An Ecological Approach to Learning in (Not and) Development

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Agenda

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- Behavioral Flexibility and Learning to Learn
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Inspirations

- Instant converts James Gibson’s ideas, Behavior of animals in their environments need to be explained, perception and behavior play out in real time.
- Exposure to a dynamic systems framework in Esther Thelen’s laboratory.
- Inspired by the observations of infants and young children’s behaviours.

Central ideas

- Development and learning in animal environment ecosystem
    - development describes important changes in the system
    - learning is what the animal does about it
    - Development ⟷ Learning

Central ideas

- Functional behaviours
  - allows animals to do the things they need and want to do
- Animals and their environments share a reciprocal relationship, and form a behavioral ecosystem
- Affordance (possibilities for action)
  - The fit between animal and environment that makes a specific behavior possible

Central ideas

- Development and learning are not parallel processes
    - Generally, learning is nested in and responsive to developmental changes
    - Learning can take any amount of time
- Perceiving and acting are a continuous loop
- Behaviour flexibility
    - The ability to select and modify behaviors based on changes in developments
    - It entails perceiving and exploring affordance and the ability to create new affordance

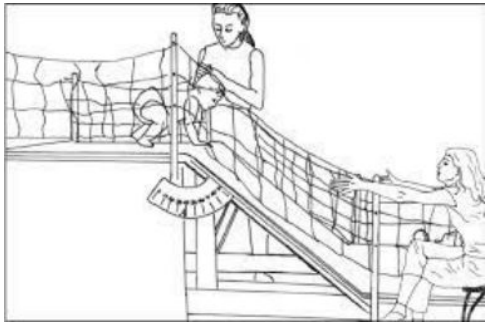
Scope of an Ecological Approach

- Definition of Ecological Approach
    - A framework for studying learning in development
- The goal of the approach: understanding the functional behaviors
- Target object: all animals that use perception to guide behavior in a changing ecosystem
- Study object: infancy period

Scope of an Ecological Approach

- Two strategies:
  - Characterize the developing ecosystem
  - Examine learning and doing in the context of development
- Animal-Environment Ecosystem Selection
  - A child freely behaving in a complex physical and social environment

Perceiving affordances of the infants



- An array of adjustable apparatuses
  - Slopes, bridges, gaps, underfoot barriers etc
- Functions
  - affordance function: (successes) / (successes + failures)
  - Used affordance“threshold”to characterize possibility for actions
  - decision curve function: (successes + failures) / (successes + failures + refusals)
- Results
  - Psychophysical methods yield an S-shaped affordance function based on the infant’s success rate at each unit
  - Two curves are not superimposed

Behavioral Flexibility and Learning to Learn

- Learning is robust across changes in infants' bodies and skill levels
- Learning does not transfer from earlier to later developing skills
    - Skills have different affordance relations
    - Gathered information is different in exploring movements and lead to different actions.
- Behavioral flexibility emerges gradually after the infants acquire a new skill in development

A Process Approach

The ecological approach explains the processes that underlie learning in development and studying behaviour can directly observe the changes.

- Change over time
  - Behavior must be sampled at different time units, starting with real time and then summarized over each increasingly larger time unit for each infant.
  - Sampled daily for the developmental changes in infants' bodies and skills
    - Prevent misrepresentation results
    - Recover the pattern of change from oversampled data
  - Skill trajectories is variable, skill onset ages are arbitrary

Age, Experience, and Opportunities for Learning

The acquisition of behavioral flexibility in human infants is extremely slow

what is the explanation for this protracted learning?

Age, Experience, and Opportunities for Learning

- Age is not the actual factor
  - Age confuses the time with the factors responsible for enabling developmental change.
  - chronological age or test age is a convenient proxy for the unspecified types of practice
- A satisfying explanation is to set the actual factors responsible for change as x axis
- What are the actual factors ?
  - locomotor and postural experiences may be the factor for locomotion
  - Simulations with robots trained on infants' natural walking paths support the idea

Enabling Change through a Cascade of Behavioral and Developmental Events

- Multiple factors cooperate to secure a particular outcome
    - leg strength, balance control, social pressures, caregiving practices, and motivation coalesce for the emergence of walking
- Different pathways can lead to the same endpoint
- Earlier behavioral or developmental events “enable” the later ones
- Enable is between “induction” and “facilitation”

Enabling Change through a Cascade of Behavioral and Developmental Events

- It is not a linear causal chain
  - Visual information does not guarantee that infants will respond adaptively

- The opportunity exists to spur developments far afield from the original accomplishment
  - The development of walking allows infants to go more, see more, do more, play more, hear more, learn more, and talk more

Discussion #1

Piazza:@36_f1

- Learning does not seem to transfer from earlier to later developing skills -- experienced crawlers will try to walk down impossibly steep slopes, etc. Adults seem to be able to learn new motions/activities much quicker I think because we have the foundational functions mastered, and many things are just an extension of those. Infants don't see the transference between crawling and walking because they are still learning the foundational skill of locomotion.
- This transference adults are capable of directly parallels transfer learning that we've employed in networks. We pretrain models on ImageNet, and even when we want to apply it to a different domain or task, the foundational things it has learned from ImageNet (edges, textures, blobs, etc.) are very useful in other image applications. One example of transference in adult humans would be that we could learn archery sort of quickly because it's an application of foundational skills we've learned like locomotion and hand-eye coordination. We don't have to learn to move our arms and stand to do archery, just move our arms and stand in a specific way.
- I think it's more difficult to find a parallel example like this for perception, and I'm curious if anyone has any thoughts. Something like: We can learn _____ sort of quickly because it's an application of foundational skills we've learned like _____.

Discussion #2

Piazza:@36_f2

- The author's work seems to build well with the concept of perceiving affordances by Gibson. It makes sense to me that flexibility is import in learning. A baby must learn to adapt to changes in their environment to accomplish a particular goal.
- This I thinks supports the concept of online machine learning models, where they must learn over time and continue to learn as they are exposed to new inputs.

Piazza Reply:

- One of the key points of the author is that " animals must learn how to learn". I think this concept might be the final goal of AI. We can adopt a part of the development or a certain way that a baby uses for computer vision models. However, I am not sure whether we can develop a model to improve itself such as developing the architecture and changing the input and output data.
- The author's claim of development being a lifelong process was relevant to expanding perception in machine models. If a model is trained to run on certain data and is only familiar with that data, incrementally adding new/foreign data over time (such as what is already done with robust models) would increase the model's diversity and mimic the idea of continuous learning

Discussion #3

Piazza:@36_f5

- I loved the part "X can do more than change the timing of a later event Y, but X does not guarantee the later event Y, and other events A–Z can also lead to Y", giving yet another proposal to look about things differently than being conditioned on prior.
- The last discussion focused on how to properly do a reinforcement kind of approach to learn affordances in robots, but here the process of learning and development is a very long sequential process that has highly intertwined relations. if affordances keep changing on the fly based on what is available at that moment in time, how are we supposed to make a robot do that?

Discussion #4

Piazza:@36_f7

- The author claims infants learn to learn. However, the author did not make clear what infant learn. Did experienced infant deliberately not use previous learned solution?
- I cannot imagine how to model this learn to learn method. If action is position and learning is velocity. What infant learn seems to be acceleration, a third order effect.
- Something does not have an effect on animals' behavior and only show its effect once cross a threshold. For example, make an infant crawl one day and walk the other day. What did infant learn?