Linguistic code-switching affects Executive Function in some bilinguals: First results from a new methodology

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Introduction

- In this study, we examine the link between code-switching (CS; alternating between 2 or more languages within a conversation), and Executive Function (EF; mental processes used for reasoning, paying attention, task switching, etc.)
- Language switching is challenging and requires cognitive control
  - Similar brain regions are activated during language switching and EF tasks (Abutalebi & Green, 2007)
  - Could CS be one of the factors enhancing EF in bilinguals?
- Though some work suggests that more frequent language switching correlates with better EF task performance (Soveri, Rodriguez-Fornells, & Laine, 2011; Yim & Bialystok, 2012), there has been no evidence that within subjects, CS and EF interact directly.
- This raises the possibility that mechanisms of EF and CS in bilingualism might interact, leading to behavioral effects.
  - We test this here with a new paradigm to assess direct interaction between EF and CS, to see if EF depletion will lead to a diminishment of CS productivity.

Research Question: Does depleting EF affect subsequent code-switching productivity, and does this occur across all bilinguals?
  - Will this vary according to other aspects of linguistic experience (e.g., frequency of CS, attitudes towards CS, level of bilingualism, etc.)?
- **Hypothesis**: If CS and EF interact directly, then manipulating EF (e.g., depleting EF) may have negative effects on subsequent CS (lower productivity).

Method

Participants:
- 24 Mandarin-English Bilinguals (13 female) from Upstate New York participated for extra credit or $5
- Average age = 21.7 years old ($SD = 1.5$)
- 12 China, 6 U.S., 5 Taiwan, 1 Singapore

Procedure:
- We measured CS by asking participants to talk for 2 min. on various topics.
  - Every 20s, a beep prompted participants to switch languages
  - **Dependent Variables for CS productivity:**
    1. Reaction Time (RT) taken to point of switch after the beep,
    2. No. of words produced
- EF Depletion was done through 2 verbal tasks (see Fig. 1)
- Participants completed the CS task again with 2 different topics
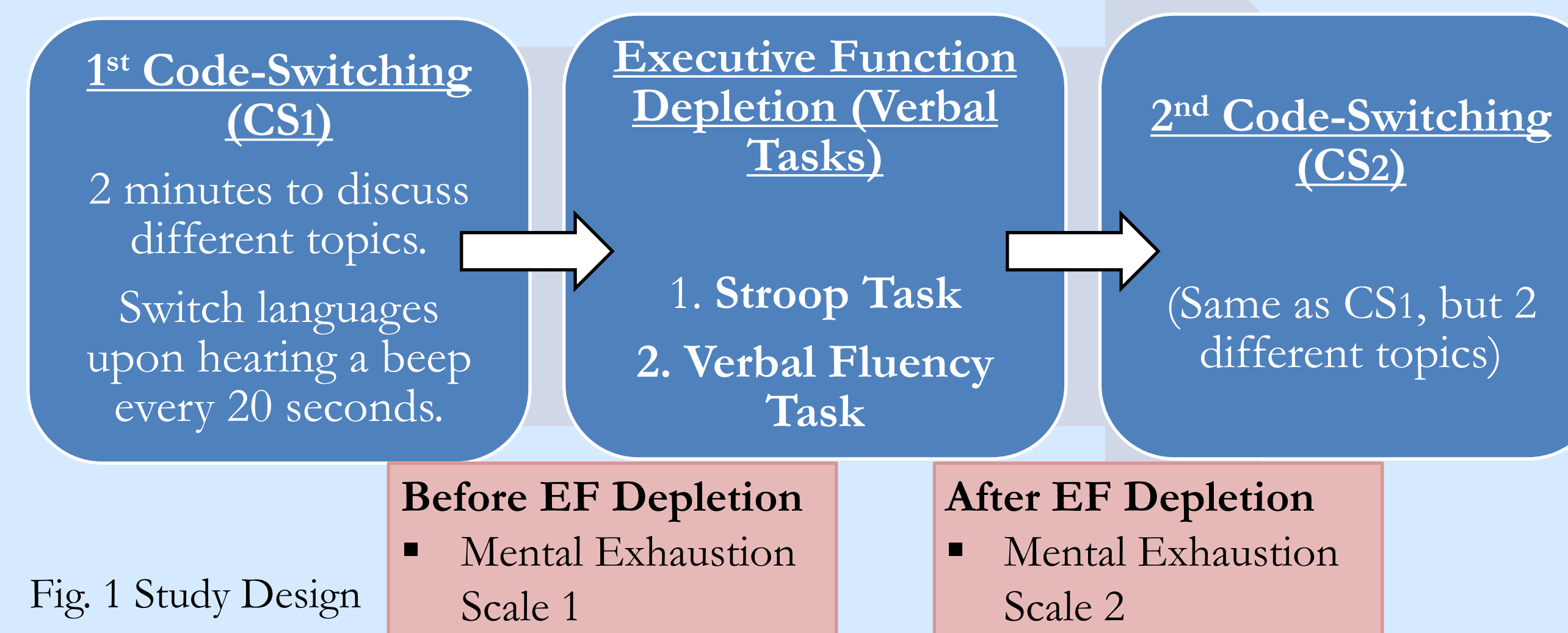- A language background questionnaire was completed at the end

Design

Fig. 1 Study Design

1st Code-Switching (CS1)
2 minutes to discuss different topics.
Switch languages upon hearing a beep every 20 seconds.

Executive Function Depletion (Verbal Tasks)
1. Stroop Task
2. Verbal Fluency Task

2nd Code-Switching (CS2)
(Same as CS1, but 2 different topics)

Before EF Depletion
- Mental Exhaustion Scale 1

After EF Depletion
- Mental Exhaustion Scale 2

Code-Switching Productivity: 2 Measures
- **Word Count difference = CS2 Word Count − CS1 Word Count**
- **RT (reaction time) difference = CS2 − CS1** (additional time taken to switch at the beeps during CS2) *RT results are not reported here*

Difference in Mental Exhaustion Level
- **Change in mental exhaustion level = Level before depletion − level after depletion**
  - Negative values: More exhausted after depletion, Positive values: Less exhausted after depletion

Participants' Self-Rating of Variables Related to the Bilingual Experience
- **Attitudes towards code-switching** (0: Negative attitude, 100: Positive attitude)
- **Level of bilingualism** (0: Complete monolingual, 100: Fully balanced bilingual)
- **Frequency of mixing languages** (0: Never, 7: All the time)

EF Depletion 1) Stroop Task (Incongruent trials only)
- Participants were told to read aloud the color of the ink of words as they appeared on a screen, ignoring the word meaning. This was completed in both languages.
- Example of stimuli: **BLACK**   **蓝(lán)**   **PURPLE**

EF Depletion 2) Verbal Fluency Task
- Participants were given 1 minute to generate items of a semantic category, alternating between Mandarin and English for each word, without repeating words in either language.
- Eg.: For "Colors" as a category ➔ "green", "粉红色", "purple", "黑色", "green", "蓝色", etc.

Results

Regression
- Univariate General Linear Model with DV: Word Count Difference
  - Initial model included Fixed factor (gender) and several covariates (Initial words produced, bilingualism level, Difference in exhaustion level, Frequency of mixing, Exhaustion X Frequency of mixing)
  - Removed insignificant factors (gender, initial words, bilingualism level)

	β	t	Std Error	p
Intercept	-3.02	-2.00	1.50	.06
Frequency of Mixing	.44	.27	1.62	.79
Exhaustion difference	1.24	.78	1.60	.45
Code-switching Attitude	4.35	3.16	1.38	.005
Mixing X Exhaustion Difference	3.19	2.09	1.53	.05

Table 1. Regression results with Word Count Difference as dependent variable

- **Code-switching Attitude:** For every 1 SD increase in attitudes towards CS (more positive attitude), overall words increased by 4.35
- **Mixing X Exhaustion Difference:**
  - **Low frequency of CS** and **high exhaustion level** (e.g., more exhausted after depletion) together corresponded to a decrease in words in CS2.

Summary of Results
- Main factors influencing participants' overall word change: 1) Attitude towards CS, 2) Interaction of participants' mixing frequency and their mental exhaustion level

Conclusion & Future Direction
- EF depletion can affect subsequent CS (i.e., less words produced subsequently), but this only occurs in bilinguals with negative CS attitudes.
- If there is a direct effect of EF on subsequent CS, would we find a similar effect in the other direction?
  - Will an increase in CS (e.g., training someone on language switching) result in improved EF performance?

References

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