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Bilingualism and Arithmetic – A Pilot Study

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It has been widely hypothesized that while doing arithmetic individuals use two distinct routes for phonological output. A direct route requires exact arithmetic which is thought to have been linked to language dependent areas of the brain. In addition, an indirect route thought to be language independent is active during arithmetic approximation that relies on visuo-spatial skills. The arithmetic double route has been incorporated on the triple code model that consists of Visual Arabic code for identifying string of digits, magnitude code for knowledge in numeral quantities, and verbal code for rote arithmetic fact. Our goal is to investigate whether language experience has an effect on the processing of exact/approximation math using bilingual participants who have access to two languages. We will measure the 2 groups (monolinguals/bilingual) processing speed to complete the 2 tasks (Exact/Approximation) in 2 codes (Arabic digit/Verbal). We hypothesized a faster reaction time in exact arithmetic task in comparison to approximation due to it being language dependent. We expect larger RTs in bilinguals when exact sums are presented in the verbal code. We also expect a main effect for the task (Exact vs. Approximation) independent of the input code when the stimulus was presented in either Arabic digit and/or verbal codes. Results from this study have implications in understanding the importance of the input code when processing numbers. Further neuroimaging studies need to be compiled to investigate brain activation during simple arithmetic when bilinguals use verbal or Arabic digit coding.

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Theoretical Background

- Dehaene and collegues (1999). proposed two independent aspects of arithmetic: exact calculation which can be seen as language dependent and approximation which can rely on non-verbal visuo-spatial cerebral network.

Triple code Model for arithmetic processing

- Visual Arabic code for identifying string of digits
- Magnitude code for knowledge in numeral quantities,
- Verbal code for rote arithmetic fact.

Direct Route

- Is active during exact arithmetic which is thought to have been linked to language dependent areas of the brain and relies on the left inferior frontal circuit. Is accomplished by visual identification (2 x 4), visuo-verbal transcoding ("two times four") and verbal sequence completion ("two times four, eight")

Indirect Route

- Is active during arithmetic approximation and is thought to be language independent which employs visuo-spatial skills and relies on visuo-spatial network of the left and right parietal lobes

- To test such idea Russian-English bilinguals were asked during exact condition to chose the correct sum from two numerically close answers while in the approximation condition the subjects were told to estimate the sum and choose the correct response.

- The subjects performance was equivalent in the two languages on the approximation task condition, but was faster on the trained sums of exact arithmetic. providing evidence that knowledge acquired by exposure to approximate problems are stored in a language-independent form. It is unclear if these findings extend to other arithmetic input codes.

Objectives/Hypotheses

- Our investigation tried to observe the mediation of language in the processing of simple arithmetic using Arabic digit coding as well as verbal code; the research question was whether language experience had an effect on the processing of exact/approximation math comparing bilingual participants who have access to two languages to monolinguals with access to one language only.

- We hypothesized faster reaction time in exact arithmetic tasks in comparison to approximation due to it being dependent on language skills.. We expected a group by task by code interaction. We anticipated larger RTs in bilinguals compared to monolinguals when exact sums were presented in the verbal code .

Methods

Participants: This pilot study consisted of college students taking psychology classes at FAU with nine males and thirty-one females participants with an average age of 24.64 (+/- 5.29). Twenty five were monolinguals and 17 bilinguals

Materials: Software called DirectRT designed by Empirisoft Inc. was used in this investigation to observe reaction time in participants. In participants were also asked to complete a language history questionnaire

Means and standard deviations by groups

	Language			
	Monolingual		Bilingual	
	Mean	SD	Mean	SD
Arabic Approximation	877.77	343.30	1002.33	401.96
Arabic Exact	784.43	330.46	838.37	259.12
English Approximation	1729.22	683.11	1540.07	450.73
English Exact	1478.30	570.22	1407.93	390.00
Spanish Approximation	0.00	0.00	1857.77	544.27
Spanish Exact	0.00	0.00	1655.68	458.22

Figure 1: Language by Task descriptive

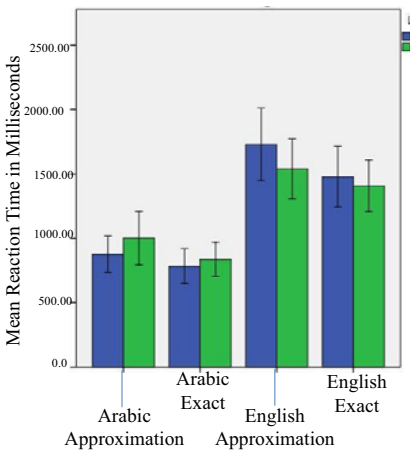
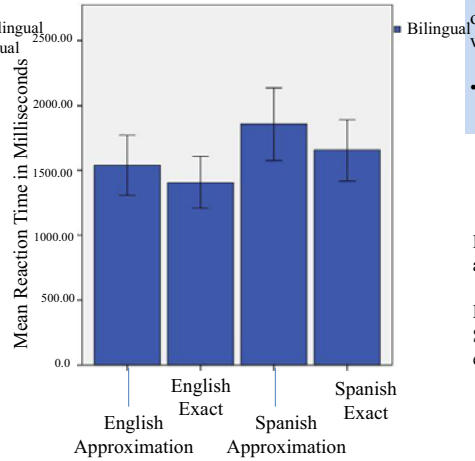


Figure 2: Verbal Task for Bilinguals participants



Results

- A 3 X 2 within-subjects ANOVA was conducted to evaluate the effects of code (Arabic digit, English and Spanish) and task (approximation and exact sums) on arithmetic processing.

The ANOVA showed significant main effects for:

- Task (Λ (Wilks' Lambda) = 0.771, F (1, 40) = 11.887, $p < .01$),
- Code (Λ (Wilks' Lambda) = 0.251, F (2, 39) = 58.290, $p < .01$),
- Task x Code x Group (Λ (Wilks' Lambda) = 0.857, F (2, 39) = 3.2585, $p < .05$.
- As predicted exact arithmetic sums were faster than approximation sums supporting the idea that exact arithmetic may be language dependent. Arithmetic sums were also faster in Arabic digit code in comparison to verbal code. (Figure 1)

- When between subject factors were evaluated between monolinguals and bilinguals The Code X Group interaction was also significant ($\Lambda = 0.155$, F (2, 39) = 10.350, $p < .01$)

- Even when observing scores in the verbal task for the bilingual group (Figure 2) it was also clear that exact arithmetic was faster when being compared to approximation task in both English and in Spanish. Scores also differed when comparing the two verbal task within the bilinguals.

Post Interview Response

- Most participants have mentioned that doing the calculation in the Arabic form was easier in comparison to the verbal task.
- When bilinguals were asked which verbal task they found to be less difficult, they mentioned almost always they were faster in the verbal task of the language they perceived more proficient in.

In addition, since the verbal task was in English and in Spanish, participants have reported to the investigators that when doing the arithmetic task in a language that they perceived not as proficient, they used various strategies to get to the successful phonological output such as transcribing it back into their first language or digits which may suggest language interference.

- Results from this study may have implications in understanding the importance of the input code in the processing of numbers.

References:

Dehaene, S, Molko, N, Cohen, L, & Wilson, A. (2004). Arithmetic and the brain. *Science Direct*, *14*, 218-224.

Dehaene, S, Spelke, E, Pinel, P, Stanescu, R, & Tsivkin, S. (1999). Sources of mathematical thinking: behavioral and brain-imaging evidence. *Science*, *284*, 970-973.