

Effort-reward decision-making in math anxious individuals

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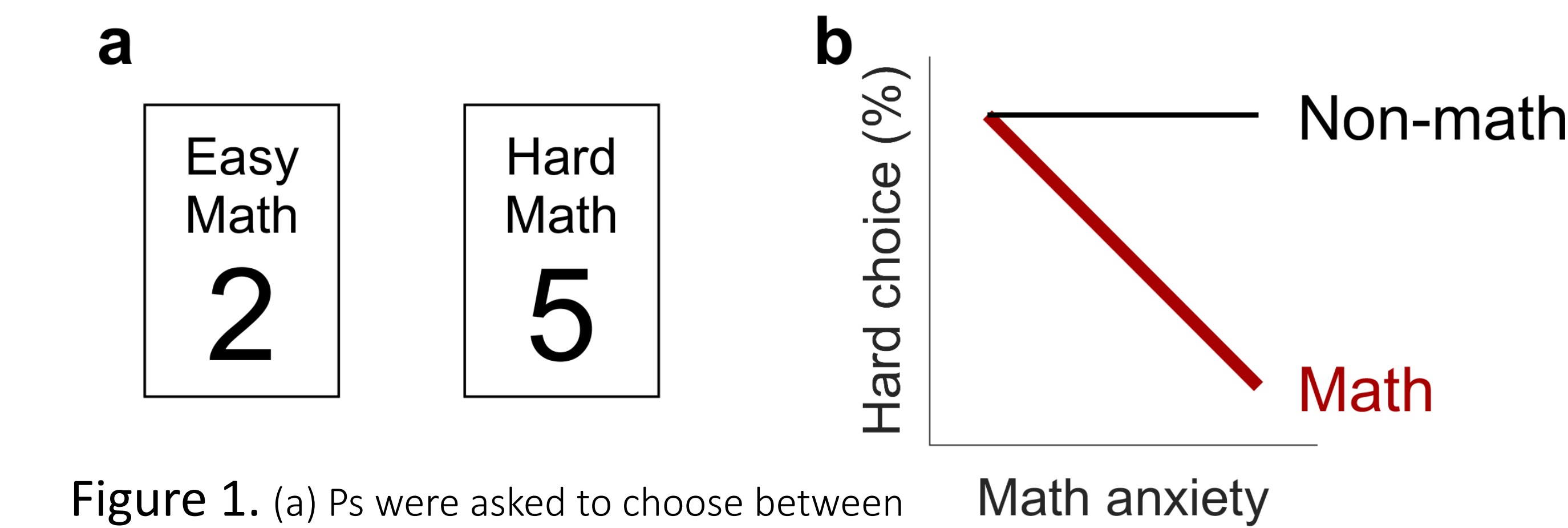
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Introduction

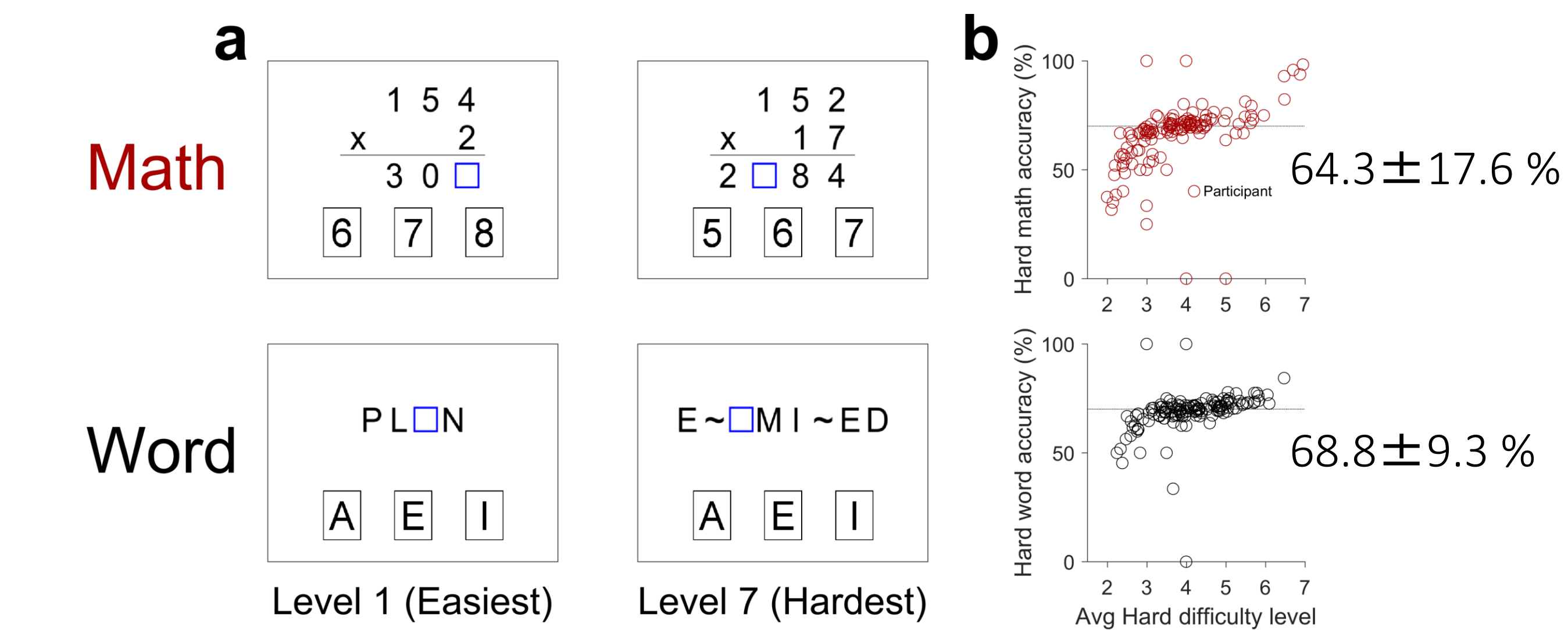
- Many individuals report strong feelings of tension, apprehension, and fear of math. This emotional reaction, termed math anxiety, has long been hypothesized to be associated with avoidance of math and poor math performance.
- To stop adverse effects of math anxiety, reducing math avoidance behavior is critical. Yet, little research has directly investigated the relationship between math anxiety and math avoidance. We aim to fill this critical gap by adopting the neuro-economics approach, i.e., effort-reward decision-making.

Methods: Choose-and-solve task

- On each math (or word) trial, participants (Ps) were asked to choose between a low-effort option (worth 2 ¢) and a high-effort option (worth 2-6 ¢; e.g. Fig. 1a). After this selection Ps solved a given math (or word) problem within 7 s for a monetary reward.
- We hypothesized that the higher one’s math anxiety, the less likely they would choose the high-effort options in the math trials, but not in the word trials (Fig. 1b).



- Using a 2-up-1-down staircase and a large pool of problems sorted by 7 difficulty levels (counts: 1972 math, 1732 word; e.g., Fig. 2a), the difficulty of high-effort problems was calibrated to a target accuracy of 71% regardless of Ps’ math and verbal competence.
- 141 Ps from Amazon Mechanical Turk completed 200 math and word trials with a trial-by-trial accuracy feedback. Ps solved low-effort (Level 1) problems quickly and accurately (RT: math 2.23 ± 0.43 s, word 2.16 ± 0.31 s; accuracy: math 95.4 ± 6.0 %, word 93.6 ± 6.3 %; $M \pm SD$) and solved high-effort problems slower and less accurately (math 3.79 ± 0.83 s, word 3.07 ± 0.62 s; Fig. 2b).



Math anxious individuals are less willing to exert cognitive effort in math-related situations, even when there are high rewards for doing so.

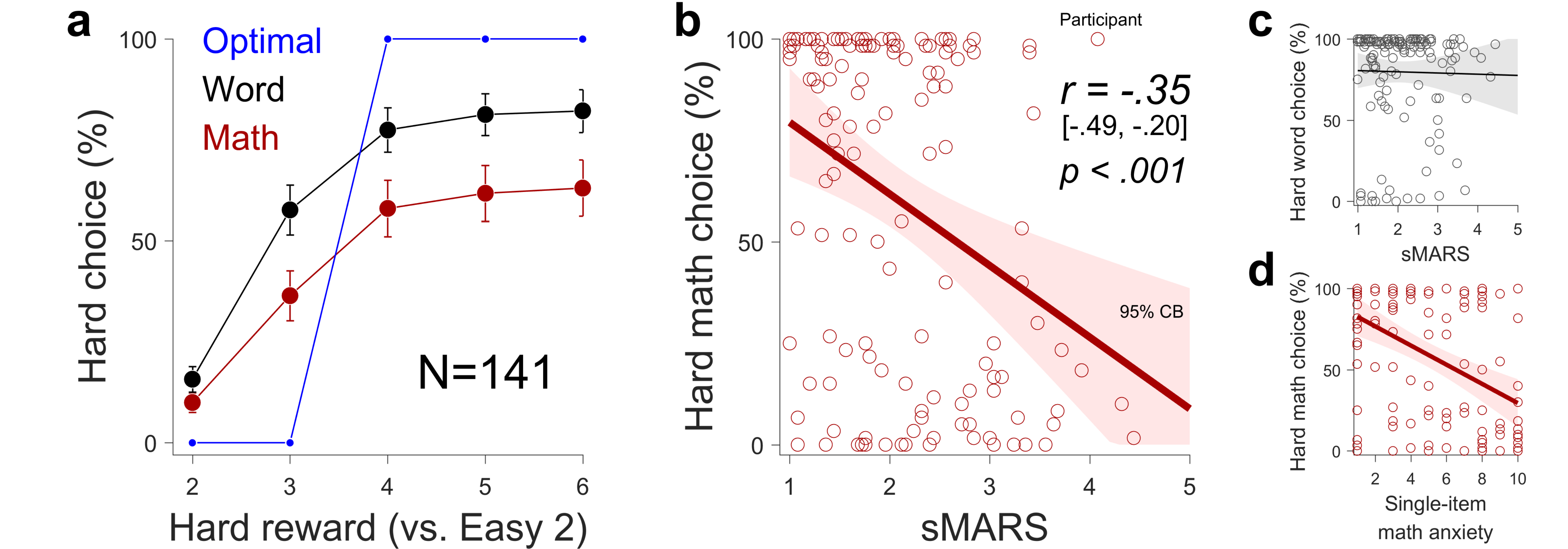


Figure 4. Test-retest correlations

Retested 103 Ps after 4 months (100 trials). The 4-month test-retest correlations were Math $r = .64$ [.51, .74] & word $r = .68$ [.56, .77].

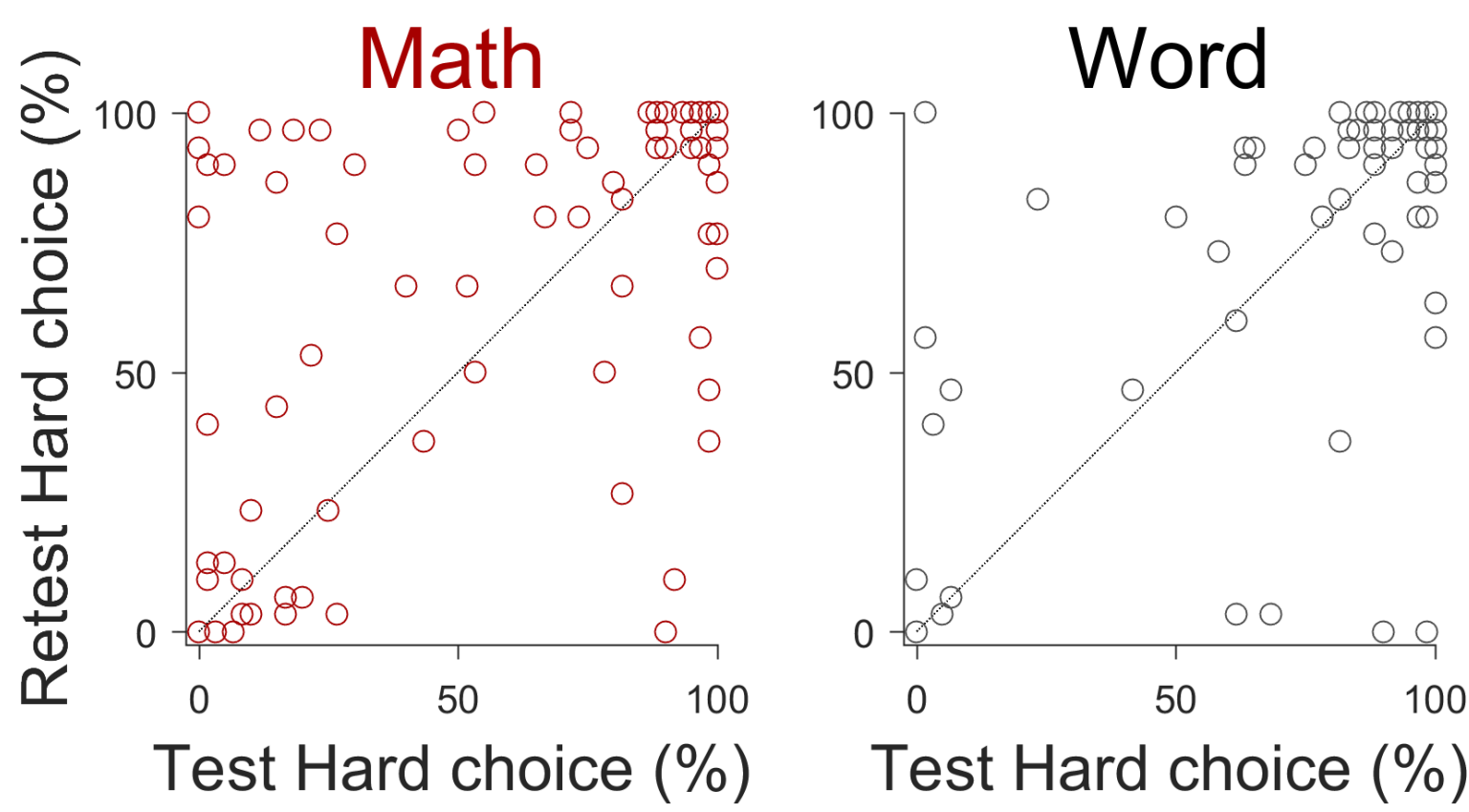
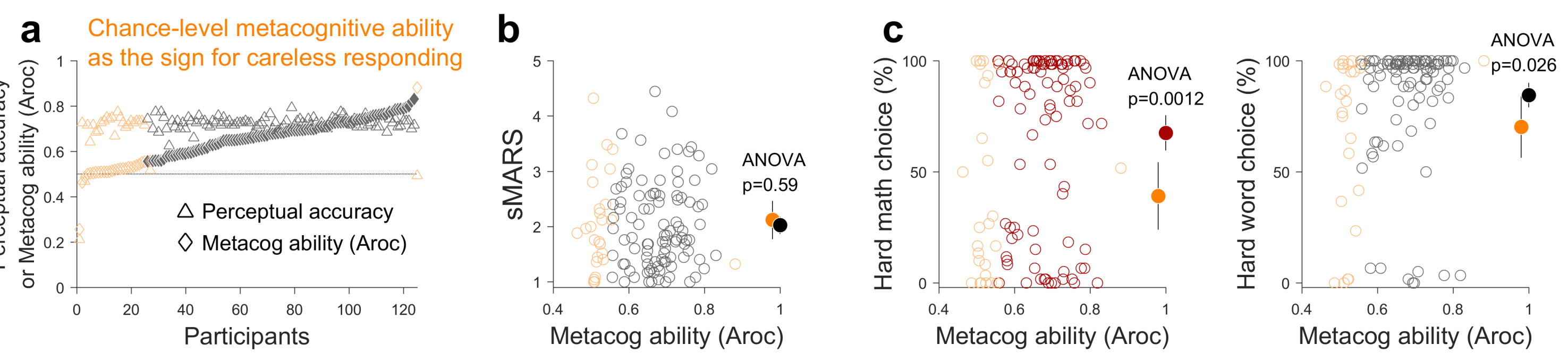


Figure 5. “Careless responding” cannot explain the observed relationship.

Careless Ps were identified using a perceptual metacognition task (Fleming et al., 2010) and permutation tests (Fig. 5a). There was no significant difference in sMARS (Fig. 5b), but careless Ps avoided the high-effort options in both math and word (Fig. 5c). The correlation between Hard math choice and sMARS remained significant after excluding them, $r(96) = -.33, p=.001$.



Discussion and Conclusion

- Our study found that math anxiety is related to Ps’ choice behavior in an effort-reward paradigm: Ps with higher levels of math anxiety were less likely to choose high-effort math options when it was more monetarily rewarding.
- This choice behavior appears to be math-specific, as the choice behavior in the non-math condition was not associated with math anxiety.
- Capitalizing on this paradigm, we are using fMRI to investigate the neural mechanisms of math anxiety and math avoidance.
- The information generated from our studies will help us better understand math anxiety and develop effective preventions and interventions.

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