Cognitive Neuroscience
Core Knowledge

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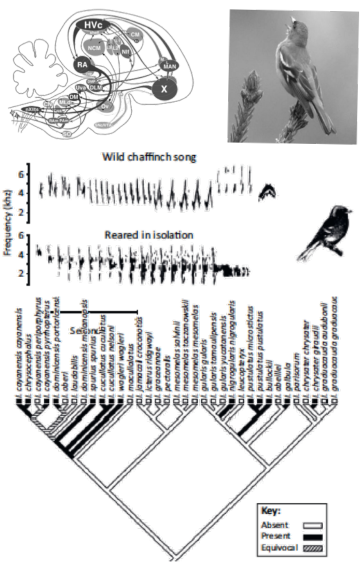
https://sites.google.com/site/laboratoryanimalcognition/

Syllabus

① Intro – Core knowledge hp – Objects
② Agents
③ Numbers
④ Space

Tinbergen's 4 questions



1 What is it for | CURRENT UTILITY
2 How does it work | MECHANISM
3 How did it develop | ONTOGENESIS
4 How did it evolve | PHYLOGENESIS

Tinbergen 1963; Bateson & Laland 2013

Assumptions of the comparative approach

- **Concepts like** representations or mental processes are used also for other species
  - A representation is a functional isomorphism between different systems
  - Processes carried out in the representation system (brain) MUST produce valid inferences about the events and their relations in the represented system (environment) on the basis of a formal correspondence

Assumptions of the comparative approach

- The other species HAVE TO HAVE representations since they are adapted thanks to behaviors mediated by the NS
- We can wonder about the quality of the representation
  - however, we can score their behavioural responses to certain stimuli/conditions
  - we can register their brain activity in response to certain stimuli/conditions

Choice of the animal model

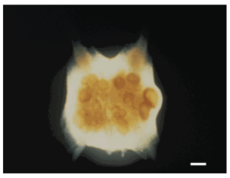
• **General models**

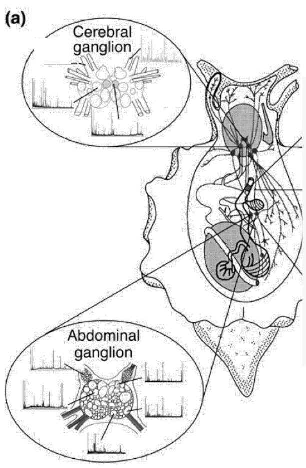
representative for the study of common and shared issues

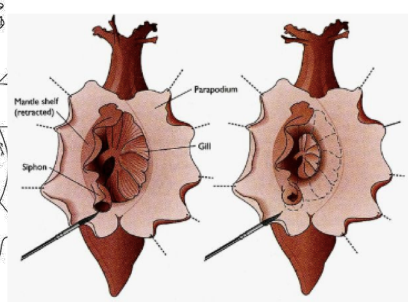
Aplysia californica and learning

• [...] *the selection of the appropriate model system for a specific problem is one of the great strategic decision one makes within biology [...] fortunate for implicit memory storage because it is extremely conserved [...] you can study it in flies, worms, snails, ...mice and rats and human beings [...] they all share almost the same mechanisms* [...] E. Kandel

Choice of the animal model







Choice of the animal model

- **General models**

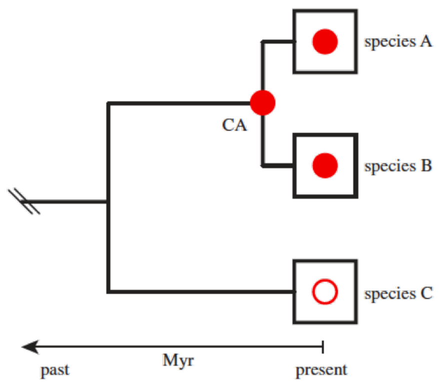
representative for the study of common and shared issues
Aplysia californica and learning

- **Specific models**

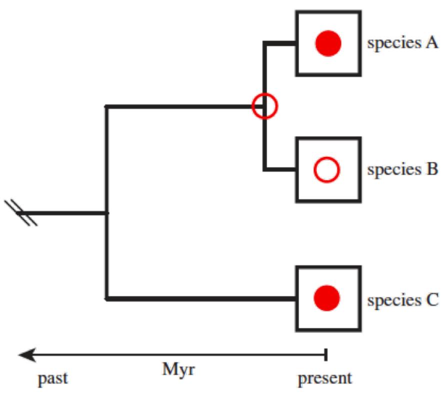
representative for the study of specific issues
Food hoarders and hippocampal hypertrophy

Phyletic trees

DIVERGENT EVOLUTION
HOMOLOGY



CONVERGENT EVOLUTION
HOMOPLASY



Core Knowledge

- There are some problems that are common to all evolutionary niches (all organisms have to cope with objects, agents, magnitudes and navigation) hence it is reasonable to assume that there is a tool-kit of shared cognitive abilities (Spelke, 2000).
- These would be
- Given at birth
- Independent from experience and formal culture/acculturation
- Largely shared between species
- At the basis of learning processes

phrenology

- The phrenologists were wrong for two aspects
  1. Reference to attitudes and not mental functions or cognitive processes
  2. External inspection of the skull to find bumps defining individual's abilities
- However, they anticipated correctly two concepts
  1. Plasticity
  2. Modularity

modularity

- Fodor proposed a strong version of modularity
- The criticisms are both on the empirical and theoretical basis
- Indeed
  - not all modules seem to be inborn
    - maybe the instruments to learn (Karmiloff-Smith, 1992)
  - the modules are not completely isolated from the others (Farah, 1994)

modularity

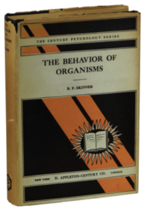
- The debate is still open, at least for the issue whether the different cerebral areas are domain-specific
  - There are several examples in this sense
- As for innateness, there is a biological hystory which is predisposed
  - Besides the biological constraints to learning, the organisms have basic and core knowledge

behaviorism

- EQUIPOTENTIALITY

all pairs of events can be associated by all species with identical readiness (and within the only limit of the motor and sensory organization of each species)

The misbehavior of organisms (1961)



BIOLOGICAL HISTORY

- *ceteris paribus*, there are predispositions that favour some associations stimulus-response as compared to others: there are constraints on what can be learned, the organism is not a *tabula rasa*

ISTINCTIVE DRIFT

- after having been conditioned to a specific learned response, each animal gradually changed it, drifting towards instinctual behaviors related to natural and species-specific motor responses to get food; such drift arose in spite of delay or preclusion of reinforcements

a soft version of modularity

the "Core knowledge" hypothesis

Core knowledge

objects

Objects

1. Continuity principle:

- physical objects exists and move continuously in time and space;
- they cannot appear / disappear spontaneously and suddenly,
- and cannot cover the same space of other objects

Objects

2. Cohesion principle:

- physical objects are connected entities
- they cannot spontaneously be fragmented when they move
- they cannot mould/merge with other objects

3. Contact principle:

- two objects interacts only when there is reciprocal contact
- motion because of collision

Objects

- [...] The Gestalt school of psychology labelled "naïve physics", all those untrained common intuitions of the observed physical phenomena (Bozzi, 1990; Smith & Casati, 1994) that we simply cannot elude in our everyday reasoning. Many of these notions are over-simplifications that nevertheless predict the exact outcome of physical events, although they are sometimes based on a misunderstanding of the proper underlying principles.

Objects

- Quite surprisingly, when the naïve beliefs lead to erroneous predictions of the final effect, we discover that those beliefs are also resilient to experience, which may not be sufficient to provide the correct knowledge of the phenomena (e.g., Caramazza *et al.*, 1981; Hecht & Proffitt, 1995). This makes apparent that some significant effort is necessary to understand the exact formal mechanisms of nature: there is a real battle in our heads between common implicit beliefs and formal acquired rules. [...] Chiandetti & Vallortigara 2017

Objects

FORMAL PHYSICS

- it is based on formal mathematical principles
- it explains events we cannot directly see
- it is used to explain the natural world

E.g.: gravity law

INTUITIVE PHYSICS

- it is based on intuitions / personal experiences
- it explains only events we directly see or infer from our senses
- it is used to predict events in order to survive

E.g.: you shake the tree to get an apple

Objects

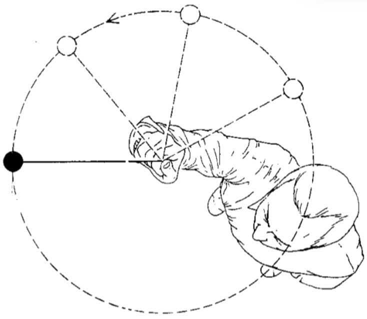

REPORTS

Curvilinear Motion in the Absence of External Forces: Naïve Beliefs About the Motion of Objects

MICHAEL MCCLOSKEY, ALFONSO CARAMAZZA, BERT GREEN

+ See all authors and affiliations

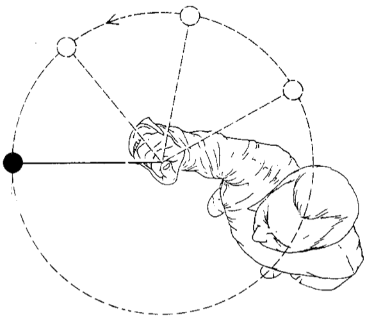
Science 05 Dec 1980:
Vol. 210, Issue 4474, pp. 1139-1141
DOI: 10.1126/science.210.4474.1139

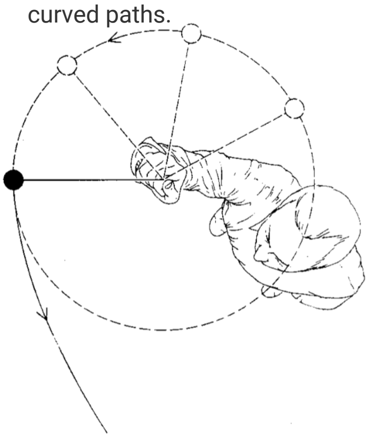


Imagine that someone has a metal ball attached to a string and is twirling it at high speed in a circle above his head. In this diagram you are looking down on the ball. The circle shows the path followed by the ball and the arrows show the direction in which it is moving. The line from the center of the circle to the ball is the string. Assume that when the ball is at the point shown in the diagram, the string breaks where it is attached to the ball. Draw the path the ball will follow after the string breaks. Ignore air resistance.

Objects

University students were asked to draw the path a moving object would follow in several different situations. Over half of the students, including many who had taken physics courses, evidenced striking misconceptions about the motion of objects. In particular, many students believed that even in the absence of external forces, objects would move in curved paths.

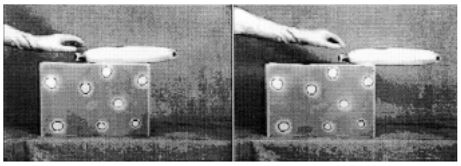




Objects

DOING

SEEING



(Cacchione & Krist, 2004)

Objects

SEEING

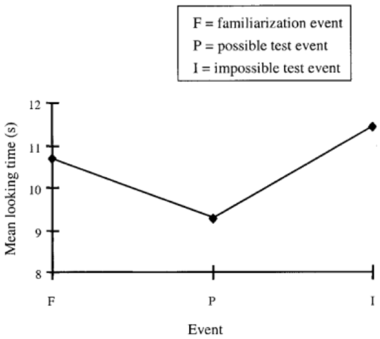
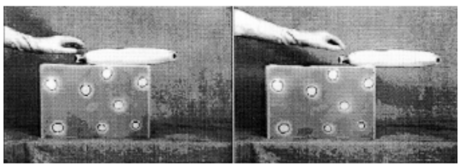


Figure 7. Mean looking times in Experiment 3 (n = 7).



(Cacchione & Krist, 2004)

Objects

SEEING

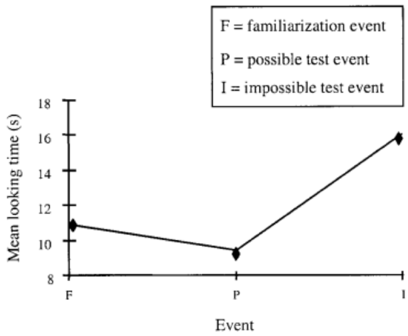
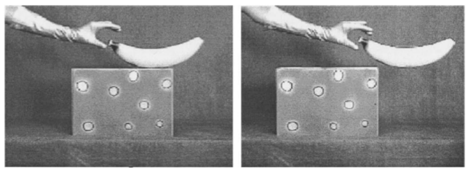
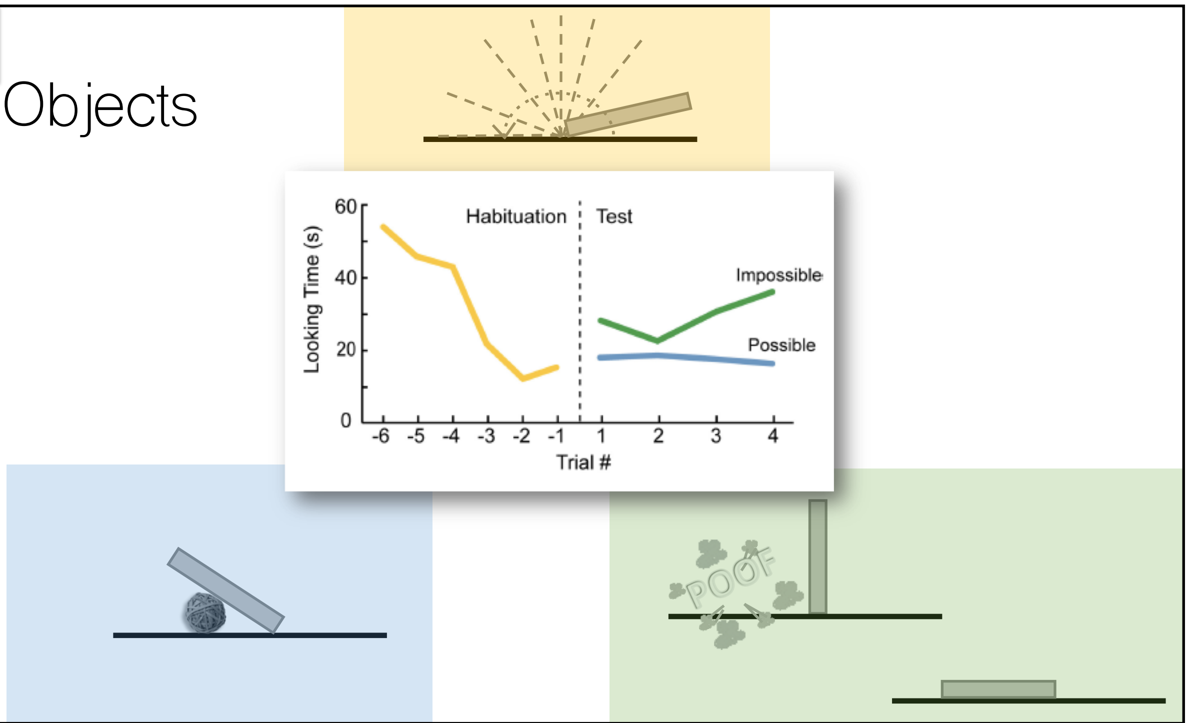


Figure 3. Mean looking times in Experiment 1 (n = 9).



(Cacchione & Krist, 2004)

Objects



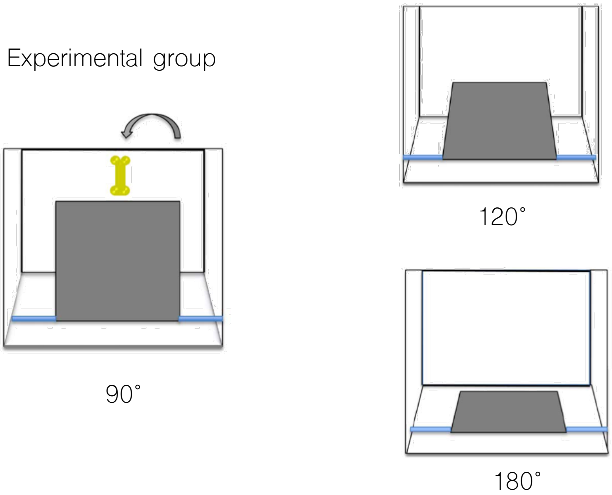
Objects

- Seeing surprising events can trigger
  - Increment in infants' looking times
  - alterations in facial expressions
  - pupil dilation
  - changes in cerebral blood flow or brain electrical activity
- These various responses have been taken as an indication of the detection of a discrepancy between what was expected and what is observed, and have been documented across many knowledge domains

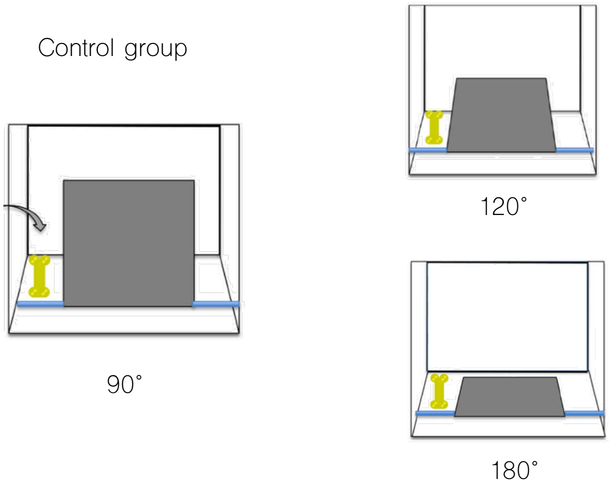
Objects

- The psychologist R. Baillargeon
  - showed that 2-months olds look longer the physically impossible event
  - our infants reason in the terms of a folk physics
    - infants can display perseveration errors because of PFC immaturity
  - Objects
    - are solid
    - are impenetrable
    - occupy a certain space
    - influence the orientation of other objects
    - need adequate support
    - ...and several other intuitive features

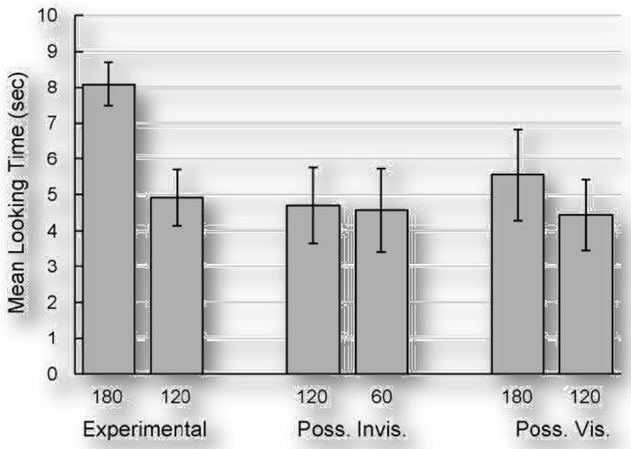
Objects



Objects

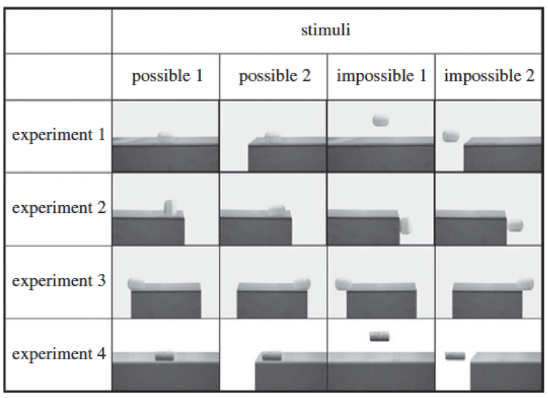


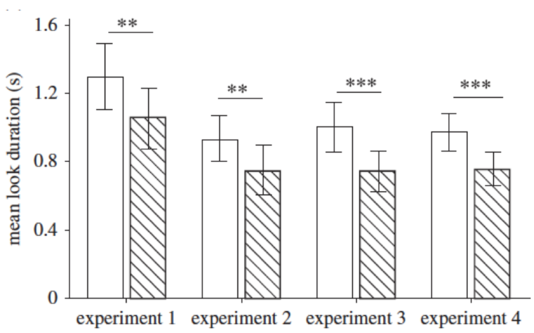
Objects



Pattison et al., 2011

Objects





Bird & Emery, 2009

Rooks' performance

Born experimenters


RESEARCH ARTICLES

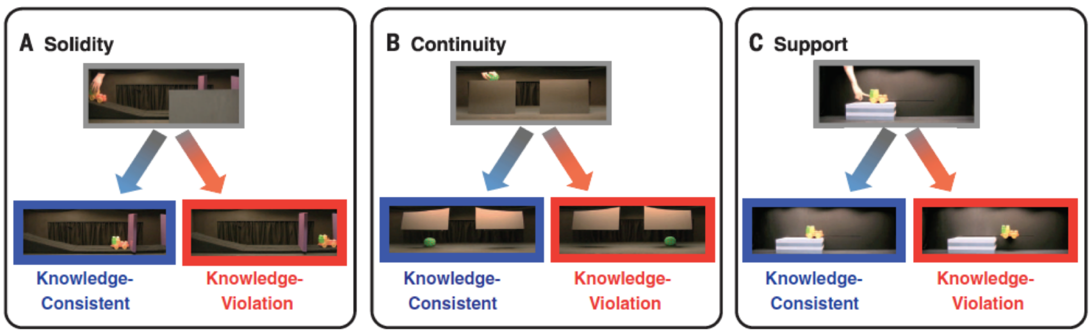
COGNITIVE DEVELOPMENT

Observing the unexpected enhances infants' learning and exploration

Aimee E. Stahl* and Lisa Feigenson

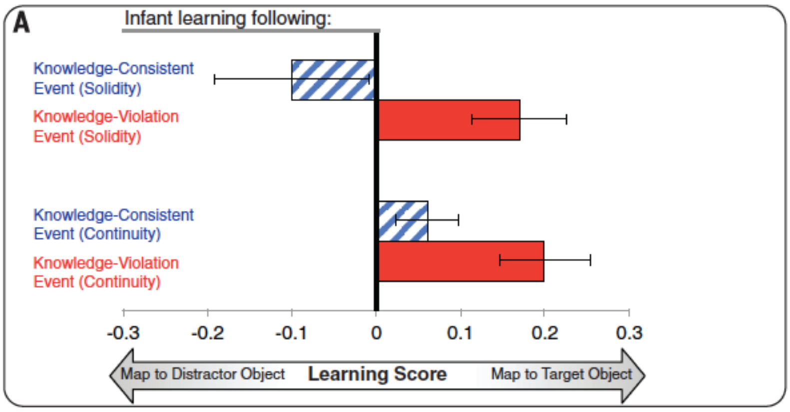
- Stahl and Feigenson explored what happens soon after a baby watches a simple but impossible event
- They evaluated the behavior of 110 11-months-old infants
- The babies watch an object (ball, toy-car) during a physically plausible or implausible event

Born experimenters



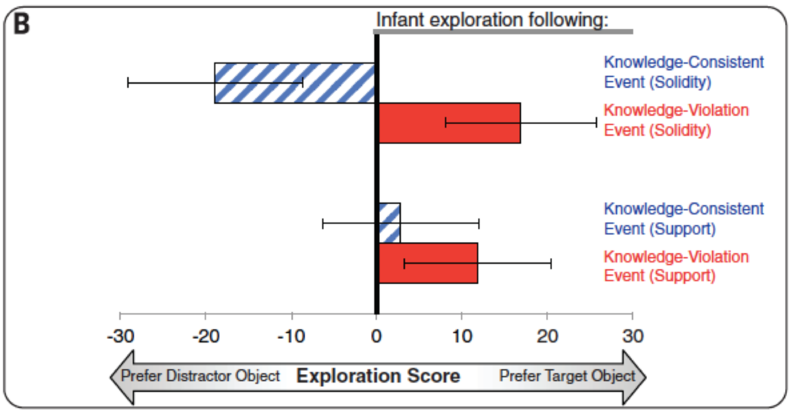
Born experimenters

- First they asked whether infants more effectively learn new information about objects that violate expectations than about objects that accord with expectations



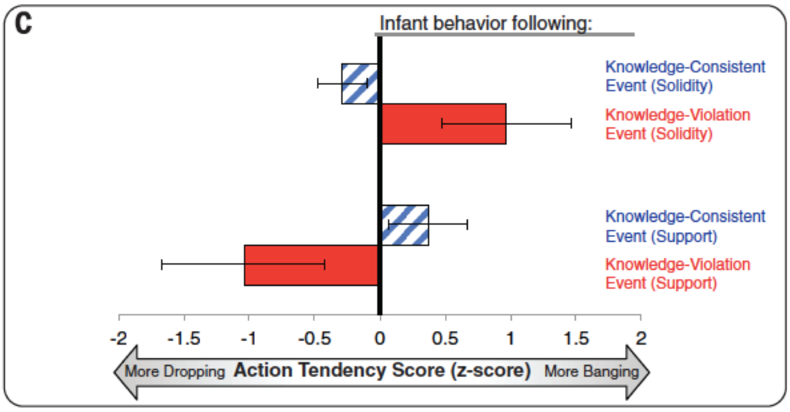
Born experimenters

- Then they asked whether infants preferentially seek information from objects that violated expectations



Born experimenters

- And finally whether their exploratory actions test plausible explanations for an observed violation



Core knowledge

- Born experimenters, who proceed systematically in the light of a discrepant info as compared to their hypothesis

- Far from obviating the need for learning, core knowledge may be a foundational understanding from which learning begins:
    - If a learner has a basic repertoire of core expectations about the world, then detecting a violation of these expectations—a conflict between what was predicted and what is observed—might signal a special opportunity for learning.

Core knowledge

- If core knowledge support intuitions during all lifespan
- Then, older children should still take advantage from this set of knowledge during learning

Core knowledge

Cognition 163 (2017) 1–14

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Cognition

journal homepage: www.elsevier.com/locate/COGNIT

ELSEVIER

Original Articles

Expectancy violations promote learning in young children

Aimee E. Stahl [a,*], Lisa Feigenson [b]

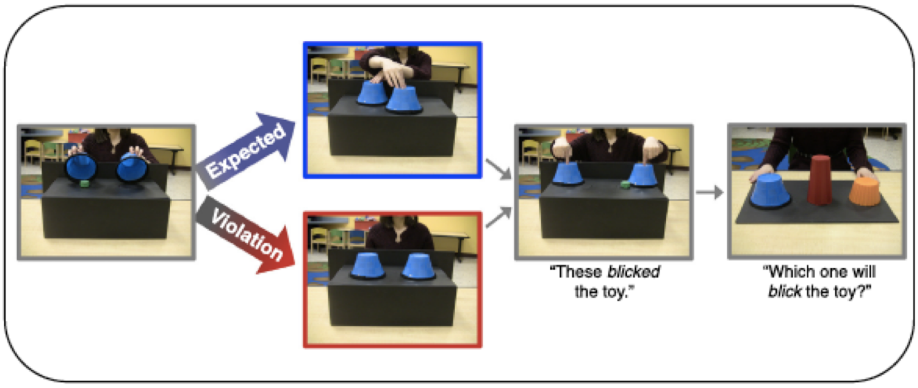
[a] The College of New Jersey, 2000 Pennington Road, Ewing, NJ 08628, United States
[b] Johns Hopkins University, 3400 North Charles Street, Baltimore, MD 21218, United States

- Using an explicit tatsk (rather than fixation time) they tested kids from 3 to 6 years of age

Core knowledge

- They showed an event in accord to/violating spatiotemporal continuity:
  - A toy was hidden by a cup; by lifting the cup up, the toy could be revealed in place (expected) or not (revealed under the other cup: violation)
- To all kids, immediately after the oject was seen, a label was attributed to the action performed "These cups ***blicked*** the toy!"

Core knowledge

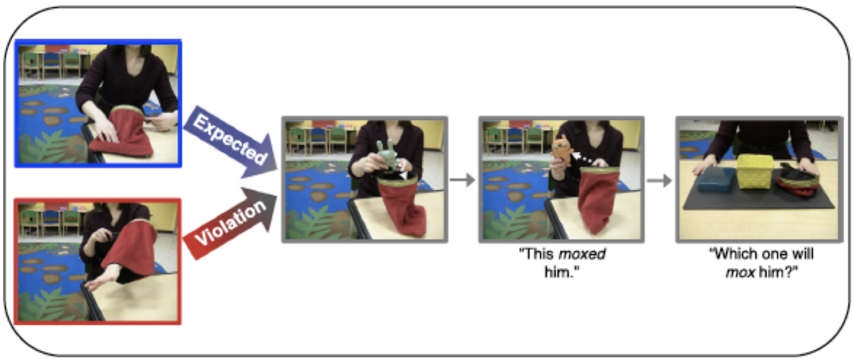


Core knowledge

- Kids were then tested on learning the new verb:
- They were shown a blu cup with other distractors (each labelled with verbs describing new but possible actions) and were asked to indicate the one that could «blick» the toy

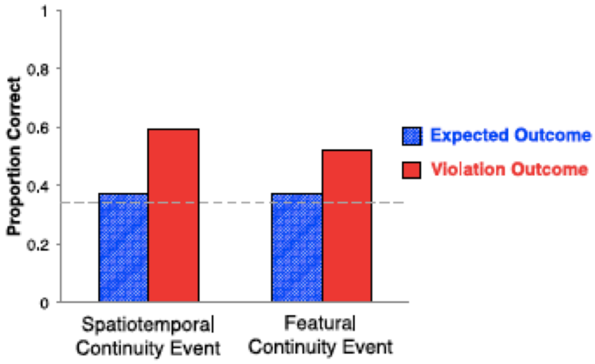
Core knowledge

They violated also another principle, i.e., featural continuity of visual features



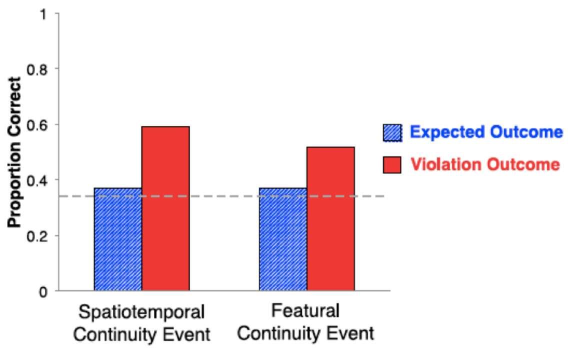
Core knowledge

- Kds leart significantly more the new verb when associated with the impossibile event



Core knowledge

- Same results have been obtained when using names instead of verbs (i.e. «the blue cups are blickers»)



Core knowledge

- To conclude, kids that watched the expected outcome performed at chance, showing that they did not learn the new word (verb or noun)
  - This was expected because the task was difficult
- Kids that watched the unexpected event, instead, learnt significantly better the new word
  - And despite the fact that they were exposed to the new word only once (an example of one-trial learning)

Core knowledge

The criteria hypothesized by Spelke (2000) seem to be satisfied as for the system of knowledge that support our reasoning on the behaviour of inanimate objects:

- Given at birth
- Independent from experience and formal culture/acculturation
- Largely shared between species
- At the basis of learning processes