AUTOMATICITY OF PLACE VALUE PROCESSING IN DUAL LANGUAGE IMMERSION SECOND GRADERS

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DOES THE LANGUAGE IN WHICH CHILDREN LEARN MATH CHANGE THE WAY THEY PROCESS TWO-DIGIT NUMBERS?

Automaticity of Processing

the act of seeing an Arabic numeral completely activates its magnitude representation (the quantity of the number) without intention, even if the number is not relevant to the task

(Dehaene, Bossini, & Giraux, 1993; Ganor-Stern, Tzelgov, & Ellenbogen, 2007; Zbrodoff & Logan, 1986)

decomposed parallel processing

decade and unit digits are processed in *parallel* and simultaneously

English-speaking children develop parallel processing around 4th grade,

(Nuerk et al. 2004)

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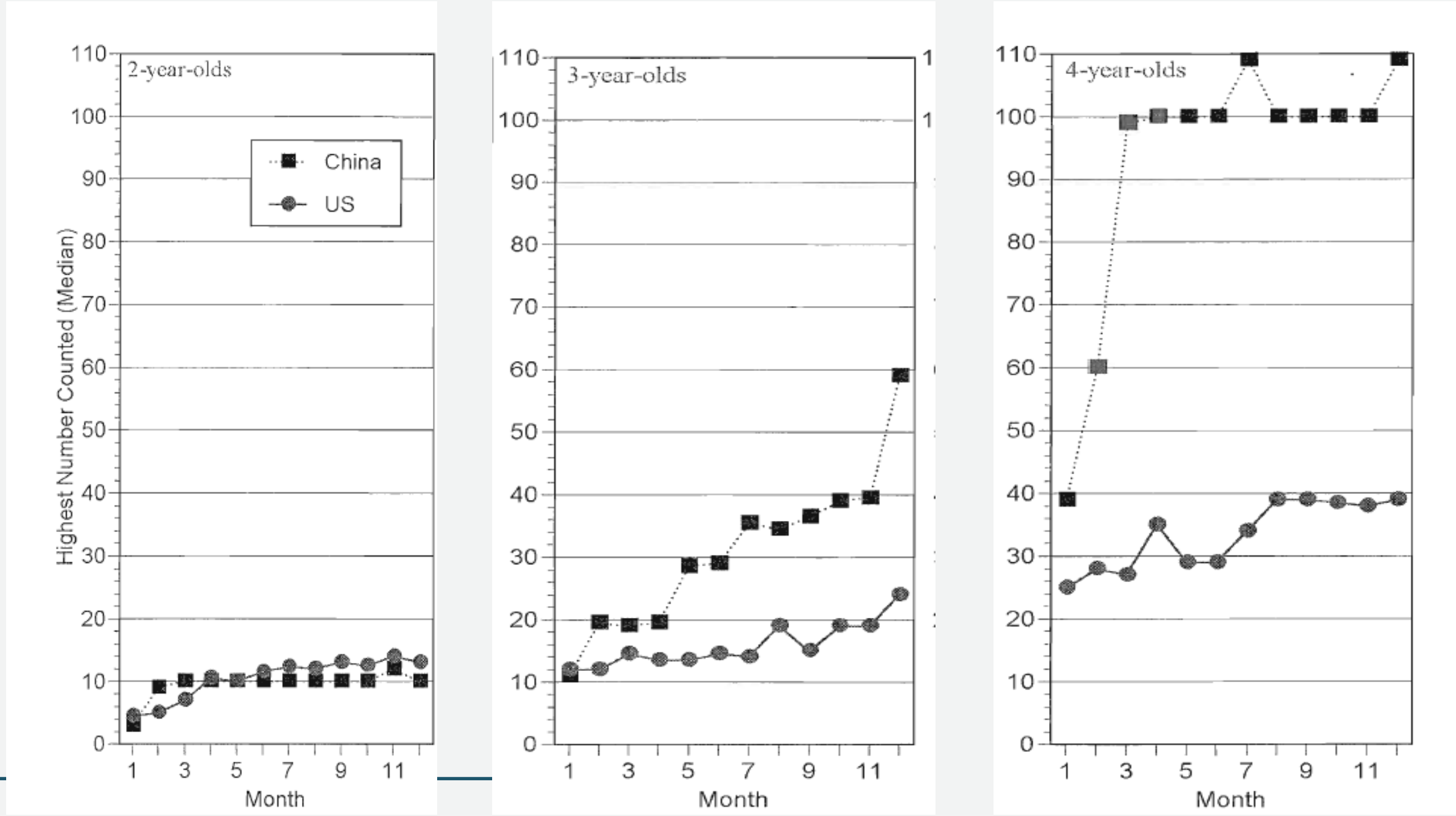
but Chinese students consistently use parallel processing as early as 2nd grade.

(Chan et al., 2011)

decomposed sequential processing

decade digits are processed *sequentially* from left to right



(Miller, Smith, Zhu, & Zhang, 1995)

Transparency / Regularity

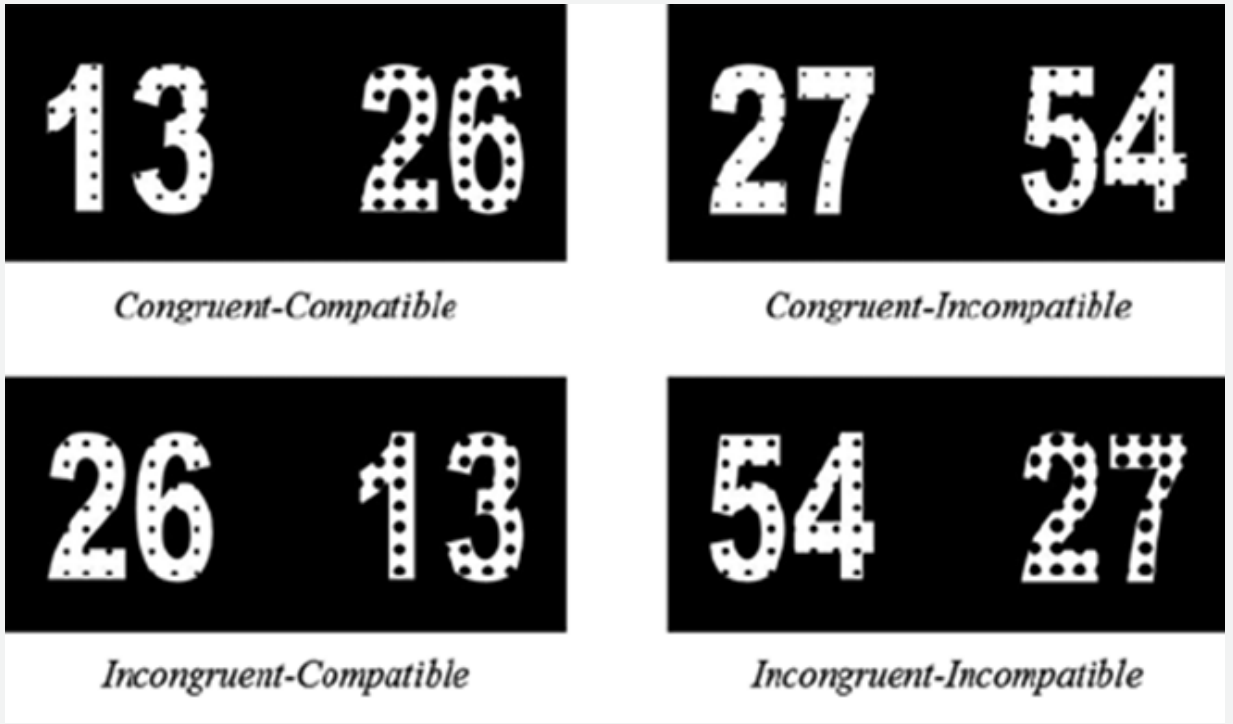
It's easier to learn to count in Chinese than in English.

(Miller, Smith, Zhu, & Zhang, 1995; Miller, Smith, & Zhang, 2004; Miura, Okamoto, Kim, Steere, & Fayol, 1994; Zhou, Chen, Chen, Jiang, Zhang, & Dong, 2007).

Arabic Written	English Spoken	Mandarin Written	Mandarin Spoken
1	One	一	Yī
2	Two	二	Èr
3	Three	三	Sān
4	Four	四	Sì
5	Five	五	Wǔ
6	Six	六	Liù
7	Seven	七	Qī
8	Eight	八	Bā
9	Nine	九	Jiǔ
10	Ten	十	Shí
11	Eleven	十一	Shí yī
12	Twelve	十二	Shí èr
20	Twenty	二十	Èr shí
21	Twenty-one	二十一	Èr shí yī
40	Forty	二十	Sì shí
41	Forty-one	四十一	Sì shí yī
42	Forty-two	四十二	Sì shí èr
100	One hundred	一百	Yī bǎi
142	One hundred forty-two	一百四十二	Yī bǎi sì shí èr

Figure 1.

Predicted reaction times (RTs)

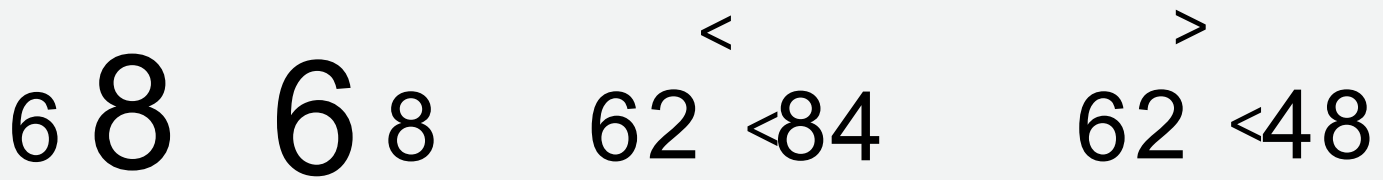


Note: Included with the permission of W. W. L. Chan (Chan et al., 2011). Numerical values for estimated RTs are inaccurate, but the pattern of difference between decomposed sequential processing and decomposed parallel processing remains.

Congruency

It takes longer to process incongruent trials because the size difference interferes with processing the numerical magnitude.

- In congruent trials on the numerical-Stroop, the physically larger number is also the numerically larger and in incongruent trials the physically larger number is the numerically smaller.



Compatibility

(only important for two-digit numbers)

Adults take longer to process incompatible pairs than compatible pairs.

- A pair of numbers is unit-decade **compatible** if comparisons between both the decade and unit digits lead to the same decision (e.g., for the pair 62_84, both 6 < 8 and 2 < 4).
- The pair of numbers is **incompatible** of the two comparisons for decade and unit digits lead to different decisions (e.g., for the pair 62_48, 2 < 8, but 6 > 4)

Hypothesis

Native English-speaking children who learn Mandarin at school through a Dual Language Immersion program will display increased evidence (via significantly higher inverse efficiency scores on the incongruent-compatible condition of the dot-number Stroop task) of decomposed parallel processing in comparison to their English monolingual peers.

GERMAN

FRENCH

CHINESE

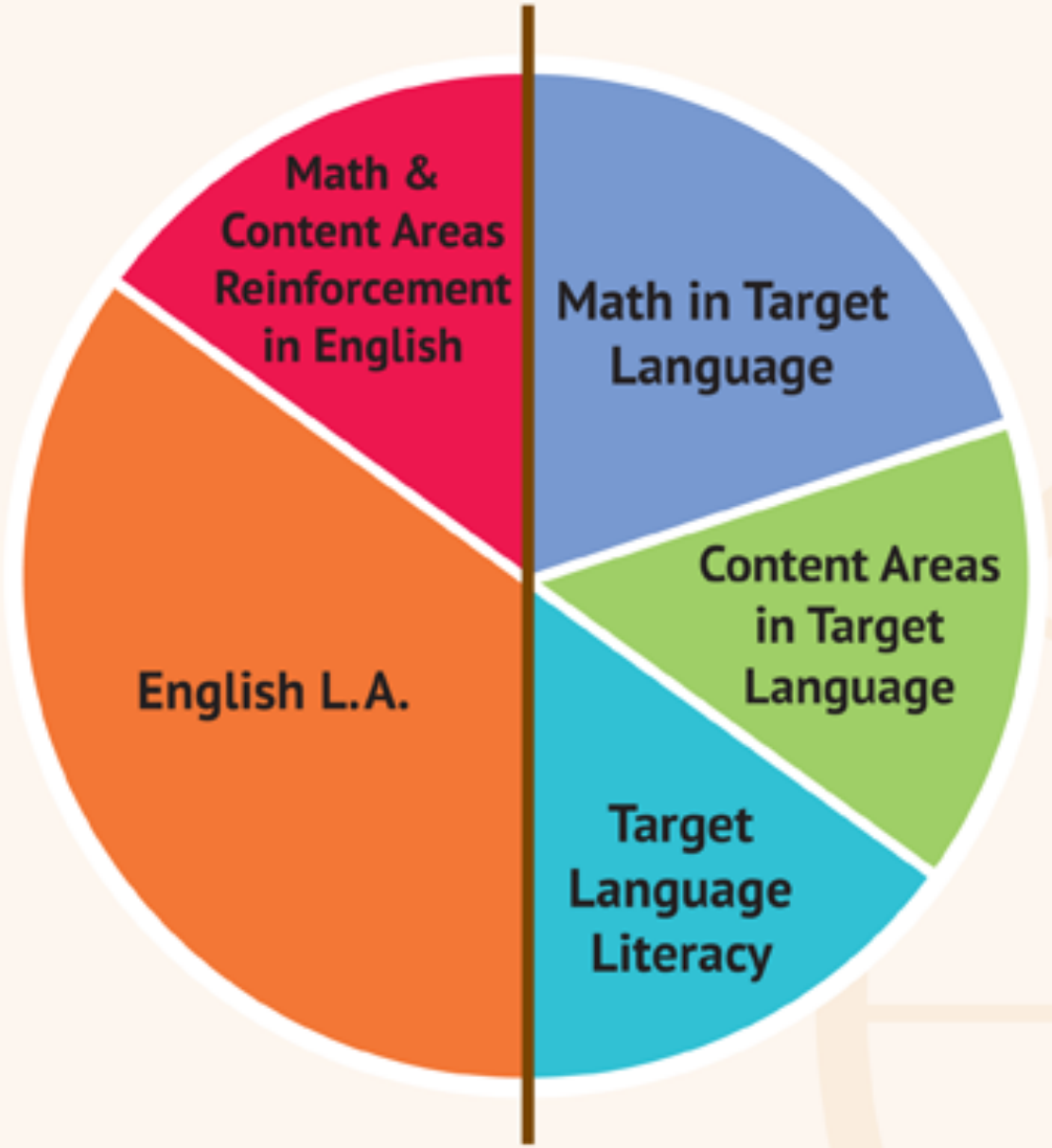
RUSSIAN

PORTUGUESE

SPANISH

- 50% of the day is in English and 50% of the day is in the target language.
- English-speaking children enter first grade and become functionally fluent in the target language.
- Children in DLI use the same curriculum as their English-speaking peers that attend the same school

Dual Language Immersion Instructional Time : Grades 1-3



- Math in Target Language (20%)
- Content Areas in Target Language (15%)
- Target Language Literacy (15%)

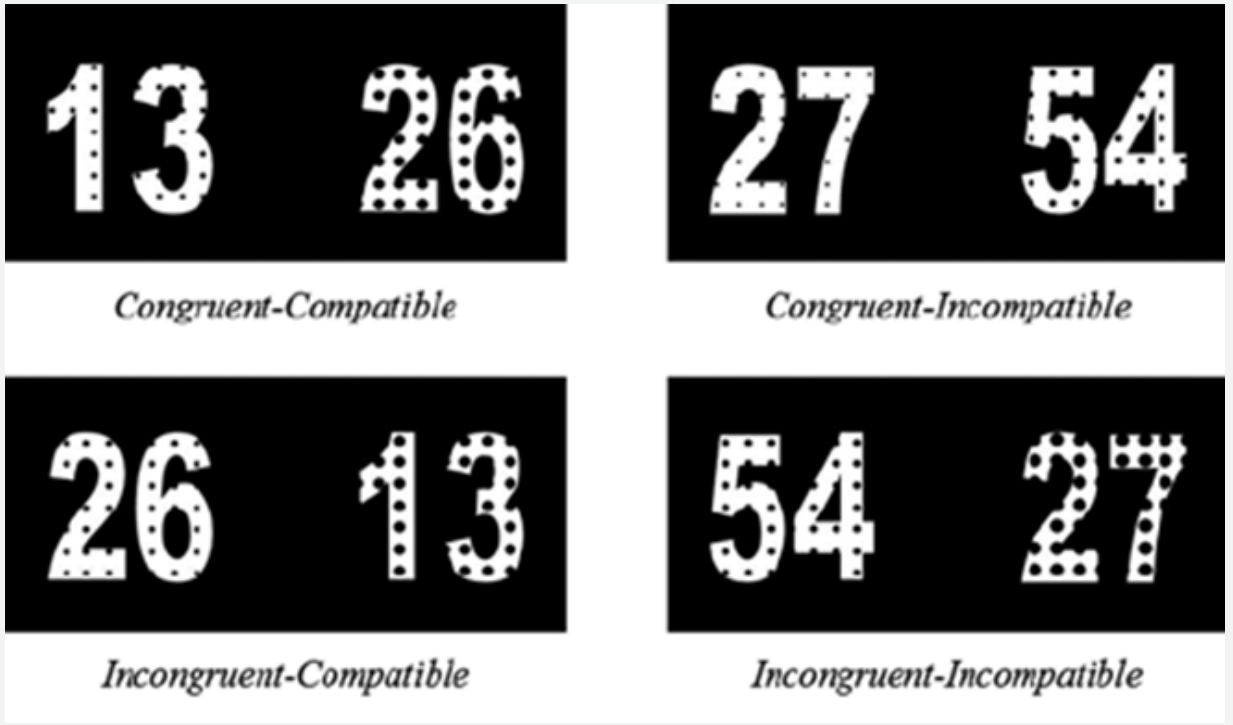
- English L.A. (35%)
- Math and Content Areas Reinforcement in English (15%)

UTAH DUAL LANGUAGE IMMERSION

Hypothesis

Figure 1.

Predicted reaction times (RTs)



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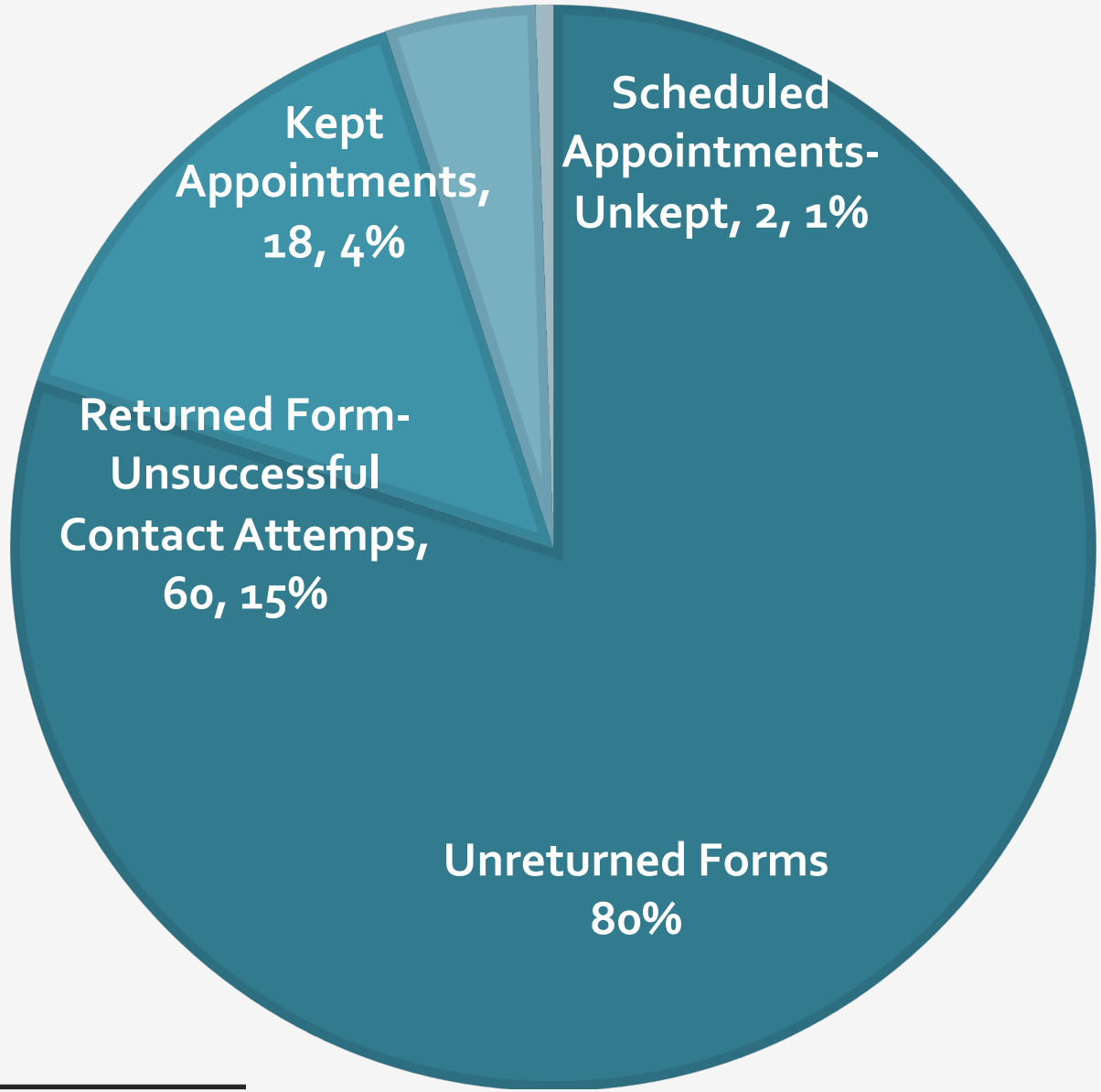
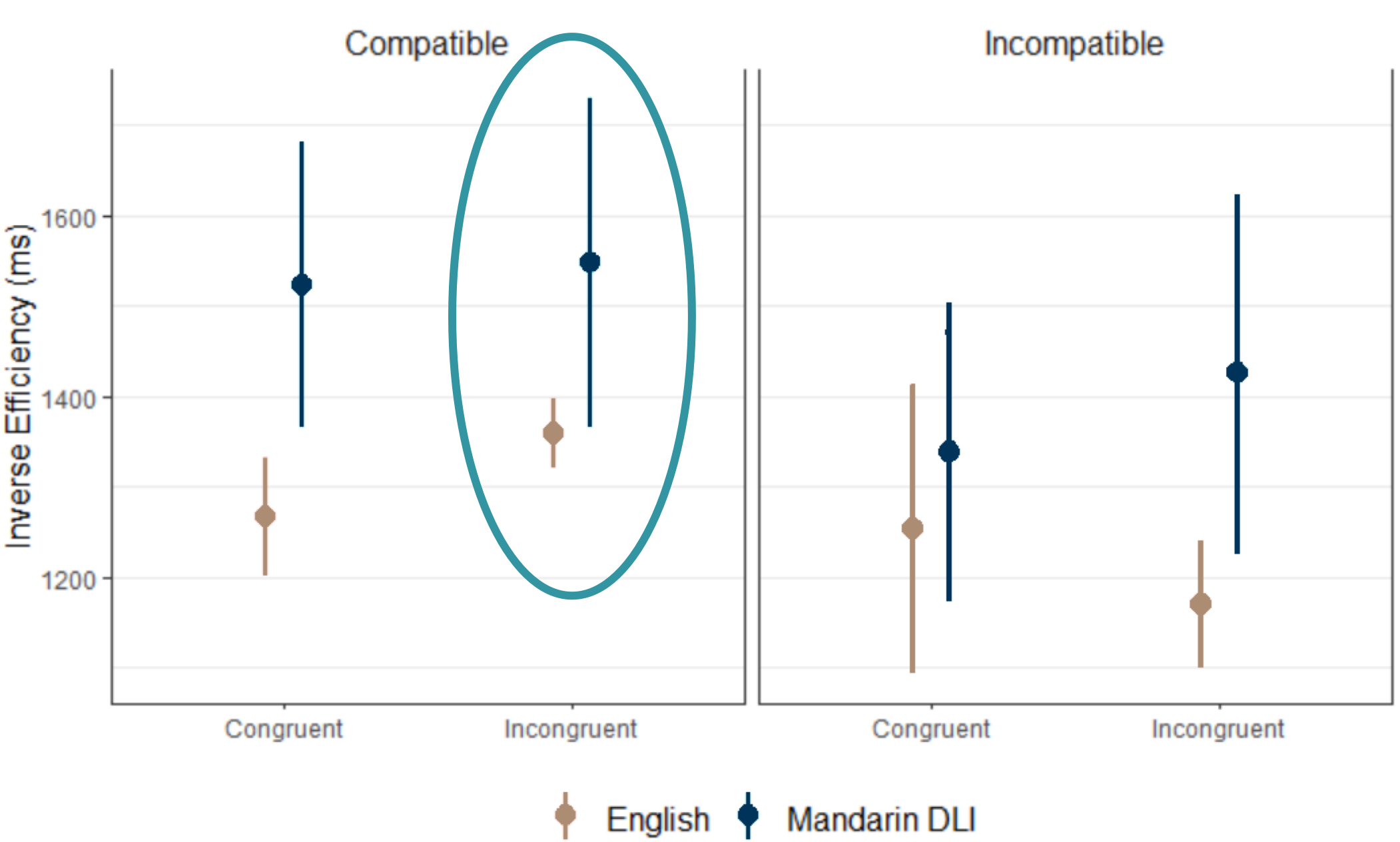

Scheduled Appointments- Unkept, 2, 1%
Kept Appointments, 18, 4%
Returned Form- Unsuccessful Contact Attemps, 60, 15%
Unreturned Forms 80%

Participants

Table 2

Demographic data

Language of math instruction	Female	Male
Mandarin	6	4
English	3	1
Totals (N = 14)	9	5
Age	M= 8.3	SD= 0.6



Accuracy and reaction time were combined into one measure of corrected reaction time- inverse efficiency (IE). IE was calculated for each participant by dividing the average reaction time of correct trials by the proportion of correct trials.

Analysis

- 2x2x2 mixed design ANOVA
  - inverse efficiency
  - Within-participant factors: congruity and unit-decade compatibility
  - Between-participant factors: language group

$F((12) = 0.38, p = 0.55, \eta^2 = .03$

- Independent samples t-tests
  - condition (compatible-incongruent, incompatible-congruent, compatible-congruent, and incompatible-incongruent)
  - language group (English or Mandarin DLI)

- In the compatible-incongruent condition, the Mandarin sample showed higher IE in comparison to the English sample (though still insignificant).

$t(12) = -0.63, p = 0.54, d = -.37.$

Discussion

- Children in the English monolingual sample seem to have slower inverse efficiency scores in Compatible Incongruent condition.

MAYBE

- This indicates a possibility that they are still using decomposed sequential processing.

MAYBE

- Mandarin DLI students appear to be using, or are potentially beginning to use, decomposed parallel processing as indicated in their relatively low inverse efficiency scores on the Compatible Incongruent condition.

MAYBE

Future Directions

- Increased sample size
- Measures of participants' fluency in target language
- Math skills and cognitive measures delivered in target language
- Increased attention to variables introduced by model of dual language immersion education
- Validation of dot-number Stroop as provoker of N450 event-related potential
- Exploratory dot-number Stroop research between languages that use regular base-10 numerical systems, irregular base-10, and regular base-20

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