

Does bilingualism make you smarter? An investigation of language and cognitive control

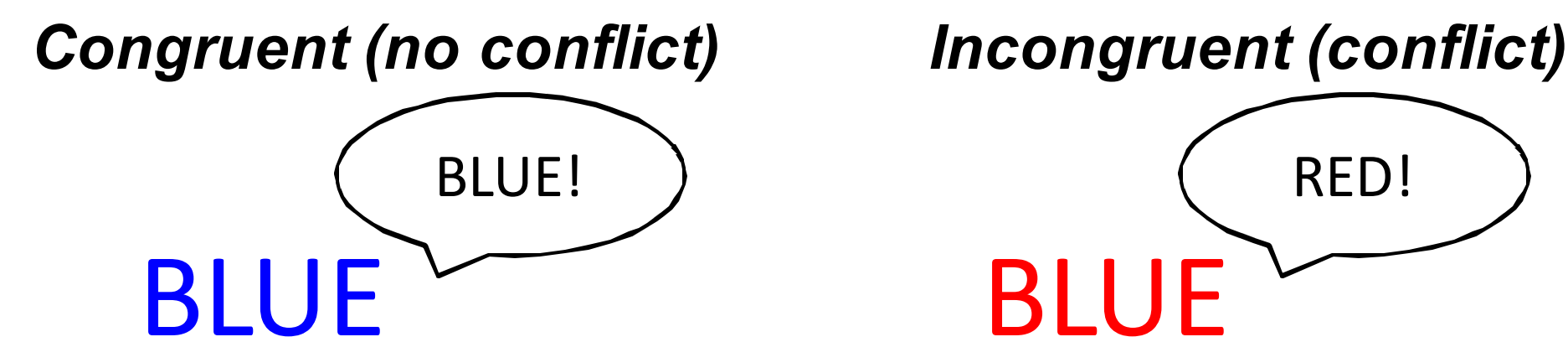
Susan E. Teubner-Rhodes, Alan Mishler, Ryan Corbett, Llorenç Andreu, Monica Sanz-Torrent, John C. Trueswell, and Jared M. Novick



1. Background

The Bilingual Advantage in Cognitive Control

Relative to monolinguals, balanced bilinguals, who are equally proficient in two languages, possess superior cognitive control,^{1,2} the ability to regulate thoughts and behavior. For example, bilinguals are better at the Stroop task, which requires cognitive control to name the font color but **not** read the word:



Theories of the Bilingual Advantage

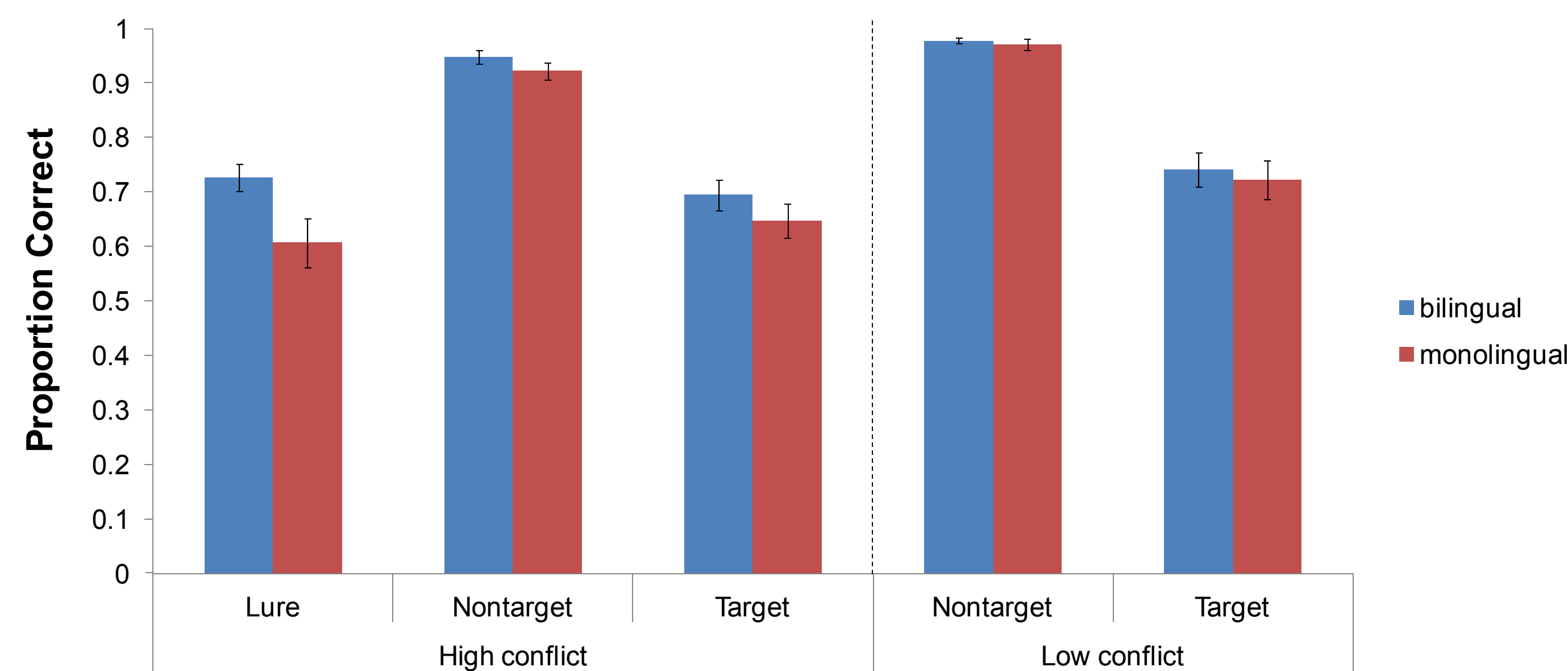
- Conflict resolution:** Bilinguals exhibit less difficulty than monolinguals on conflict trials: they are not as slow relative to congruent trials compared to monolinguals.¹
- Conflict monitoring:** Bilinguals are faster and more accurate at both conflict **and** non-conflict trials on Stroop-like tasks, when trial type is unpredictable. This suggests that the advantage is in detecting and adjusting to the presence of conflict under high monitoring demands.² This may be due to bilinguals' frequent language switches and monitoring for intrusions from the other language.

Cognitive Control in Language

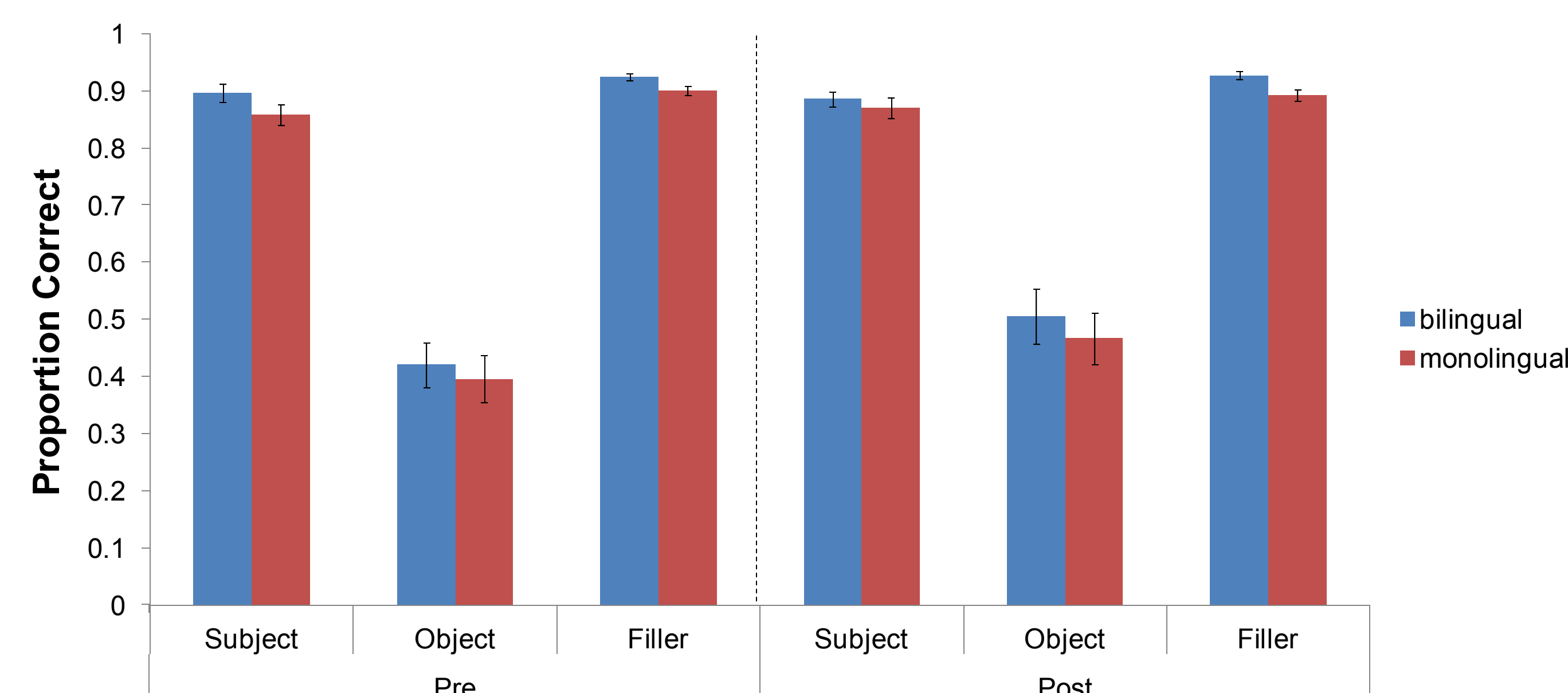
- One important cognitive control function is to override initial misinterpretations of sentence meaning. The ability to do this draws on the same neural resources as the Stroop task.^{3,4}
- Extensive cognitive control training (on Stroop-like tasks) leads to improvements in comprehending sentences susceptible to misinterpretation.⁵

4. Results

Bilinguals were more accurate (and faster) than monolinguals on **all** trial types only in the **high-conflict 3-back task**



Bilinguals exhibit increased sentence comprehension overall



2. The Present Study

Does the bilingual advantage reflect increased conflict resolution or conflict monitoring?

- Conflict resolution** predicts that bilinguals are selectively better on conflict trials.
- Conflict monitoring** predicts that bilinguals are better on both conflict and non-conflict trials, due to flexible recruitment of cognitive control.

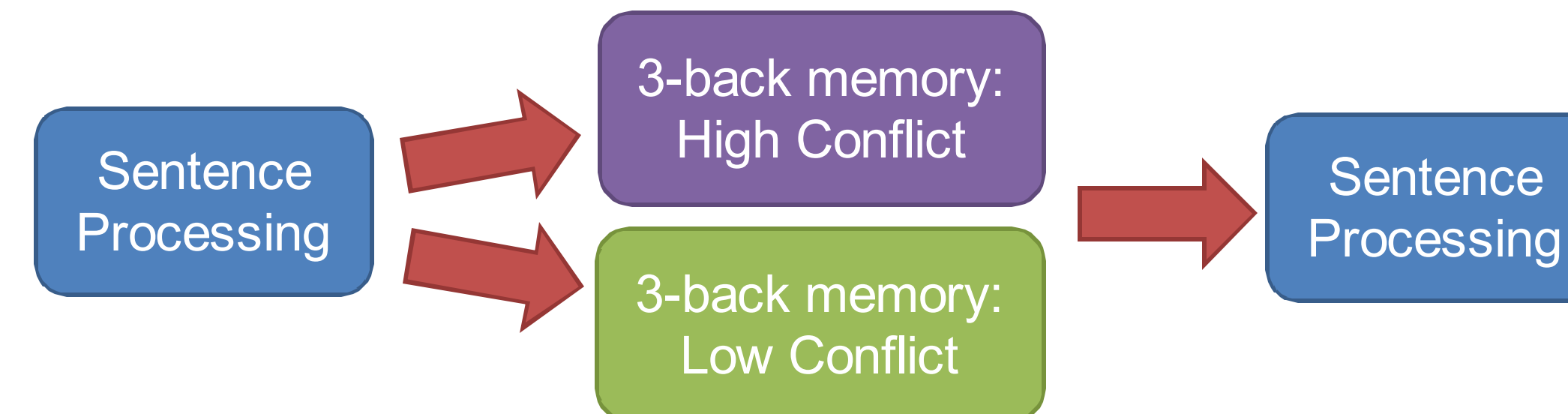
Does the bilingual advantage extend to language processing?

- Conflict resolution** predicts that bilinguals will have increased comprehension selectively on sentences susceptible to misinterpretation.
- Conflict monitoring** predicts that bilinguals will have better sentence comprehension overall when they have to monitor for misinterpretations.

Does brief practice with a cognitive control task influence sentence re-interpretation abilities differentially in bilinguals and monolinguals?

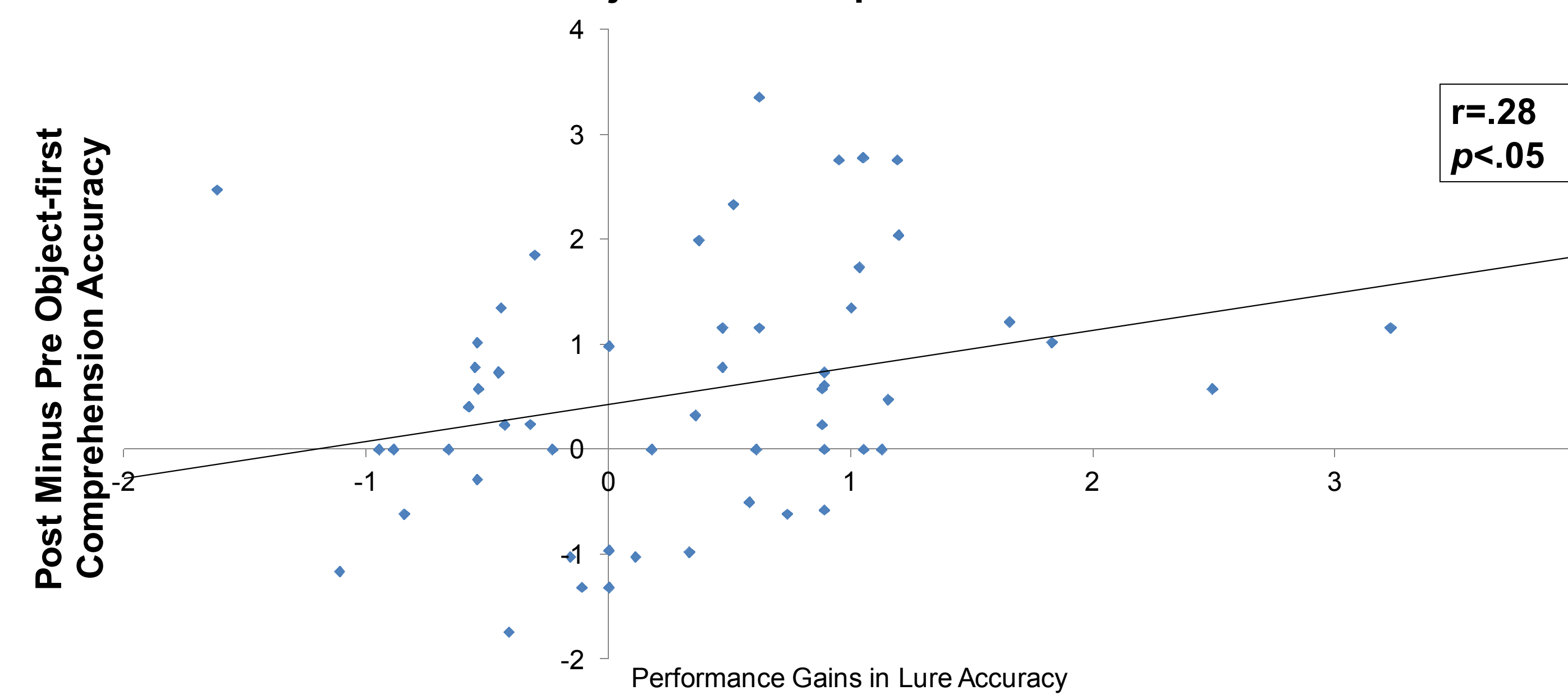
- Improvements in cognitive control following long-term practice transfer to sentence revision in monolinguals,⁵ but the effect of short-term practice is yet to be explored in either monolinguals or bilinguals.
- Brief practice may result in increased recovery from misinterpretation in both language groups, but it is also possible that bilinguals will show larger practice gains, due to better conflict detection and rapid adjustments in control.

To address these questions, we tested Spanish-Catalan balanced bilinguals (n=59) and Spanish monolinguals (n=51) on sentences susceptible to misinterpretation, before and after brief practice on a memory task with high or low conflict.



4. Results (cont.)

All subjects: Improvement on lures predicts improvement on object-first comprehension



- Bilinguals outperformed monolinguals on sentence comprehension and the high conflict memory task, but the advantage was not specific to conflict trials (e.g., lures or object-first sentences). The groups performed equivalently on the low conflict memory task, suggesting equivalent baseline memory and attention abilities.
- Improvement only on lure trials** predicted improvement selectively on object-first sentences (e.g., the ones requiring reinterpretation).
- This correlation is significant in bilinguals ($r=.39, p<.05$), but not monolinguals ($r=.15, p=.45$). However, these correlations are not significantly different from each other, so we cannot say that bilinguals had greater transfer of gains in cognitive control following practice.

3. Design

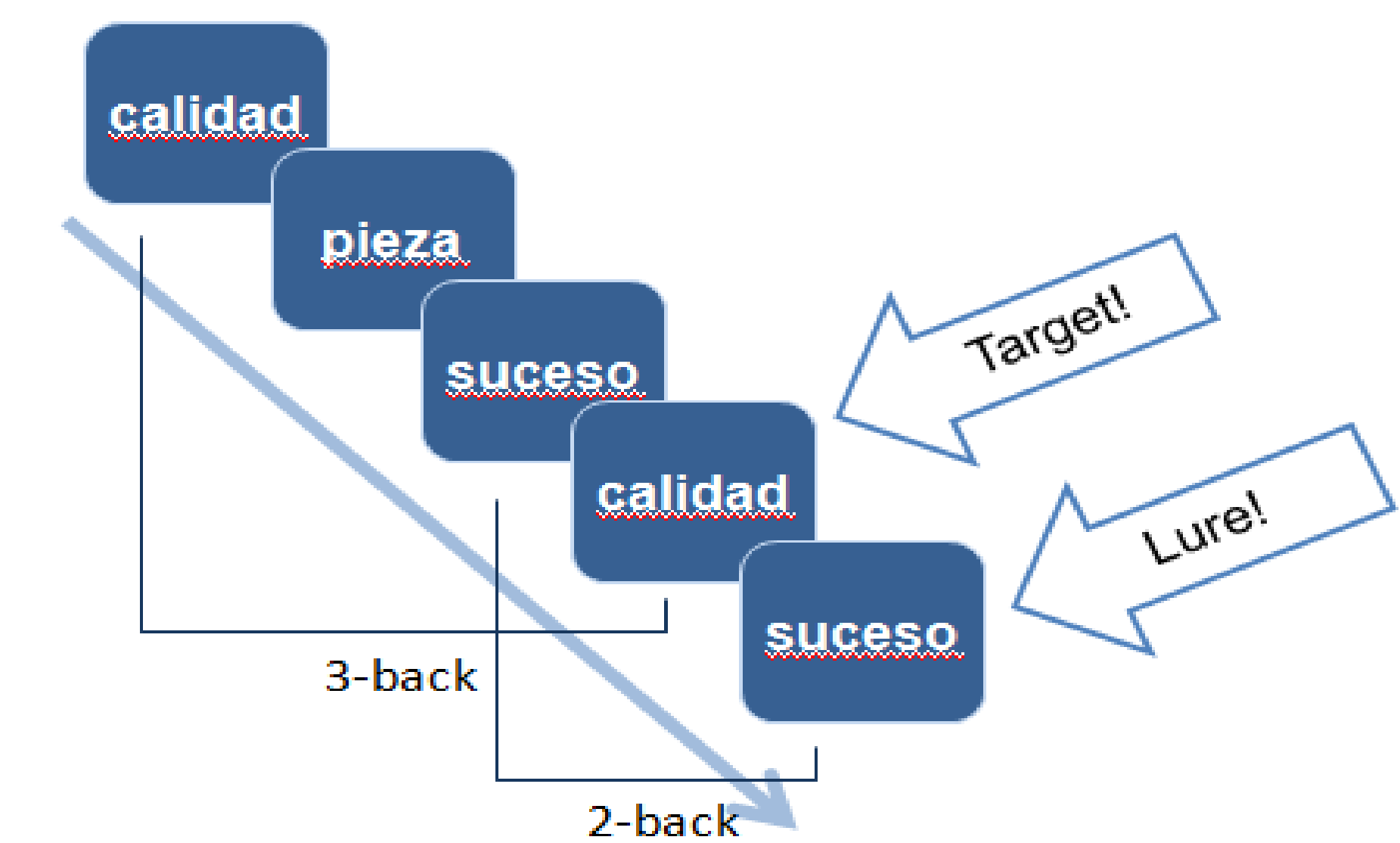
Language Processing: Revising misinterpretations in Spanish⁶

Usually, the first noun in a sentence is the "actor" (the subject) but sometimes the thing that's "acted upon" (the object) occurs first. Readers temporarily interpret the first noun as the actor until they encounter conflicting evidence (here, the word **el**), forcing them to revise their initial interpretation.

- Subject-first sentences:** Este es el cajero que cuestionaba **al** gerente...
(Translation: This is the cashier who questioned the manager...)
- Object-first sentences:** Este es el cajero que cuestionaba **el** gerente...
(Translation: This is the cashier who the manager questioned...)

Participants read sentences at their own pace. After each sentence, they answered true/false probes testing for persistent effects of misinterpretation.

3-Back Memory Task



Words appeared one at a time. Participants identified whether the item was a 3-back match. Only the high conflict version contained "lures," which had appeared before but not in the 3-back position, requiring cognitive control to override a familiarity bias.

5. Conclusions

- Our results support the conflict monitoring account of the bilingual advantage. Bilinguals were faster and more accurate overall on the high conflict memory task (not just on lure trials) and had better comprehension on the sentence processing task.
- This finding is unlikely to be due to baseline differences in memory or attention, as bilinguals and monolinguals performed equivalently on the low conflict memory task.
- Brief practice with conflict resolution selectively improves comprehension of sentences susceptible to misinterpretation, but only in individuals who benefitted from practice. Regardless of language status, recruitment of cognitive control under high monitoring demands transfers to sentence reinterpretation, suggesting shared underlying processes.
- Life-long bilingualism may act as a sort of mental "training," conferring advantages in cognitive control. Because these abilities appear to be flexible, early language training may help prevent and treat cognitive disorders, or vice versa. Future studies should explore whether acquiring a second language as an adult also benefits cognition.

References

- Bialystok, E., Craik, F. I. M., Klein, R., & Viswanathan, M. (2004). Bilingualism, aging, and cognitive control: Evidence from the Simon task. *Psychology and Aging, 19*, 290-303.
- 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.
- January, D., Trueswell, J. C., & Thompson-Schill, S. L. (2009). Co-localization of Stroop and syntactic ambiguity in Broca's area: Implications for the neural basis of sentence processing. *Journal of Cognitive Neuroscience, 21*, 2434-2444.
- Novick, J. M., Kan, I. P., Trueswell, J. C., & Thompson-Schill, S. L. (2009). A case for conflict across multiple domains: Memory and language impairments following damage to ventrolateral prefrontal cortex. *Cognitive Neuropsychology, 26*, 527-567.
- Hussey, E., Teubner-Rhodes, S. E., Dougherty, M., Bunting, M., & Novick, J. M. (2010). Improving garden-path recovery through cognitive control training. Presented at AMLaP.
- Del Río, D., Maestú, F., López-Higes, R., Moratti, S., Gutiérrez, R., Maestú, C., & del-Pozo, F. (2011). Conflict and cognitive control during sentence comprehension: Recruitment of a frontal network during the processing of Spanish object-first sentences. *Neuropsychologia, 49*, 382-391.