

## How numerical are Approximate Number System representations? (#78603)

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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?

Can participants multiply ANS representations?

### 3) Describe the key dependent variable(s) specifying how they will be measured.

Participants will be asked to solve multiplication problems in two conditions, symbolic and non-symbolic. In both cases participants will be presented with two multiplicands and asked whether, when multiplied, they are equal to a target. In all cases the two multiplicands will be numerically equal. For instance, participants might be shown 2, then 2, and then the target 4. In this case they should respond "correct". On correct trials the target will be the correct answer to the multiplication, on incorrect trials it will be either higher or lower by a factor of 0.7. In the symbolic condition participants will be shown Hindu-Arabic numerals, in the non-symbolic condition participants will be shown dot arrays. The primary dependent variable is accuracy.

### 4) How many and which conditions will participants be assigned to?

See above. All manipulations are within subjects.

### 5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.

Our primary analysis will be a 7 (number: 2, 3, 4, 5, 6, 7, 8) by 2 (display-type: symbolic, non-symbolic) within-subjects ANOVA. We predict that there will be an interaction whereby accuracy will be high throughout the symbolic condition, but that participants' performance on the non-symbolic trials will vary by number. We predict that performance will be above chance level for numbers within the subitizing range (2, 3 and 4), but at chance levels for numbers outside the subitizing range (5, 6, 7 and 8).

A secondary analysis will be conducted. One-sample t-tests will be conducted separately for each level of the number factor, comparing mean accuracy in each case to 50%.

### 6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.

We will remove any participants (or entries) who:

1. Withdraw before the end of the experiment
2. Are aged under 18
3. Enter nonsensical items to the free-text items. E.g. if 'which country are you from' doesn't contain a reasonable response, i.e. a country, town or city (written with or without typos/spelling mistakes) (to exclude bots / non-serious respondents)
4. Do not select the same answer to two identical multiple-choice questions (about educational status) presented at the start and end of the study (to exclude bots/dishonest respondents)
5. Do not correctly identify the 'strange word' embedded within two sets of experimental instructions (to ensure people read the task instructions).
6. Have accuracy at or below 67% for any question in the symbolic-arithmetic task.

### 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.

100 complete datasets will be collected. If, after exclusions, fewer than 80 complete datasets remain, then we will collect replacement data in batches of 20 until, after exclusions, at least 80 complete datasets remain.

### 8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

We further predict that, within the non-symbolic task, accuracy will be highest for 2x2, will be substantially lower for 3x3, and then lower again for 4x4. We will check these predictions with three paired-sample t-tests.