Benjamin Pitt
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In a new paper, @LanguageMIT, @spiantado and I show that people's ability to think exact number thoughts depends on what specific number words they know. Here's a thread on what we found and how it connects to some deep questions about thinking.

1:05 PM · Feb 8, 2022

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People have long argued about how people get number concepts like 7 and 42. Are they just naturally part of the human conceptual repertoire? Or do you need to have a set of symbols, like the number words "one, two, thee...", to think exact number thoughts?

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One clue comes from cultures that have few or no exact number words, sometimes not even a word for "one"! (See these papers on the Pirahã, Mundurukú, and Nicaraguan Homesigners; @mcxfrank @ev_fedorenko @LanguageMIT @MarieCoppola68 @pierrepica @StanDehaene)

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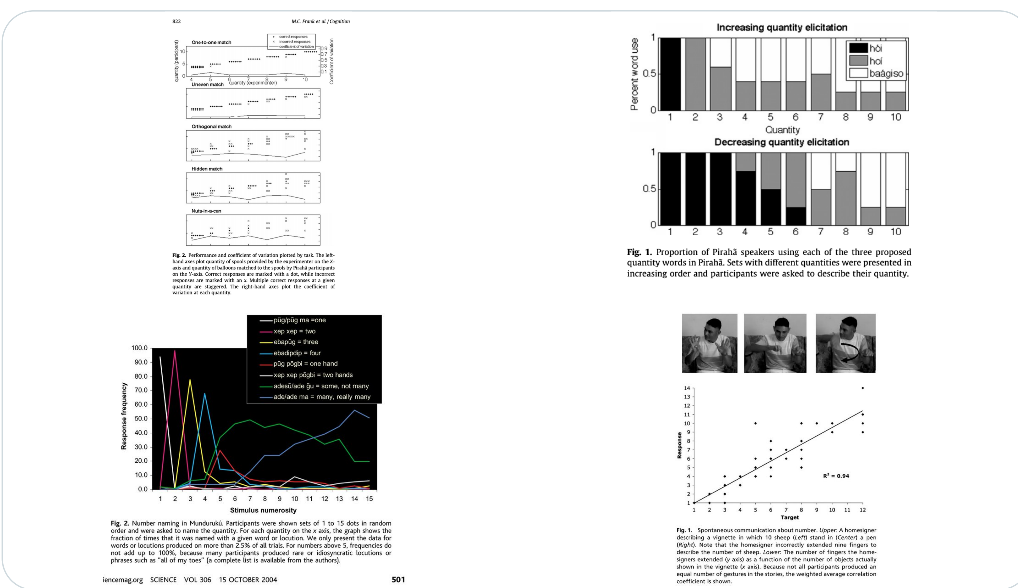
These groups don't seem to have exact number concepts larger than 3 or 4. After that, it's all approximation.



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But some have argued that comparisons of entire cultures, like American undergraduates vs. indigenous Amazonians, is problematic because many cultural and linguistic differences could explain the differences in numerical cognition. @D_Casasanto, Rochel Gelman, Brian Butterworth

The results are consistent with the Whorfian claim that Pirahã lack number concepts because they lack number words, but results are no less consistent with the opposite claim, which is arguably more plausible. Gordon's data suggest that keeping track of large exact quantities is not critical for getting along in Pirahã society. In the absence of any environmental or cultural demand for exact enumeration, perhaps the Pirahã never developed this representational capacity—and consequently, they never developed the words.

use their Portuguese counting words? Mundurukú culture differs from Western culture in innumerable ways, and it certainly uses numbers far less often than we do. It remains possible that one or more of these many differences were responsible for the differences in performance, and not just the lack of a counting vocabulary.

This evidence from cultures with very limited number vocabulary does not convince us that differences in performance can be explained in terms of language rather than other aspects of culture (see also Box 1). Of course, it

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To avoid this problem, we studied the Tsimane', an indigenous Amazonian group, where there are *individual differences* in how well adults can recite the number words. Some people don't know what word to say after "five", others stop at "twelve", and others at "eighteen" etc.

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We used this individual variation in verbal counting ability to test the role of language in number concepts in the *same* culture and language. So instead of comparing groups, we were comparing neighbors from the same small community.

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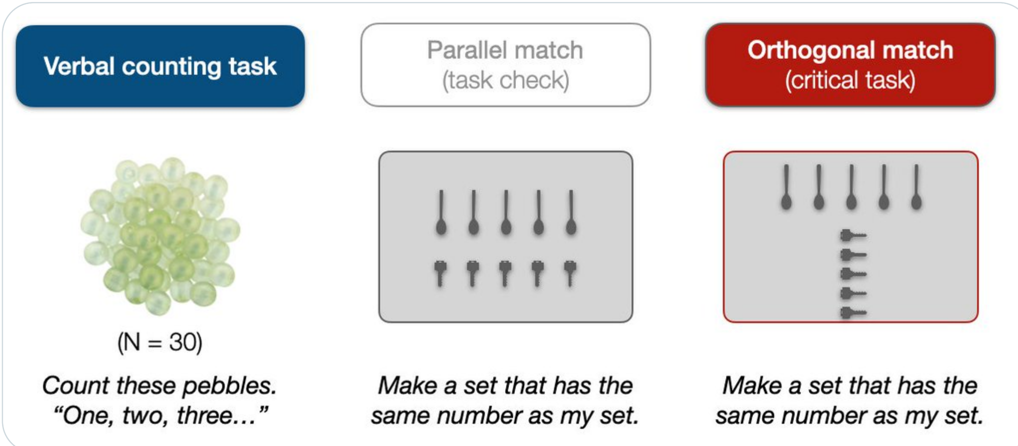
It's easy to tell when someone doesn't know the number words (e.g. they miss one), but how do you figure out what number *concepts* people have without using language? You use a numerical matching task...



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In each trial, we put out some number of white buttons and asked the participant to make another set of objects (ie. glass beads) that had the exact same number. They didn't have to tell us how many there were - just to make their set of objects match ours, with unlimited time.

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@rosemschneider, @ErikBrockbank, @RomanFeiman, & @barner_ucsd used similar tasks (but without allowing counting) in their cool new paper on the relationship between kids' counting knowledge and their understanding of exact equality.

sciencedirect.com
Counting and the ontogenetic origins of exact equ...
Humans are unique in their capacity to both represent number exactly and to express these ...

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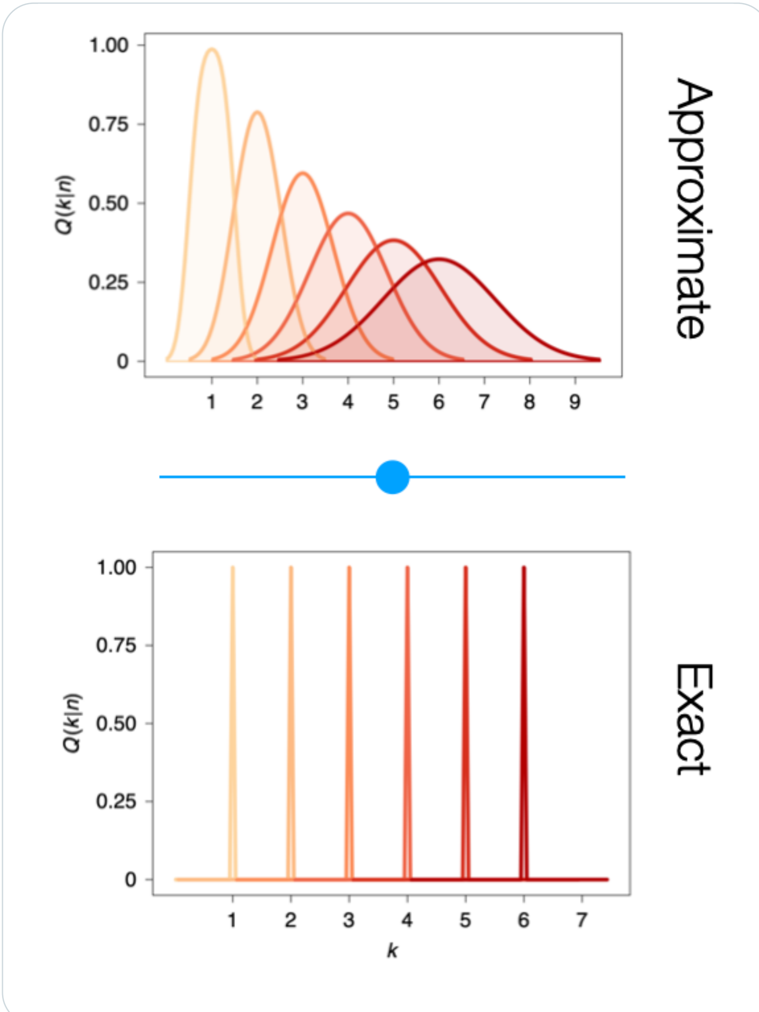
To figure out our participants' highest numerical matches, we built a generative Bayesian model of their responses. This allowed us to use the psychophysics of number to estimate when participants were using exact number representations vs. approximation: their "switchpoint."



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And then we just compared these switchpoints (Y-axis) to participants' highest *verbal* counts (X-axis). As you can see, these fell below the Y=X line, which means that participants used exact number concepts but only for numbers that were within the set of count words they knew.

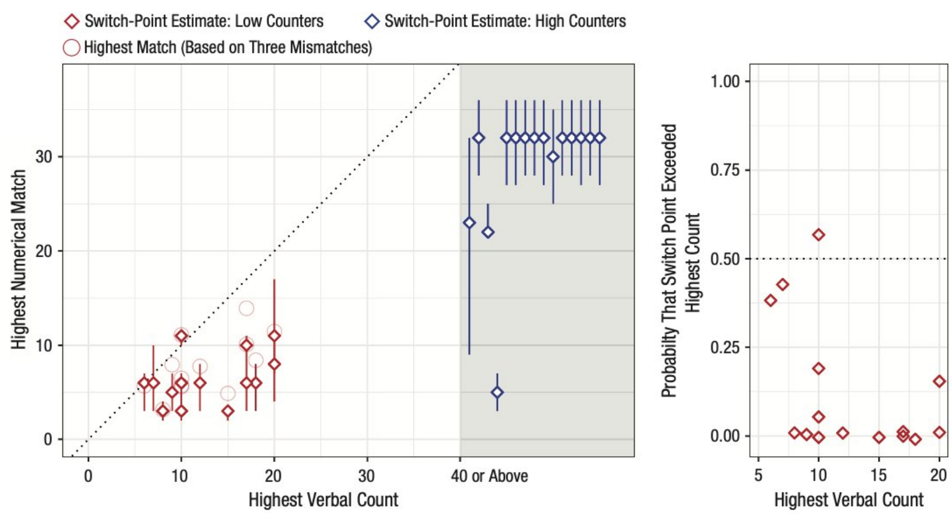

Fig. 2. Overview of results. The graph on the left shows participants' estimated switch points as a function of their highest verbal counts, separately for low counters (red shapes) and high counters (blue shapes). The switch point is defined as the number at which participants switched from exact to approximate number representations. Diamonds indicate median estimates, and error bars indicate 50% confidence intervals. Red circles show results from an alternative measure of highest numerical match that was based on the set size at which participants produced three mismatches. The graph on the right shows the probability that low counters' switch points exceeded their highest verbal counts. Above the dashed line, participants' switch points likely exceeded their verbal count range; below the dashed line, they likely did not.

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In other words, if they knew how to say the number words only up to 10, then they could copy sets of objects up to about 10, but no further. For 11 and up, they'd fall back on numerical approximation..

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This shows that the specific point at which people stop knowing the words, they also stop performing accurately on our matching task: Without the verbals labels (or something like them), you don't seem to have a mental representations of the exact quantity for numbers beyond 4!

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Findings like this also bear on one of the oldest and most debated questions in cognitive science: Can language give people new conceptual abilities? These findings suggest the answer is: Yes, at least in the domain of numbers.

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