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

a soft version of modularity

the "Core knowledge" hypothesis [Spelke 2000]

modularity
Fodor and the radical position

- How does the brain/mind work?
- One or more cognitive systems?
  - General purpose mechanism?
  - Different areas and processes
    - Increases speed and efficacy

Domain specificity
Mandatory operation
Limited central accessibility
Fast processing
Informational encapsculation
Shallow outputs
Fixed neural architecture
Specific breakdown patterns
Ontogenetic pace and sequencing

modularity
Evolution of complex forms

- Herbert Simon, 1969

Tempus

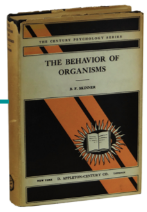
Hora

modularity

Innateness

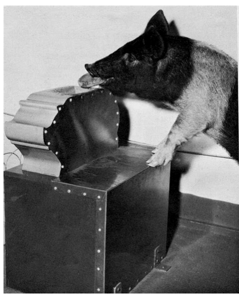
- The Breland

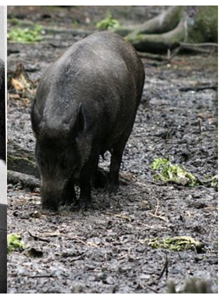
The misbehavior of organisms (1961)



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





Biological constraints to learning processes

BIOLOGICAL HISTORY

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

Neuron
Perspective

Neuroscience Needs Behavior: Correcting a Reductionist Bias

John W. Krakauer,[1,*] Asif A. Ghazanfar,[2] Alex Gomez-Marin,[3] Malcolm A. MacIver,[4] and David Poeppel[5,6]
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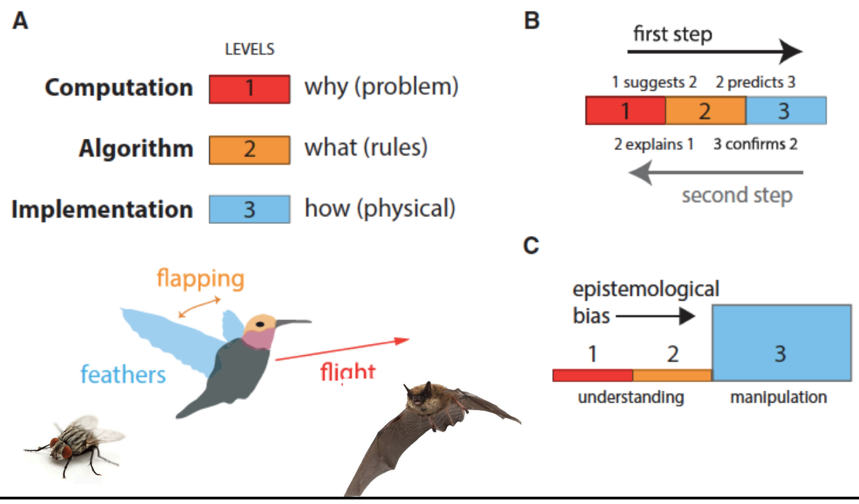
http://dx.doi.org/10.1016/j.neuron.2016.12.041

Marr's 3 levels of analysis

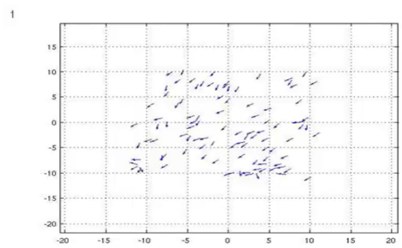
"[…] *trying to understand perception by understanding neurons is like trying to understand a bird's flight by studying only feathers. It just cannot be done.*" (Marr, 1982/2010)



well-designed behavioral experiments: a first step, before implementation

Emergence

- From 'neuron' to 'neurons' (networks?)
- Neurons in their aggregate organization cause effects that are not apparent in any single neuron (*emergence*)
  - behavior itself is emergent from aggregated neural circuits and therefore should also be studied in its own



observing or dissecting an individual bird, or even several birds, could never derive such a rule

How to overcome the gap?

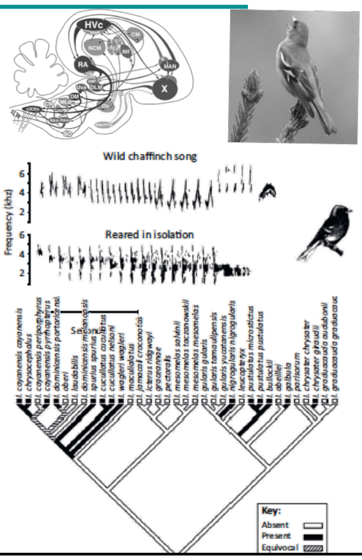
- From psychology, cognition, perception and behaviour to neurons and circuits?
  - Technologies like optogenetics or TMS can show causal relations and not only correlations
    - But is causal-mehcanistic explanation an understanding?
  - Levels of explanation should be taken together rather than considered as separate or subordinate (e.g., the case of the cardiac rhythm, ion channels and cell membrane)

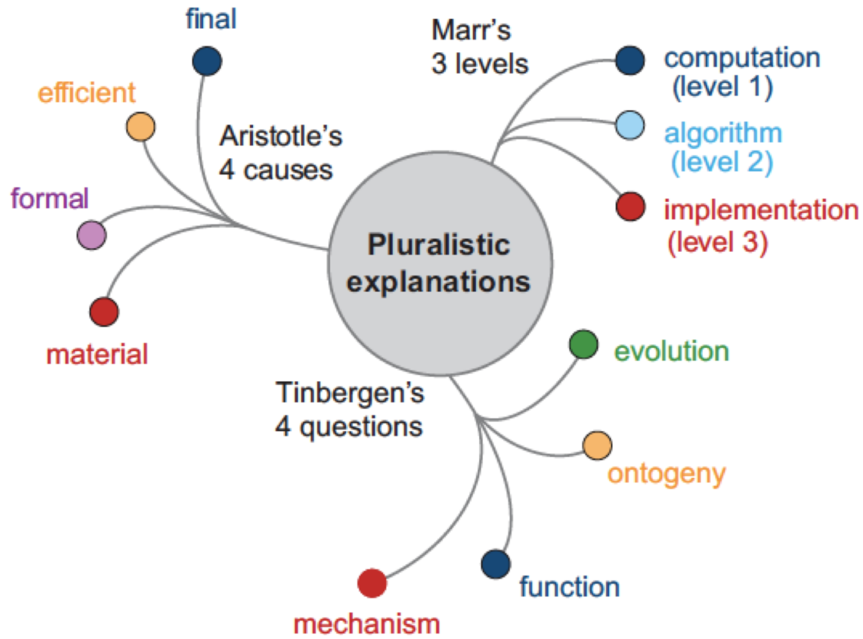
Ion channels do not beat, heart cells do. Neural circuits do not feel pain, whole organisms do.

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





Core Knowledge

Objects – principles

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 or place of other objects

Objects – principles

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 – naïve physics

- [...] 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 – naïve physics

- 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

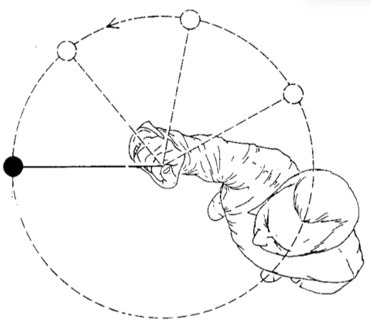
Objects

REPORTS

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

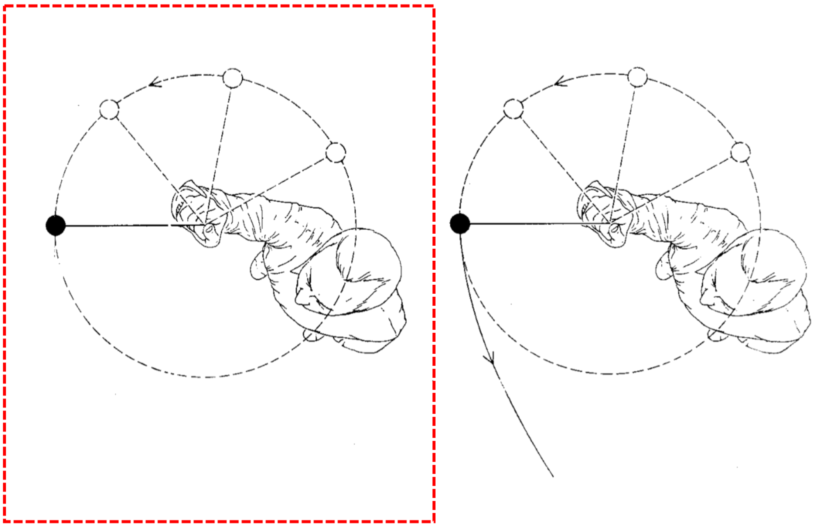
MICHAEL MCCLOSKEY, ALFONSO CARAMAZZA, BERT GREEN
+ See all authors and affiliations

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.

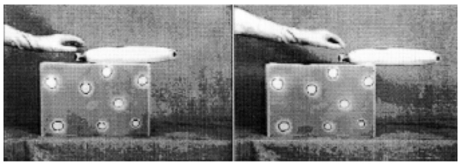
Objects



Objects

DOING

SEEING



(Cacchione & Krist, 2004)

Objects

SEEING

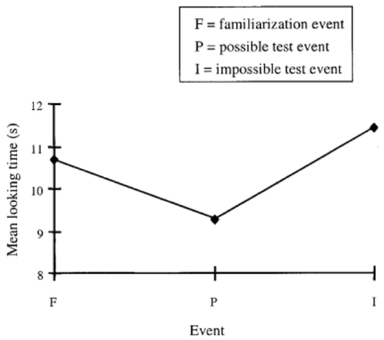
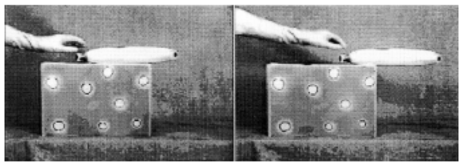


Figure 7. Mean looking times in Experiment 3 (*n* = 7).



(Cacchione & Krist, 2004)

Objects

SEEING

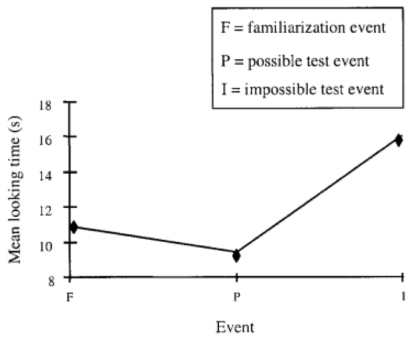
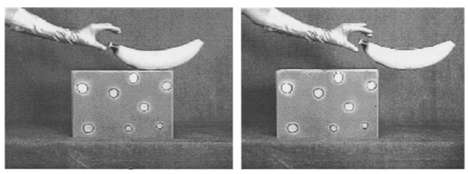
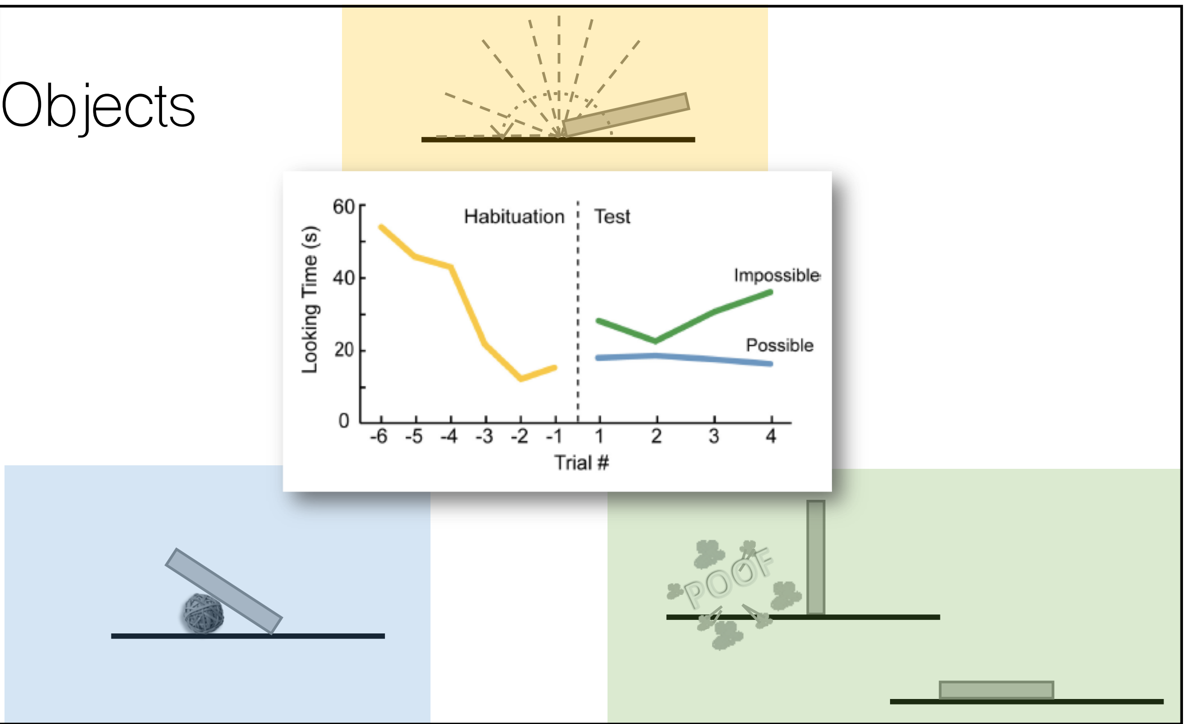


Figure 3. Mean looking times in Experiment 1 (*n* = 9).



(Cacchione & Krist, 2004)

Objects



Objects

SEEING

- 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

Objects

- The psychologist R. Baillargeon
  showed that 2-months olds look longer the physically impossible event
  - our infants show early object permanence
  - 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

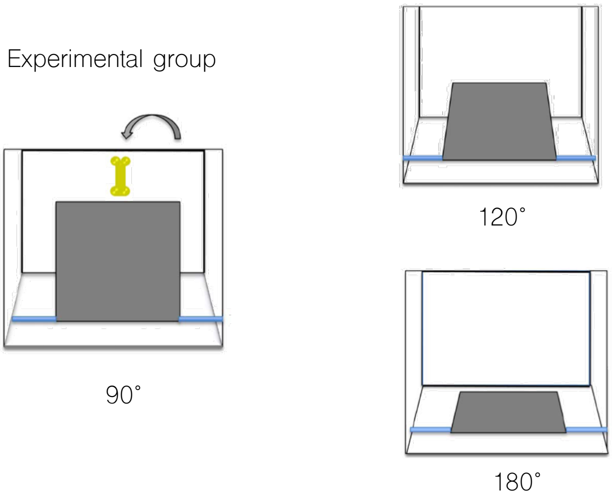
Objects

SEEING

SEEING

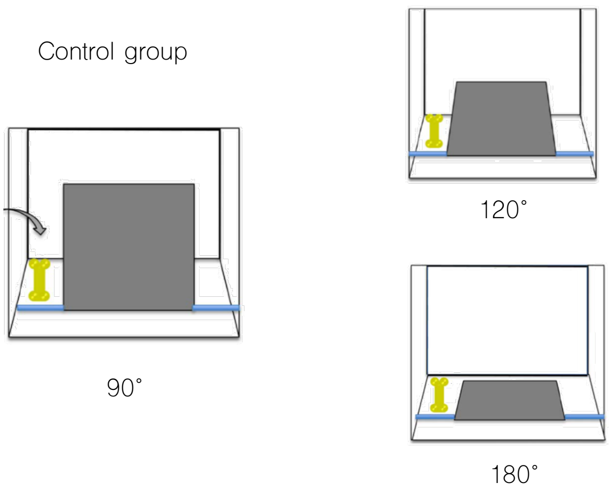
Objects

Experimental group

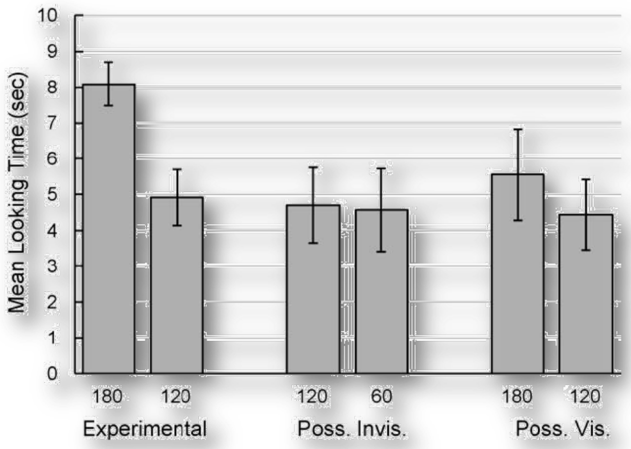


Objects

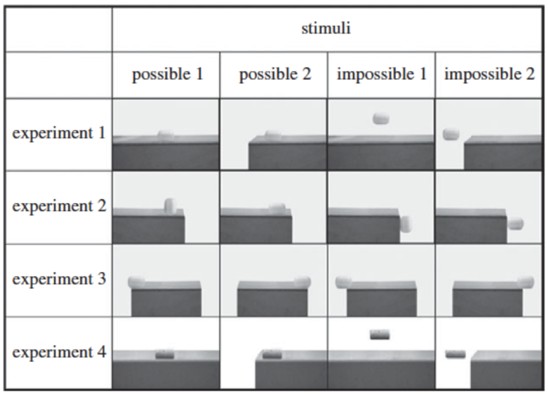
Control group

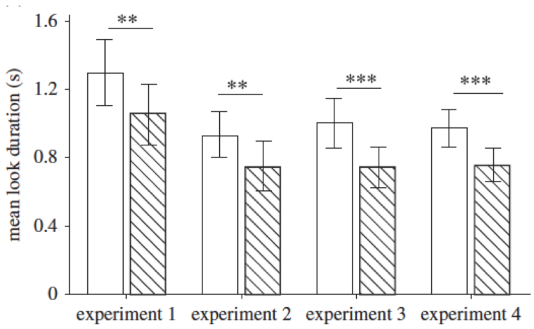


Objects



Objects





Bird & Emery, 2009

Objects

- Chicks infer correctly the object physical properties when the possibility to have lernt them from experience are extremely reduced
  - Chiandetti & Vallortigara 2011

Born experimenters


RESEARCH ARTICLES

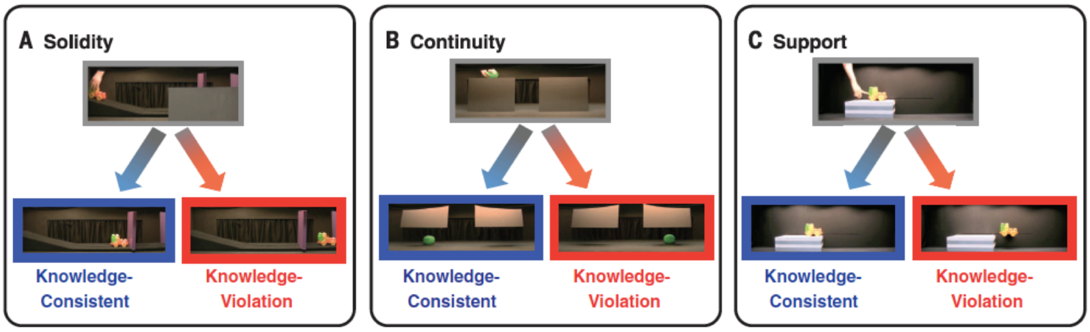
COGNITIVE DEVELOPMENT

Observing the unexpected enhances infants' learning and exploration

Aimee E. Stahl* and Lisa Feigenson

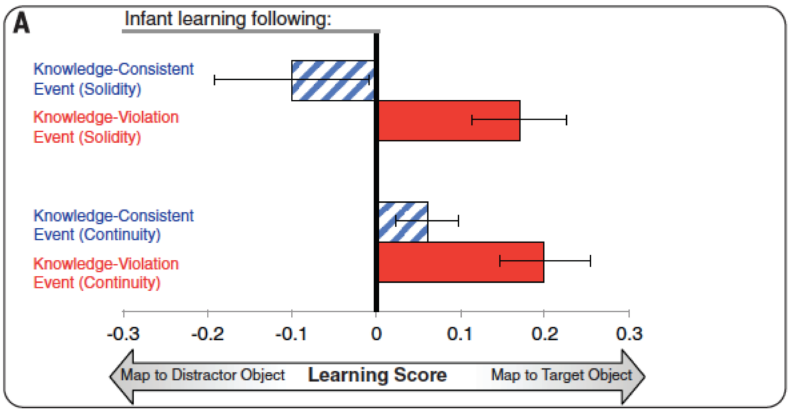
- Stahl and Feigenson explored what happens soon after a baby watches a simple but impossible event
- They evaluated the behavior of 11-months-old infants [n=110]
- The babies watch an object (ball, toy-car) during a physically plausible or implausible event

Born experimenters



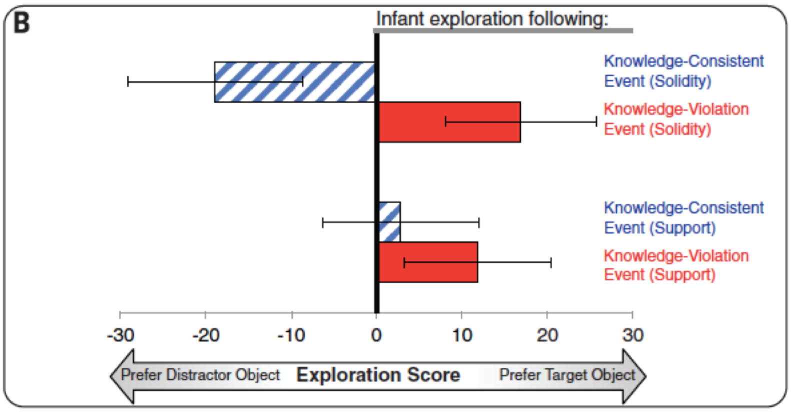
Born experimenters

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



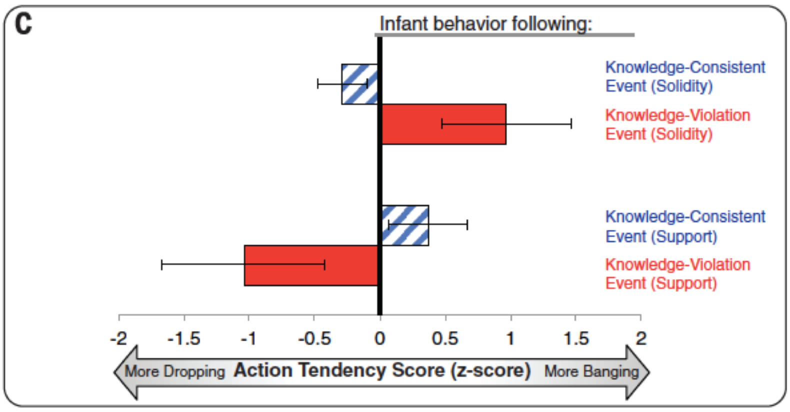
Born experimenters

- 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



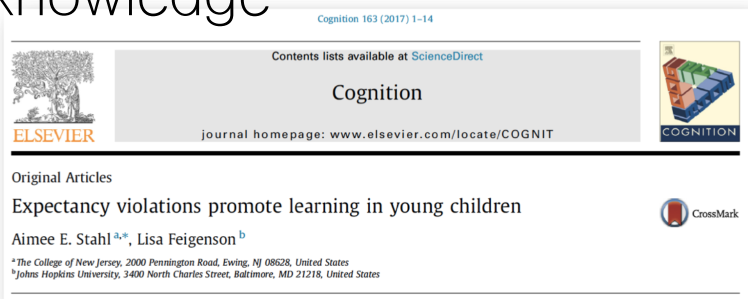
Core knowledge

- 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


Cognition 163 (2017) 1–14

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Cognition

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

Original Articles

Expectancy violations promote learning in young children

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

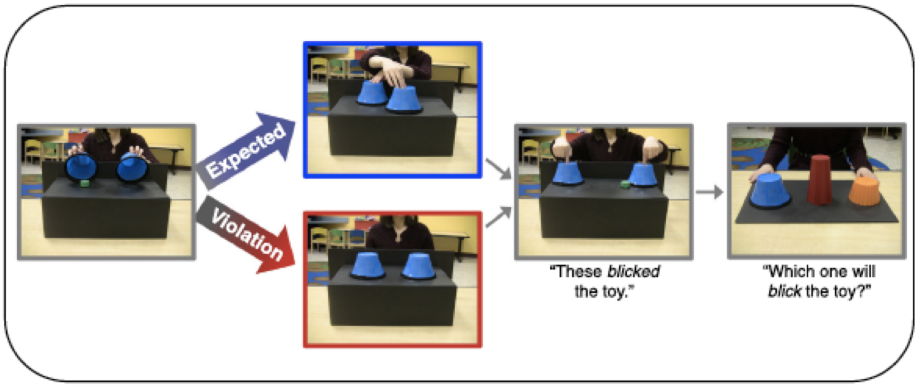
[a] The College of New Jersey, 2000 Pennington Road, Ewing, NJ 08628, United States
[b] Johns Hopkins University, 3400 North Charles Street, Baltimore, MD 21218, United States

- 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

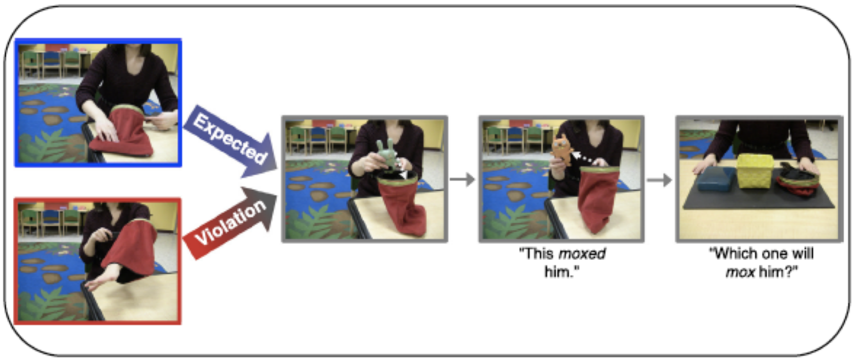


Core knowledge

- 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

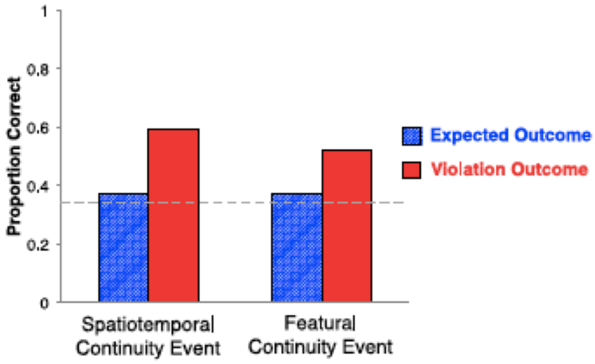
Core knowledge

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



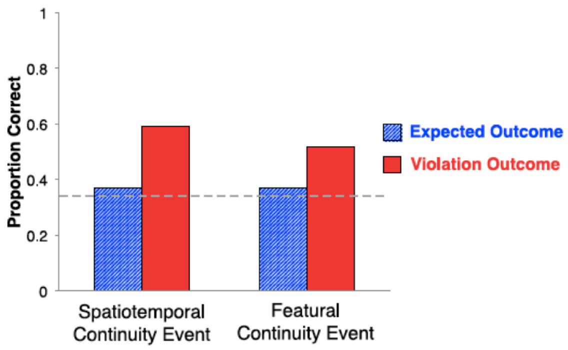
Core knowledge

- Kds learnt 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