

9.85 Cognition in Infancy and Early Childhood

The perception of agency and
goal-directed action in infancy;
agency and attachment

Today

- Woodward -- intentional reasoning in infancy; Gergeley -- teleological reasoning in infancy
- Recognizing agents
- Attributing goals to agents
- Attachment to agents

Discussion: Agents v. objects

- You have just traveled to another planet. How will you recognize its agents?
- If a baby were sensitive to these features, would you be satisfied that she had a concept of agency?

Why care about distinguishing agents from objects?

- “... what we really see are bags of skin stuffed into pieces of cloth and draped over chairs. There are small restless black spots that move at the top of the bags of skin, and a hole underneath that irregularly makes noises. The bags move in unpredictable ways, and sometimes one of them will touch us. The holes change shape, and occasionally salty liquid pours from the two spots.” (Gopnik, *Scientist in the Crib*)

Agents and objects

- Basic ontological distinction.
- One of the first to appear (at least in some forms as we'll discuss)
- One of the last to go (Alzheimer's patients distinguish dogs from planes even after they fail to distinguish dogs from cats).
- How do we do it?

What agents and objects share

- Size
- Shape
- Color
- Subject to occlusion, displacement, etc.
-- “Spelke” object status.

What might distinguish agents and objects

- Morphological cues
 - Eyes
 - Faces
- Dynamic cues
 - Self-initiated movement
 - Non-Newtonian movement
- Functional cues
 - Contingent behavior
 - Communicative behavior
 - Equifinal (goal-directed) movement

What might distinguish agents and objects

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 - Eyes
 - Faces
- **Dynamic cues**
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 - **Non-Newtonian movement**
- **Functional cues**
 - **Contingent behavior**
 - **Communicative behavior**
 - **Equifinal (goal-directed) movement**

Self-initiated movement

- Spontaneous movement = animate agent
- Perceptual triggering (Premack).

Self-initiated movement

Even infants distinguish physical and psychological causality ...

- Expect physical objects to move only through contact -- and to move if contacted.
- Allow animate agents to move without contact

Self-initiated movement

- By age five, children think 'move' can apply to a passively moved object but reject 'move' for a passively moved agent.



Is the box moving?

Yes



Is the dog moving?

No

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Self (vs. other) initiated movement

- “In this respect, causation has priority over movement in distinguishing animates from inanimates.” (Dowty, 1991)



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Self-initiated motion

- So objects do not move themselves
- Agents do ...
- But is that sufficient for babies to treat an entity as an agent for other purposes?
- No

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Non-Newtonian movement: biological motion

- Adults are very sensitive to subtle features of movement.
- point light displays
- squirmles
- Evidence for dedicated brain regions for detecting biological motion
- Superior temporal lobe sulcus, premotor cortex

Non-Newtonian movement: biological motion

- Babies (3-months) are also sensitive to characteristics of biological motion
- they distinguish biological from non-biological motion.
- they prefer to look at walking movements to random movements

Non-Newtonian movement: biological motion

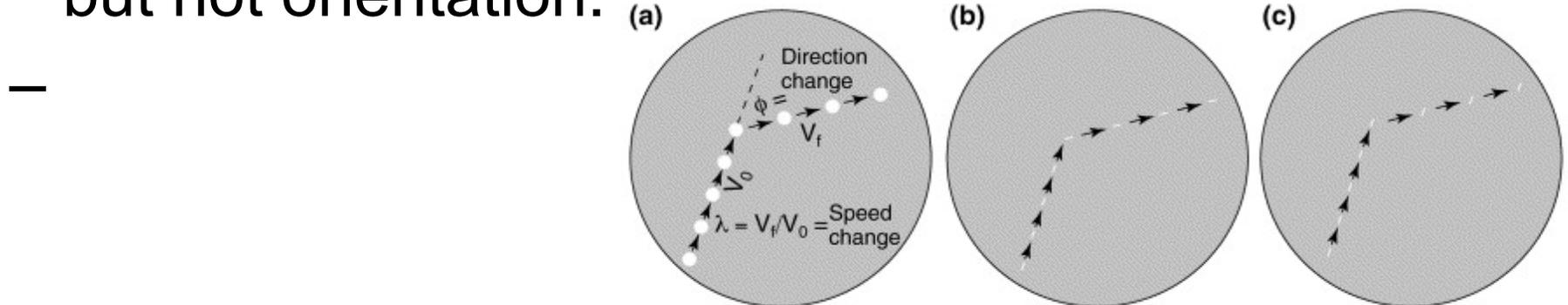
- Moreover, 3-month-olds distinguish a right-side-up walker from an upside-down walker ...
- and an upside-down walker from a random display.
- 5 and 7-month-olds made no distinction between upside-down and random.

So what makes motion “biological”?

- Objects (with a few recent exceptions -- smart vacuum cleaners, smart missiles) don't adapt to their environments.
- Infants might distinguish animates from inanimates on the basis of
 - Changes in trajectory
 - Sudden starts and stops
 - “Headings”

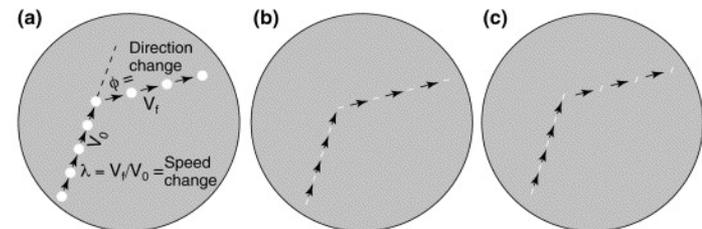
Non-Newtonian movement: biological motion

- Factors affecting perception of animacy
 - A = symmetric circle changes direction and speed.
 - B = rectangle changes direction, speed and orientation.
 - C = rectangle changes direction and speed but not orientation.



Non-Newtonian movement: biological motion

- Factors affecting perception of animacy
 - A = symmetric circle changes direction and speed.
 - **B= rectangle changes direction, speed and orientation.**
 - C= rectangle changes direction and speed but not orientation.
 - **wolfpack**
 - **not a wolfpack**



Functional cues: Contingent behavior

- Considerable evidence that infants are sensitive to contingent v. non-contingent interactions with a “conversational” partner.
 - “Chasing” disks v. independently moving disks.
 - Contingency-mobile
 - Still-face (even in newborns!)
 - Video-playback of mother/child interactions
 - Live-replay-live

Functional cues: Contingent behavior

- Trevarthen -- “Primary intersubjectivity”
-- baby flirting (from birth)
- babies flirting
- toddler flirting

“The interactions are calm, enjoyable, and dependent upon sustained mutual attention and rhythmic synchrony of short "utterances" which include, beside, vocalizations, touching and showing the face and hands, all these expressions being performed with regulated reciprocity and turn-taking. Newborn and adult spontaneously display a mutually satisfying intersubjectivity.”

(Trevarthen and Aitken, 2001, p. 6)

Functional cues: Contingent behavior

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4. Communicative relations

- Infants interact differently with agents and objects.
 - Neonatal imitation of protruding tongue but not protruding tongue-like object.
 - By 2-months, babies greet a new object by reaching, a new person by cooing.

Functional cues: communicative behavior

- If an adult treats something as a communicative partner infants “follow its gaze”

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Figure removed due to copyright restrictions. Figure 5. Johnson, Susan C. "Detecting agents." *Philosophical Transactions of the Royal Society Lond. B* 358, no. 1431 (2003): 549-59.

Functional cues: communicative behavior

- Moreover, babies use the position of communication to determine the “head” of the object.
 - If the confederate is sitting next to the baby and the green blob slants right, baby looks right.
 - If the confederate is across from the baby and the green blob slants right, baby looks left.

Interim summary: recognizing agents

- By six months of age, infants **discriminate** many characteristic features of agents and objects.
- Dynamic cues
 1. Self-initiated movement
 2. Non-Newtonian movement
- Functional cues
 1. Contingent behavior
 2. Communicative behavior

Interim summary: recognizing agents

- But we do not know when and how babies bind these features together
 - e.g., when do infants decide that something that moves by itself is also more likely to act contingently, at a distance and have eyes, etc. ...
- And when do babies bind these features to goals, intentions and mental states?

Having goals: the “aboutness” of intentional action

- A rock rolling downhill (or a person accidentally tripping) are not ‘about’ anything.
- However, intentional action is about things in the world.
- Intentional action is either **goal-directed** or **referential**.
- e.g., if I wave vigorously at the lights in an MIT classroom, my action is
 - either **about** trying to make the lights turn on
 - or **about** trying to communicate something (“these are the lights I was complaining about”)

The “aboutness” of intentional action

- Note that understanding action as **goal-directed** and **referential** does not necessarily require understanding mental states
 - I could infer that your action aims at an end state, X, without deciding that you ‘want’ to achieve X.
 - I could infer that your action refers to an object or concept without deciding that you ‘think’ or ‘believe’ X.
- However, inferring mental states like desire and belief does require treating action as about things in the world.
- That is, understanding the ‘aboutness’ of intentional action is at least a pre-requisite to theory of mind.

Interpreting action as goal-directed

- What do you see here?
- Heider and Simmel, 1944

Functional cues: equifinal (goal-directed movement)

- What about babies?

Figure 1 removed due to copyright restrictions.
Csibra, Gergely. "Teleological and Referential Understanding of Action in Infancy." *Philosophical Transactions of the Royal Society Lond. B* 358, no. 1431 (2003): 447-58.

Functional cues: equifinal (goal-directed movement)

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Csibra, Gergely. "Teleological and Referential Understanding of Action in Infancy." *Philosophical Transactions of the Royal Society Lond. B* 358, no. 1431 (2003): 447-58.

Functional cues: equifinal (goal-directed movement)

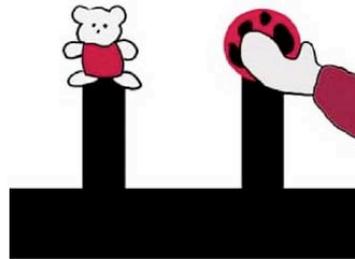
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Csibra, Gergely. "Teleological and Referential Understanding of Action in Infancy." *Philosophical Transactions of the Royal Society Lond. B* 358, no. 1431 (2003): 447-58.

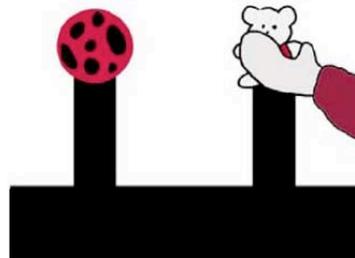
Interpreting actions as goal-directed

- Change of trajectory versus change of goal

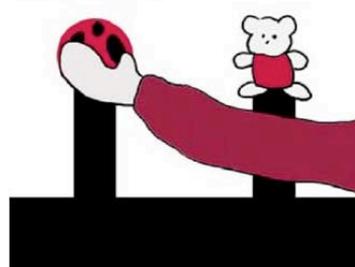
Habituation event



New goal event



New path event



Beyond equifinality -- actions as having goals

- 6-month-olds dishabituated to the new goal (but not the new reach).
- Younger infants looked equally long at both events.

Interpreting action as goal-directed

- The Gergeley, Csibra, Woodward, and Sommerville studies suggest that infants interpret action as goal-directed in looking-time measures.
- Converging evidence?
- Imitation studies ... do infants imitate the action or the intended goal of the action?

Interpreting action as goal-directed

- Do infants imitate actions or goal of actions?
- 18-month-olds
 - Completed action
 - Incomplete action
 - Baseline
 - Machine control

Interpreting action as goal-directed

- **Completed action -- babies perform complete action**
- **Incomplete action -- babies 'read through the goal' to perform complete action**
- Baseline -- babies don't perform complete action
- Machine control -- babies don't perform complete action.
- Congruent with other findings: Tomasello -- babies imitate intentional actions ("there") but not identical accidental actions ("whoops")

Interpreting action as goal-directed

- Suggests that infants are not just copying adult actions.
- Rather they treat human (and only human) action as goal-directed.
- They shape their actions around adult goals, not just around adult behavior.

Interpreting action as goal-directed -- and rational with respect to the goals

- Rational imitation ...
- Earlier study of deferred imitation showed that babies would imitate novel actions, even after a 1 week delay.

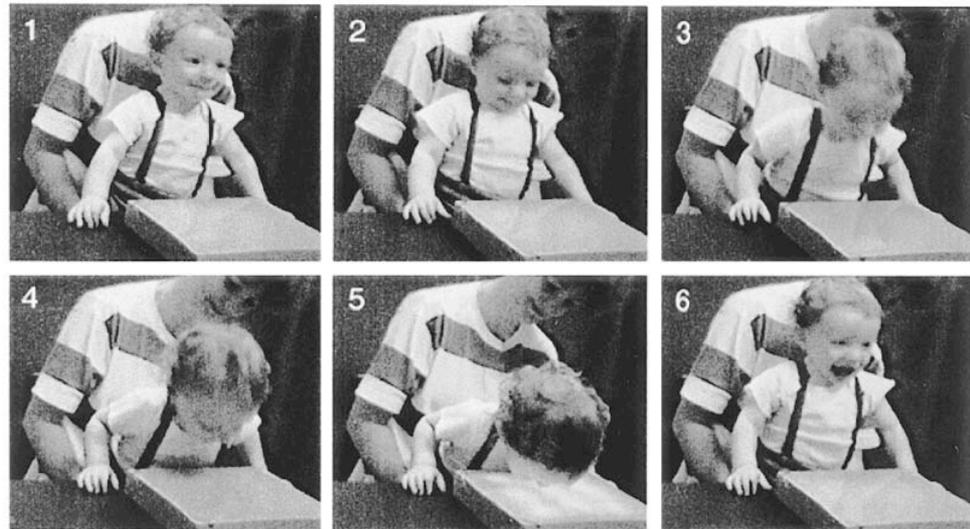


Figure 1. A 14-month-old infant imitating the novel act of head-touching. Infants of ten react to successful imitation with a smile, as illustrated in panel.

Courtesy of Elsevier, Inc., <http://www.sciencedirect.com>. Used with permission.

Interpreting action as goal-directed -- and rational with respect to the goals

- Gergeley and Csibra
 - Bizarre -- if they understand the goal, why use their heads?
 - Babies (having encountered relatively few developmental psychologists) might assume that adults are rational; use the best means to reach a goal.
 - Might not assume heads were necessary if there were an alternative explanation for why adults didn't use their hands.

Interpreting action as goal-directed -- and rational with respect to the goals

Figure 1 removed due to copyright restrictions. Gergely, György, and Gergely Csibra. "Sylvia's Recipe: The Role of Imitation and Pedagogy in the Transmission of Human Culture." In *Roots of Human Sociality: Culture, Cognition, and Human Interaction*. Edited by Nicholas J. Enfield and Stephen C. Levinson. Berg Publishers, 2006, pp. 229-55.

Interpreting action as goal-directed -- and rational with respect to the goals

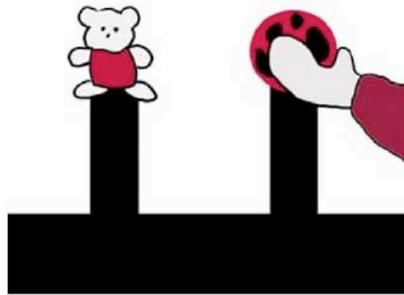
- Model Hands-free condition: 75% of babies imitated the action with their heads (replicating Meltzoff)
- Model Hands-occupied condition: 73% of babies performed the action with their hands.

Interpreting action as goal-directed -- and rational with respect to the goals

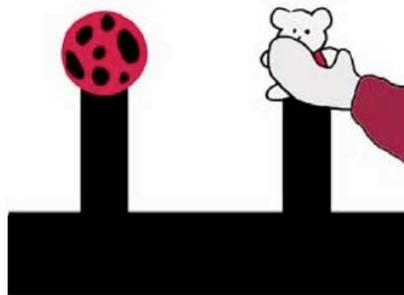
- Imitation is not an automatic process “triggered” by identification with a human actor.
- Instead children consider A) the agent’s goals and B) the situational constraints on the model and themselves with respect to those goals.

Moreover, infants' ability to recognize agents' goals is related to their own ability to act

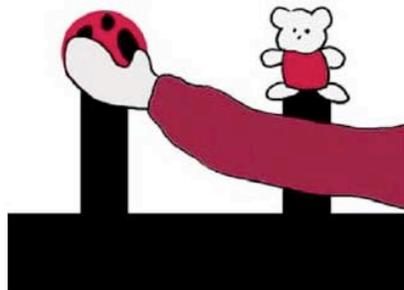
Habituation event



New goal event



New path event



Three-month-old infants and sticky mittens

Relationships between being able to do an action and understanding the action

J.A. Sommerville et al. / Cognition 96 (2005) B1–B11

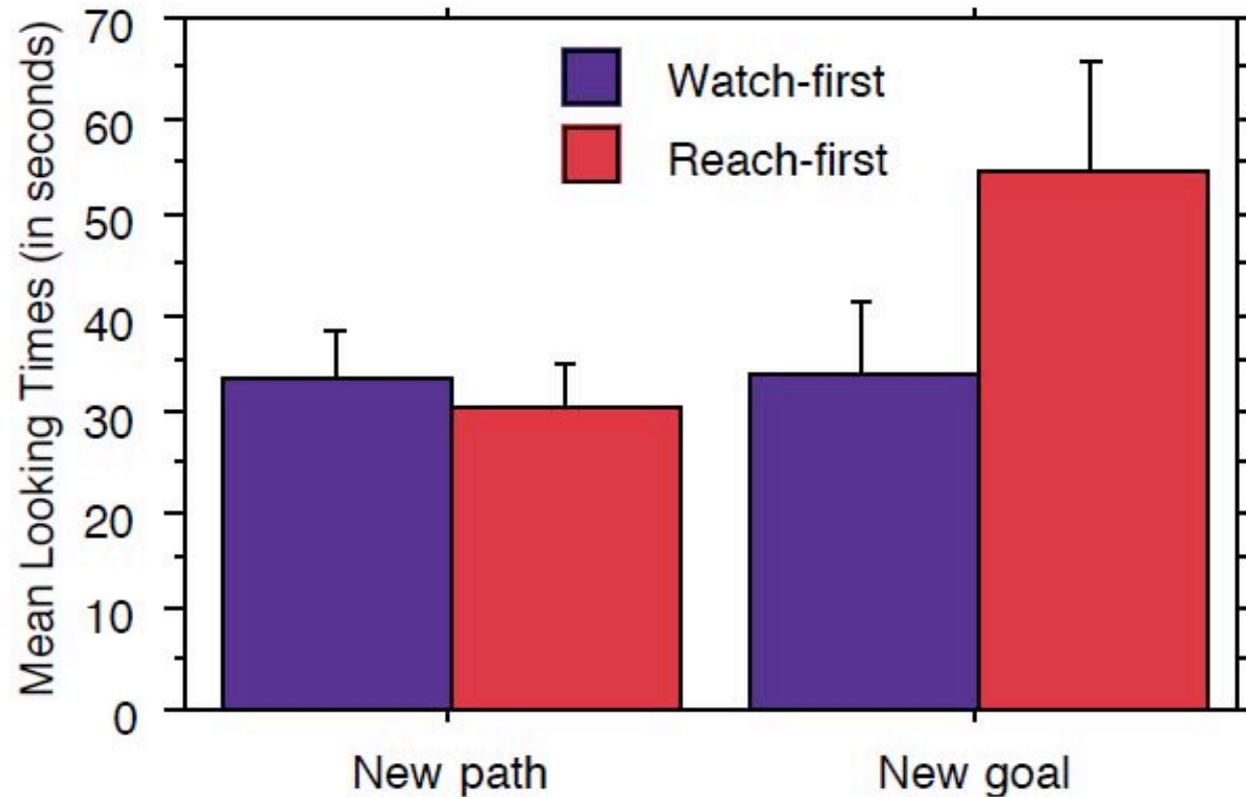


Fig. 3. Looking times to test events (habituation task).

Action production and action comprehension

- Infants' ability to perform an action themselves helps them understand the goal-directed nature of the action in others.
- Confirmed by means-end studies as well.

Understanding hierarchies of actions

Habituation event



New goal event

New means event



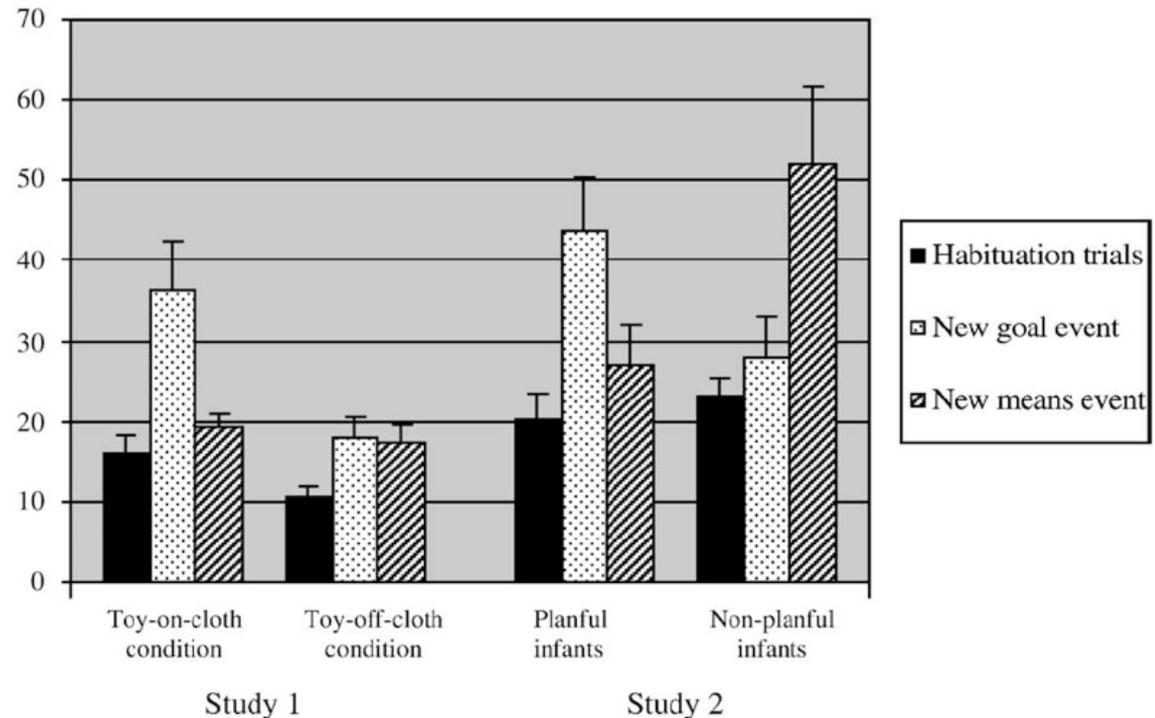
Fig. 1. (a) Toy-on-cloth condition. (b) Toy-off-cloth condition.

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12-month-olds are more interested in ends than means



Fig. 3. A planful solution.



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What about 10-month-olds?

Action production and action comprehension

- By 12-months, infants create action representations that are hierarchically organized around goals.
- The infants' own action experience appears to affect their representational understanding.

Agents and emotions

- Infant attachment:
 - ethology (Lorenz)
 - clinical and behavioral research (Bowlby, Ainsworth, & Main)
 - cognitive models of attachment (Johnson)

Ethology of attachment

- insects, amphibians and reptiles are generally independent from their parents at birth
- birds and mammals are generally not
- attachment could be entirely driven by the adult ...

neotony and releasing mechanisms



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ethology of attachment

- insects, amphibians and reptiles are generally independent from their parents at birth
- birds and mammals are generally not
- could be entirely driven by the adult ...
- but it turns out that infants learn to attach to the caregiver as well.
- Konrad Lornez -- imprinting 1935

ethology of attachment

- Imprinting -- phase sensitive learning
 - Lorenz, critical period 13-16 hours after hatching for greylag geese
 - used recently to aid endangered species



Image: Wikimedia/Superbass. CC-BY-SA-3.0. This content is excluded from our Creative Commons license. For more information, see <http://ocw.mit.edu/fairuse>

Image removed due to copyright restrictions. American Eagle Foundation. Human imprinting prevention. http://www.eagles.org/images/content/about/eaglet_puppet.jpg

ethology of attachment

- imprinting as a biological mechanism to ensure proximity to caregivers in order to ensure access to food
- feeding not necessary for imprinting however
- also not sufficient

Harlow's monkeys

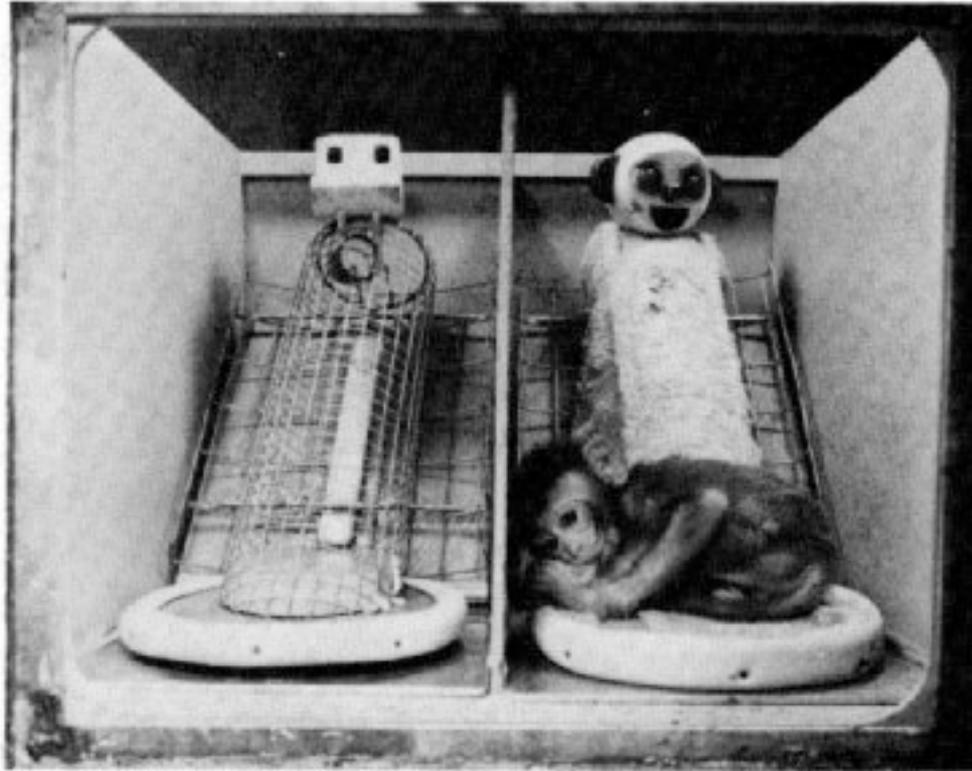


Figure 4. Wire and cloth mother surrogates.

Image: Public Domain. Harlow, Harry F. "The nature of love." *American Psychologist*, 13, no. 12 (1958): 673-685.

Attachment to cloth mother regardless of feeding

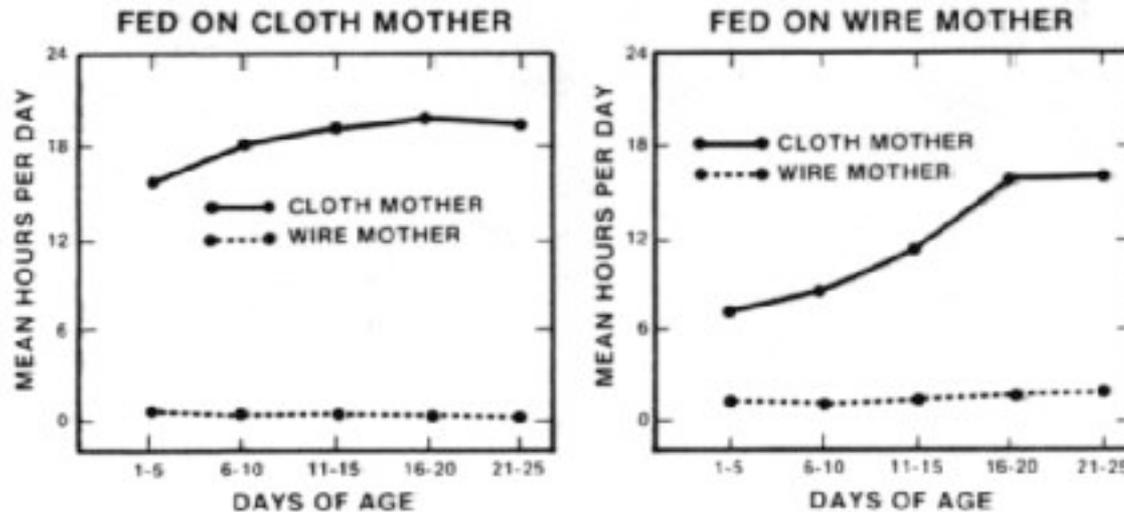


Figure 5. Time spent on cloth and wire mother surrogates.

Image: Public Domain. Harlow, Harry F. "The nature of love." *American Psychologist*, 13, no. 12 (1958): 673-685.

And persistent attachment ...

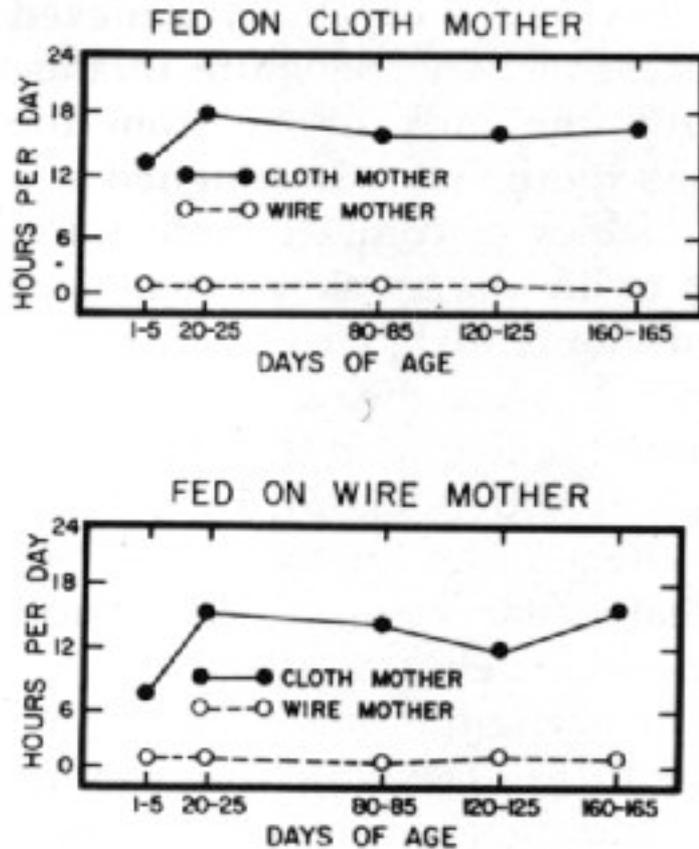


Figure 6. Long-term contact time on cloth and wire mother surrogates.

Image: Public Domain. Harlow, Harry F. "The nature of love." *American Psychologist*, 13, no. 12 (1958): 673-685.

learned to perform complex tasks when
only reward was viewing 'mother'

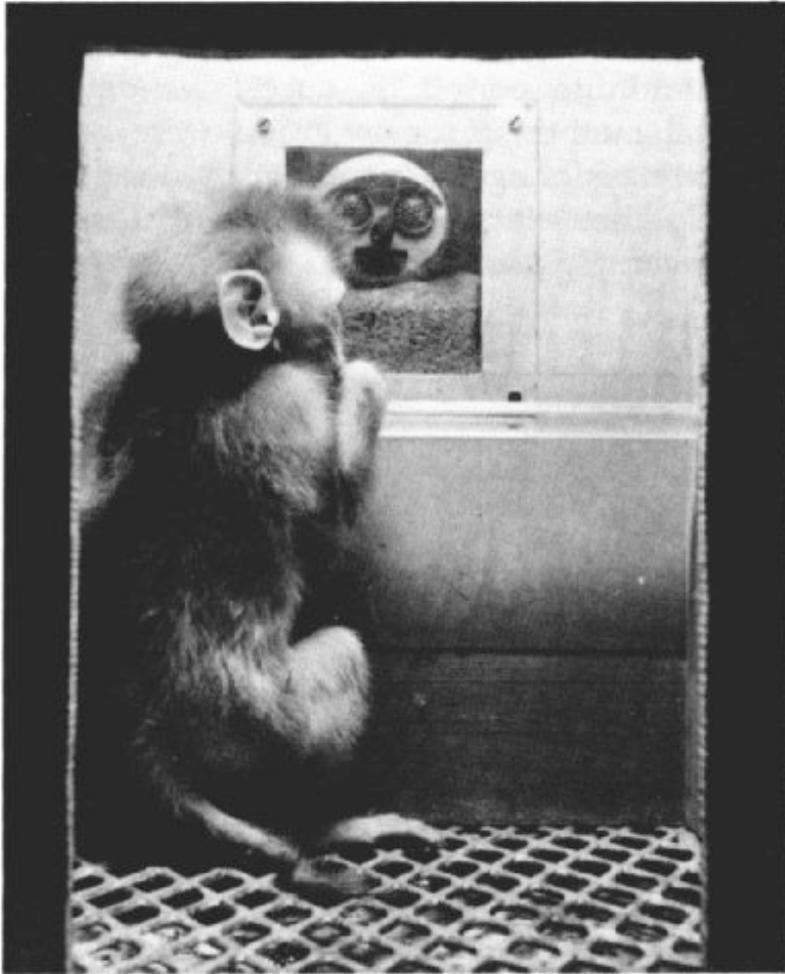


Image: Public Domain. Harlow, Harry F. "The nature of love."
American Psychologist, 13, no. 12 (1958): 673-685.

Figure 21. Visual exploration apparatus.

learned to perform complex tasks
when only reward was viewing
'mother'

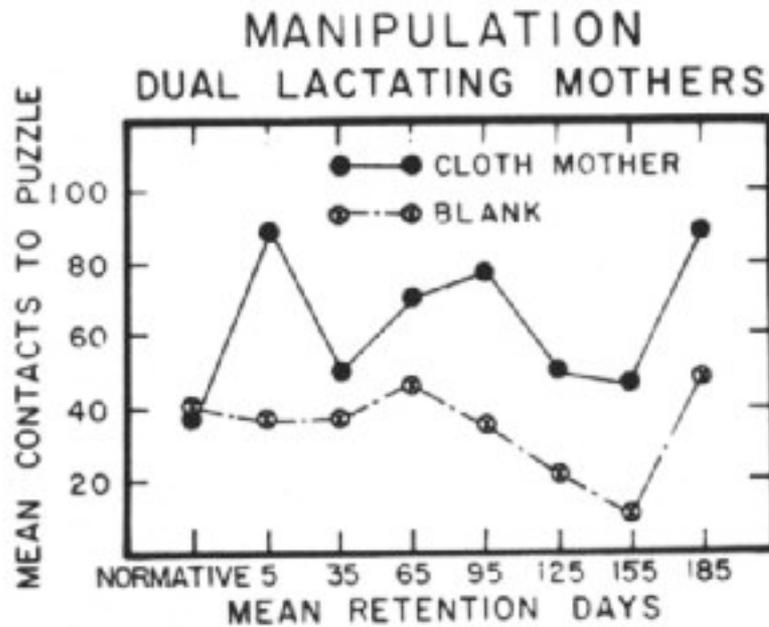


Figure 24. Retention of puzzle manipulation responsiveness.

Image: Public Domain. Harlow, Harry F. "The nature of love."
American Psychologist, 13, no. 12 (1958): 673-685.

Attachment as 'secure base for exploration'

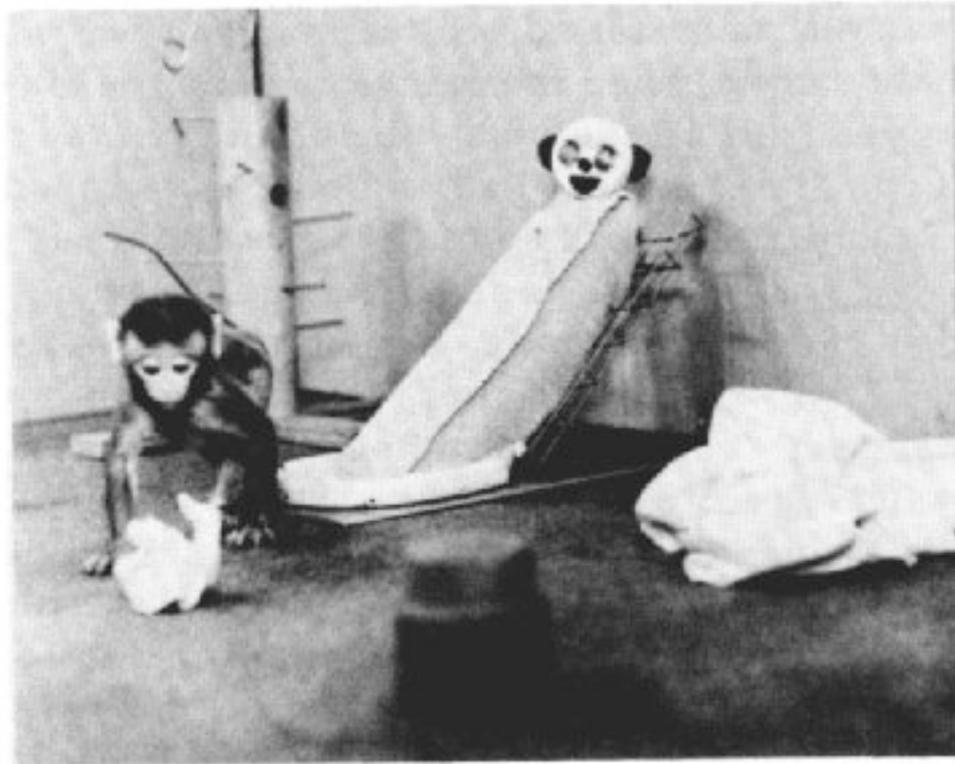


Figure 17. Object exploration in presence of cloth mother.

Image: Public Domain. Harlow, Harry F. "The nature of love." *American Psychologist*, 13, no. 12 (1958): 673-685.

Saddest picture ...



Figure 19. Response in the open-field test in the absence of the mother surrogate.

Image: Public Domain. Harlow, Harry F. "The nature of love." *American Psychologist*, 13, no. 12 (1958): 673-685.

Robertson and Bowlby... *A two-year-old goes to the hospital: A scientific film (1952)*

Robertson began by studying 66 British children institutionalized in tuberculosis sanatoriums ... went onto study routine practice of sending children 'to hospital' by themselves.

Image removed due to copyright restrictions. Robertson Films.
http://www.robertsonfilms.info/2_year_old.htm

Bowlby's attachment theory

- WHO asked Bowlby to look at children separated from their mothers by WWII
- found host of bad outcomes (aggression, delinquency, psychopathology)
- non-organic “failure to thrive”
- (post-Ceausescu Romanian orphanages)

Early thesis too strong

- exclusive emphasis on maternal separation
- e.g. kibbutz-raised children show no effect of 'institutionalization'
- subsequent research stressed nature of separation and nature of other attachments

Led to work on the nature of attachment and quality of caregiving

- Mary Ainsworth -- infants 12-18-months
- strange situation protocol

%	Type of Attachment	Description	Mother's Behavior
20	Insecure avoidant	Unconcerned by mother's absence. Unresponsive on return. Strongly avoidant of mother and stranger.	Unresponsive. Child feels unloved and rejected.
70	Secure	Upset, subdued when mother leaves. Happy on reunion. Avoidant of stranger when mother not there, but OK when present.	Sensitive & responsive. Child feels positive and loved.
10	Insecure resistant	Intense distress on separation. Fear of stranger. Clingy and rejecting on return.	Inconsistent. Child feels angry and confused.

Image by MIT OpenCourseWare.

Ainsworth and Bell's conclusions

- The primary caregiver's behaviour determines the attachment style of the child. A sensitive primary caregiver leads to a securely attached child. Insecure attachment will lead to problems in later life.

Critiqued for cultural bias

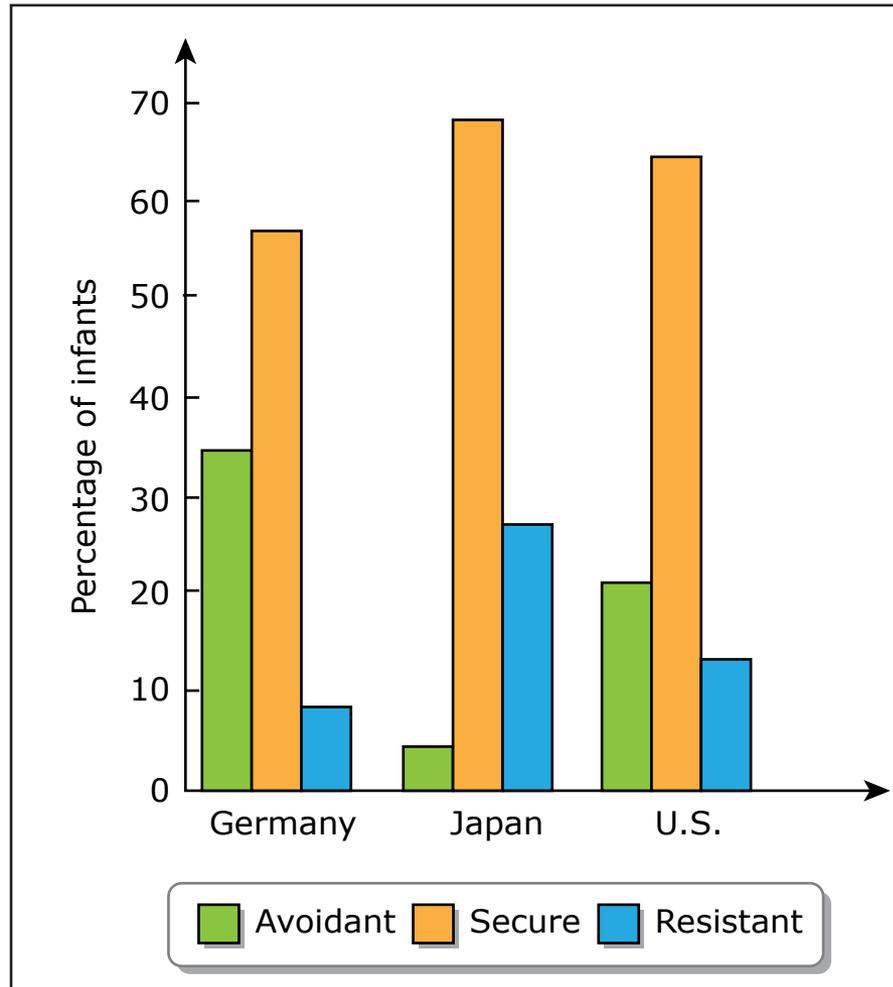


Image by MIT OpenCourseWare.

Critiqued for effects of the child

- Infant temperament correlates with infant attachment
 - ‘difficult’ temperament is a risk factor for insecure attachment
- but attachment status is distinct from temperament status
 - babies with easy temperaments can have insecure attachments
 - babies with difficult temperaments can have secure ones
- Current research is on genotyping
 - polymorphisms of oxytocin receptors, dopamine receptors, serotonin receptors
 - genetics underpinnings to attachment status

Internal working model

- Johnson, Dweck, & Chen, Psychological Science, 2007
- 12-16-month-old infants
- Looking-time paradigm, followed by strange situation

Internal working model

- Test: “Responsive caregiver”

Internal working model

- Test: “Unresponsive caregiver”

Internal working model

- Second study: 'mother' moves down -- infant either approaches or backs away.
- Looking-time reverses -- secure infants look longer at backing away; insecure at approach.

Figure removed due to copyright restrictions.

Figure 1. Johnson, Susan C., et al. "Evidence for Infants' Internal Working Models of Attachment." *Psychological Science* 18, no. 6 (2007): 501-2.

Summary

- Infants can use a wide range of cues to distinguish agents from objects
 - Morphological cues (eyes, faces)
 - Dynamic cues
 - Functional cues
- When reasoning about agent action, infants assume that action is goal-directed and rational with respect to situational constraints
- Across species however, we recognize not just agents or conspecifics in general but particular agents.
- Attachment to these agents is critical for typical development, exploration and learning.
- In human beings, early attachment relations may support abstract inferences about human relationships more generally.

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