9.85 Cognition in Infancy and Early Childhood

Objects and Number

Today

- Proposals due Thursday
- Feigenson: What are the two core systems?
- McCrink or Wynn: What is the evidence for either large approximate, or small exact number systems?
- Finish objects
- Number

Number

- how many are there in this room?
- one reason to introduce objects before number ...
- can count objects (also agents and ‘events’) but, as we just saw in the duck/ ball experiment ... “how many there are” depends on what counts for counting ...

Interim summary: infant object knowledge

- Infants have some initial expectations of objects ...
  - solidity, continuity, contact causality
- But they don’t impose all the constraints on objects that adults do ...
  - gravity, inertia
- And, until about 12 months, initial object knowledge appears to depend heavily on spatiotemporal distinctions ...
- Rather than on an understanding of distinct object ‘kinds’.

What do you know about objects?

- What is this?
- What's it for?
- Suppose I use it to pound a nail?
- To gesture at my lecture notes?

Image: OpenClip Art. Public Domain.

Understanding objects as artifacts

- "Design stance"
- Adults judge artifacts
  - On the basis of intended function rather than current use.
  - On the basis of original designer's intention rather than other intentional uses.

Functional fixedness

- Once you know the purpose of an object (boxes are for containment) it makes it more difficult to see other uses (box is for support)

- Adults are much faster to solve the problem when the tacks are outside the box than inside the box.

Why do we experience functional fixedness?

Because we have a design stance -- an abstract concept of artifact function that plays a role in problem-solving.

Why might children not have a design-stance?

- More complex than understanding object affordances

- Requires understanding goals of both the inventor and the user.

- Design stance requires coordinating two mental states: the inventor's intentions about the user's goals

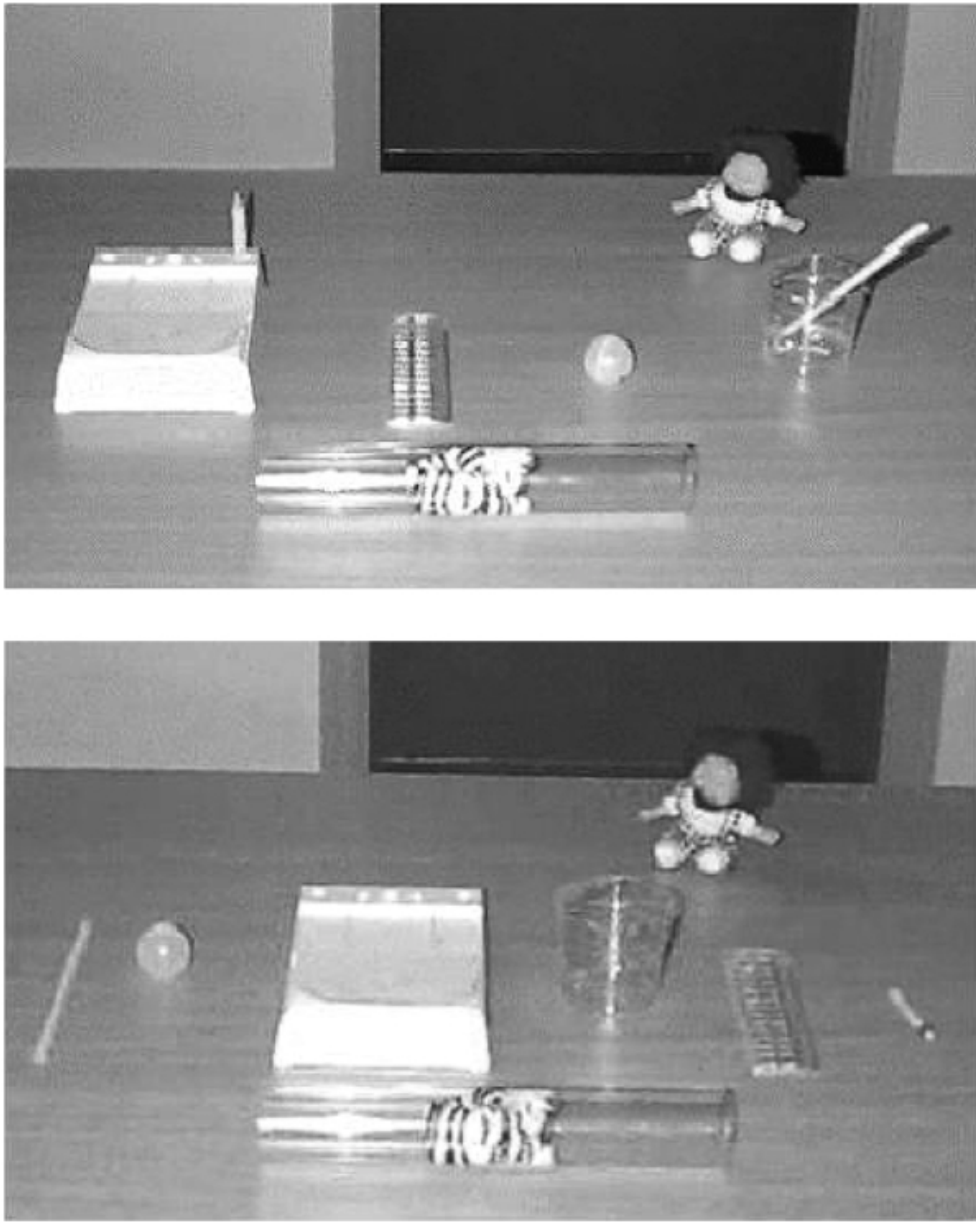
Understanding objects

- If children don’t have a design stance …

- they might not be subject to functional fixedness -- their problem solving might not be constrained by what an object is designed “for”.

A

B



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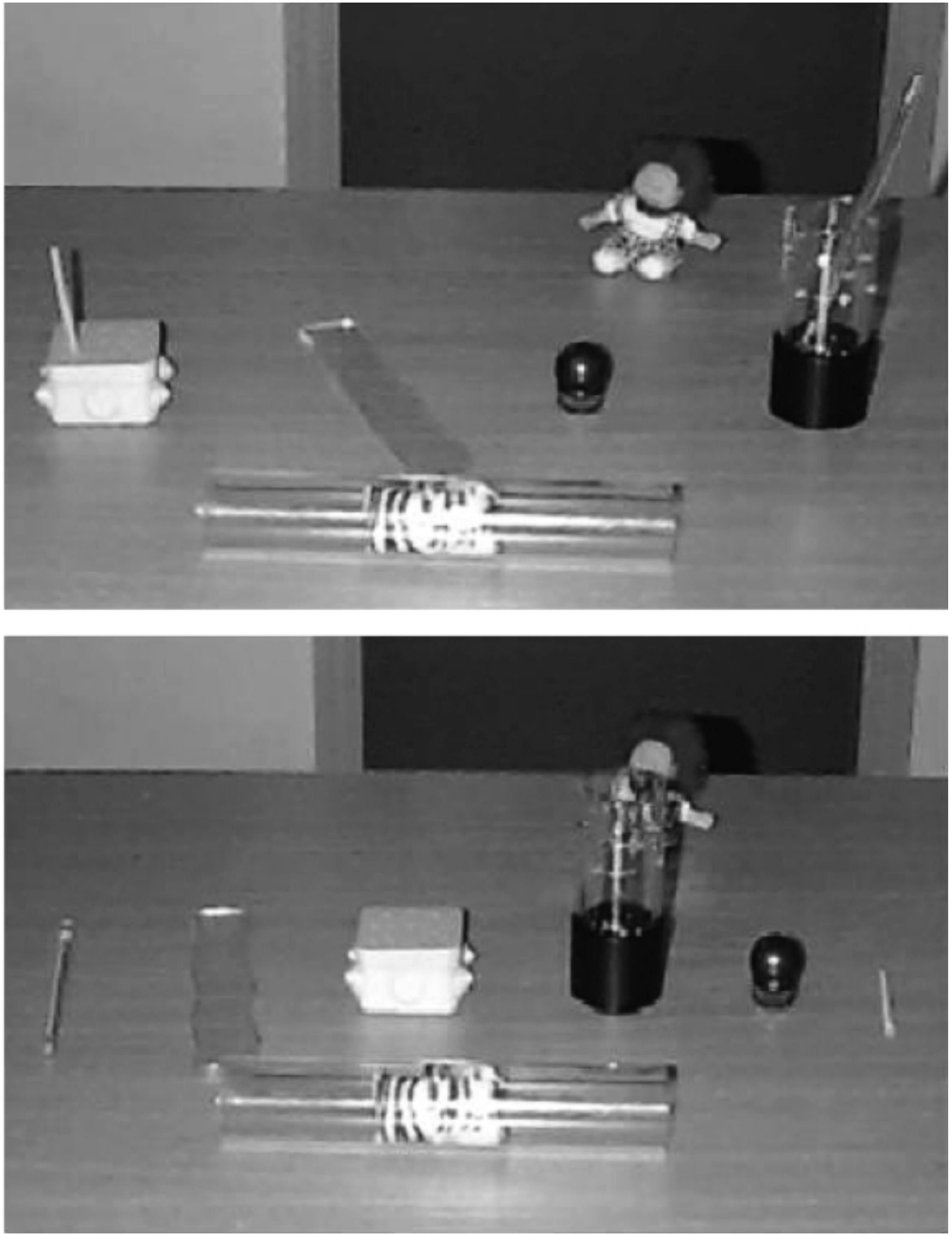
Prior knowledge or conceptual change?

- Is it just an interference effect – older children know more about pencils and so it inhibits them more?
- Or is it that older children are more likely to think in terms of design stance?
- Try it showing children novel functions.

A

B



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Implications

- Adult artifact concept is constructed around a core property-- its design.
- Artifact concept is primed by function demonstrations and this seems to block the availability of other functions.

Functional fixedness

- Younger children process information about object's function but not as a "core" property.

- Converging evidence:
  - 7-year-olds "What can you do with a brick?"
  - 5-year-olds "What can you do with a brick?"

- 7-year-olds more variations on design function; 5-year-olds more novel functions.

"It is not ignorance but the illusion of knowledge that is the greatest obstacle to discovery" (Daniel Boorstein)

Take-home riddle: There are three lamps in a room and three switches outside. You can flip the switches any way you want but you can only walk into the room once. How can you figure out which switch activates which lamp?

Two intuitions about number

- “The knowledge of mathematical things is almost innate in us … This is the easiest of sciences, a fact which is obvious in that no one’s brain rejects it;for layman and people who are utterly illiterate know how to count and reckon.” (Roger Bacon; 1219-1294)

Two intuitions about number

- "It must have required many ages to discover that a brace of pheasants and a couple of days were both instances of the number two."(Russell, 1872-1970)

What’s the relationship between number and objects?

- In order to know “how many” things there are you have to individuate objects.
- But you might be able to individuate objects but
  - Only represent them as individuals.
  - Only represent approximations (a lot; a little)
  - Represent exact number (but maybe only for small sets -- “subitizing”)
  - Represent both of these but not represent relations (adding,subtracting)
  - Represent all of these, and integrate them into a mature count system ...

Approximate number understanding

- In adults
- In children

Core system 1: Approximate representations of large numbers

Approximate number

- Tested on arrays of 8 dots
- Do babies look longer at the array with the same number of dots or different number of dots?

Core system 1: Approximate representations of large **numbers**

- Why do we think this applies to **numbers?**
- Because numerical distinctions are recognized controlling for all other factors (density, area, contour length, etc.) and hold cross-modally.

Core system 1: **Approximate** representations of large numbers

- Why **approximate**?
- Because discrimination depends on the ratio.
- 6-month-old infants can discriminate numerosities with a 1:2 ratio (8 dots v. 16; 16 v. 32) but not a 2:3 ratio (8 v. 12; 16 v. 24).
- 10-month-olds can do 2:3

Core system 1: Approximate **representations** of large numbers

- Why do we think these are abstract **representations**? (Rather than something specific to visual stimulation)
- Because they are cross-modal.
  - Infants can track the number of sounds (controlling for rate and duration).
  - Sounds are subject to the same ratio limits: 1:2 at 6 months; 2:3 at 9 months
- Because they support computations.

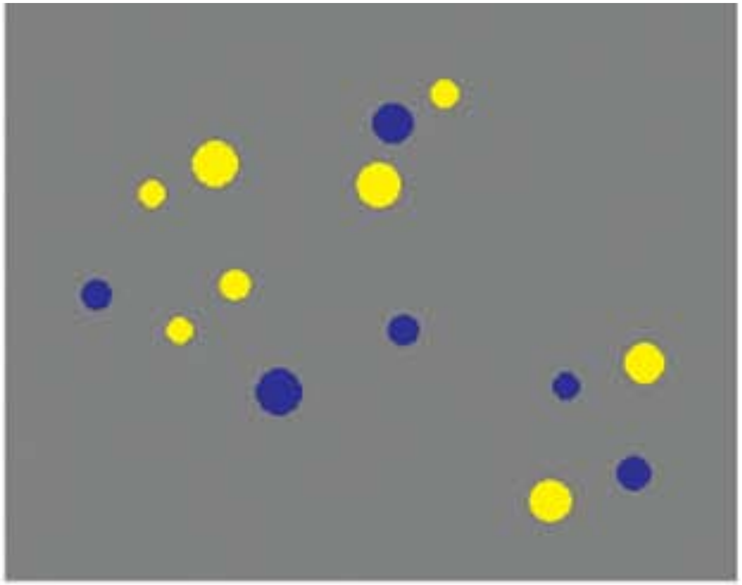
Core system 1: Approximate **representations** of large numbers

Figure removed due to copyright restrictions.
Figure 1. McCrink, Koleen, and Karen Wynn. "Large-Number Addition and Subtraction by 9-Month-Old Infants." *Psychological Science* 15, no. 11 (2004): 776-81.

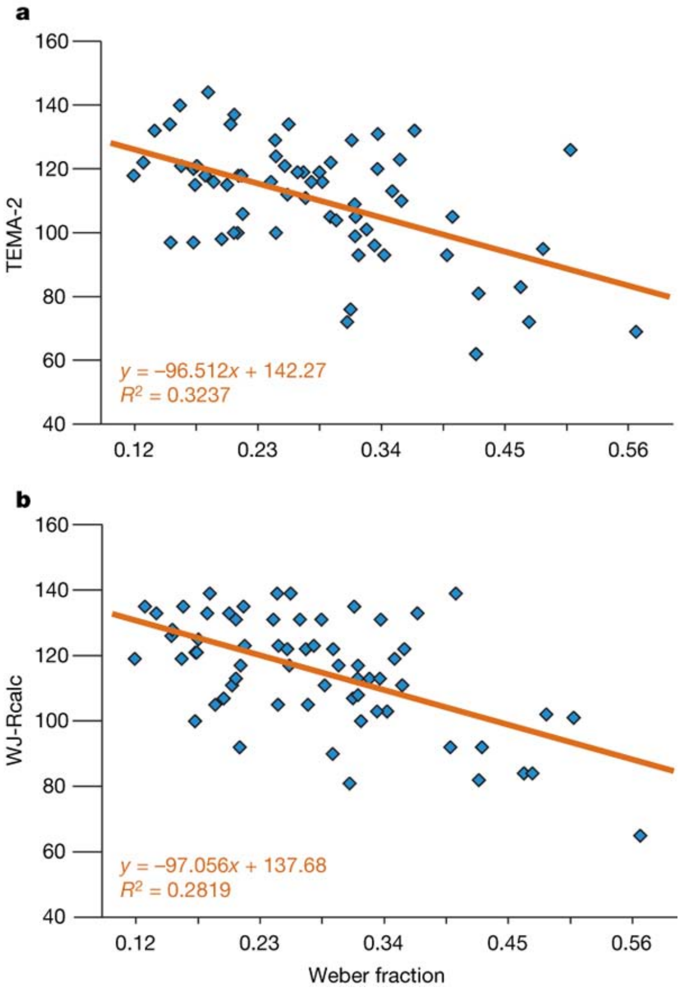
Core system 1: Approximate **representations** of large numbers

- Baseline looking times to 5 v. 10 were not significantly different.
- But infants who had seen an addition operation looked longer at 5.
- Infants who had seen a subtraction operation looked longer at 10.

Just approximate discrimination -- does it matter?



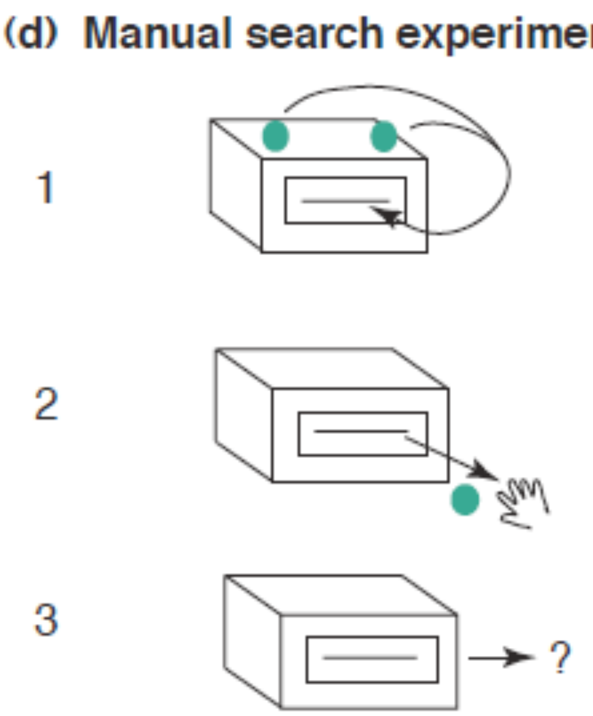
14-year-olds' number discrimination abilities correlate with their math scores



Justin Halberda, Michèle M. M. Mazzocco & Lisa Feigenson
Nature **455**, 665-668(2 October 2008)

Core system 2: Exact small number

- Converging evidence:
- Shown 1 object hiding; they didn't search long after retrieving 1.
- Shown 2 objects, searched after retrieving only 1.
- Shown 3 objects, searched after retrieving only 2.
- But shown 4 objects -- looked just like 1 object.



Core system 2: Exact small number

- 10-month-olds spontaneously go for the larger number on 1 v. 2 and 2 v. 3
- But they fail on 3 v. 4, 2 v. 4, 3 v. 6 and even on 1 v. 4.
- Note that this is not due to the ratio -- there’s an upper limit on the number of objects they can track.
- Small exact number system may use same mechanisms used for multiple object tracking -- “object files”. Works to 3 or 4 and then collapses entirely.

Dissociations between systems 1 and 2.

- Large approximate number discrimination is sensitive to ratio
- Small exact number discrimination is sensitive to absolute number of individuals.

What about symbolic understanding of number?

- Two distinct representations of number in infants.
- But neither represents the information we have in integers.
- The large number system doesn't appreciate that the difference between 1 and 2 is the same as the difference between 14 and 15.
- The small number system doesn't go past 3 or 4.

What about symbolic understanding of number?

- The count list of integers tells you that each symbol is in one-to-one correspondence with each event.
- That each succeeding number is exactly one more than the one before.
- That the ordinal position of the last word is the cardinal number of things in the set.

What about symbolic understanding of number?

- When do children understand this?
- Children “learn to count” (as in learn the count list) at 2.
- But it takes another year and a half before they understand how counting represents number.

What about symbolic understanding of number?

- If you ask a one-knower “How many fish on this card?” (Cards contain 1-8 fish).
- They’ll tell you “one” for one fish and “two fish” for everything else.

What about symbolic understanding of number?

- It takes 6-9 months after children are “one-knowers” for them to become “two-knowers”
- It takes 6-months after that for them to become “three-knowers” (typically after age 3).
- A few months later, they become able to count.

What about symbolic understanding of number?

- Children learn one the way they learn "a" or "the" in language -- as a singular determiner.
- Children become "two-knowers" about when they begin to mark plurals in speech.
- Children then notice that "one" and "two" are also part of what first looks to them like an arbitrary list.
- They notice the addition of an object file parallels the order.
- And map the successor function from the count list onto the concept of number. They induce "counting".

Area inhabited by the Pirahã tribe

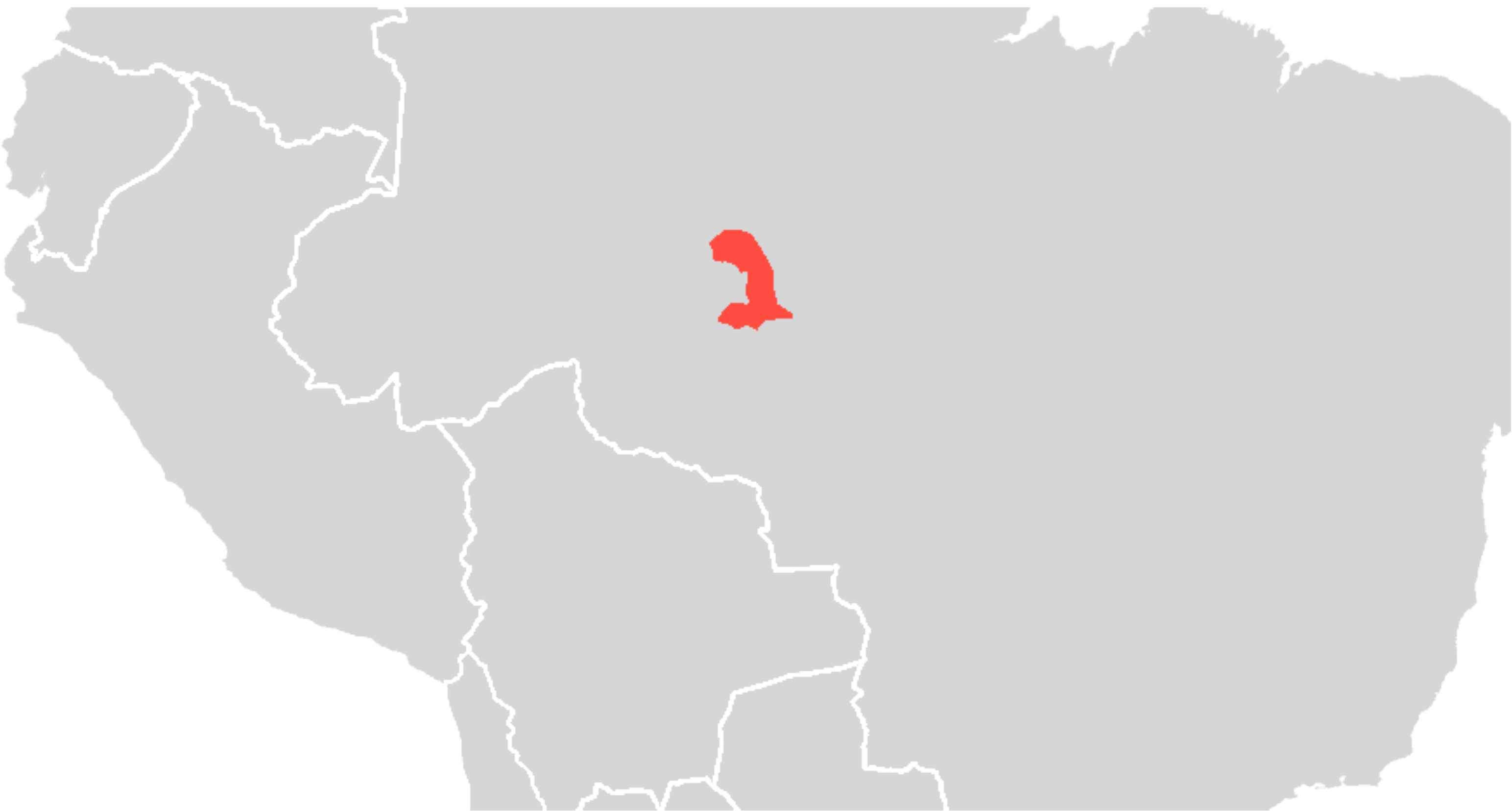
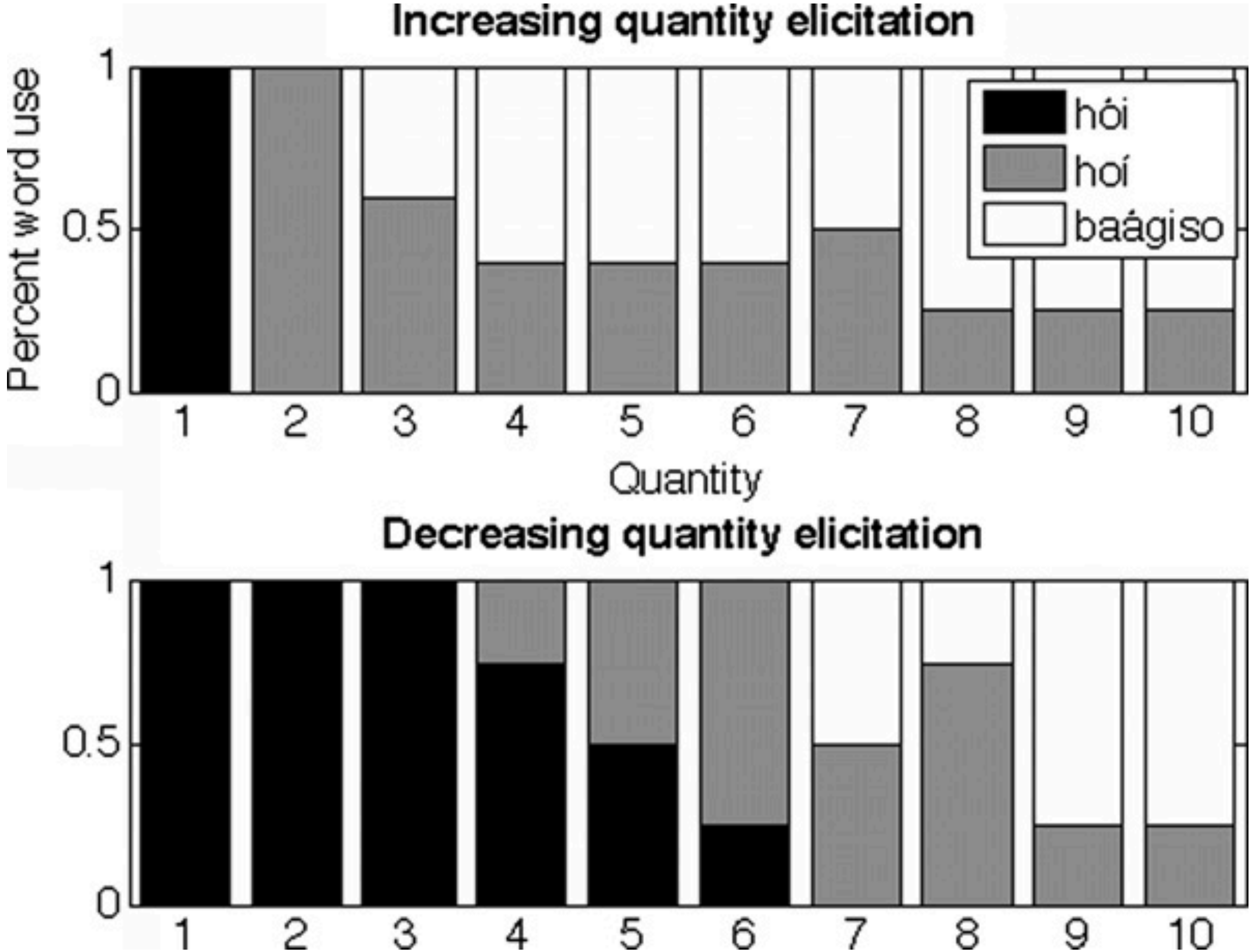


Image: Wikimedia. Davius. Public Domain.

Dan Everett

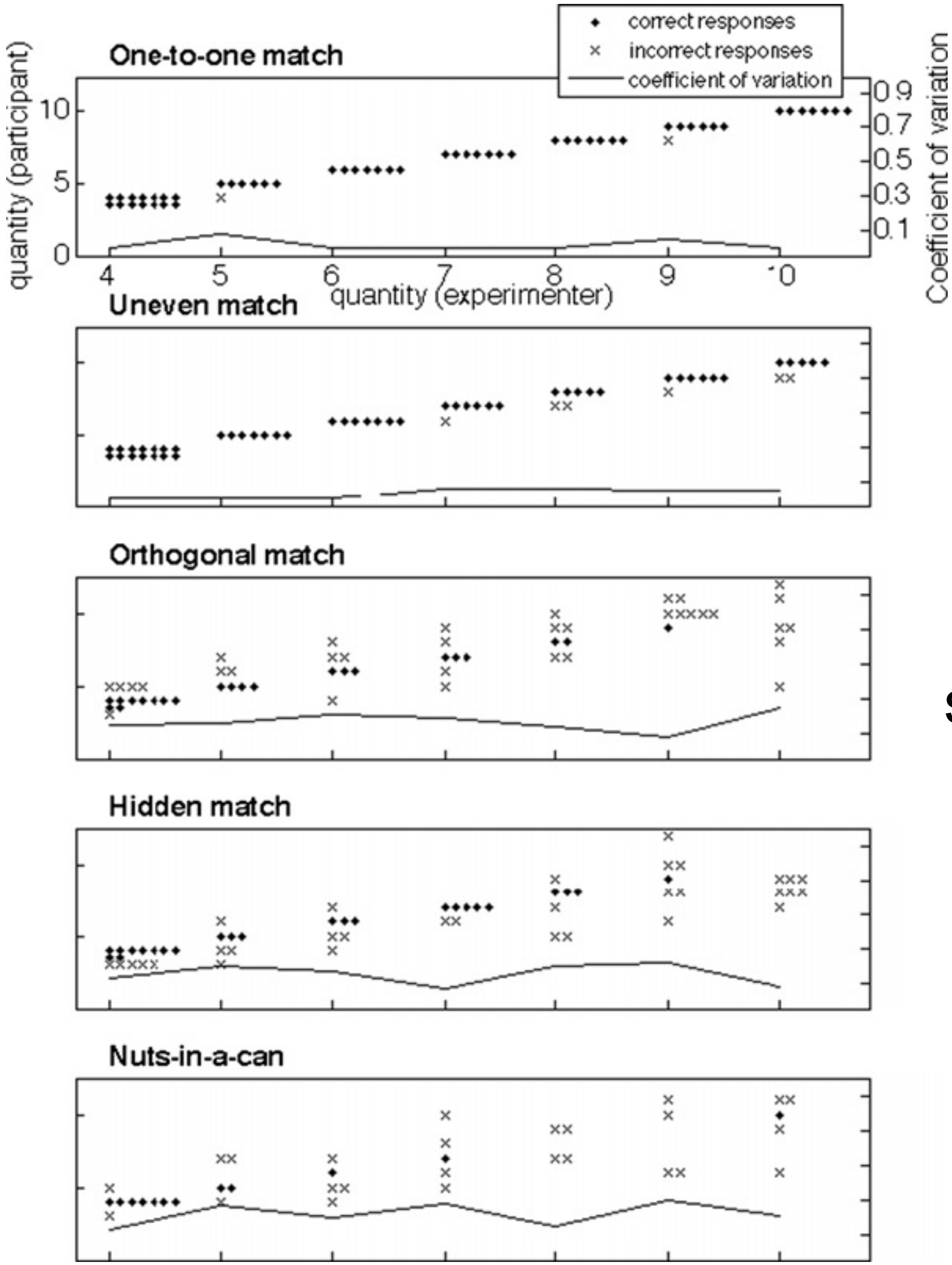
http://daneverettbooks.com/dans-books/general-public-books/dont-sleep-there-are-snakes/

No words for number (not even one)



Success and failures

- number without language



success and failure at number

http://langcog.stanford.edu/materials/piraha.html

Do numbers require language? no

This evidence argues against the strong Whorfian claim that language for number creates the concept of exact quantity (and correspondingly, that without language for number, any task requiring an exact match would be impossible).

Does memory for number require language?
yes

"Numbers may be better thought of as an invention: A cognitive technology for representing, storing and manipulating the exact cardinalities of sets."

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Number

- So when is number easy?
- When it relies on core systems
- When is number hard?
- When it has to go beyond.

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