The effects of distinct code-switching types on cognitive control

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Code-switching, that is, the alternation between languages in a single sentence or conversation, provides a unique window into the dynamics of language control mechanisms and their relation to general cognitive control processes. Prior studies suggest that cognitive control is enhanced while reading sentences that start in one language and end in another (e.g., Adler et al. 2020; Bosma & Pablos, 2020). The current project investigates whether more common types of code-switching engage cognitive control differently, and whether this is modality dependent, as code switching is primarily a spoken language phenomenon.

Typical forms of code-switches are one-word insertions and dense switching (multiple switches spanning more than one word), see Table 1 for examples and experimental design. According to the Control Process Model (Green & Wei 2014), insertional switching entails a narrow attentional state while dense switching promotes a broader attentional state. We tested this in a conflict adaptation paradigm (Adler et al. 2020). We had early US Spanish-English bilinguals listen to (Experiments 1, 2), or read (Experiment 3) unilingual Spanish sentences, sentences with dense or insertional switches to English. After each sentence participants saw a flanker trial and indicated the direction of the center arrow, ignoring the flanking arrows. If code-switches modulate attentional focus, we expected this to carry over to the following flanker trial. This would lead to a smaller conflict effect (difference in reaction time to incongruent vs. congruent flankers) after sentences with insertional compared with dense code-switching as narrow attention will lead to less interference from the flanking arrows, and after code-switches compared with unilingual sentences.

Experiment 1 was conducted over the internet (*n*subjects = 111; 15 items/per condition). Unilingual sentences, sentences with dense and insertional switches were presented auditorily in a blocked design. We did not find any effect of switching or switch type on the RT to the flanker trials [Fig 1. congruency x switch: $b = 1.26$, $SE = 5.74$, $T = 0.22$, N.S.; congruency x dense vs. insertional switches: $b = 0.62$, $SE = 3.31$, $T = 0.19$, N.S. (all analyses on raw RTs)]. In Experiment 2 (in-lab, *n*subjects = 34) blocks consisted of unilingual Spanish sentences intermixed with either dense or insertional switches (12 items/condition). In contrast to prediction, the conflict effect was *larger* after listening to a sentence with a switch compared to a unilingual sentence; and was *larger* after an insertional switch than after dense switches [Fig 2. congruency x switch: $b = 27.83$, $SE = 11.42$, $T = 2.44$, $p < .05$; congruency x switch x switchtype: $b = -55.65$, $SE = 22.84$, $T = -2.44$, $p < 0.05$]. To see whether our results were due to the use of spoken rather than written language, we conducted a preregistered web-based version of Exp. 2 in which participants (n=128) read the sentences self-paced, phrase by phrase. Again, we found that the conflict effect was larger after a switch than after a unilingual sentence. This time we did not see any differences in the size of the conflict effect between insertional and dense switches [Exp.3, Fig 3. congruency x switch: $b = 61.31$, $SE = 6.87$, $T = 8.91$, $p < .0001$; congruency x switch x switchtype: $b = 2.21$, $SE = 13.75$, $T = 0.16$, N.S.]. An ongoing web-based listening version of Exp. 3 (n>90) yields similar results.

We therefore have no evidence that processing common types of code-switches enhances cognitive control. When mixed with Spanish sentences, code-switches to English may even recruit less cognitive control than the unilingual Spanish sentences in our English-dominant participants. In addition, code-switching without an interactive context may be unexpected and draw attention away from the flanker task, leading to a larger conflict effect after a code-switch, especially when the switch is a one-word English insertion in a Spanish auditory stream (Exp. 2).

Table 1. Examples of the sentences and flanker conditions with the code-switches indicated in bold. Each sentence was followed by a flanker trial (either congruent or incongruent).

Condition	Example	Congruent Flanker	Incongruent Flanker
Unilingual Spanish	El abogado está agradecido por el apoyo que recibió del testigo ayer.	←←←←← Or →→→→→	← ←→←← Or →→←→→
Dense code-switching	El abogado está **grateful for the support** que recibió **from the witness** ayer.		
Insertional code-switching	El abogado está agradecido por el **support** que recibió del testigo ayer.		
Translation	*The lawyer was grateful for the support that he received from the witness yesterday.*		

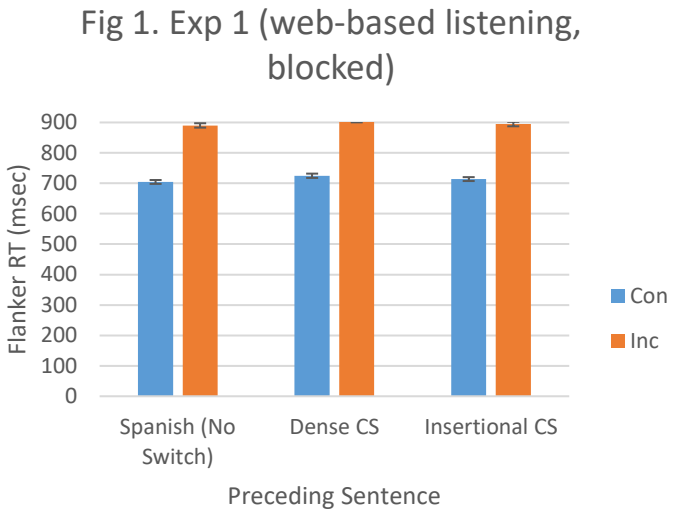
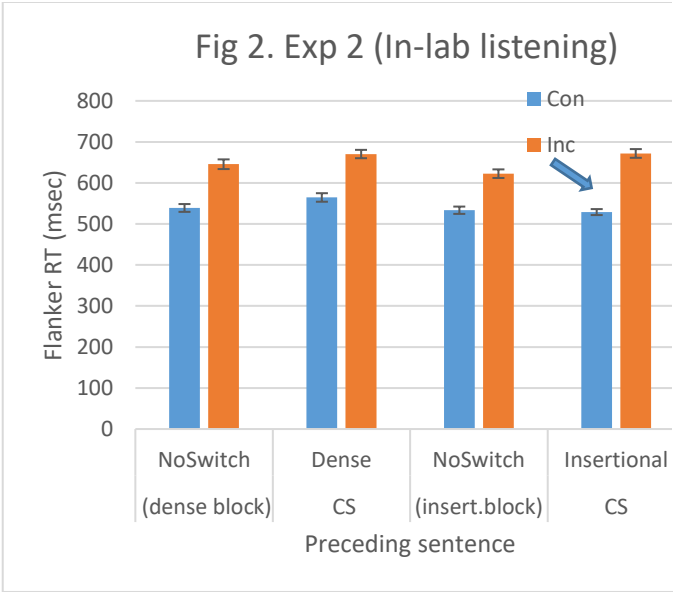
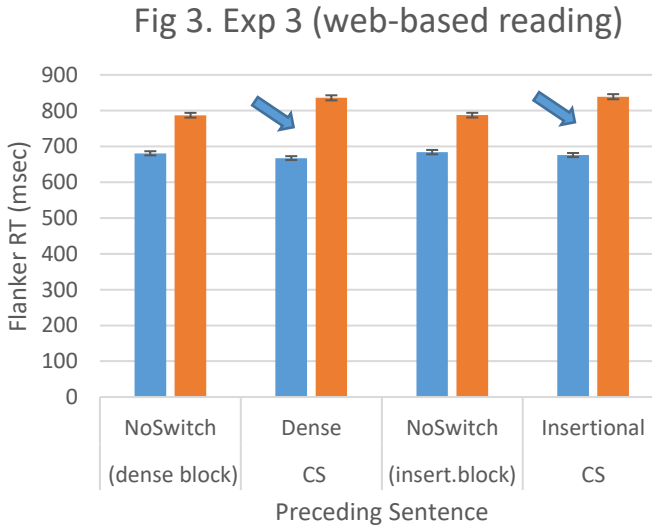


Fig1, 2 and 3. RTs to Flanker trials as a function of the preceding sentence type. Error bars are SEs. Blue: congruent flankers; Orange: incongruent. In Exp 1, blocks only had one type of sentence; In Exp 2 and 3 blocks had unilingual Spanish sentences intermixed with dense or insertional code-switches (CS). The conflict effect is larger after a CS than after a unilingual sentence in Exp 2 and 3, and larger after an insertional than dense switch in Exp 2.





References: Adler et al.,(2020) *JEPLMC*; Bosma & Pablos (2020). *J. Neurosci.*; Green & Wei (2014), *LCN*