Iconicity in Mathematical Notation - Symmetry and Commutativity (#27413)

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1) Have any data been collected for this study already?
No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?
Symmetric symbols express commutative mathematical relationships. Visual properties of symbols are connected to their meaning and initial interpretation.

3) Describe the key dependent variable(s) specifying how they will be measured.
The total number of 'true' responses given in conditions expressing commutativity for vertical symmetry vs. horizontal symmetry out of 70 trials.

4) How many and which conditions will participants be assigned to?
Participants will be asked if they believe a commutative statement with new symbols expressing a mathematical operation i.e. "4 V 3 is equal to 3 V 4" to be 'true' or 'false'.
Visual symbol properties will be controlled while manipulating a left/right (vertical) symmetry. This is achieved by using symbols with a single axis of symmetry once with their symmetry axis being oriented vertically (i.e. V) and once rotated by 90 degrees for a horizontal symmetry axis (i.e. >). We will use 10 different symbols presented in each orientation with 7 different commutative statements. This result is 70 trials presenting a vertical symmetry and 70 trials presenting a horizontal symmetry.
There will be filler trials in which participants will be asked if the operation "is greater than" or "is less than" it's opposite, i.e. "4 □ 3 is greater than 3 □ 4".
Trial order will be randomized.

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.
According to our main hypothesis a symbol with vertical symmetry should be significantly stronger associated with commutativity than a symbol without horizontal symmetry. We will test this hypothesis by comparing total number of 'true' responses in the commutativity condition between the trials presenting vertically symmetric symbols and those with rotation of the symmetry axis. We will do this by calculating a paired sample t-test (or non-parametric alternative as adequate) and compare the p-value with a one-sided alpha level of 5%.

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.
We will exclude any participants that answer 100% of trials with only 'true' or only 'false'. Furthermore, we will interview participants on what they think the study was about and if they used any strategy for responding. We will exclude any participants that report having used a pattern, i.e. true, false, true, false.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.
We will collect a dataset of 30 participants for analysis. Excluded participants will be replaced.

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)
We will further explore the main hypothesis with secondary analyses of the effect in individual participants and for individual symbols. For this purpose we will first run mixed effects logistic regression models separately for each participant: True (0/1) ~ Symmetry (0/1) + (1|symbol). This will help us to further quantify a possible effect by collection evidence of the number of participants who express this effect.
We will also explore possible differences between the 10 symbols we used, with a similar individual analysis approach for each symbol: True (0/1) ~ Symmetry (0/1) + (1|participant).