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INTRODUCTION

Multiplication problems can be represented in several ways, like Arabic digits or spoken number words. Models of arithmetic have proposed that children rely on verbal rehearsal to encode these facts into memory, suggesting that the format of the encoded problems could influence solution retrieval.

Access to semantic memory is reflected on the amplitude of the N400 [1]. Our previous work showed that when children verify the correctness of simple multiplication problems presented as Arabic digits, a robust N400 is elicited with larger amplitude for incorrect than correct problems. In contrast, the effect observed in adults who completed the same task was a target P300 to correct solutions only [2,3,4].

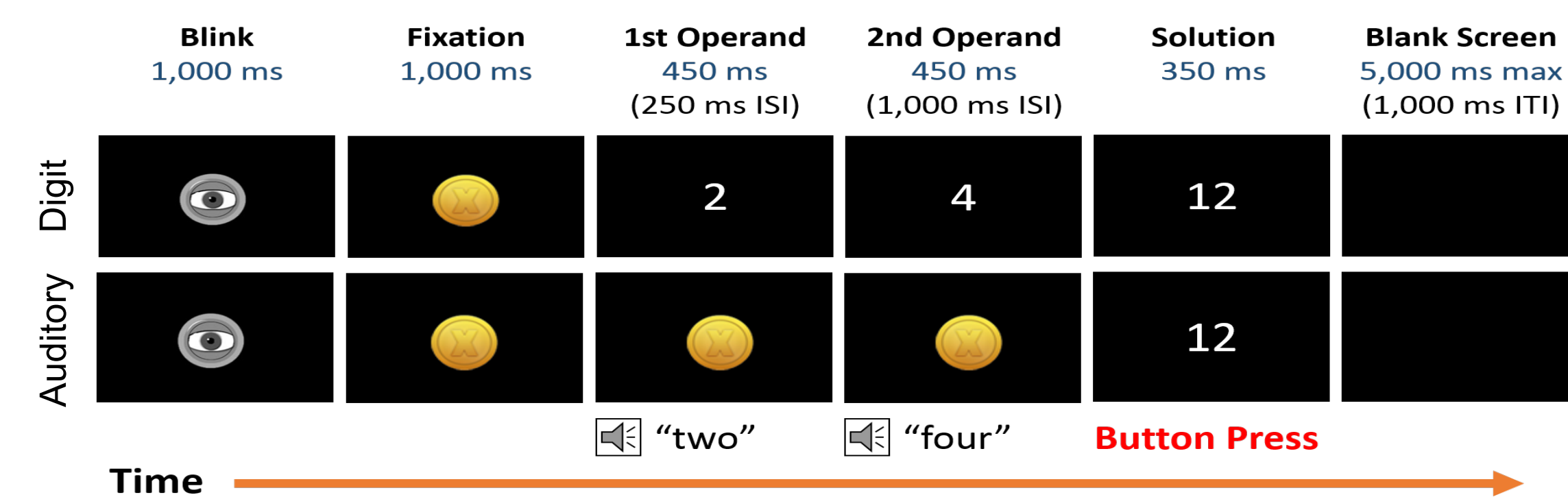
The current study measured the effect of operand format on multiplication fact verification in children to determine if memory access differs for words and digits. We compare our findings to a word-picture verification task to determine if math and language engage similar brain processes.

METHODS

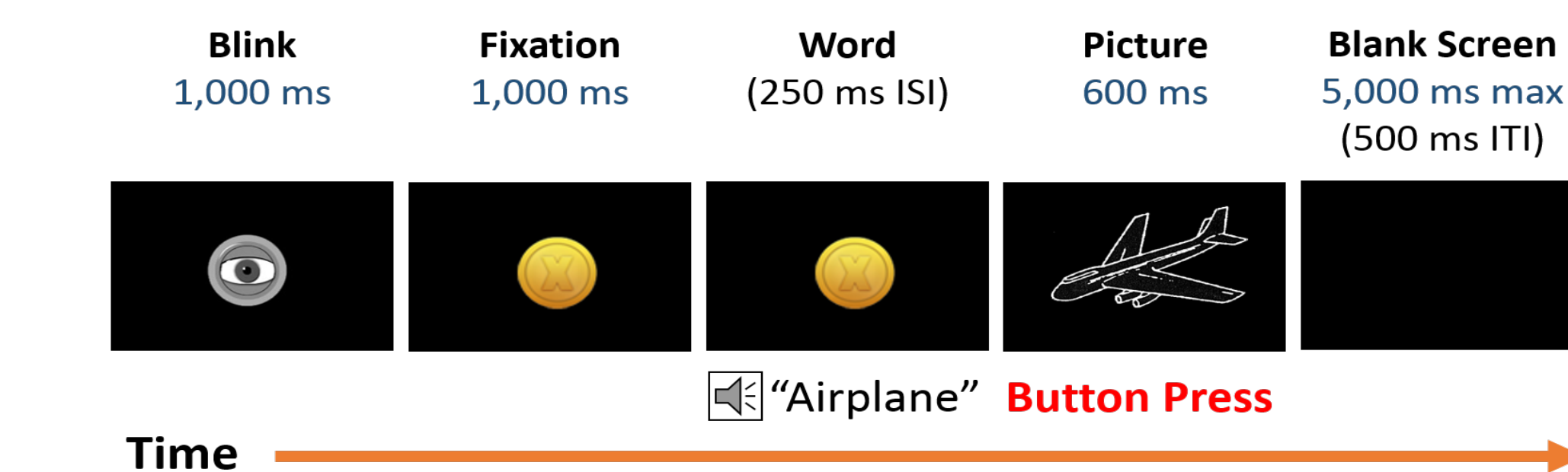
Participants: 55 elementary school children (grade 3-5; 27 female)

Standardized Measures: math fluency (WIAT-III), working memory (WJIII) and phonological awareness (WJIII).

Math Tasks: Judge the correctness of solutions to multiplication problems with operands presented as either Arabic digits, or spoken words. Solutions are always presented as Arabic digits and are 50% correct and 50% table-related incorrect (e.g., 2 4 8 versus 2 4 12).



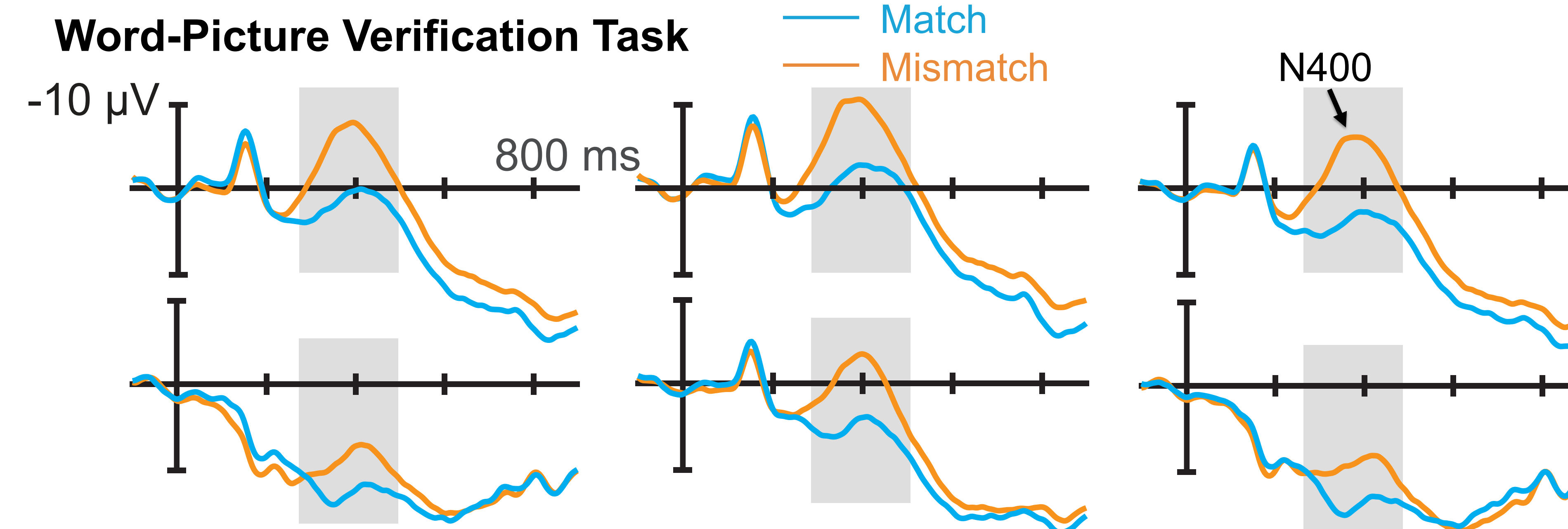
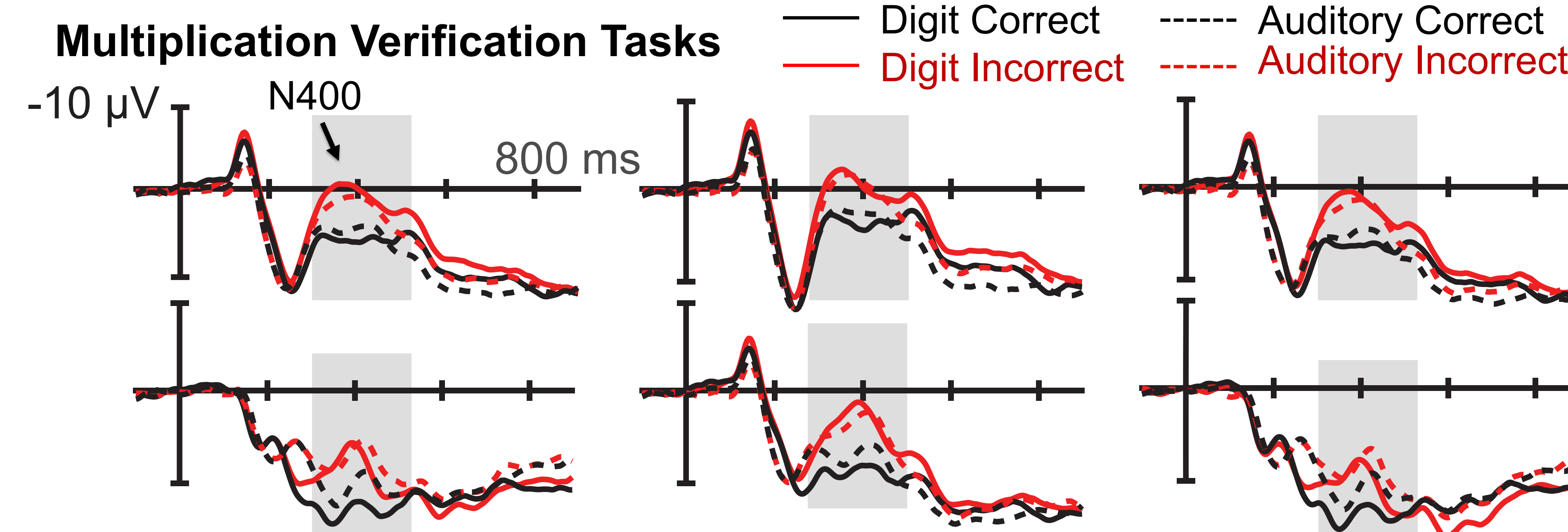
Word-Picture Verification Task: Judge the semantic fit of pictures to preceding spoken English word; 50% match/mismatch (“airplane” – airplane/umbrella)



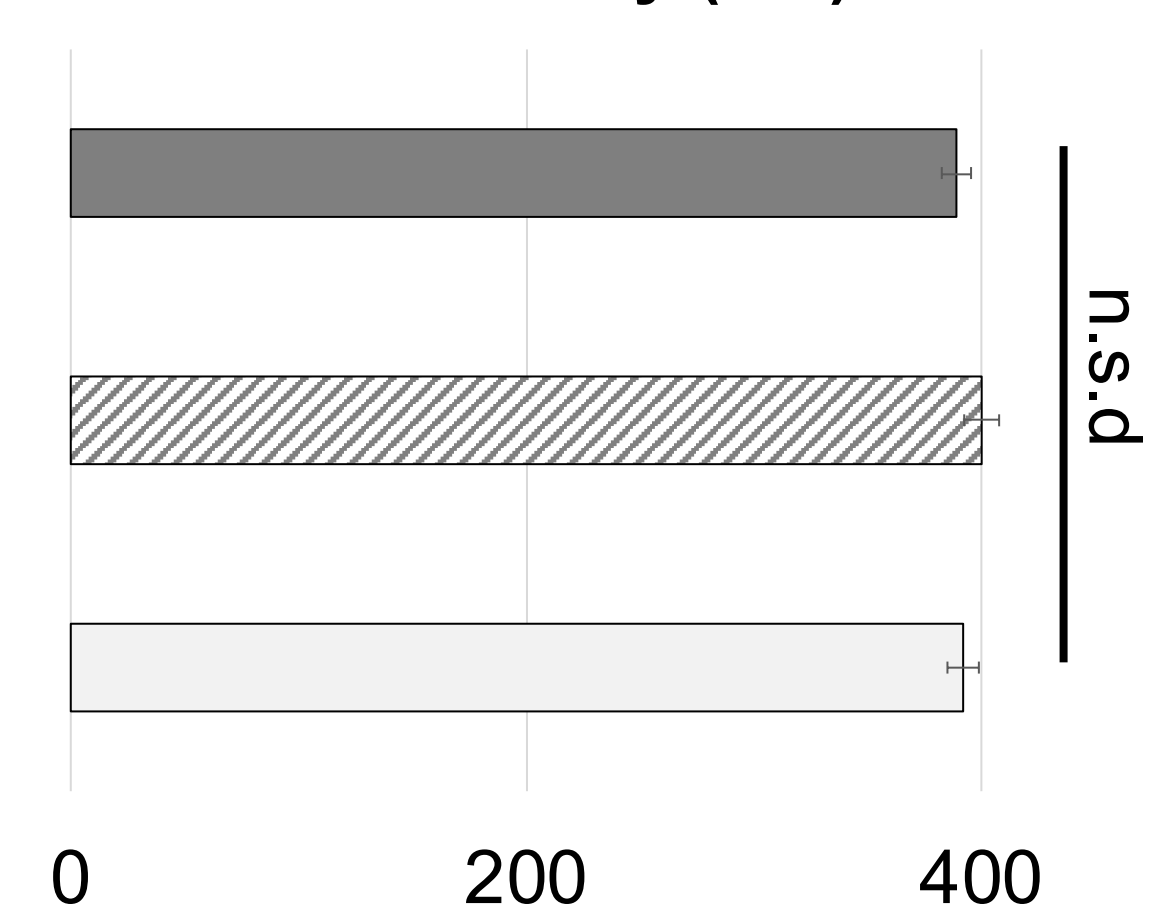
Task Order: All children performed the Arabic digit task during Session 1 and the Auditory tasks (spoken number word and word-picture verification tasks) during Session 2.

- On average, the time difference between Session 1 and Session 2 was 5 months (range: 2 days – 17 months).
- 21 children moved up one grade level between Session 1 and Session 2 (average time between sessions: 7 months; range: 3 – 17 months).
- 34 children were in the same grade level for the two Sessions (average time between sessions: 3 months; range: 2 days – 10 months).

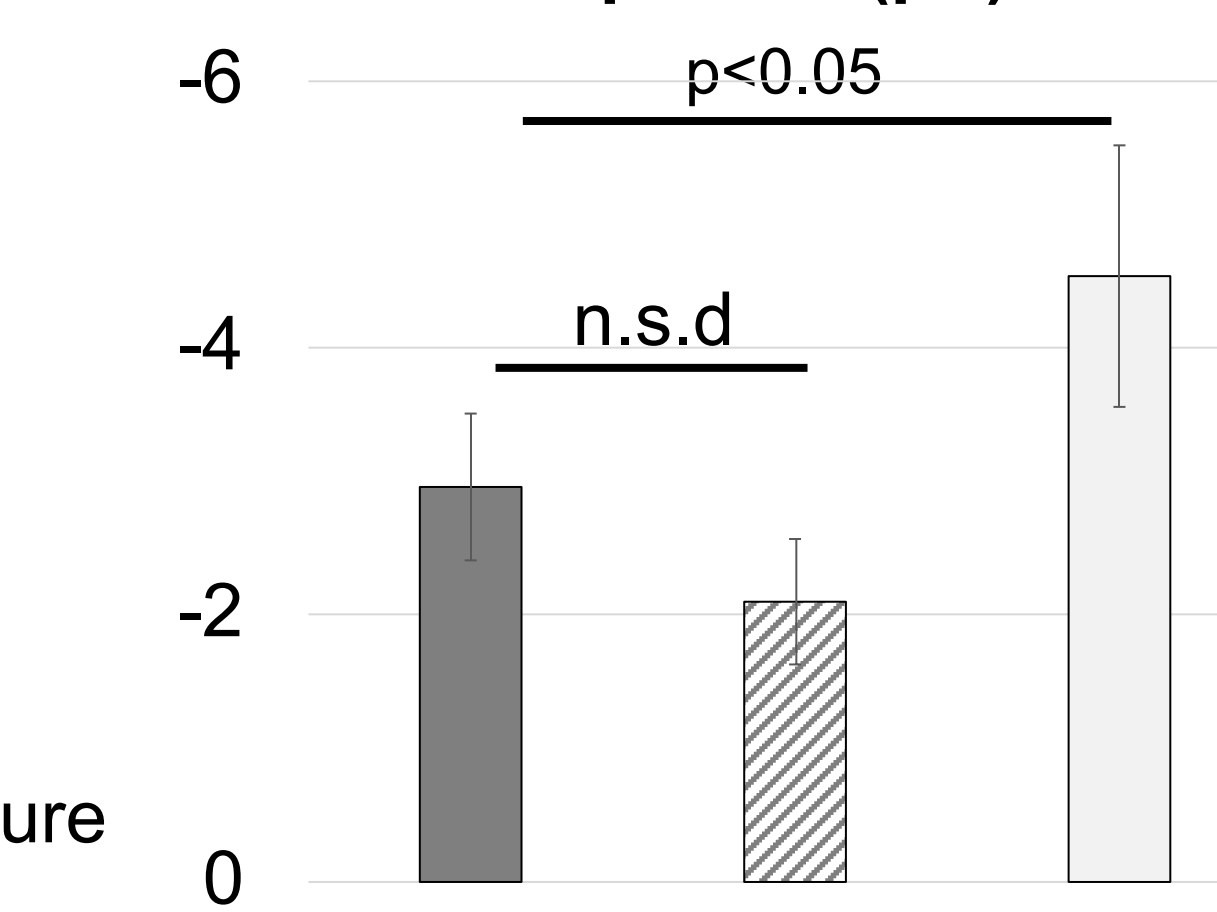
TASK COMPARISON: N400 EFFECT



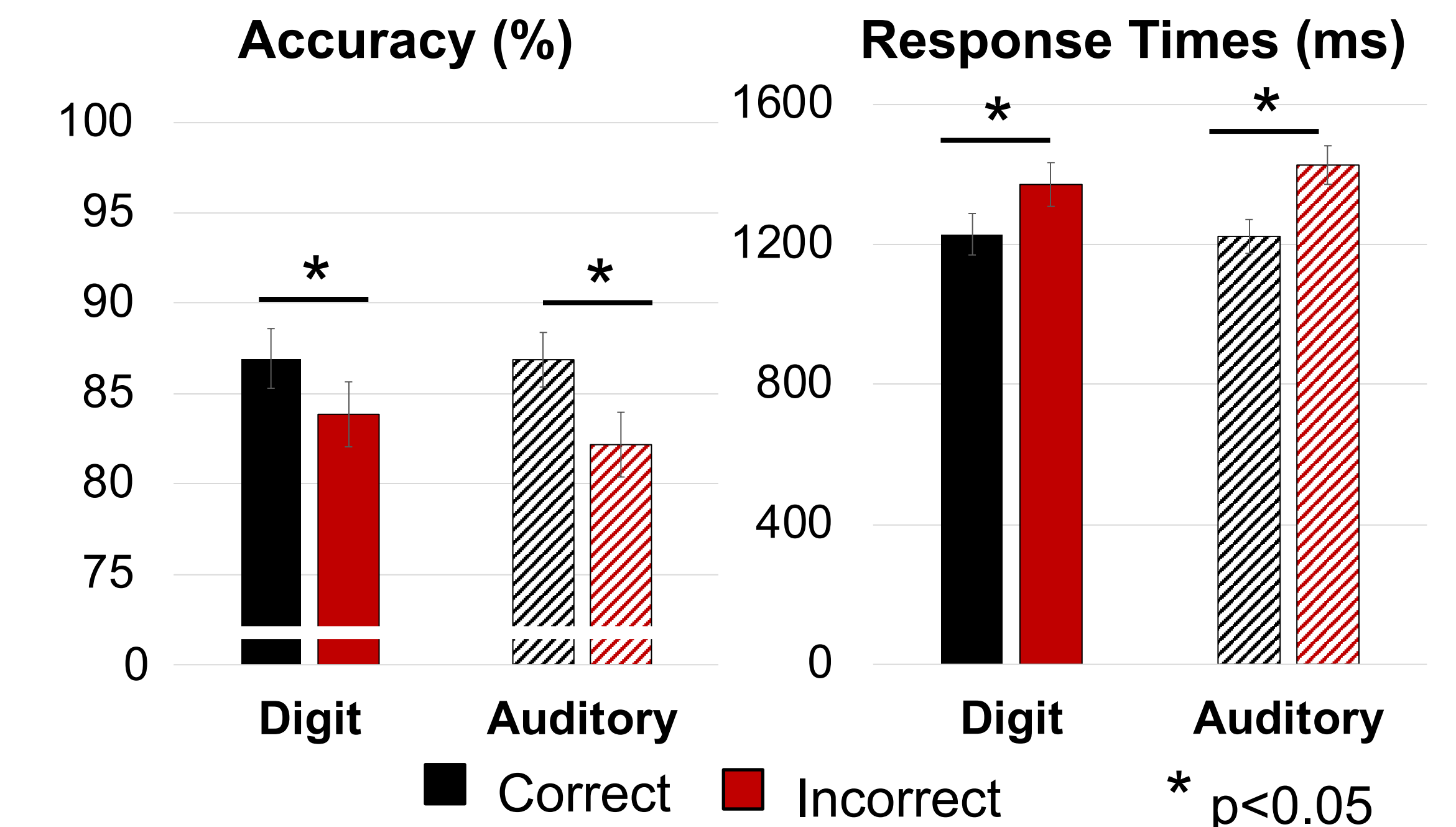
N400 Effect (incorrect – correct)
Latency (ms)



N400 Effect (incorrect - correct)
Mean amplitude (µV)



BEHAVIORAL RESULTS



No effect of format on both accuracy and RT ($F(1,54)=0.46, p=0.5$)

CONCLUSION

- Children showed an arithmetic N400 effect at the solution, with more negative amplitude for incorrect than correct problems. This was true when the digit solutions were preceded both by digit and spoken word operands.
- There were no effect of format on performance (accuracy and response times) across the two math tasks, indicating that operand format did not influence multiplication fact verification. Responses to correct solutions were faster and more accurate in both tasks.
- Children also showed an N400 effect in the word-picture verification task, with more negative amplitude for mismatch than match trials.
- The timing of the N400 was similar across the three tasks, but the amplitude was larger in the word-picture task.
- A frontal format effect was observed for multiplication trials with auditory operands, but not digits. This could be similar to the positivity observed in language studies⁵ or due to the format switch (Arabic solutions) in the task. There was also a sustained match effect in the word-picture task.
- Overall, the results indicate that 1) verifying math facts and word-picture (mis)matches engage similar semantic level processes, 2) retrieving multiplication facts from memory occurred similarly regardless of operand format.

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TASK COMPARISON: ANTERIOR EFFECT

