?”
“我要一杯coffee，加milk和sugar。”
“我要一杯咖啡，what do you like?”

Do you code-switch?

- **When** do you code-switch?
  - Who are you talking to when you code-switch?
  - What are you talking about when you code-switch?
  - Where are you when you code-switch?

- **How** do you code-switch?
  - Do you feel like you are mixing the two languages?
  - If so, is it because you cannot explain something well in the language you are speaking in?
  - If so, does it seem like an inefficient way of speaking?
  - Do you feel like you are speaking a special language?

Why do code-switching occur?

- **Traditionally,** code-switching was considered to be spoken by semi-linguals (i.e., those who are not fluent in either L1 or L2)

Code-switching was something that these speakers did to complement each language (such as communication strategies or broken language) or when you were talking to a foreigner (as in *foreigner talk*)

Thus, there were no rules as to how code-switching occurred

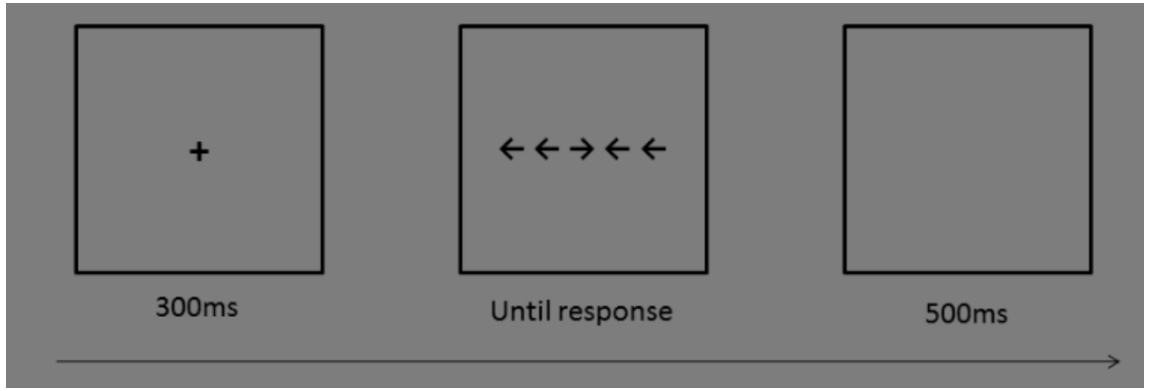
- **Recent studies show that even the most balanced bilinguals code-switch**

There is some syntactic rule as to why code-switching occurs, but there are different views as to what these rules are

What is and is not acceptable switch of language?

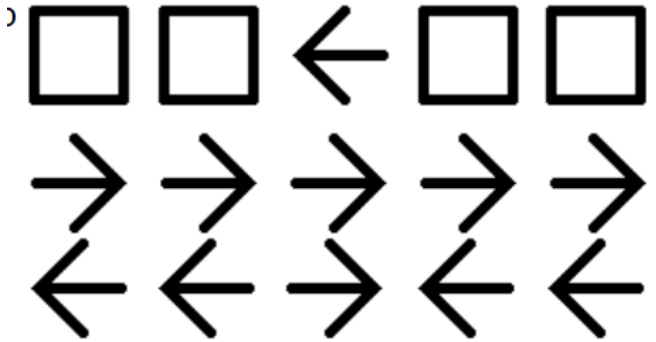
Grammaticality judgments different judgments depending on the community

Gollan & Goldrick (2016)



<u>Experiment 1 – young bilinguals</u>

- read aloud 16 paragraphs
  - grammatical, low-switch (13 switches)
  - grammatical, high-switch (26 switches)
  - ungrammatical, low-switch
  - ungrammatical, high-switch
- objective measure of proficiency – Multilingual Naming Test
- Executive function tests
  - Stroop task
  - Trail Making Test A and B
  - Flanker Task



neutral condition

congruent condition

incongruent condition

Grammatical Low-switch

He then lit it by striking un cerillo debajo del asiento de su chair. The truly meticulous manera en que hacía papá his cigarettes was indeed an art. He took his first puff, detuvo la respiración, and then exhaled smoke through his nose with a healthy satisfaction. Blowing smoke through his nose siempre me fascinaba. For me it was nothing short of a miracle. Me pregunté, how did he do it? Someday I would find out. Someday yo aprendería, porque todos los hombres learn how, and I would get to be a man como mi padre.

Grammatical High-switch

Luego lo prendió by striking a match debajo del asiento of his chair. The truly meticulous manner en que hacía papá his cigarettes was indeed un arte. He took his first puff, detuvo his breath, and then exhaled smoke through las narices with a healthy satisfaction. Blowing humo through his nose siempre fascinated me. Para mi it was nothing short of a miracle. I asked myself, cómo lo hacía? Someday I would find out. Algún día I would learn how, because all los hombres learn how, and I would get to be

Ungrammatical Low-Switch

He then lit it by striking un cerillo debajo del asiento of his chair. The truly meticulous manner in which Dad rolled his cigarettes was an art. He took his first chupazo, detuvo su respiración, y luego exhaled smoke through his narices con una healthy satisfaction. Blowing humo por la nose always fascinated me. For me it was nothing short of a miracle. I asked myself, how lo hacía? Algún día I would find out. Someday I would learn how, because all hombres aprenden, y I would get to be a hombre como mi papá.

Ungrammatical High-switch

Luego lo lit by striking a match debajo del seat of his chair. The verdadera meticulous manner in which Dad rolled his cigarrillos era un art. He dio el primer puff, held his breath, and luego echó humo through his nose with a healthy satisfaction. Blowing humo through his nose always me fascinaba. For me it was nothing short de un miracle. I asked myself, ¿cómo did he do it? Someday yo would find out. Someday yo aprendería how, because all hombres learn how, and I would get to be a hombre como mi papá.

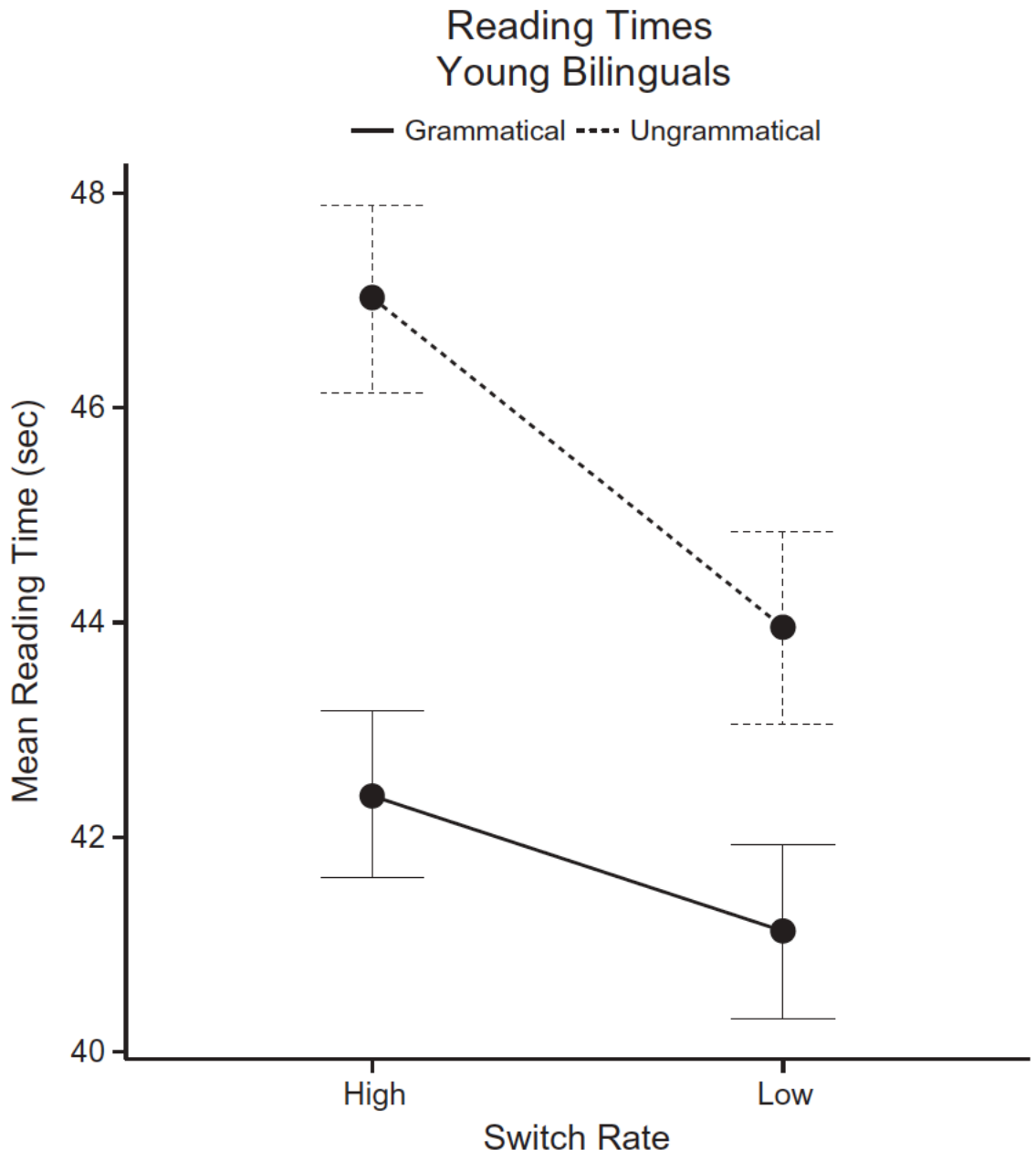
Gollan & Goldrick (2016)

Experiment 1 – young bilinguals

Whole paragraph reading times

Ungrammatical > Grammatical

Ungrammatical paragraphs with high switch-rate were especially difficult



Gollan & Goldrick (2016)

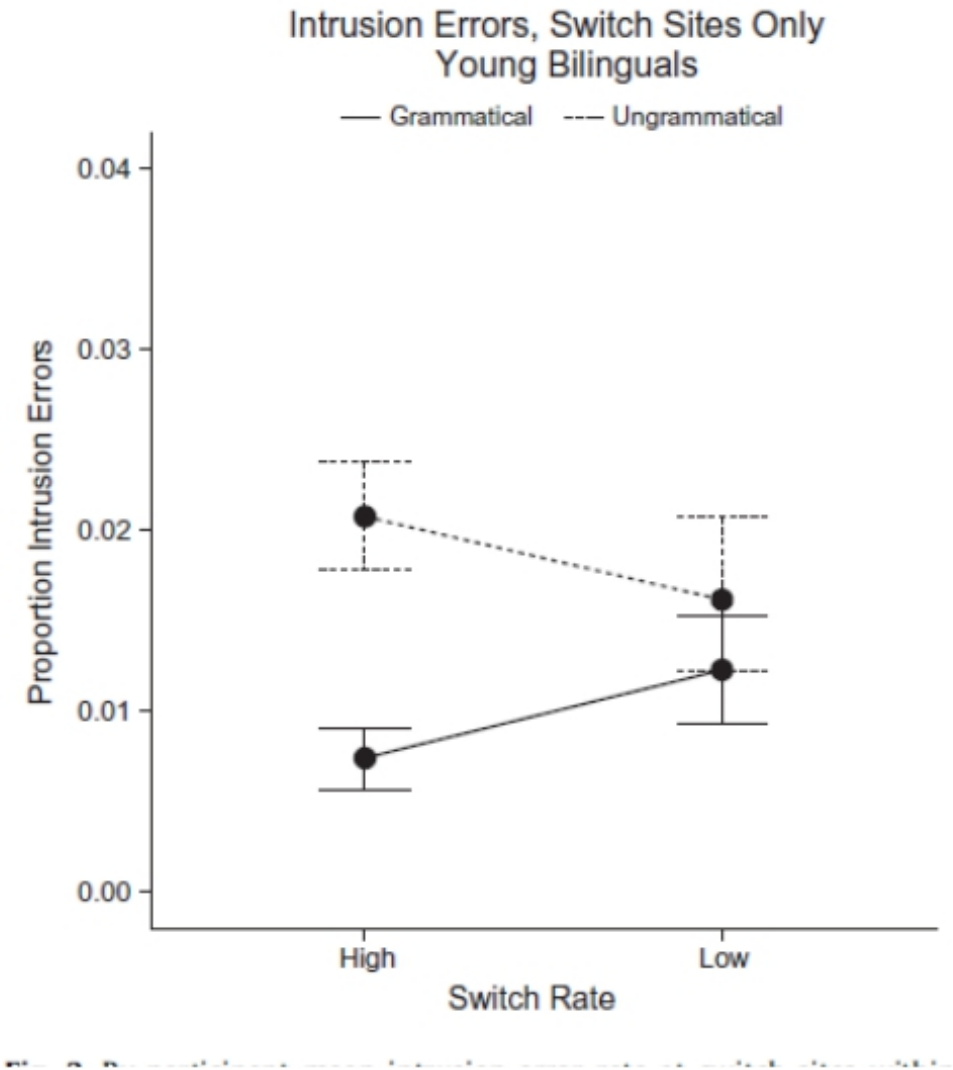
Experiment 1 – young bilinguals

Intrusion Errors

More intrusions at switch sites than non-switch sites

Switch costs in ungrammatical paragraphs.
No switch costs in grammatical paragraphs (but maybe a speed-accuracy?)

No difference for intrusion errors between content and function words.



Gollan & Goldrick (2016)

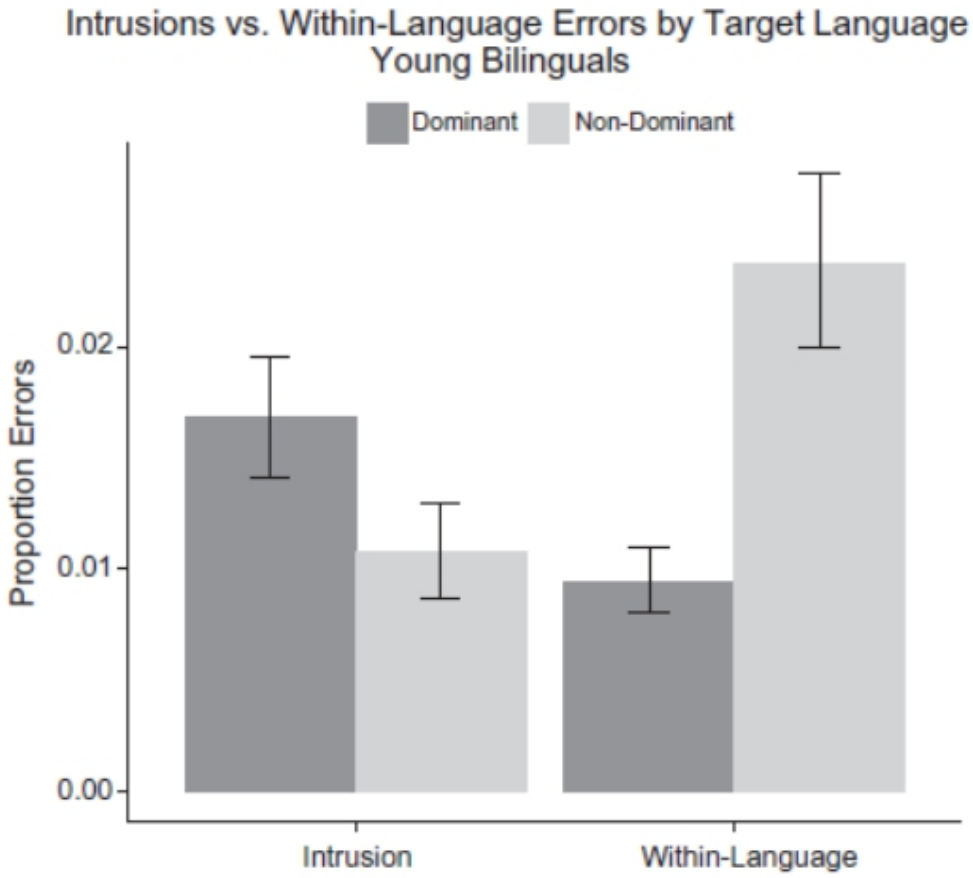
<u>Experiment 1 – young bilinguals</u>

Intrusion Errors

More intrusion in the dominant language than the less dominant language.

reversed-dominance effect

Inhibition of dominant language



Gollan & Goldrick (2016)

Experiment 1 – young bilinguals

Executive control

Stroop and trail tasks
interacted with reading times, but not
with intrusion errors.

Those who were not good at Stroop
and trail tasks showed slower
reading
times in ungrammatical paragraphs.

Same pattern of results in older bilinguals

Table 2
Summary of regressions examining effects of individual differences in executive function in younger bilinguals. Significant effects are shown in bold; the second column summarizes the predicted effect in words (if observed) and the cells to the right provide coefficient values (standard errors in parentheses; $^{*}p < .05$, $^{**}p < .005$, $^{***}p < .0005$). Non-bold cells give coefficients with $.15 > ps > .05$. Cells with dashes have coefficients with $ps > .15$.

		Stroop	Flanker	Trails
Reading Times	Main Effect: Longer reading times (RTs)	–	–	2.03 (1.13)
	Interaction with Type: Reading Time Even Longer on Ungrammatical	**10.96 (3.1)*** **	−4.63 (2.54)	**1.79 (0.43)*** **
	Interaction with Type, Rate	–	–	–
Intrusion Errors	Main Effect: Increased intrusions	–	–	**0.31 (0.12)***
	Interaction with Type	–	–	–
	Interaction with Type, Rate	–	–	–
Within Errors	Main Effect	–	–	–

Gollan & Goldrick (2016)

- A robust effect of grammaticality – ungrammatical paragraphs took longer than grammatical paragraphs
- No difference between content and function words – not due to reading mechanisms.
- Trail task seemed to show some effect (i.e., fewer language intrusions) on language switch, but not within-language errors. But, this did not interact with grammaticality, so executive control function independently from language specific controls.
- Since executive control tasks did not interact with grammaticality, and grammaticality interacted with language switch costs, this seems to suggest that language control mechanisms are language-specific.
- Aging also did not modulate grammaticality effects language-specific control mechanisms