

Spatial Biases in Arithmetic: The Effect of Operation Order and Visual Spacing on Calculations

Michał Obidziński^{1*}, Martyna Sroka¹, Krzysztof Cipora^{1,2}, & Mateusz Hohol²¹Jagiellonian University in Kraków; ²Loughborough University; * michał.obidzinski@uj.edu.pl <https://mcll.edu.pl>

Mathematical
Cognition and
Learning Lab

JAGIELLONIAN UNIVERSITY
IN KRAKÓW

Loughborough
University

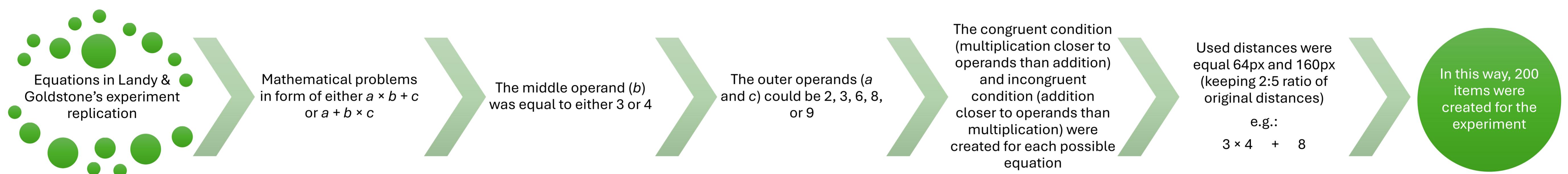
Conceptual replication of the third experiment of Landy & Goldstone (2010) – conducted online

Key changes to the procedure: forced-choice test instead of open tasks; smaller, more natural spacing between operands and operators

SHORT OVERVIEW

Math4Speed test was used to investigate relationship between overall mathematical performance and congruency/incongruency effect

There are significant differences between congruent (C) and incongruent (/) stimuli: RTs are faster, and accuracy is significantly better for C vs /

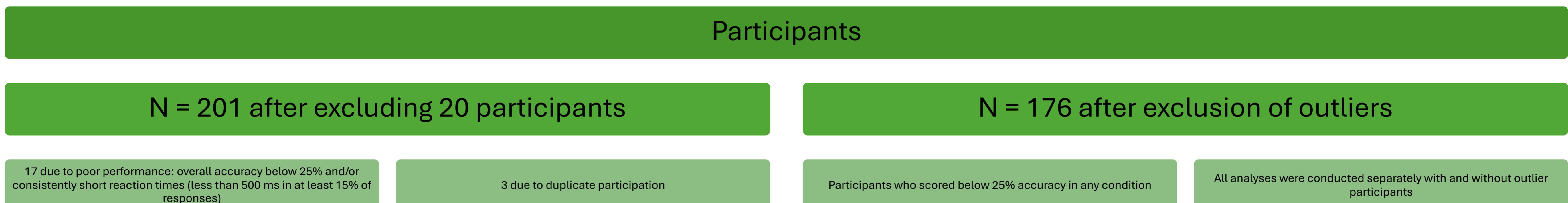


Procedure in Landy & Goldstone's replication:

- Stimuli: mathematical problems
- Presented with 4 possible answers (similar to a school test)
- Among the four options: one is correct, one reflects an operation-order error, and two are ± 2 from the former two
- Example: for $3 \times 4 + 8$, the options could be 20, 36, 18, and 38
- Responses were given using the computer keyboard (D, F, J, and K keys)
- A short training session preceded the main task

Math4Speed:

- Speeded arithmetic task involving the four basic operations: addition, subtraction, multiplication, and division (Loenneker et al., 2024)
- There were 4 separate sections for operations
- Each section consisted of 50 items and ended after a 2-minute deadline or when all equations had been answered
- Answers were given in an open format



Results – ANOVA for Congruency (2) \times Operation Order (2), and Correlation

Accuracy	Reaction Time	Error type	Correlation with Math4Speed
<p>Overall</p> <ul style="list-style-type: none"> Congruency: $F(1, 200) = 22.85$, $p < .001$, $\eta^2_p = .1$ Both, main effect of Order ($p = .099$) and Interaction ($p = .331$) are not significant 	<p>Overall</p> <ul style="list-style-type: none"> Congruency: $F(1, 185) = 75.27$, $p < .001$, $\eta^2_p = .29$ No significant effect of Order ($p = .088$) Interaction effect, $F(1, 185) = 13.18$, $p < .001$, $\eta^2_p = .07$ 	<p>Overall</p> <ul style="list-style-type: none"> Congruency: $F(1, 200) = 25.74$, $p < .001$, $\eta^2_p = .11$ Order: $F(1, 200) = 5.54$, $p = .020$, $\eta^2_p = .03$ No significant Interaction ($p = .912$) 	<p>Overall</p> <ul style="list-style-type: none"> M4S x Accuracy: $r = .21$, $p = .002$ M4S x RT: $r = -.64$, $p < .001$
<p>Without outliers</p> <ul style="list-style-type: none"> There is no significant effect 	<p>Without outliers</p> <ul style="list-style-type: none"> Congruency: $F(1, 175) = 126.85$, $p < .001$, $\eta^2_p = .42$ Order: $F(1, 175) = 8.14$, $p = .005$, $\eta^2_p = .04$ Interaction: $F(1, 175) = 8.77$, $p = .004$, $\eta^2_p = .05$ 	<p>Without outliers</p> <ul style="list-style-type: none"> Congruency: $F(1, 175) = 11.37$, $p < .001$, $\eta^2_p = .06$ No significant effect of Order ($p = .240$) No significant interaction ($p = .850$) 	<p>Without outliers</p> <ul style="list-style-type: none"> M4S x Accuracy: $r = .16$, $p = .04$ M4S x RT: $r = -.65$, $p < .001$

