Language and the Mind
LING240
Summer Session II, 2005



Lecture #9
"Smartness" & Navigation

What makes humans special?

Cognitive Achievements

Humans	Other Animals
-art/science of cooking	find & recognize food
-competitive games w/ elaborate rules	play fighting
-attempts to explain why world works the way it does	navigate world of obstacles
- laws and political systems	familial hierarchies & social groups

What makes Humans So Smart? (Spelke 2003)

- 2 possibilities, both of which make reference to *core knowledge systems*
- These are specialized systems that develop in infancy and provide the core for mature abilities

Possibility #1

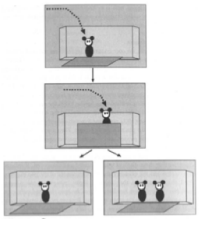
- The core cognitive systems of humans are uniquely human
- Similar to Descartes' answer:
  - –Humans are the only animal endowed w/ reason
  - –Reason is the source of all distinctive cognitive achievements of humans
  - –Example: Natural understanding of Euclidean geometric principles, astronomy, optics, physics

Evidence against Possibility #1

- Many core cognitive systems have been explored, and (so far) none of them seem to be unique to humans

–Object Mechanics
–Natural Geometry

Object Mechanics: 5-month old babies know that objects continue to exist even when they can't see them



Results:

*Infants look longer at the 1-puppet screen, showing they represent 2 puppets in their minds

Important later manipulations:

The same result obtains even if the shapes, colors, and spatial locations of the objects in both displays are new

Object Mechanics: 5-month old babies know that objects continue to exist even when they can't see them

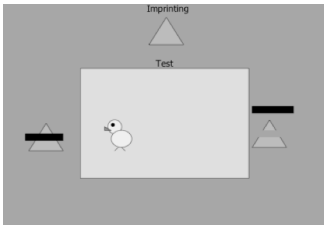
…but so do adult rhesus monkeys and 1-day old chicks

Object Mechanics: Human infants fill in the surfaces and boundaries of partially occluded objects

- 4-month olds perceive the unity of a moving, center-occluded object
- Movement (common motion of discontiguous parts) is a crucial factor

Object Mechanics: Human infants fill in the surfaces and boundaries of partially occluded objects

But newborn chicks do, too…



Natural Geometry

Humans	Non-humans
Both blind and blindfolded children are able to deduce geometric relationships between objects experienced one-at-a-time	Bees compute relationship between hive and food source Tunisian ants dead reckon their way home after long torturous treks

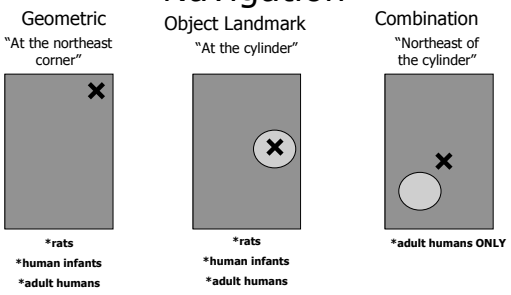
So…

- Neither core systems of object mechanics and natural geometry are unique to humans
- *Possibility #1 can't be right*

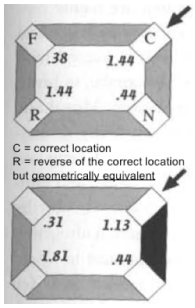
Possibility #2

- Although the core knowledge systems of humans and non-humans are the same, humans have language and *that* allows humans to combine information from different core systems
- "Neo-Whorfian view": language as toolkit

Navigation



Navigation



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)

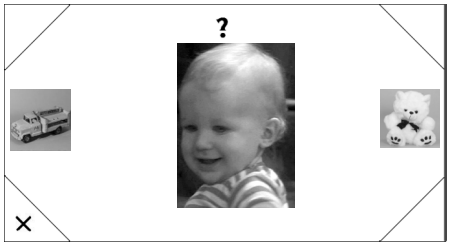
But toddlers are unable to use the color of the wall to encode a location best described as "left of a black wall"

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.

But can toddlers *really* not do it?

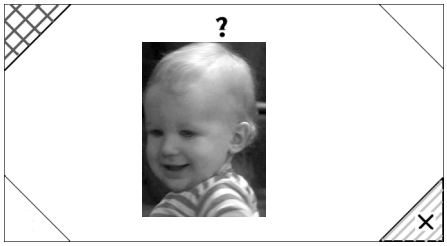
- Maybe wall color just isn't a very salient property for toddlers
- How about trying more salient landmarks? (Hermer & Spelke, 1996)

More Salient Landmarks



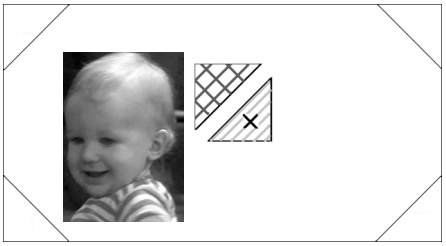
…but still no change in behavior

But what about other cues? Part 1



No change in behavior - still search for object at both rotationally equivalent corners…

But what about other cues? Part 2



But what about other cues? Part 2

The toddlers find it now - as long as they don't have to combine the geometric & non-geometric cues.

So when does this ability develop?

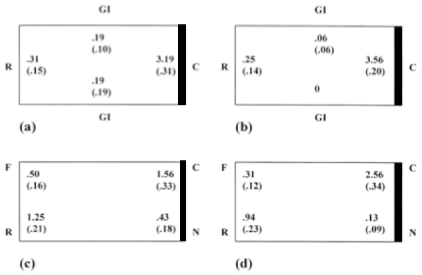
"Language, Space, and the Development of Cognitive Flexibility in Humans"

- Hermer-Vazquez, Moffet & Munkholm

Experiment #1

- Participants: 16 children between the ages of 3 and 4 years and 16 children between the ages of 5.4 and 6 years
- Participants placed in a rectangular chamber
- Two conditions:
  - Direct Landmark: Use of non-geometric cue as landmark
  - Indirect Landmark:a blend of geometric cue and wall color

Experiment #1 Results

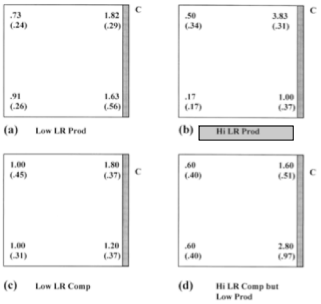


a) 3-4yo DL **b)**5-6yo DL **c)**3-4yo IL **d)**5-6yo IL a, c also have darkened wall

How do we determine what makes kids become more flexible?

- Kids get "smarter" in many ways
- Expt 2: children given a battery of tests which measure cognitive development
  - General Processing: digital span, IQ, spatial memory span
  - Development of Spatial Language: comprehension & production
  - Active use of spatial language: production of "left" and "right"
- Test: find the correct location, one room all white walls; one room with one colored wall

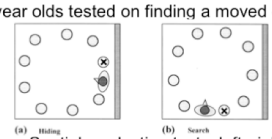
Experiment #2 Results



- Only children with high production of spatial language seem able to behave adult-like

Does spatial language production help other kinds of spatial tasks that require combining info?

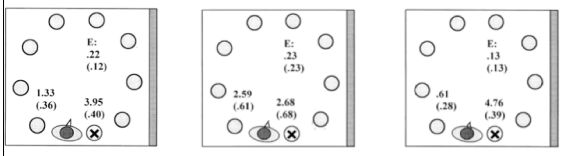
- 6 year olds tested on finding a moved object



- Given Spatial production tests; left, right, above below etc.

All subjects including rats learn to search near dwarf quickly, but wide variation in absolutely correct answer

Experiment #3 Results



All children | Low LR Prod | High LR Prod

Some Thoughts…3

- There is a correlation between spatial language production and the ability to combine non-spatial and spatial information.
- But…rats can be trained to do the same thing after hundreds of trials (Biegler & Morris, 1996)
- So spatial language production isn't absolutely *necessary*….just really helpful?

Limitations of Core Knowledge Systems

- Domain Specific: represent only selection of entities in child's environment
- Task Specific: guide only actions/thoughts relevant to child's life
- **Encapsulated:** processes of each are separate from the other systems
- **Isolated:** representations from each system do not readily combine

But with human language…

- "...system that has none of the limits of the core knowledge systems..."
- "...a unique system for combining flexibly the representations they share with other animals..."
- You can create an expression "left of the blue wall" that allows you to combine representations from both the geometric and object representation systems

Property of Human Language

- Compositional Semantics: ability of a speaker to apply meanings of a set of words and rules for combining them to create and understand new combinations from the meanings of their parts
- "...natural languages can expand the child's conceptual repertoire to include not just the preexisting core knowledge concepts but also any new well-formed combination of those concepts."

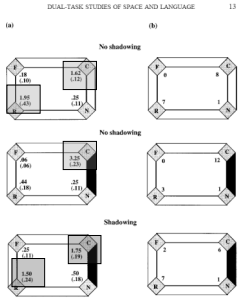
But how do we know language is *really* what's responsible?

"Sources of Flexibility in Human Cognition: Dual-Task Studies of Space and Language"
Hermer-Vazquez, Spelke & Katnelson (1999)

Experiment 1

- Same set-up as Spelke experiments - 2 rectangular rooms, one with blue wall & one without.
- The reorientation task was performed on subjects in both rooms.
- But in the room with the blue wall, subjects were asked to verbally shadow (repeat as fast they could a passage recorded on tape) during the reorientation task.
- Shadowing: Interferes with linguistic combination since they assume you can't do two language tasks at onces

Experiment #1 Results



Adults revert back to just relying on geometric info to reorient themselves!

But …

- It is was not obvious that it was the verbal shadowing that impaired the use of nongeometric information. Maybe it's not a *language* problem, but simply a *memory* problem since verbal shadowing is a very demanding task…
- If the nongeometric search requires more resources than a geometric search, then it is possible that the shadowing task simply took too much memory space.
- If that was true, it's not language but general cognitive processing ability that helps bridge the gap between core knowledge systems

Experiment #2a

Group 1: performed a visual search task while engaged in verbal shadowing

Group 2: performed a visual search task while engaged in rhythm shadowing with non-verbal response – tapping

Group 3: performed a visual search task while engaged in rhythm shadowing with verbal response – repeating a nonsense syllable"na"

Visual Search: say whether a screen full of T's contains the letter L

Experiment #2a Results

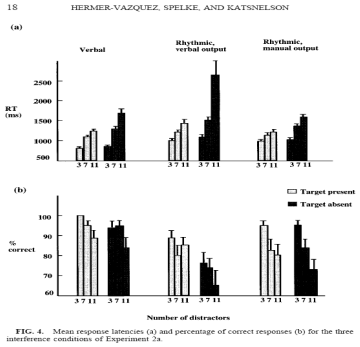


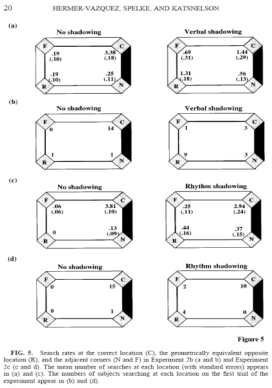
FIG. 4. Mean response latencies (a) and percentage of correct responses (b) for the three interference conditions of Experiment 2a.

Rhythm shadowing is at least as demanding on attention and memory as verbal shadowing

Experiment #2b & #2c

Like experiment 2a, except better training for verbal shadowing for 2b and shadowing was non-verbal for 2c (clapping to rhythms).

Experiment #2b & #2c Results



However…

These findings could mean two things:

1: Verbal shadowing may interfere with the combination process of the geometric and nongeometric information but the subjects can remember and detect both types of information.

OR

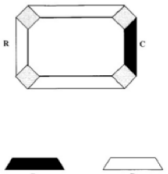
2: Verbal shadowing prevents the subjects from detecting and remembering the nongeometric landmark.

Experiment #3

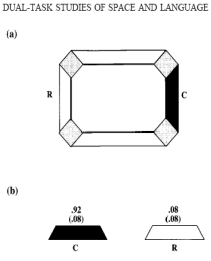
- Purpose: to see whether subjects detect and remember nongeometric information during verbal shadowing
- Different from experiment 1 and 2b in that:
  - The object was hidden directly behind the blue wall, not in the corner, so subjects did not have to conjoin geometric and nongeometric information
  - The short blue and white walls were removed and carried out of the room so that the subject did not rely on his/her sense of orientation.

Procedure

1. The object was hidden behind the white wall or the blue wall.
2. The subject had to close his or her eyes and was spun around.
3. The walls were removed and carried out of the room.
4. The shadowing, disoriented subject was led out of the room, told to stop, open his or her eyes, and presented with the two walls – white and blue.



Experiment #3 Results



Disoriented, shadowing subjects correctly located the hidden object behind the wall of the appropriate color, indicating that they noticed and remembered the relevant nongeometric information.

Experiment #4

- Does language allow people to combine geometric and nongeometric information only in situations in which they are disoriented or does it allow for such combinations in any situation?
- Same as experiment 3, but the walls were removed along with the corners so the subjects could not locate the hidden object by forming a direct association between the object and the nongeometric cue (color). They would have to use spatial language: "to the left of the blue wall"
- If verbal shadowing impairs the encoding of geometric and nongeometric information only in reorientation tasks, then experiment 4 results should equal experiment 3 results.

Experiment #4 Results

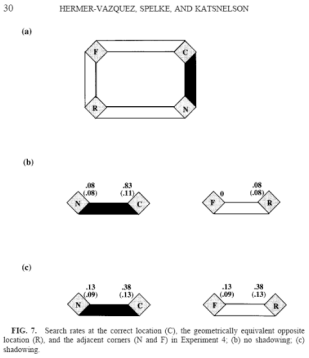


FIG. 7. Search rates at the correct location (C), the geometrically equivalent opposite location (R), and the adjacent corners (N and F) in Experiment 4; (b) no shadowing, (c) shadowing.

1. Subjects can detect and remember nongeometric information but fail to combine the two when shadowing
2. Disorientation does not matter. Shadowing causes subjects to fail to conjoin information regardless whether the information is to be used to reorient the self or to locate a movable object.

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 <u>extraordinarily</u> helpful.)

Helpful, but not necessary…

Rhesus Monkeys Use Geometric and Nongeometric Information During a Reorientation Task

S. Gouteux and C. Thinus-Blanc
Center for Research in Cognitive Neuroscience

J. Vauclair
Université de Provence

All white rectangular room

Table 1

Number of Trials (Out of 50) During Experiment 1 for the Subjects as a Function of Their Search Location (Correct, Rotational, Geometrically Inappropriate Corners)

	Box			
Monkey	C	R	N	F
Orcas	21	20	4	5
Krill	25	24	1	0
Crevet	23	25	2	0
Average (%)	46	46	4.7	3.3

Note. C = correct; R = rotational; N = near misses; F = far misses.

One blue wall

Table 3

Number of Trials (Out of 50) During Experiment 2 for the Subjects as a Function of Their Search Location (Correct, Rotational, Geometrically Inappropriate Corners)

	Box			
Monkey	C	R	N	F
Orcas	37	8	4	1
Krill	35	14	1	0
Crevet	41	8	0	1
Average (%)	75	20	3.5	1.5

Note. C = correct; R = rotational; N = near misses; F = far misses.

Two Possibilities

They cheated.
They separately encoded:
a) reward is **left of a short wall** (a **geometric** rep)
b) reward is **near the blue wall** (a **non-geometric** rep)
Using both representations, they were able to uniquely determine the correct location

They didn't cheat.
They directly encoded:
Reward is **left of the blue wall** (a **combined** rep)

(Even though they don't have language to help them form that kind of representation)

One blue wall: Non-geom cue is distant from hidden object

Table 4
Number of Trials (Out of 50) During Experiment 3 for the Subjects as a Function of Their Search Location (Correct, Rotational, Geometrically Inappropriate Corners)

	Box			
Monkey	C	R	N	F
Orcas	41	6	3	1
Krill	34	16	0	0
Crevet	45	4	0	1
Average (%)	80	17	2	1

Note. C = correct; R = rotational; N = near misses; F = far misses.

Conclusion: They didn't cheat

They directly encoded: reward is opposite the checkered wall (a **combined** rep) and left of the short wall (a **geometric** rep)

Rhesus monkeys can form and use representations that combine geometric and non-geometric information

But Rhesus monkeys don't have language

Therefore, language is not necessary to form such conjoined representations

Just because rhesus monkeys can combine geo & non-geo spatial info without language, this doesn't mean that humans **don't** use language to do this.

They take Hermer-Vazquez's data to have demonstrated that language **is** necessary **for human beings** to combine these

Does this mean that rhesus monkeys are the ones that are more flexible?