

# The developmental invariance of cumulative semantic interference in blocked cyclic picture naming

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**Cumulative semantic interference (CSI)** is a robust empirical phenomenon of increasing latencies and error rates when sequentially naming objects from the same semantic category.

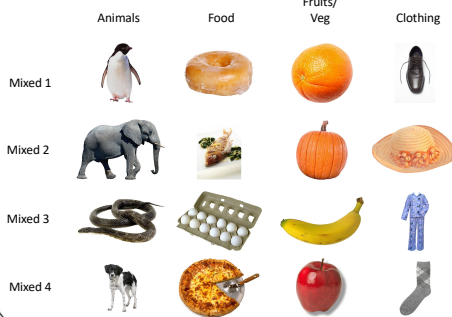
Theoretical accounts vary in the extent that they posit a strong role for cognitive control in reducing (or creating) CSI effects, particularly in the blocked cyclic naming paradigm (e.g., Belke & Stielow, 2013; Roelofs, 2018; Shao, Roelofs, Martin, & Meyer, 2015). Among other things, such contributions raise the challenge of distinguishing true language- $\gamma$  effects from *ad hoc* task effects. The alternative is that CSI effects chiefly reflect more automatic processes, such as priming or incremental learning (e.g., Oppenheim et al., 2010).

Some support for the role of cognitive control has been claimed from studies of individual differences within neurotypical adult populations, but the evidence is inconsistent (e.g., Crowther & Martin, 2014; Patra et al., 2021). Detecting differences may simply require larger and broader samples than researchers typically use.

To assess the impact of cognitive control, we consider possible longitudinal changes in the effect within a large cohort of (bilingual) children. Development in this age range has been linked to decreased interference in many cognitive control tasks (e.g., a Stroop/PWI-like color-picture interference task), apparently as a function of prefrontal cortex maturation (Diamond, 2002; La Heij & Boelens, 2011; Wright et al., 2003). We also consider systematic variation associated with (1) bilinguals' language dominance and (2) developmental language disorder, as additional clues to the origin of the effect.

## METHOD

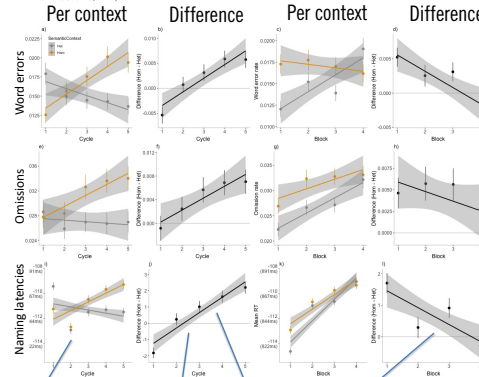
- N = 200 Spanish/English early/simultaneous bilingual children, 5-12 years old, each tracked longitudinally for 2-4 years
- One session of blocked cyclic naming each year in each language (English, Spanish)
- Each item was used in only one language, and normed for high name agreement among the youngest children



## The basic effects of interest

### The cycle x context interaction

This is the classic measure of cumulative semantic interference in the blocked cyclic naming paradigm. The difference between conditions typically increases most between the first cycle and the second, so researchers sometimes omit the first cycle and measure/report it as a main effect (e.g., Belke & Stielow, 2013).



Kids get slower after the 2<sup>nd</sup> cycle, probably due to lack of sustained attention

Within blocks, kids get slower and more error prone in the single-category condition

All effects continue to increase beyond the 2<sup>nd</sup> cycle

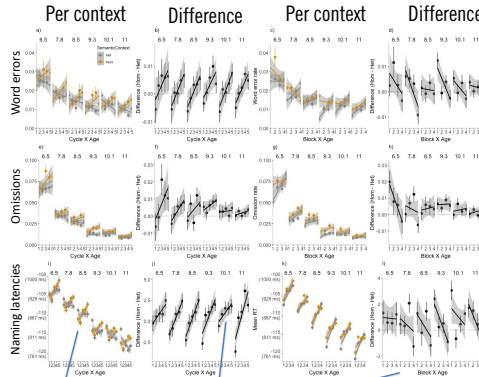
Across blocks, kids get slower and more error prone in the mixed-category baseline condition

## Semantic context effects are stable with age

Although several previous studies have convincingly verified the existence of cumulative semantic interference effects in children (Boelens & La Heij, 2017; Charest, 2017; Charest & Baird, 2021; Ladányi & Lukács, 2016; Navarrete et al., 2021; Snyder & Munakata, 2013), between-subjects comparisons and relatively small sample sizes in most studies have hindered attempts to quantitatively assess their developmental trajectory.

- If cognitive control reduces semantic interference, then interference effects should generally decrease with age. If it creates interference, then the effects should increase.
- Incremental learning accounts can also motivate a prediction of decreasing interference effects with age, on the basis that error should be greater earlier in the learning process (but see simulations in the box on the right).

### The cycle x context interaction



Older kids are faster and more accurate; omissions drop to near floor

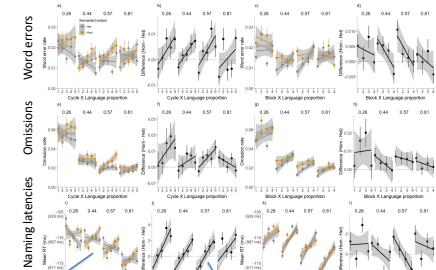
There's some question of how to adjust for changing base rates (transformations!), but error and RT effects are basically stable

\* Cross-sectional analyses yield basically equivalent results

## Semantic context effects are at least as strong in one's weaker language

Structured parent/teacher interviews provided estimates of each child's proportional use of each language, which gradually shifted over the period of the study (Oppenheim et al., 2020). We treat these proportions as rough estimators of their relative cumulative experience in each language.

- Cognitive control accounts don't offer obvious predictions for this contrast, but asymmetric cued language switching costs (e.g., Meuter & Allport, 1999) might imply stronger inhibitory control in one's dominant language.
- But incremental learning accounts can predict stronger interference effects in the one's less-used language, again on the basis that error should be greater earlier in the learning process



With increased language use, responses are faster and more accurate.

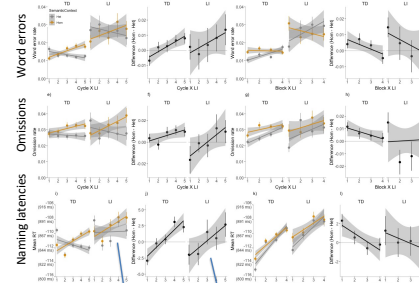
Longitudinal analyses suggest similarly strong effects in each language

\* Cross-sectional analyses indicate weaker effects in the dominant language

## Semantic context effects are comparable for kids with DLD

Our test battery included an assessment for bilingual developmental language delays (DLD, aka SLI).

- DLD is often characterized as involving executive control deficits, sometimes specifically in inhibitory control (e.g., Kapa & Plante, 2015).
- DLD has also been characterized as involving implicit learning deficits, but these have been increasingly constrained to tracking transitional probabilities between elements (i.e., sequential learning), as in syntax and phonology (e.g., Ullman & Pierpont, 2005), rather than the simpler persistent priming / interference that has been claimed to underlie cumulative semantic interference.



Children with DLD show more errors and slower responses.

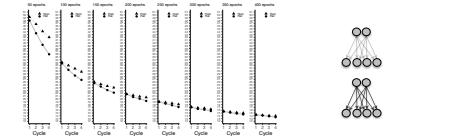
But their semantic context effects are of a similar magnitude

\* Cross-sectional analyses yield similar results

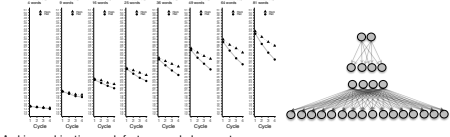
## SIMULATIONS (based on Oppenheim, Dell, & Schwartz, 2010)

It's tempting to think of an incremental learning model as just accumulating weight changes via practice, but for real kids (and models) practice is also associated with vocabulary growth (cf. Heap's law).

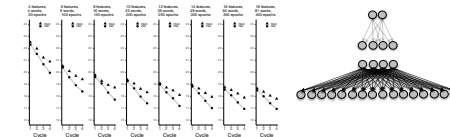
- Increasing practice while holding everything else constant does produce priming and interference effects that rapidly decrease with age



- But priming and interference can also increase as vocabularies expand (holding practice constant)



- And in combination, such factors may balance out



Thus, any changes in the cumulative semantic interference effect will represent a mixture of opposing forces.

## CONCLUSIONS

Childrens' semantic interference effects in blocked cyclic naming are remarkably stable throughout a broad range of ages, in contrast to Stroop-like effects that greatly diminish with prefrontal cortex development. Besides general increases in speed and accuracy, the only major change in performance involved repetition priming, apparently driven by increases in sustained attention. Thus, cognitive control does not appear to strongly modulate semantic blocking effects.

This stability does not specifically support incremental learning accounts, but based on simulations, we suggest that contrasting influences of factors such as increasing practice and increasing vocabulary size might balance out. It might seem overly convenient to assume that these cancel out exactly, but the language system clearly needs to maintain some balance to maintain fluency despite a continually growing vocabulary.