

How do 3rd-grade children understand the commutative principle of multiplication?

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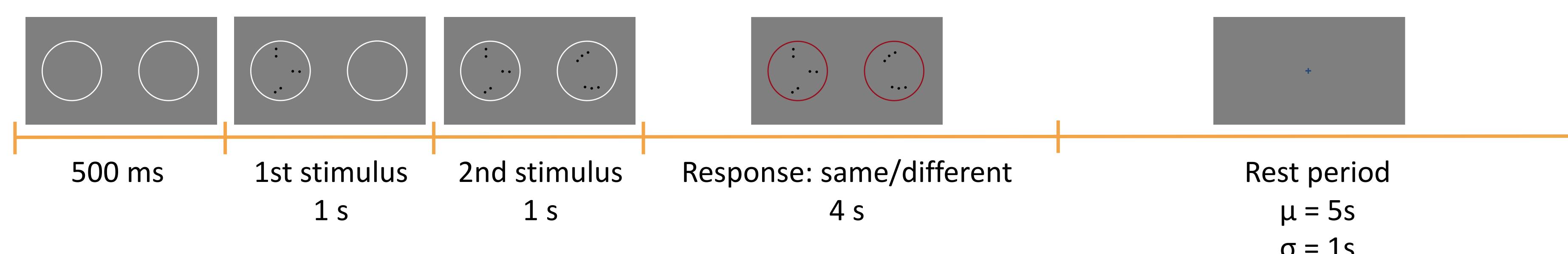
Introduction

School-age children learn the basic rules of arithmetic and implicitly experience some of their properties, such as commutativity. These properties are often taught as calculation strategies and are thus intrinsically tied to symbolic calculation. As a result, children's knowledge that 2×3 equals 3×2 may only

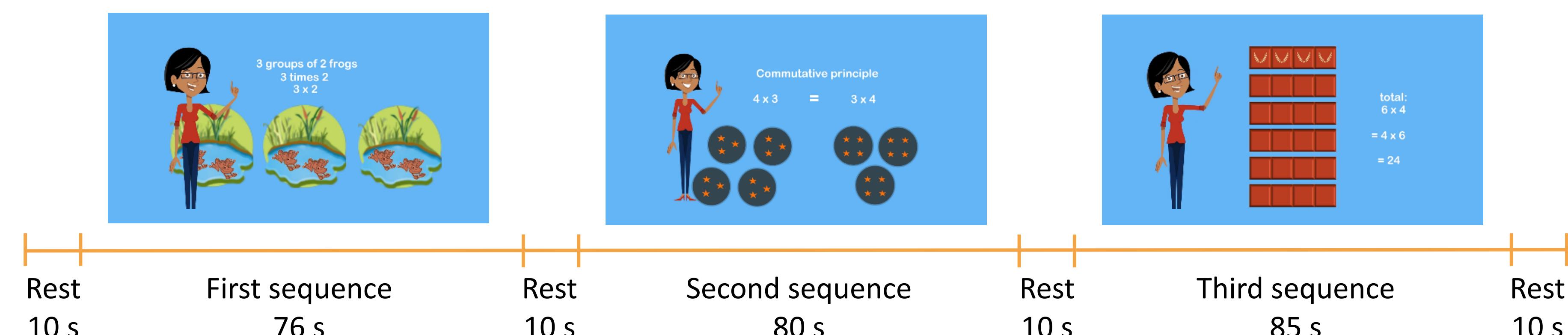
reflect a shallow understanding of commutativity. In the present study, we investigated 3rd-graders' understanding of commutativity in symbolic versus non-symbolic contexts, and we assessed their corresponding brain activity in both passive and active tasks.

Methods

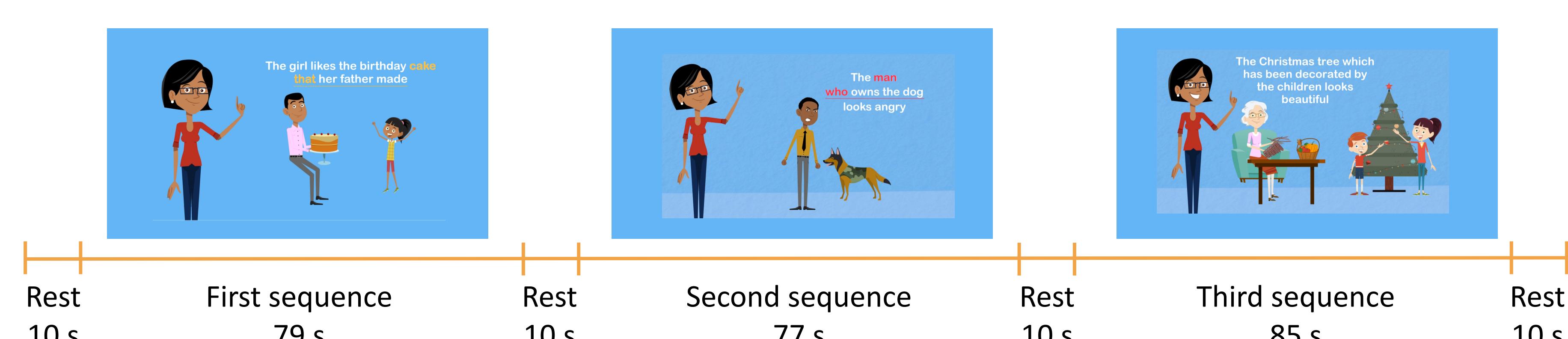
Pre and post tests – symbolic and non-symbolic judgment of commutativity – active task



Training phase – arithmetic movie – passive task



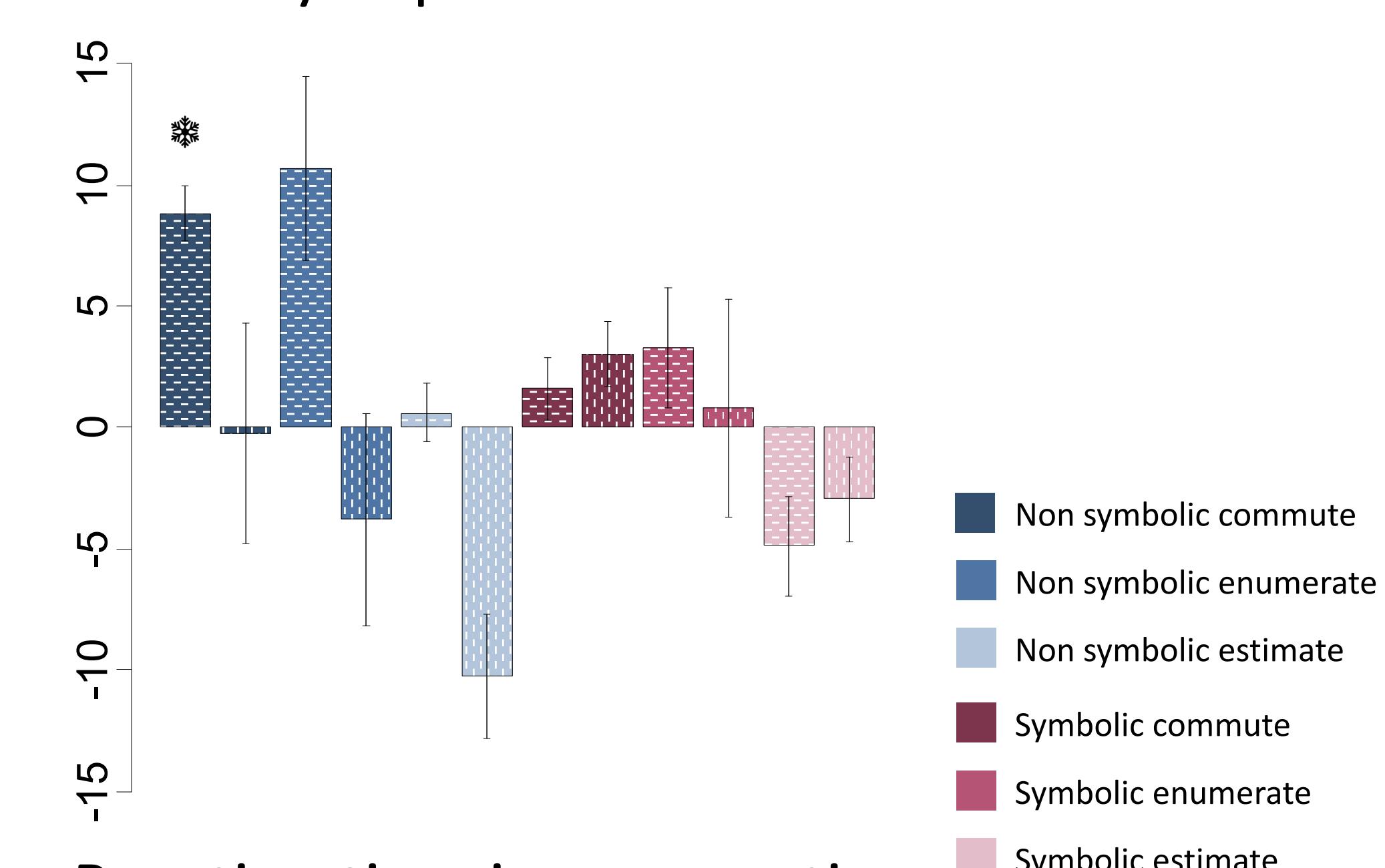
Control phase – grammar movie – passive task



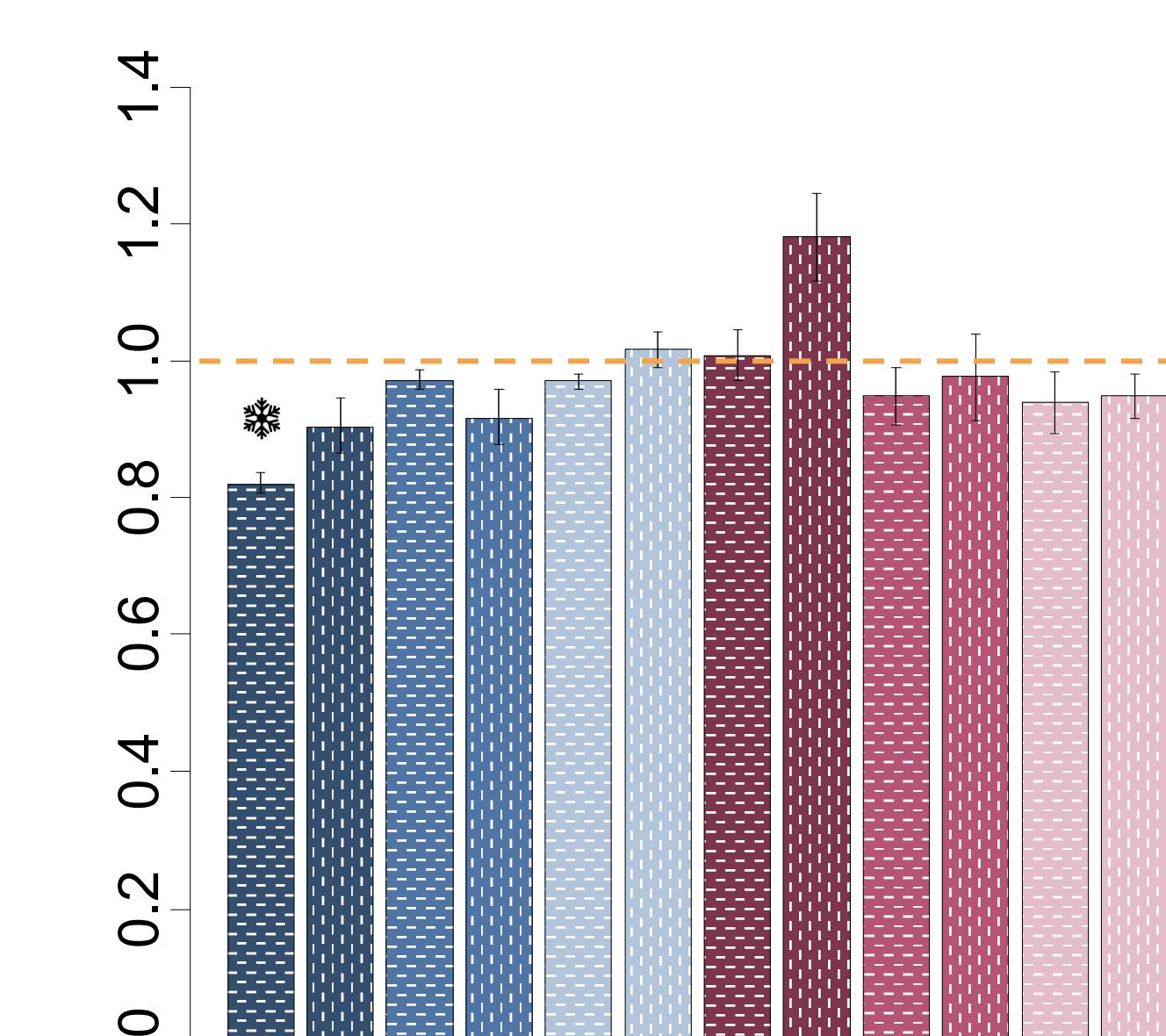
Behavioral results

Significant learning effect for the non-symbolic commutative condition:

Accuracy improvement

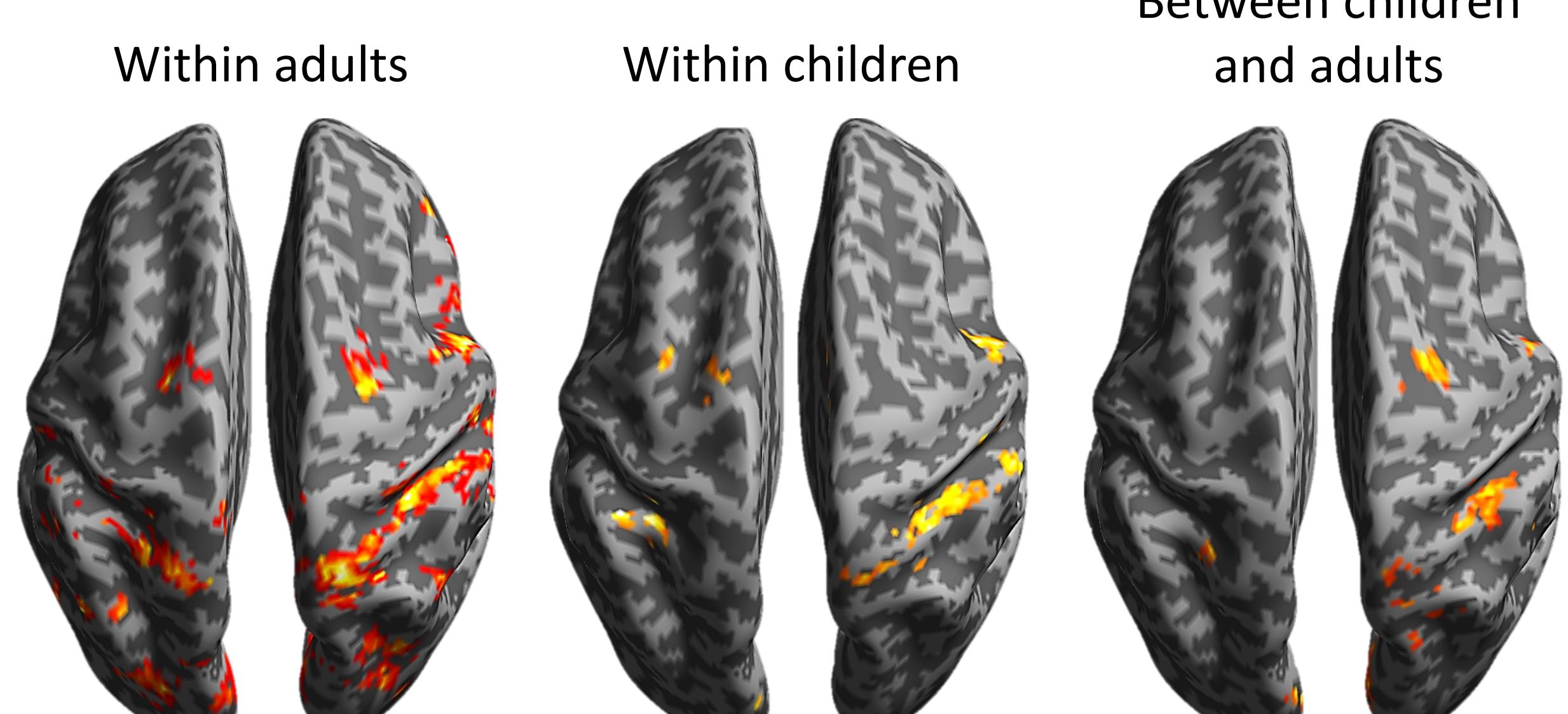


Reaction time increase ratio

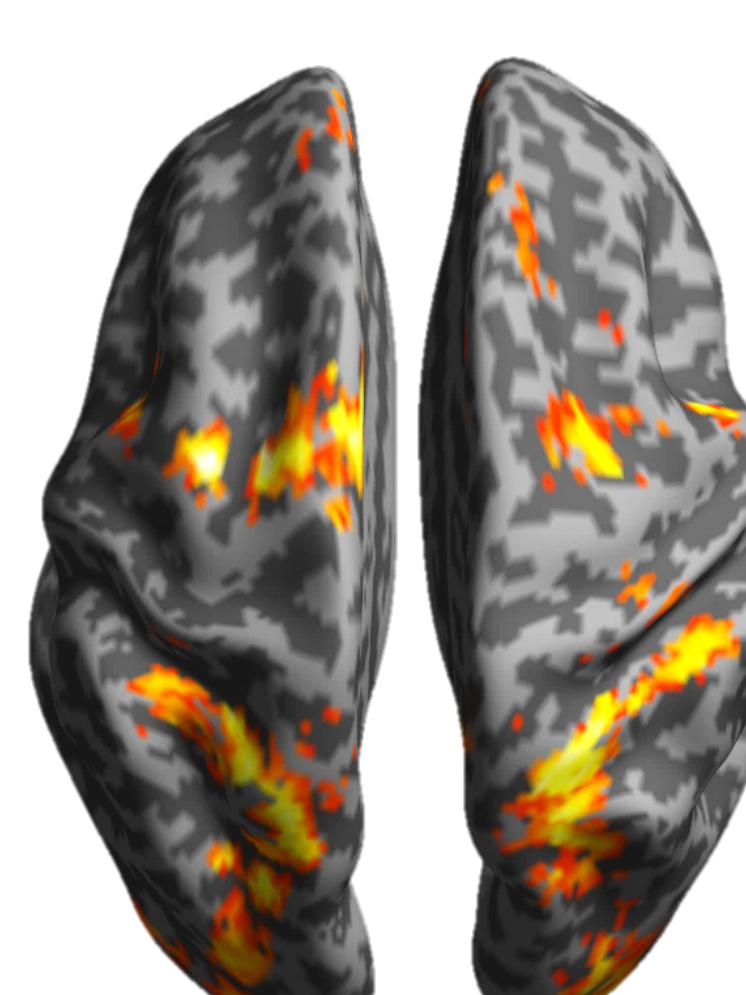


fMRI results

Inter-subject correlations during the arithmetic movie



Decrease of correlated activation in children between pre- and post-tests



References and acknowledgments

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Conclusions

- Children mastered commutativity in symbolic contexts more than in non-symbolic contexts.
- After training, their performance in non-symbolic trials significantly improved compared to a group of children trained on a grammar lesson.
- The analysis technique of inter-subject correlations proved relevant to track the evolution of brain activation during both the passive viewing of the commutativity lesson and the manipulation of commutative pairs.
- The right intraparietal sulcus, a site commonly associated with math processing, exhibited changes of activity during both the passive viewing of the commutativity lesson and the manipulation of commutative pairs.