

Six Lessons from Babies

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Embodiment Hypothesis

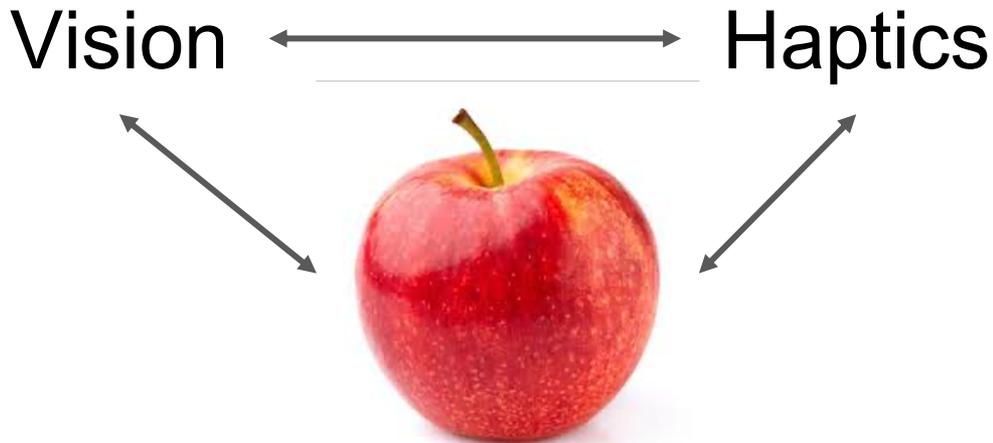
Abstract. The embodiment hypothesis is the idea that intelligence emerges in the interaction of an agent with an environment and as a result of sensorimotor activity. In this paper we offer six lessons for *developing* embodied intelligent agents suggested by research in developmental psychology. We argue that starting as a baby grounded in a physical, social and linguistic world is crucial to the development of the flexible and inventive intelligence that characterizes humankind.

6 Lessons

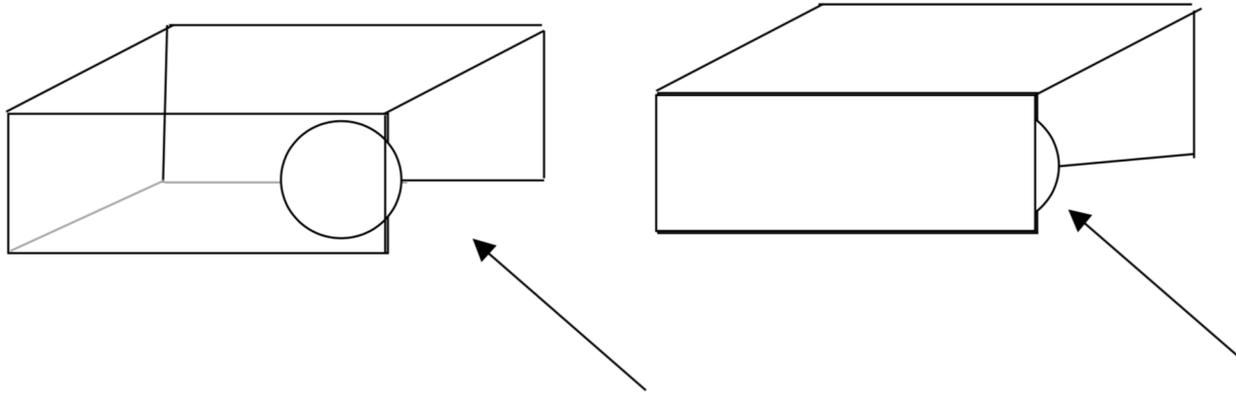
1. Be Multi-model
2. Be Incremental
3. Be Physical
4. Explore
5. Be Social
6. Learn a Language

1. Be Multi-Modal

Babies experience of the world is profoundly multi-modal. We propose that multiple overlapping and time-locked sensory systems enable the developing system to educate itself – without defined external tasks or teachers – just by perceiving and acting in the world.



Transparent Objects



9 month old babies are better at retrieving object from opaque box than from the transparent box.

Infants who played with the transparent containers: sought out and rapidly found the openings and retrieved the object from the transparent boxes.

Tucker and Ellis task

Is this a pitcher?



Yes

No



Yes

No



No

Yes



No

Yes

Faster response, when Yes button is on the same side as the handle.

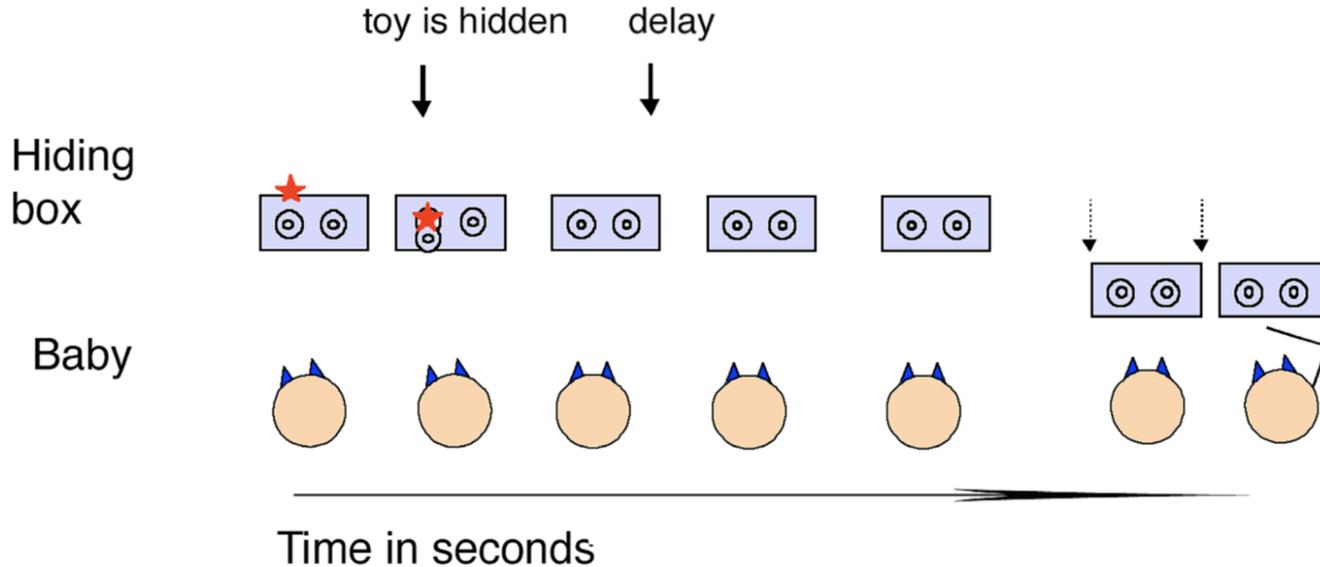
2. Be Incremental

- Babies develop incrementally, and they are not smart at the start. We propose that their initial prematurity and the particular path they take to development are crucial to their eventual outpacing of the world's smartest AI programs.
- Experience of babies changes over time as their capabilities increase.

Audition and Vision

- Infants look in the direction of sound.
- Infants look at visual events that match what they hear.
- Children without audition show altered and more disorganized visual attention.

A-not-B and Self-Loocomotion



Children that have self-loocomoted reach for where the toy is hidden as opposed to children who haven't yet self-loocomoted who search where they searched before.

Ordering Matters

- Opening kittens eyes early disrupts olfactory development and the subsequent coordination of vision and olfaction.
- Disrupting the developmental order of audition and vision in owls disrupts spatial localization in both modalities.

3. Be Physical

Babies live in a physical world, full of rich regularities that organize perception, action, and ultimately thought. The intelligence of babies resides not just inside themselves but is distributed across their interactions and experiences in the physical world. The physical world serves to bootstrap higher mental functions.

3. Be Physical

a.



b.



I see a dax in here.

c.



Where is the dax?

3. Be Physical

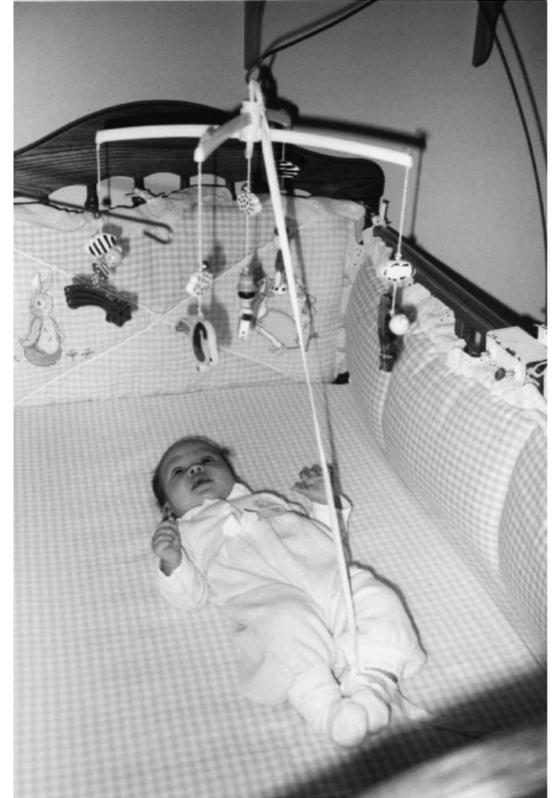
- People routinely and apparently unconsciously gesture with one hand when speaking of one protagonist in a story and gesture with the other hand when speaking of a different protagonist.
- People also use space as a mnemonic, looking in the direction of a past event to help remember that event. (Hollywood Square experiment)

4. Explore

Babies explore – they move and act in highly variable and playful ways that are not goal-oriented and are seemingly random. In doing so, they discover new problems and new solutions. Exploration makes intelligence open-ended and inventive.

4. Explore

- Reaching: Different babies go about learning how to reach objects in different ways.
- Infant Conjugate Reinforcement: Infants increase kicking above baseline levels (where they don't control the mobile toy).



5. Be Social

Babies act and learn in a social world in which more mature partners guide learning and add supporting structures to that learning.

5. Be Social

- Mothers' facial gestures and the sounds they make are tightly coupled to the babies' behavior.
- Parents provide the structure for learning by imitating their babies.
- Parents introduce objects, call out their names, shake them to make babies attend to them.

6. Learn a language

Babies learn a language, a shared communicative system that is symbolic. And this changes everything, enabling children to form even higher-level and more abstract distinctions.

6. Learn a language

- Gain direct access to knowledge of other people.
- Explicit categorization and generalizations for supervised category learning.
- Language learning may be key to becoming symbolic.

6. Learn a language

- Languages are symbol systems: symbols are abstract. Most words by themselves do not indicate what we are referring to.
 - Infact, if symbols are too close to the actual world, they aren't used as symbols.
- It has long been suggested that the way into symbolic processing is through language, and though this idea remains controversial, we believe it is worth taking seriously.

6 Lessons

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Discussion

- Think of 2 examples among papers we have read in class that operationalize these insights
- Think of 2 ways, not covered in class, in which we can invoke insights from this paper