# Metacognitive Monitoring on Math Equivalence Problems

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## FRAMEWORK

### METACOGNITION

METACOGNITION is the knowledge, monitoring, and regulation of cognition (Flavell, 1978).

- Knowledge of person, task, and strategies
- Monitoring of cognition
- Regulation of behavior in response to metacognitive monitoring

Previous research shows that the predictive strength of metacognition is robust across many academic domains (e.g., Dignath et al., 2008).

In the recent literature, there is empirical evidence to support the fact that even very young children are able to be metacognitive (e.g., Baten et al., 2017; Coughlin et al., 2015; Marulis et al., 2016).

In this study, we focus on children's ability to monitor their uncertainty in the domain of mathematics.

METACOGNITION IN MATHEMATICS

Previous work speaks to the predictive role of metacognition in mathematics performance, though empirical work is sparse in comparison to other domains (Baten, et al., 2017; Schneider & Artelt, 2010; Stillman & Mevarech, 2010).

### MATHEMATICAL EQUIVALENCE

| 2 + 3 = __ + 1 | 2 + 3 + 1= __ |
|---|---|
| Math Equivalence Problem | Simple Arithmetic Problem |

MATHEMATICAL EQUIVALENCE PROBLEMS have operations on both sides of the equal sign (McNeil & Alibali, 2005).

- Critical to developing understanding of algebra
- Predicts achievement in elementary school (McNeil et al., 2017)
- Children (ages 7 to 11) in the US exhibit misconceptions and add up all the numbers and write the total in the blank
- Entrenchment of strategies used to solve simple arithmetic problems

### RESEARCH QUESTIONS

Can children accurately monitor their uncertainty while solving math equivalence problems? In other words, do they know when they have solved a problem correctly vs. incorrectly? Do they tend to be overconfident or underconfident?

### ACKNOWLEDGEMENTS & CONTACT

This research was supported by the Multidisciplinary Training Grant in Developmental Process at Indiana University. Additionally, special thanks to Bloomington Montessori School, The Project School, Adventist Christian Elementary, and Covenant Christian School.

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## METHOD

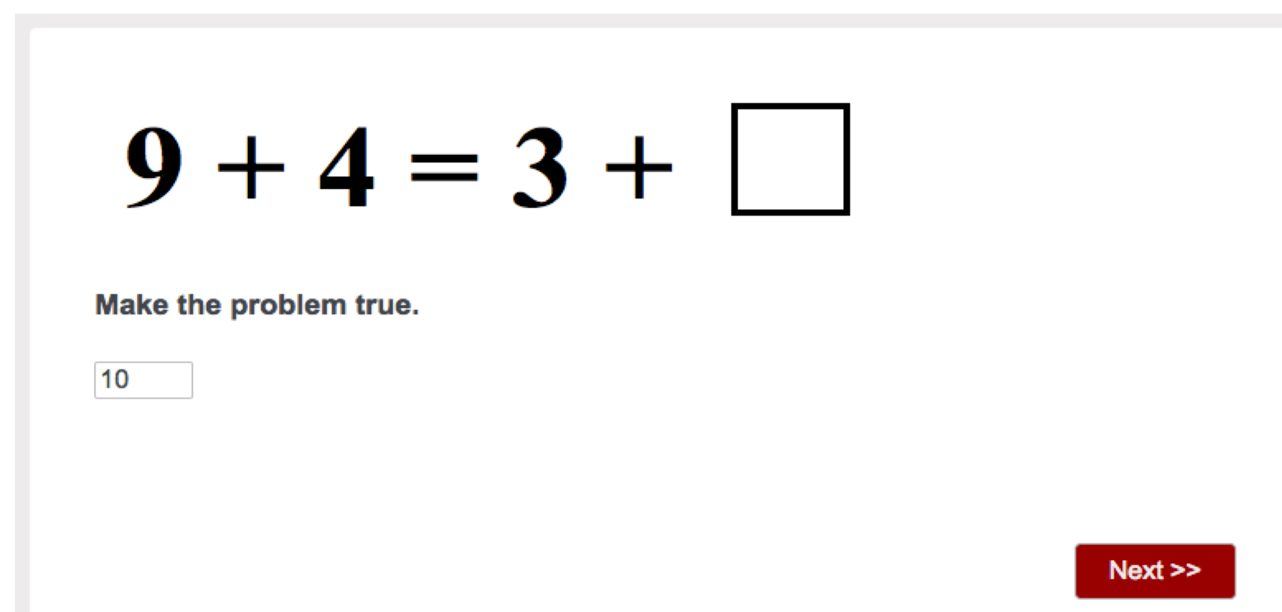
The Sample: *n* = 52 children in 1st (14), 2nd (22), and 3rd (16) grade (48% female) from local private schools in Bloomington, Indiana.

Children were assessed in two sessions in which they:
1) Completed a pretest in a whole-class setting in order to establish a baseline of prior knowledge.
2) Worked in a one-on-one setting with an experimenter to assess problem-solving accuracy and metacognitive uncertainty monitoring.

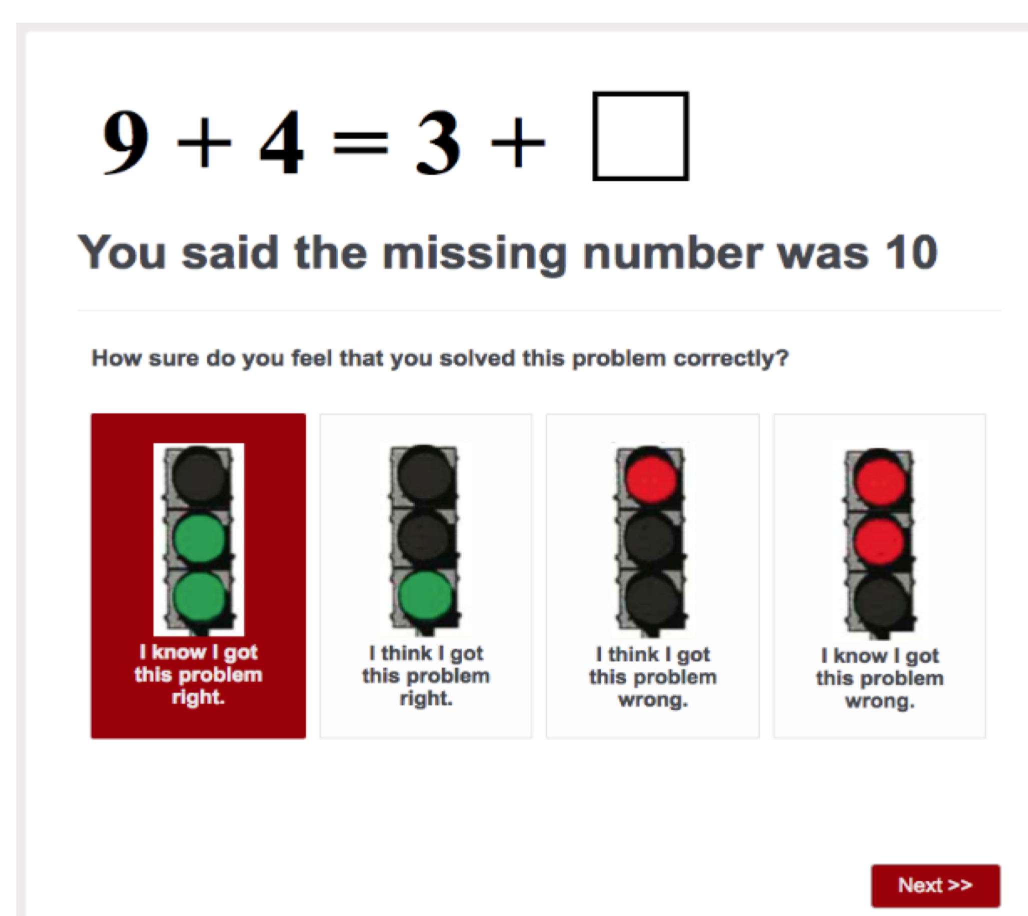
There were 5 mathematical equivalence problems (some children worked on Set 1, others worked on Set 2; problems are matched and are structurally equivalent in both sets).

| Set 1 | Set 2 |
|---|---|
| A) 7 = 4 + ___ | A) 8 = 3 + ___ |
| B) 3 + 7 = 3 + ___ | B) 4 + 6 = 4 + ___ |
| C) 9 + 4 = 3 + ___ | C) 5 + 9 = 4 + ___ |
| D) 3 + 7 + 8 = ___ + 8 | D) 8 + 3 + 7 = ___ + 7 |
| E) 5 + 3 + 4 = 5 + ___ | E) 4 + 5 + 3 = 4 + ___ |

Children were told to figure out what number should go in the box to make the problem true.




Children were then prompted to rate their metacognitive uncertainty (Desoete et al., 2000, 2006, 2008).




| ACCURACY | CERTAINTY |
|---|---|
| Participants received 1 point for each problem they solved correctly (or within + or – 1 of the actual answer). | Participants' responses were coded on a scale from 1 = I KNOW I got this problem WRONG to 4 = I KNOW I got this problem RIGHT. |

## RESULTS

### Problem-Solving Accuracy

| Accuracy | Percent Correct |
|---|---|
| Pretest Percent Correct | 30% |
| One-on-On Session Percent Correct | 47% |

There was a grade difference in accuracy $F(2, 52) = 3.686$, $p = .02$.
(One-on-One Session: 1st Grade = 26%, 2nd Grade = 46%, 3rd Grade = 66%).

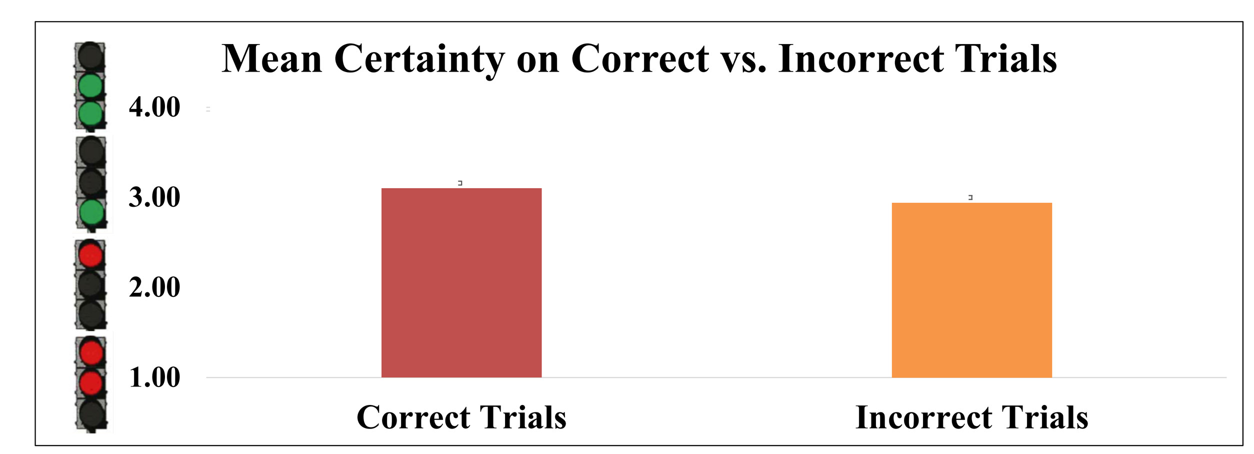
### Certainty During One-on-One Session

| Uncertainty Ratings | Average Uncertainty |
|---|---|
| I KNOW I got this problem RIGHT | 41% |
| I THINK I got this problem RIGHT | 43% |
| I THINK I got this problem WRONG | 14% |
| I KNOW I got this problem WRONG | 2% |

### Metacognitive Monitoring

There was a small to moderate positive correlation between accuracy and certainty during the one-on-on session ($r = .36$, $p = .008$).

Also conducted within-subjects analysis with participants who were variable in their accuracy. Within the trimmed sample (N = 20), children were similarly confident on correct and incorrect trials ($F(1, 19) = .631$, $p = .44$).




Further, when looking at the relations between accuracy and certainty on math equivalence problems there are four possible categories:

| | I KNOW / THINK I got it RIGHT | I KNOW / THINK I got it WRONG |
|---|---|---|
| Problem Correct | 44% (Match) | 3% (Mismatch) |
| Problem Incorrect | 40% (Mismatch) | 13% (Match) |

Children were able to MATCH the correctness of their answers to their feelings of uncertainty: 57% of the time

This is ACCURATE METACOGNITIVE UNCERTIANTY MONITORING

## DISCUSSION:

Results show that 1st, 2nd, and 3rd graders struggle to solve math equivalence problems correctly, yet they are often confident that they have. On average, participants were accurate 47% of the time, they were confident they had solved the problems correctly 84% of the time, and they were able to accurately monitor their uncertainty 57% of the time. Thus, while these results suggest that some children are able to metacognitively monitor their uncertainty (i.e., they know when they solved problems correctly vs. incorrectly), many children are not able to do so. We are currently working to assess the relations between metacognitive monitoring and help seeking as well as academic performance. Future work in this area may include developing student interventions to scaffold students' metacognitive monitoring skills in mathematics.