Psych 56L/ Ling 51: Acquisition of Language

Lecture 15

Language & Cognition I

Announcements

Be working on HW3

Review questions available for language and cognition

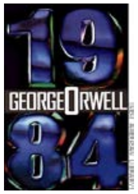
Please fill out course evaluations for this class

Remember to look at extra credit options (especially the first one, which is a webgame)

Sapir-Whorf hypothesis

The structure of one's language influences the manner in which one perceives and understands the world.

"Don't you see that the whole aim of Newspeak is to narrow the range of thought? In the end, we shall make thought crime literally impossible, because there will be no words in which to express it…" - George Orwell, *1984*



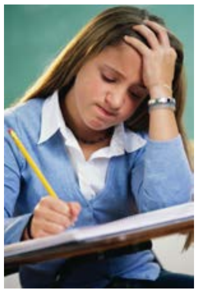
"Neo"-Whorfian question

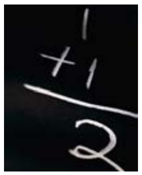
Language as a Toolkit: Does language augment our capacity for reasoning and representation?

Also sometimes referred to as "language as augmenter" (Wolff & Holmes 2010)

What the language toolkit can do

Language is a symbolic system that can help with cognitive off-loading.





Cognitive off-loading example (from Wolff & Holmes 2010)

FIGURE 3 | Series of gears in which the first turns clockwise. In which direction will the last gear turn?

"This problem could be solved by mental simulation; that is, by imagining the first gear turning to the right, then the second gear turning to the left, and so on. Alternatively, people might notice that each successive gear turns in the opposite direction from the previous one and generate the parity rule that 'odd and even gears turn in different directions'. This rule, which may depend on linguistic coding, can then be applied more quickly than the laborious process of mentally rotating each gear."

Language as a toolkit

Today:

Navigation (combining core knowledge system information)

→ geometric + landmark or color information

Number (combining core knowledge system information)

→ small, exact numbers & large, approximate numbers

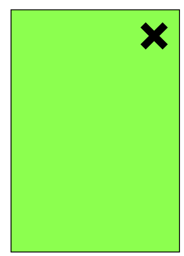
Next time:

Theory of Mind (realizing that someone can have a different point of view than you - when does this realization come, and how?)

Navigation

Geometric

"At the northeast corner"



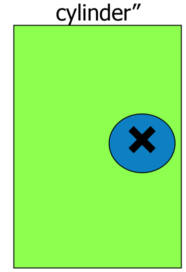
*rats

*human infants

*adult humans

(Object) Landmark

"At the (blue) cylinder"



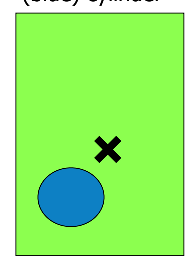
*rats

*human infants

*adult humans

Combination

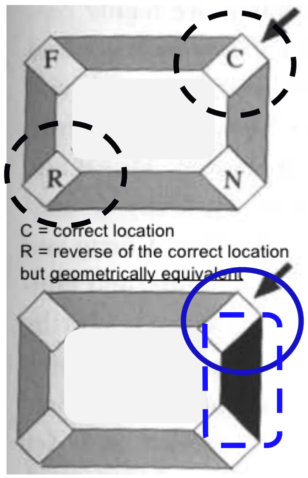
"Northeast of the (blue) cylinder"



?????

Navigation

Toddlers can find it here.



Toddlers (1.5 to 2 years old) are able to encode the location of the hidden object with respect to the geometric shape of room (left of a short wall)

But toddlers are unable to use the color of the wall to encode a location best described as "left of a black wall"

Explanation: the length of a wall is part of the geometry of a room, but the color of a wall is not. The geometric system can't talk to the system that represents the colors of objects.

Toddlers can't find it here by combining cues.

But can toddlers *really* not do it?

Maybe wall color just isn't a very salient property for toddlers. How about trying more salient landmarks? (Hermer & Spelke 1996)

"Left of the truck"?

But can toddlers *really* not do it?

Maybe wall color just isn't a very salient property for toddlers. How about trying more salient landmarks? (Hermer & Spelke 1996)

No change in navigation behavior in toddlers even with more salient landmarks (toys like truck and teddy bear).

So when does this ability develop?

Hermer-Vazquez, Moffet & Munkholm 2001: children with a high production of spatial language (like "left" and "right") succeed. This usually happens somewhere between 4 and 5 years old.

Shusterman, Lee, & Spelke 2011: 4-year-old children can combine spatial and landmark cues when specifically told a landmark will be useful for navigation. (Ex: "The black wall can help you get the sticker.")

Hyde, Winkler-Rhoades, Lee, Izard, Shapiro, & Spelke 2011: a 13-year-old deaf child, deprived of most linguistic input after late infancy, performs like toddlers do (very poor when cues must be combined to solve navigation).

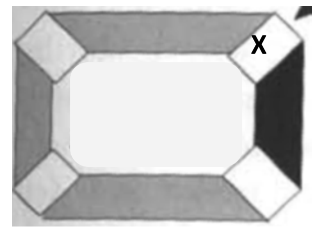
So when does this ability develop?

Implication: Language use seems integral in solving this task that requires representing information from different domains (geometry & color). Children can be prompted through language to pay attention to it, but without language, it seems difficult for humans to solve these kind of tasks.

Is language really responsible?

Hermer-Vazquez, Spelke & Katnelson 1999

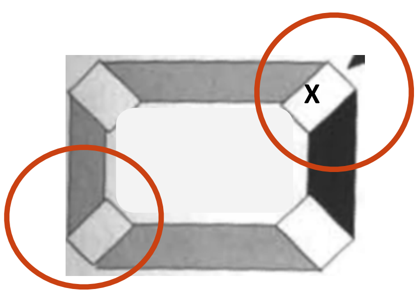
Testing adults, who were asked to verbally shadow as they performed the task. Verbal shadowing (language as meddler: Wolff & Holmes 2010) = repeating as fast as they could a passage recorded on tape. Interferes with linguistic combination abilities. [Class demo of verbal shadowing: repeat a passage while imagining that you're giving precise directions from here to the student union.]



Is language really responsible?

Hermer-Vazquez, Spelke & Katnelson 1999

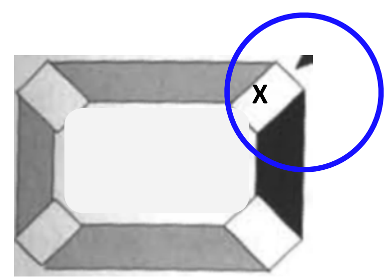
Verbal-shadowing adults behaved just like toddlers! They searched equally the correct corner and the rotationally equivalent one, seemingly unable to combine the information from geometry and color.



Is language really responsible?

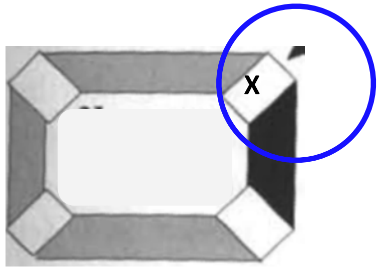
Hermer-Vazquez, Spelke & Katnelson 1999

Experiments with adults who were doing nonverbal shadowing (repeating a rhythm by clapping) did not show this result, despite the fact that the nonverbal shadowing (rhythm shadowing in this case) is as cognitively taxing as verbal shadowing. [Class demo of rhythm shadowing: repeat the clapping pattern while imagining that you're giving precise directions from here to the student center.]



Is language really *necessary*?

Rats (who don't have spatial language) can be trained to combine cues in the navigation task, though only after hundreds of trials. Language is useful (speeds things up), but not necessary?



Is language really *necessary*?

Gouteux, Thinus-Blanc, & Vauclair 2001: testing Rhesus monkeys (who do not have spatial language)

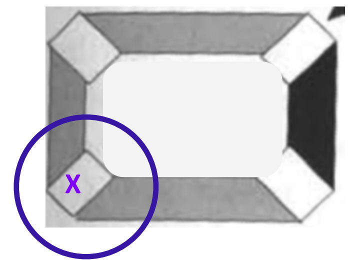
Tested 3 monkeys on location "left of wall opposite the blue wall".

~50 trials each.

Two monkeys: ~85% correct

Other monkey: ~70% correct

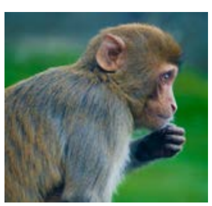
Pretty good for no spatial language!



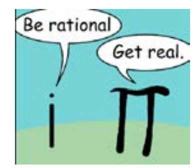
Is language really *necessary*?

So language *does* seem to play a very important role in the ability to combine information from different core knowledge systems. (Perhaps not absolutely necessary, but extraordinarily helpful - kind of like motherese for language development.)

Or maybe rhesus monkeys are just clever enough to do this without the spatial language that humans seem to rely on. Maybe humans rely on language because they have it as a tool at their disposal…



Number



5

1, 2, 3, 4, 5, 6….

6

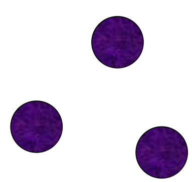
Number

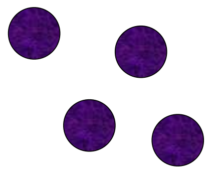
Core number systems shared by humans and other animals:

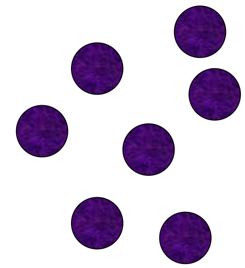
System for representing approximate numerical magnitudes
(large, approximate number sense)

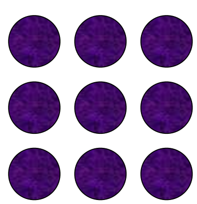
System for representing persistent, numerically distinct individuals
(small, exact number sense)

Decide fast:
How many?

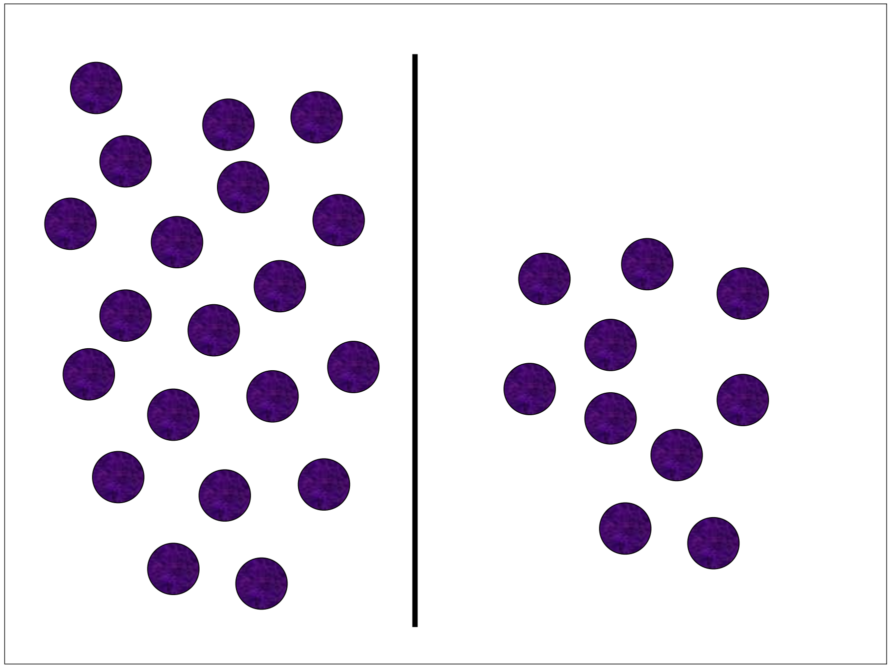
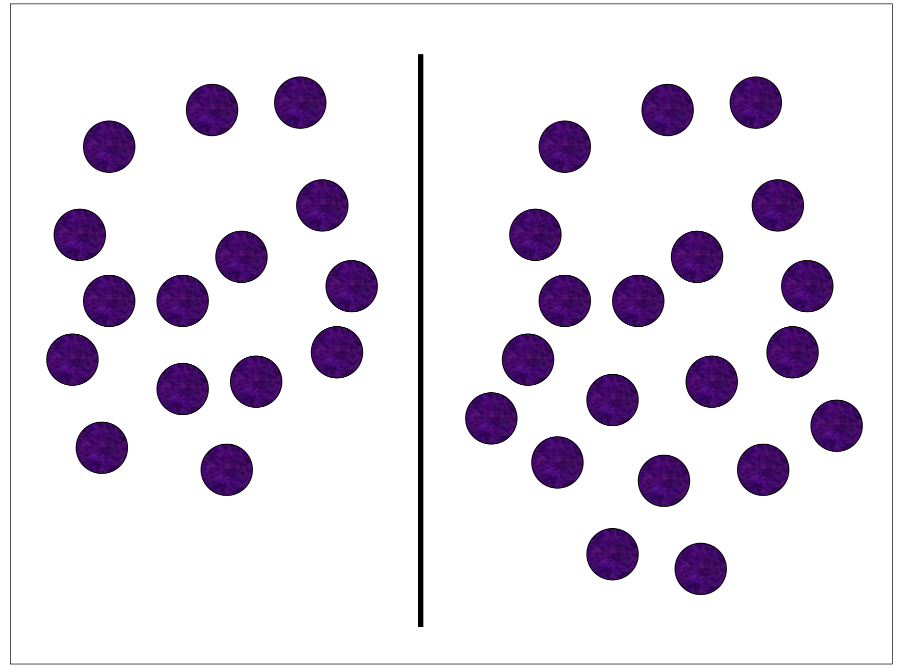
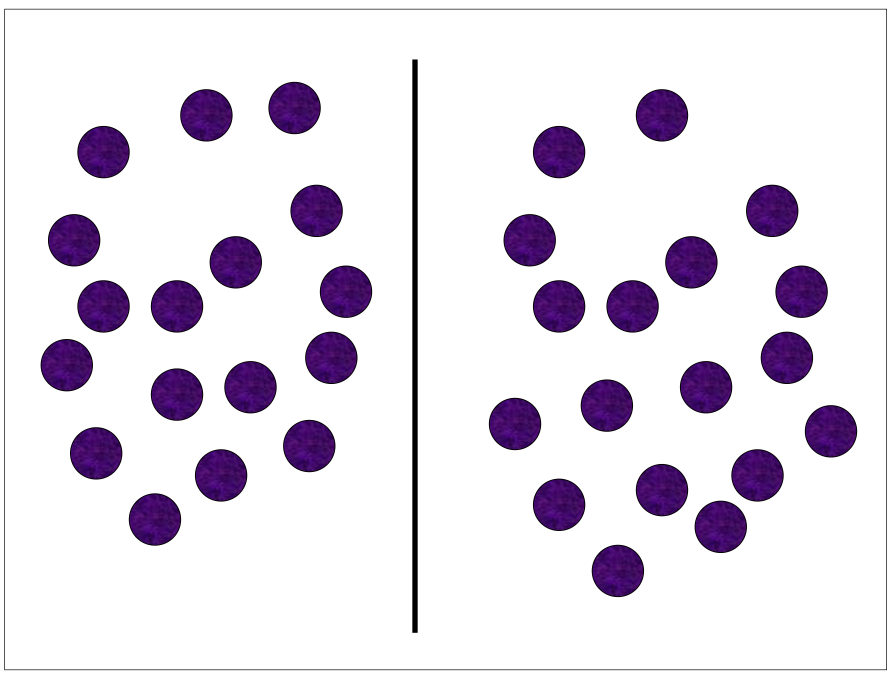
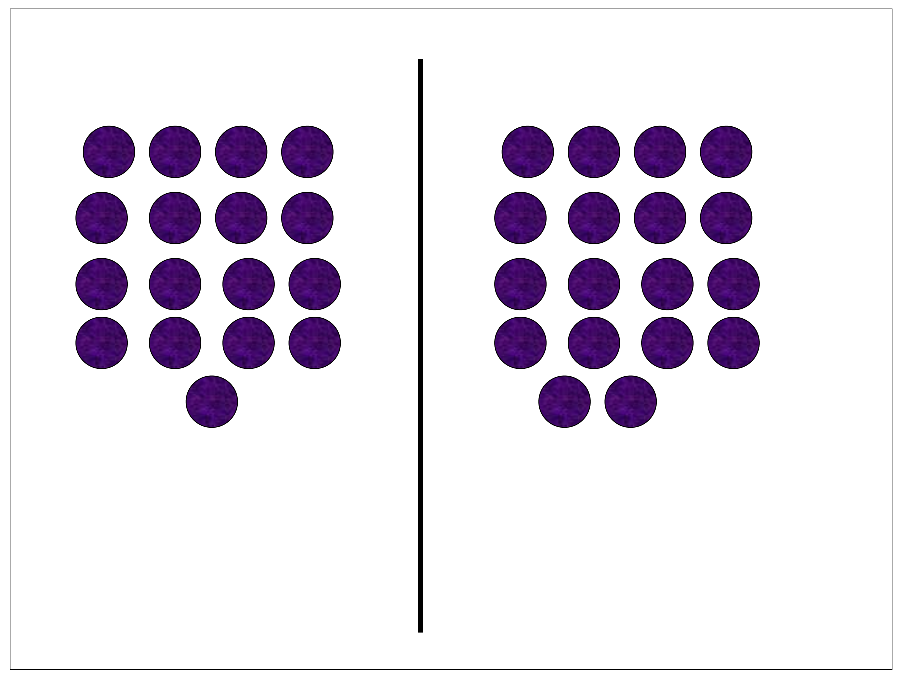








Decide fast:
Which side has more?

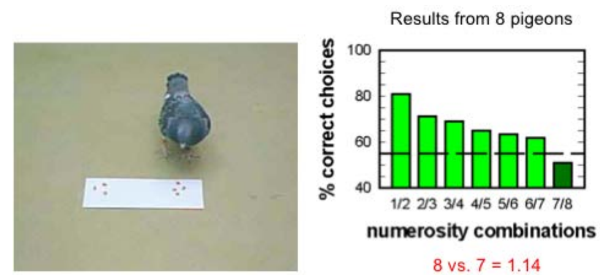





How we deal with number

Amount being represented	How represented
Very small numbers	"Subitizing"- up to 4; can tell what set looks like at a glance
Large approximate numerosities	System for representing approximate numerical magnitudes (adults at a glance can tell apart groups with a
Large exact numerosities	Combination of above systems plus language

A number sense in general isn't special

Prelinguistic infants have a system for approximating numerical magnitudes (Dehaene 1997, Gallistel & Gelman 2000), but so do pigeons, rats, fish, and other primates.



Weber Fraction Limit
for telling apart large numerosities

Age	Weber fraction
6 months	1.5-2
9 months	1.2-1.5
adult	1.15

<u>Everyone</u> can do:

12 vs. 6 = 2.0

32 vs 16 = 2.0

100 vs 50 = 2.0

6-month-olds struggle:

12 vs. 8 = 1.5

9-month-olds struggle:

12 vs. 10 = 1.2

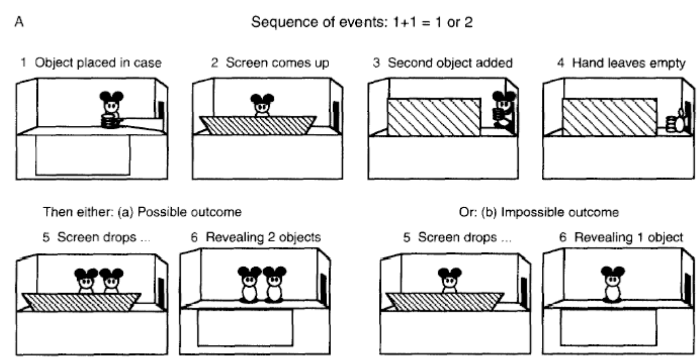
Adults struggle:

12 vs. 11 = 1.09

What about small numbers?

Wynn 1998:

Testing infant knowledge using a preferential looking paradigm. Infants are surprised by the "impossible" outcome, which means they can do addition on very small numerosities precisely.



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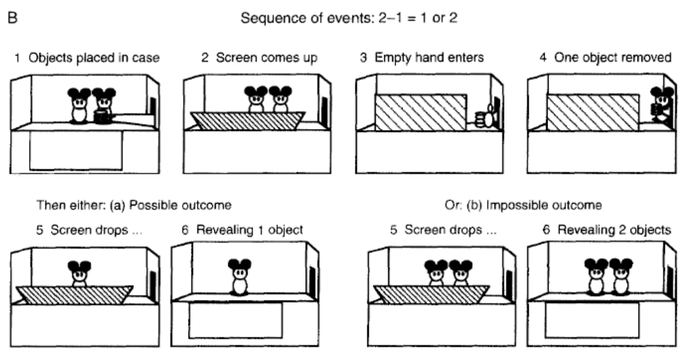
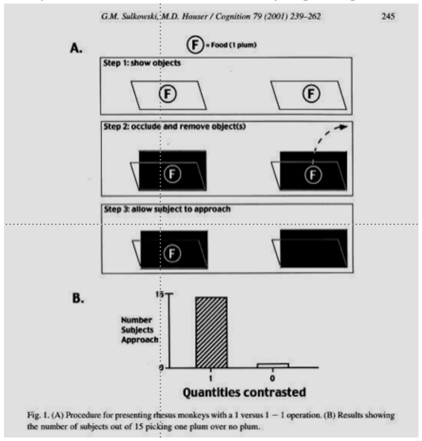


What about small numbers?

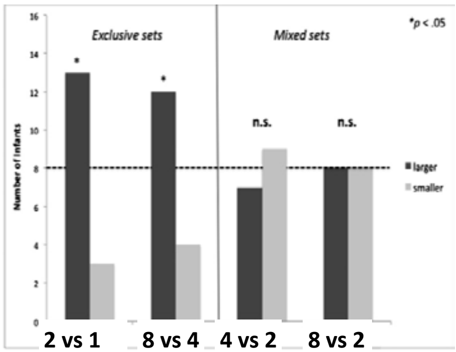
Sulkowski & Hauser 2001: Monkeys can, too

- Rhesus monkeys shown to spontaneously represent the numbers 1-3
- Test monkeys by using a procedure predicated on monkeys going to where they think food is



What about small vs. approximate numbers?

vanMarle 2012: 10- to 12-month-old infants have trouble doing comparisons across these two systems



"Infants choosing between sets that were either exclusively small (1 vs. 2) or exclusively large (4 vs. 8) chose the larger amount significantly more often than chance. Infants choosing between ''mixed'' sets, where one quantity was small and one was large, performed at chance. n.s., nonsignificant."

What human language does...

Many languages have an *exact* number system that provides names for exact quantities of any size

1, 2, 3, 4, 5…….578, 579, 580, 581, 582…

This bridges the "gap" between the two core systems.

Supporting evidence from Dehaene, Spelke, Pinel, Stanescu, and Tsivkin 1999: fMRI study showed that the exact number task recruited neural networks typically associated with language processing.

What human language does…

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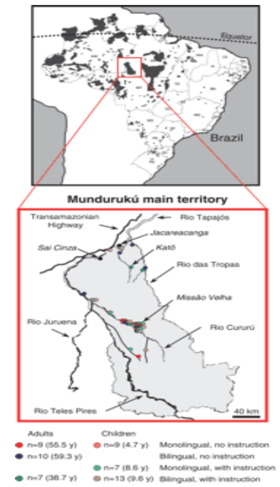
1, 2, 3, 4, 5…….578, 579, 580, 581, 582…

This bridges the "gap" between the two core systems.

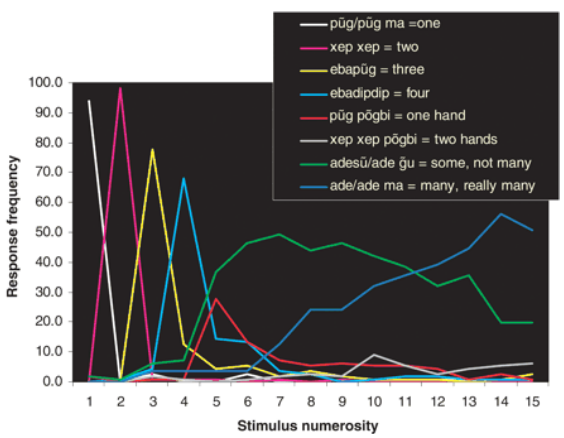
Another test of this: Look at the numerical cognition of people whose languages *don't* have an exact number system.

Languages without exact number systems

Pica, Lemer, Izard & Dehaene 2004: Munduruku speakers in Brazil who only have exact numbers for 1-5.

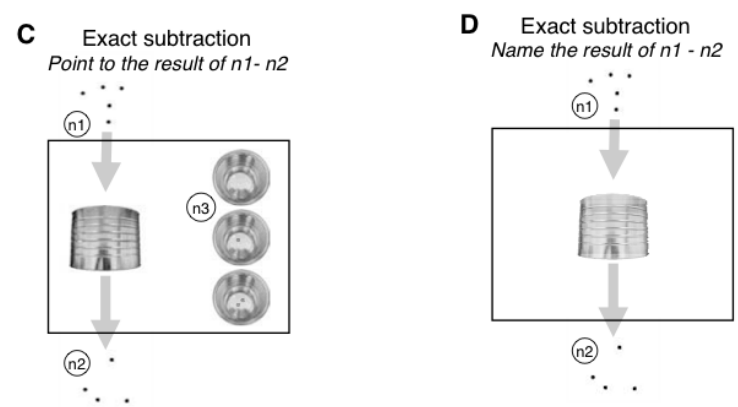


Munduruku responses when asked "how many" and shown a particular number of items



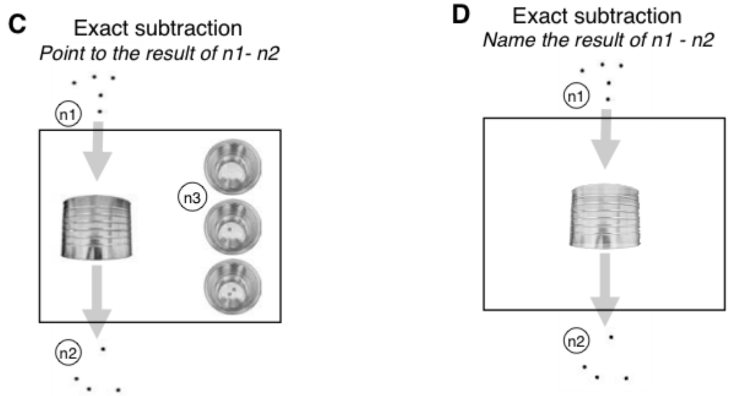
Numerosities bigger than five are "some" or "many".

Munduruku responses to exact arithmetic



Note: Even though some quantities are outside the language's number words (bigger than 5), the answer is within the number words (5 or less).

Munduruku responses to exact arithmetic



Results: Munduruku do much worse than speakers who have an exact number system (though still better than chance).

Languages without exact number systems

Gordon 2004: Pirahã speakers in Brazil who only have words for "one/two" and "many".

Table 1. Use of fingers and number words by Pirahã participant. The arrow (→) indicates a shift from one quantity to the next.

No. of objects	Number word used	No. of fingers
1	hói (= 1)	
2	hoí (= 2)	2
	aibaagi (= many)	
3	hoí (= 2)	3
4	hoí (= 2)	5 → 3
	aibai (= many)	
5	aibaagi (= many)	5
6	aibaagi (= many)	6 → 7
7	hói (= 1)*	1
	aibaagi (= many)	5 → 8
8		5 → 8 → 10
9	aibaagi (= many)	5 → 10
10		5

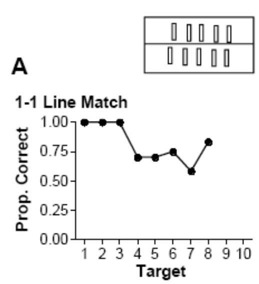
*This use of "one" might have been a reference to adding one rather than to the whole set of objects.

Languages without exact number systems

Gordon 2004: Pirahã speakers in Brazil who only have words for "one/two" and "many".

Exact arithmetic on larger numbers that are both outside the small, exact system and outside the language is very, very hard to do.

Shown batteries on one side of the line, and asked to line up batteries to match on the other side.



Languages without exact number systems

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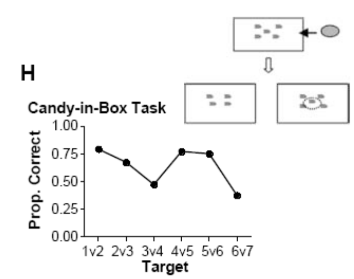
Exact arithmetic on larger numbers that are both outside the small, exact system and outside the language is very, very hard to do.

Candy put in a box with a given number of fish drawn on the top of the box. The box is then hidden. The box is then brought out again along with another box with either one more or one fewer fish painted on the box. Participants asked to identify which box contains the candy.



Gelman & Gallistel 2004:
"Language and the Origin of Numerical Concepts"

"Reports of subjects who appear indifferent to exact numerical quality even for small numbers, and who also do not count verbally, add weight to the idea that learning a communicable number notation with exact numerical reference may play a role in the emergence of a fully formed conception of number."

No language for large exact numbers =
no representation for large exact numbers

Languages without exact number systems

Note: English has imprecise words for numbers, too – but we also have exact words for numbers.

http://xkcd.com/1070/

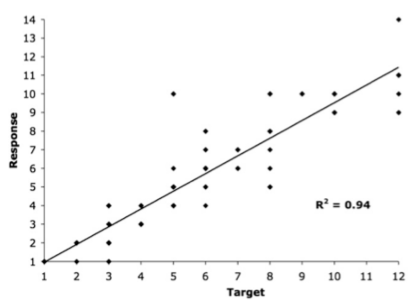
JUST TO CLEAR THINGS UP:

A FEW	ANYWHERE FROM 2 TO 5
A HANDFUL	ANYWHERE FROM 2 TO 5
SEVERAL	ANYWHERE FROM 2 TO 5
A COUPLE	2 (BUT SOMETIMES UP TO 5)

Another example: Deaf people who have not had access to a language (spoken or signed)

Spaepen, Coppola, Spelke, Carey, & Goldin-Meadow 2011
Test population: Home-signers from Nicaragua

Spontaneous communication about number: The number of fingers the home-signers extended (y axis) as a function of the number of objects actually shown in a story they were retelling (x axis).



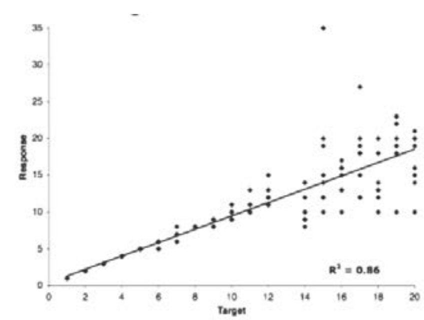
Home-signers seem able to track approximate numerosity.

Another example: Deaf people who have not had access to a language (spoken or signed)

Spaepen, Coppola, Spelke, Carey, & Goldin-Meadow 2011
Test population: Home-signers from Nicaragua

Asked to relate *exactly* how many objects were shown.

Home-signers have major difficulty once numbers go much above four.

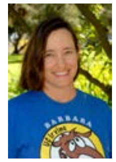


Children's numerical cognition

- English children must learn number words, and it can take them a surprisingly long time to do it.

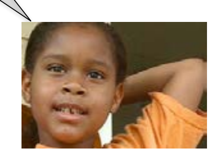
Sophisticated numerical knowledge = Cardinal Principle

The last number reached when counting the items in a set represents the entire set.



Barbara Sarnecka

1, 2, 3, 4, 5, 6....there are 6!

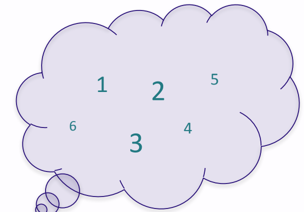


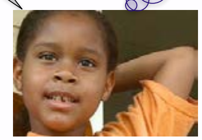
Children's numerical cognition

Children progress through different levels of knowledge on their way to discovering the Cardinal Principle (Wynn 1992, Sarnecka & Carey 2008, Sarnecka & Lee 2009).

Pre-number knowers haven't mapped any of the counting list.

1....there are 4!



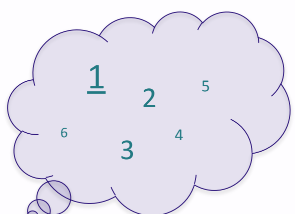


Children's numerical cognition

Children progress through different levels of knowledge on their way to discovering the Cardinal Principle (Wynn 1992, Sarnecka & Carey 2008, Sarnecka & Lee 2009).

One-knowers have only mapped 1.

1....there's 1!



Children's numerical cognition

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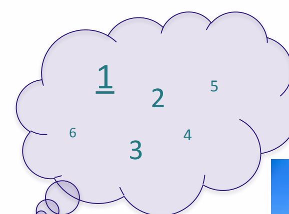
One-knowers have only mapped 1.

1, 2....there's 5!



Children's numerical cognition

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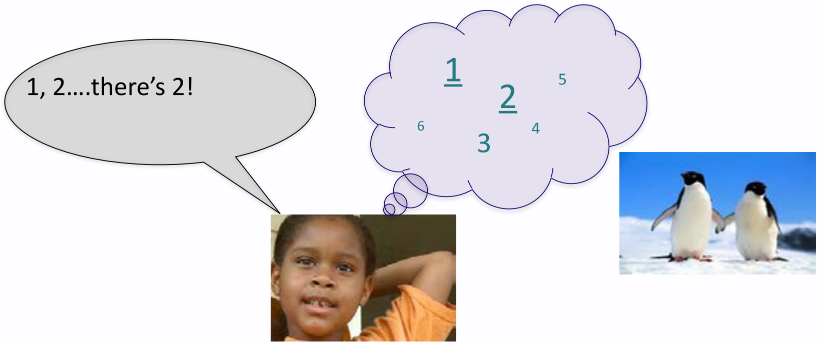
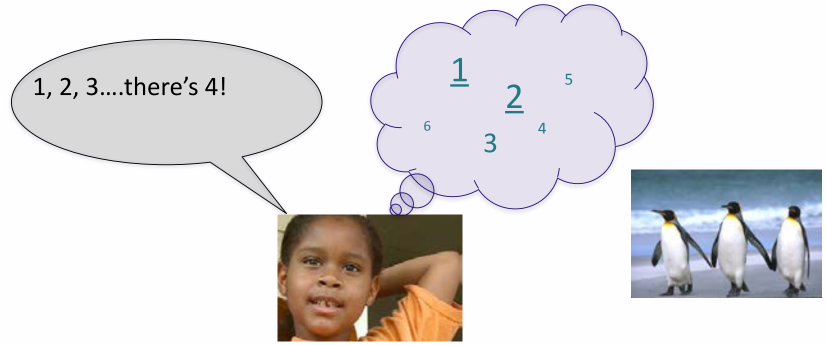
Two-knowers have only mapped 1 and 2.



Children's numerical cognition

Children progress through different levels of knowledge on their way to discovering the Cardinal Principle (Wynn 1992, Sarnecka & Carey 2008, Sarnecka & Lee 2009).

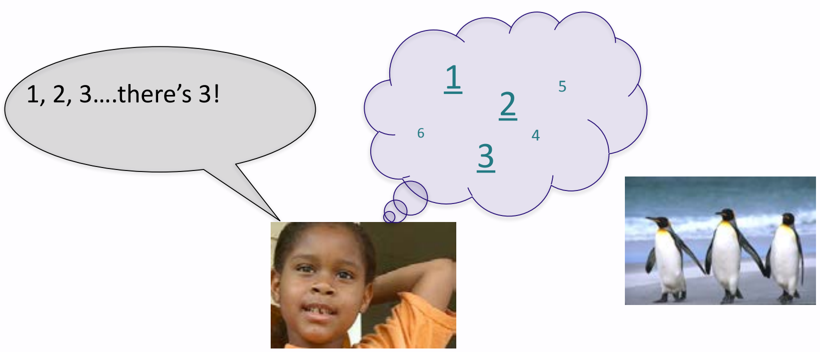
Two-knowers have only mapped 1 and 2.



Children's numerical cognition

Children progress through different levels of knowledge on their way to discovering the Cardinal Principle (Wynn 1992, Sarnecka & Carey 2008, Sarnecka & Lee 2009).

Three-knowers have only mapped 1, 2, and 3.



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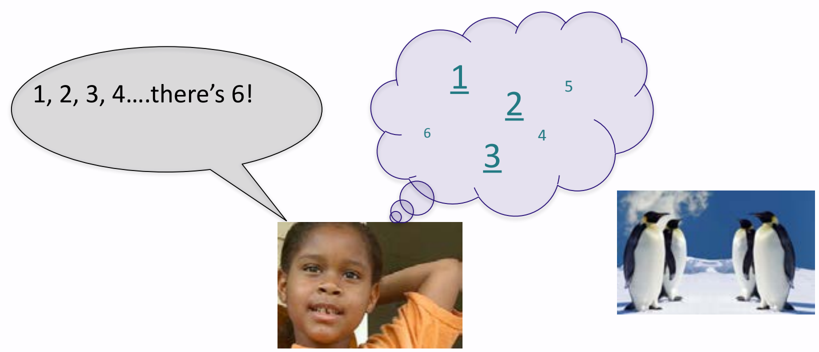
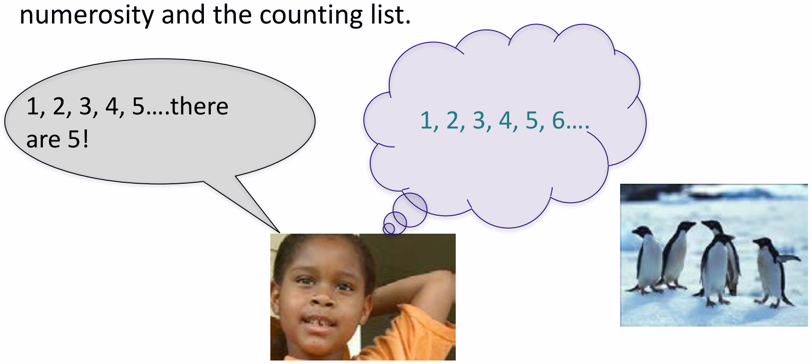


Children's numerical cognition

Children progress through different levels of knowledge on their way to discovering the Cardinal Principle (Wynn 1992, Sarnecka & Carey 2008, Sarnecka & Lee 2009).

Cardinal Principle knowers realize the mapping between numerosity and the counting list.



Children's numerical cognition

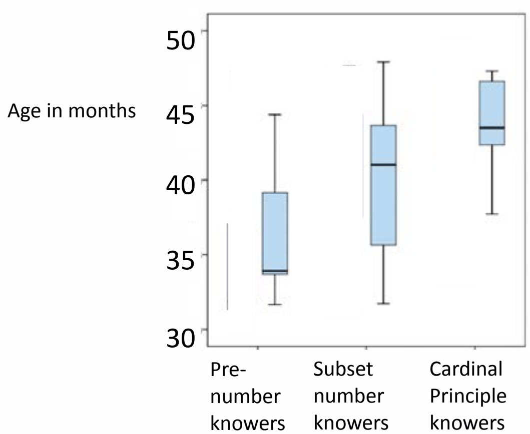
We can gauge which stage children are at using experimental methods.

Give-N Task (Wynn 1992):

"The way we play this game is: I will tell you what to put on the plate, and you put it there and sli-i-i-de it over to Kitty, like this [demonstrating]. OK, can you give one fish to Kitty?"

Children's numerical cognition

We can then get a sense of when children typically pass through the different number-knower stages.



Slusser 2010: Monolingual, High Social-Economic Status (SES) children

Using numerical knowledge

Negen & Sarnecka 2010: Tested children's non-verbal numerical cognition when they did not necessarily know the exact meaning of number words.

"Now we're going to play a *copying* game. I will give something to the anteater…(experimenter puts some items from a bowl onto his plate, and slides it to his stuffed animal)…and you give something to the bunny. You copy me and make your plate look *just like mine*."

"Now we're going to play a *remembering* game. I will give something to the bunny…(experimenter demonstrates)…and you try to remember what I gave the bunny. (Experimenter returns items to the bowl.) You give the bunny something and try to make yours *just like mine* was."

Using numerical knowledge

Negen & Sarnecka 2010: Tested children's non-verbal numerical cognition when they did not necessarily know the exact meaning of number words.

Results: Children who know more number words did a better job at replicating and remembering the number of items. Surprisingly, performance improved for all number sizes, even the ones children didn't necessarily have words for yet.

Example: Child knows "one" and "two", but improves at replicating/ remembering not only one and two, but also three, four, and five objects.

Language for numbers helps improve non-verbal comprehension and memory for numbers – may help highlight the salient concept of quantity.

Language & Cognition: Recap

Whorfianism is the belief that language influences (or determines) someone's experiences in the world. Neo-Whorfianism is a variant that believes language augments thought, so we can think more complex thoughts.

In both navigation and number, we have seen evidence for cases where language seems to enable more complex thought - or at least enable it to happen more easily.

Questions?

You should be able to answer up through question 15 on the language & cognition review questions, and up through question 8 on HW3.

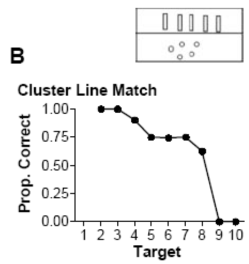
Extra Material

Languages without exact number systems

Gordon 2004: Pirahã speakers in Brazil who only have words for “one/two” and “many”.

Exact arithmetic on larger numbers that are both outside the small, exact system and outside the language is very, very hard to do.

Shown cluster of nuts on one side of the line, and asked to line up batteries to match on the other side.

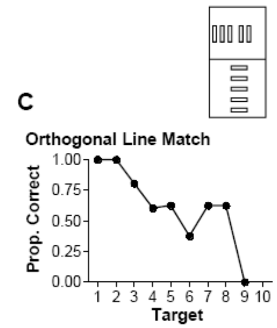


Languages without exact number systems

Gordon 2004: Pirahã speakers in Brazil who only have words for “one/two” and “many”.

Exact arithmetic on larger numbers that are both outside the small, exact system and outside the language is very, very hard to do.

Shown vertical line of batteries on one side, and asked to line up batteries to match on the other side.

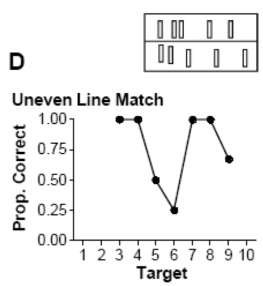


Languages without exact number systems

Gordon 2004: Pirahã speakers in Brazil who only have words for “one/two” and “many”.

Exact arithmetic on larger numbers that are both outside the small, exact system and outside the language is very, very hard to do.

Shown uneven line of batteries on one side, and asked to line up number of batteries to match on the other side.



Languages without exact number systems

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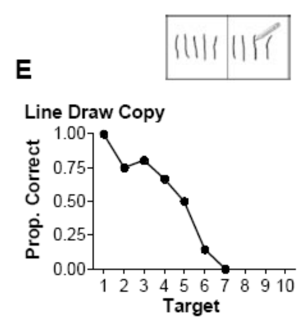
Shown lines on one side, and asked to copy number of lines to match on the other side.



Languages without exact number systems

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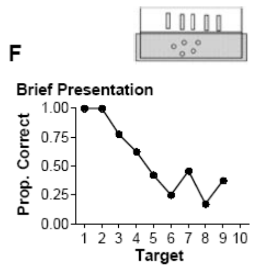
Shown cluster of nuts on one side for one second, and then asked to match number of batteries to that amount from memory.



Languages without exact number systems

Gordon 2004: Pirahã speakers in Brazil who only have words for "one/two" and "many".

Exact arithmetic on larger numbers that are both outside the small, exact system and outside the language is very, very hard to do.

Shown cluster of nuts, and then nuts are placed in a can. One nut is withdrawn at a time, and participant asked after each one if the can is empty yet.