# The early development of action skills

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# Bernstein's basic principle

- As **Bernstein** pointed out, perception and action belong together. There are too many degrees of freedom in the motor system to make totally arbitrary movements possible. Instead movements are organized into functional synergies that reduces the control problem and makes real actions the subject of the motor system.

- Actions are organized around tasks and defined by goals.
- They are initiated and maintained by  motives.
- They are guided to the goal by predictive information.

# The necessity of predictive control

Adaptive behavior has to deal with the fact that events precede the feedback signals about them. In biological systems, the delays in the control pathways can be substantial. The only way to overcome this problem is to anticipate what is going to happen next and use that information to control ones behavior.

# Innate abilities

Without innate behavior, an organism cannot develop. If all behaviors are innate the organism can neither develop. Most early behaviors have an innate base. One of the most important tasks of developmental psychology is to understand how biology has facilitated the acquisition of new behavior.

# Neonatal actions

Neonatal movements are special in the sense that all aspects of them are innate, including the motives that drive them, the sensorimotor system that supports them, and the ability to extract the information that guides them. In this sense they may be regarded as **instincts** but not reflexes?

**I like to illustrate neonatal action with an example of Newborn reaching** (von Hofsten, 1982, 1984).

This 7-days-old infant visually tracks an object and extends the arms towards it. The movements of the child reveal a number of remarkable abilities.

This example demonstrates that newborn infants are able **to visually perceive** the surrounding in a functional way and distinguish objects as units that afford reaching.

Newborns perceive the directions in space to objects around them and how they move. They fixate interesting moving objects and aim their arm movements significantly closer to it than otherwise.

This is quite remarkable since vision is the only sensory modality that has not been functional in the womb. Still, infants are prepared to use it right after they are born.

Secondly,  this newborn reaching example shows that newborn children are able **to control the movements of their arms**. They do not just move them randomly.

In other words, newborn infants are in possession of a mechanism that can translate the visual information into appropriate motor commands.

Finally, it shows that the newborn infant has an urge to extend the arms towards an object in front of them.

The movements performed are not elicited stereotyped reflexes but **goal directed movements, initiated by the child and guided by vision.**

**Summary:**

In spite of the fact that the cerebral cortex is immature at birth, many important brain functions are present .

The infant is well equipped to meet the challenges of the new mode of living. A number of innate abilities makes this possible.

Perception is prepared to receive information about the external world and relate it by various modes of action.

The movements of the newly born infant are goal-directed.

What is clear from these examples is that although newborn children show some control of reaching movements, they do not grasp objects in a functional way.

It takes several months before this is done.

I like to mention 4 major improvements in perception occur during this period and make prospective control of reaching actions possible.

# 1. Onset of motion perception

**Motion introduces time into perception and makes it possible to predict future events.** Therefore it is of great interest to trace the developmental origins of motion perception.

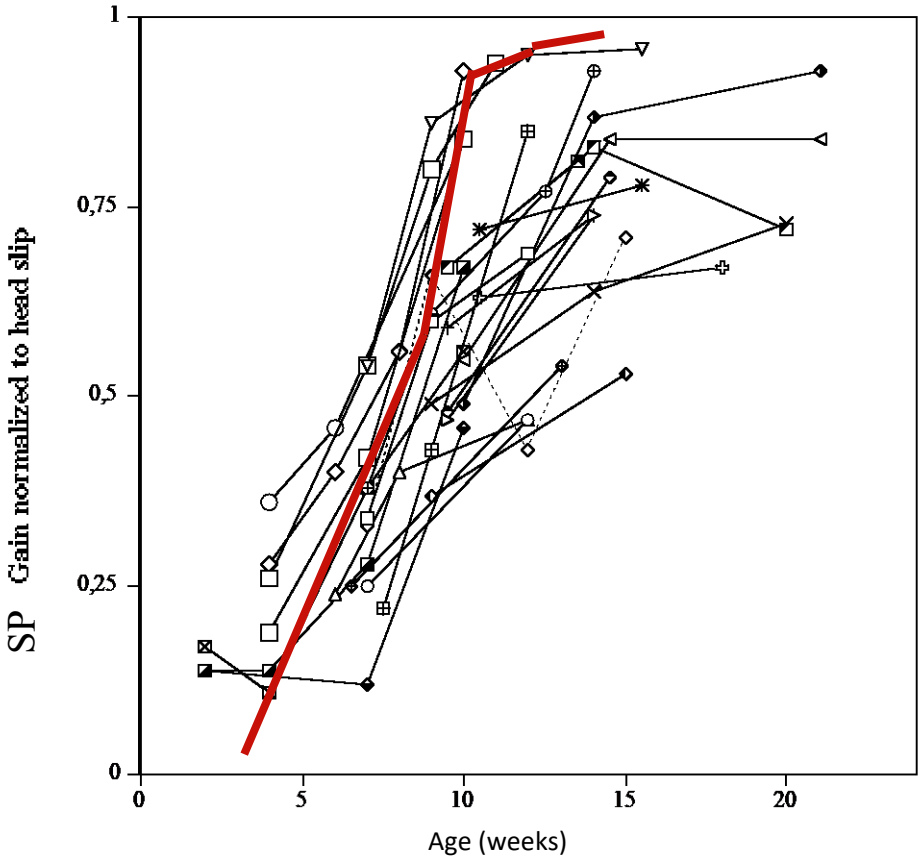
Perception of motion is fundamental for **perceiving objects**, for **the perception of ego motion**, and for **social perception**.

The onset of motion perception can best be exemplified by the onset of smooth pursuit.

# Smooth pursuit

The most basic action on moving objects is fixating them with the eyes. Smooth pursuit eye movements requires perception and anticipation of the upcoming motion.  It begins to emerge at around 6 weeks of age.

Onset of smooth pursuit eye movements coincides with onset of precise motion perception at around 8 weeks of age.




This is data from 26 subjects in 3 different studies followed longitudinally over parts of the first 5 months of life. (*von Hofsten & Rosander, 1997; Rosander & von Hofsten, 2000,2002*)

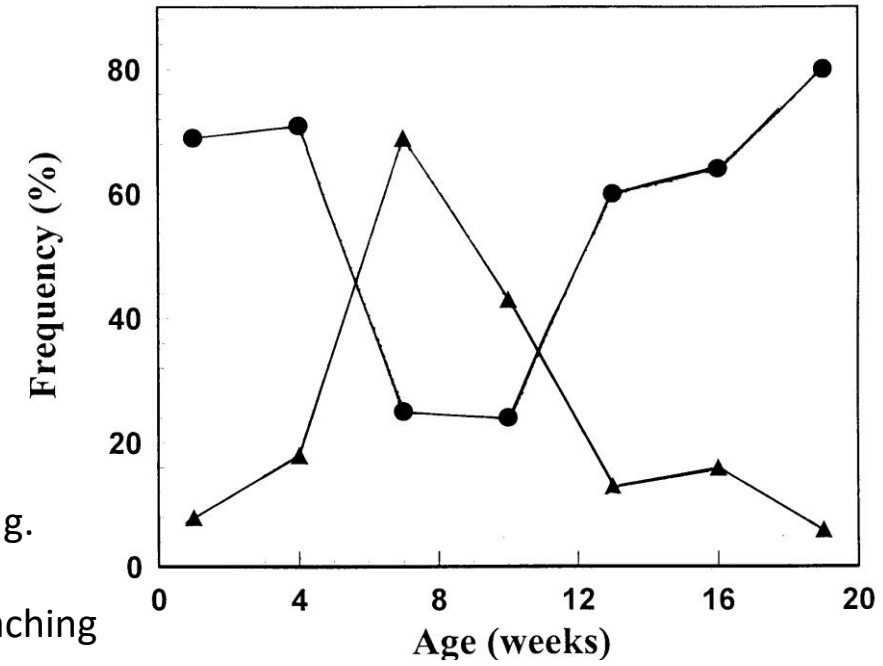
The red curve summarizes the onset of sensitivity to visual motion direction (*Atkinson, 2000*).

Thus at the end of this period, infants both perceive their own movements and extrnal objects that move

2. **Control of reaching and grasping.**

At birth, the extension of the arm is in synergy with the extension of the fingers. Around 10 weeks of age the synergy is broken up. Hand is then often flexed as the arm extends and both the agonist and antagonist muscles are activated (Gatev, 1972).

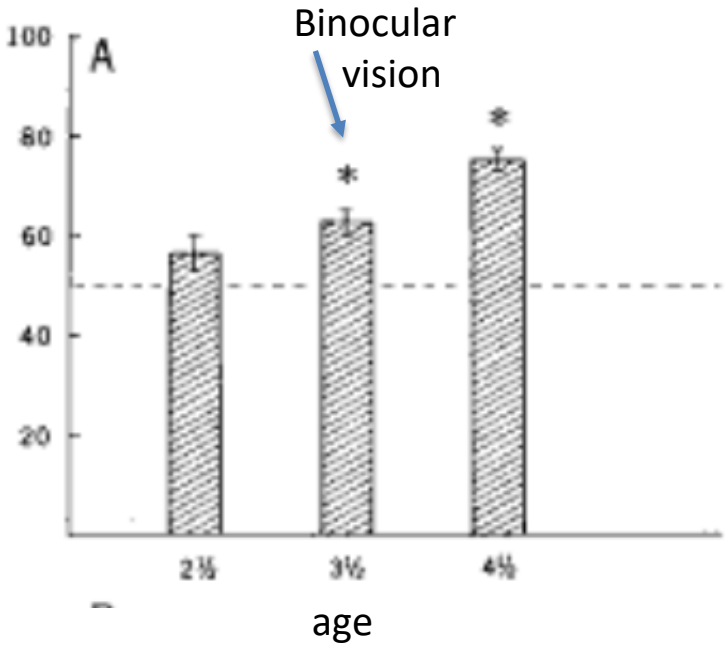
After that, the hand extends again, but only when the infant fixates the object. Extension now part of functional reaching.




Fingers flex during reaching.

Fingers extends during reaching

# 3. **Onset of binocular perception at around 12 weeks of age.**




Aslin & Fox, (Science, 1980) showed infants a stereogram with a moving artifact. Only subjects with stereo vision could see and follow it.

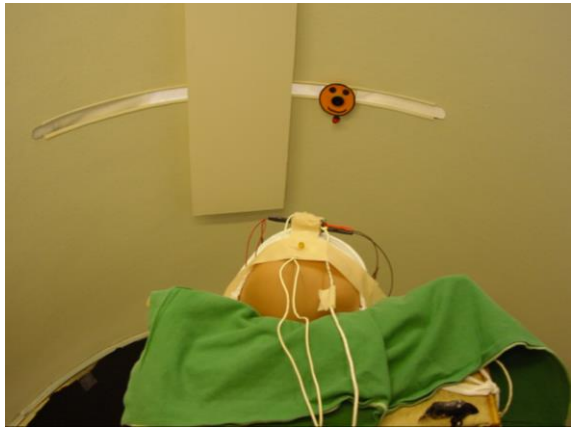
Here is a 10-week-old infant who is reaching very well but not grasping the object reached for.

4. **Perceiving the persistence of objects over occlusion.**

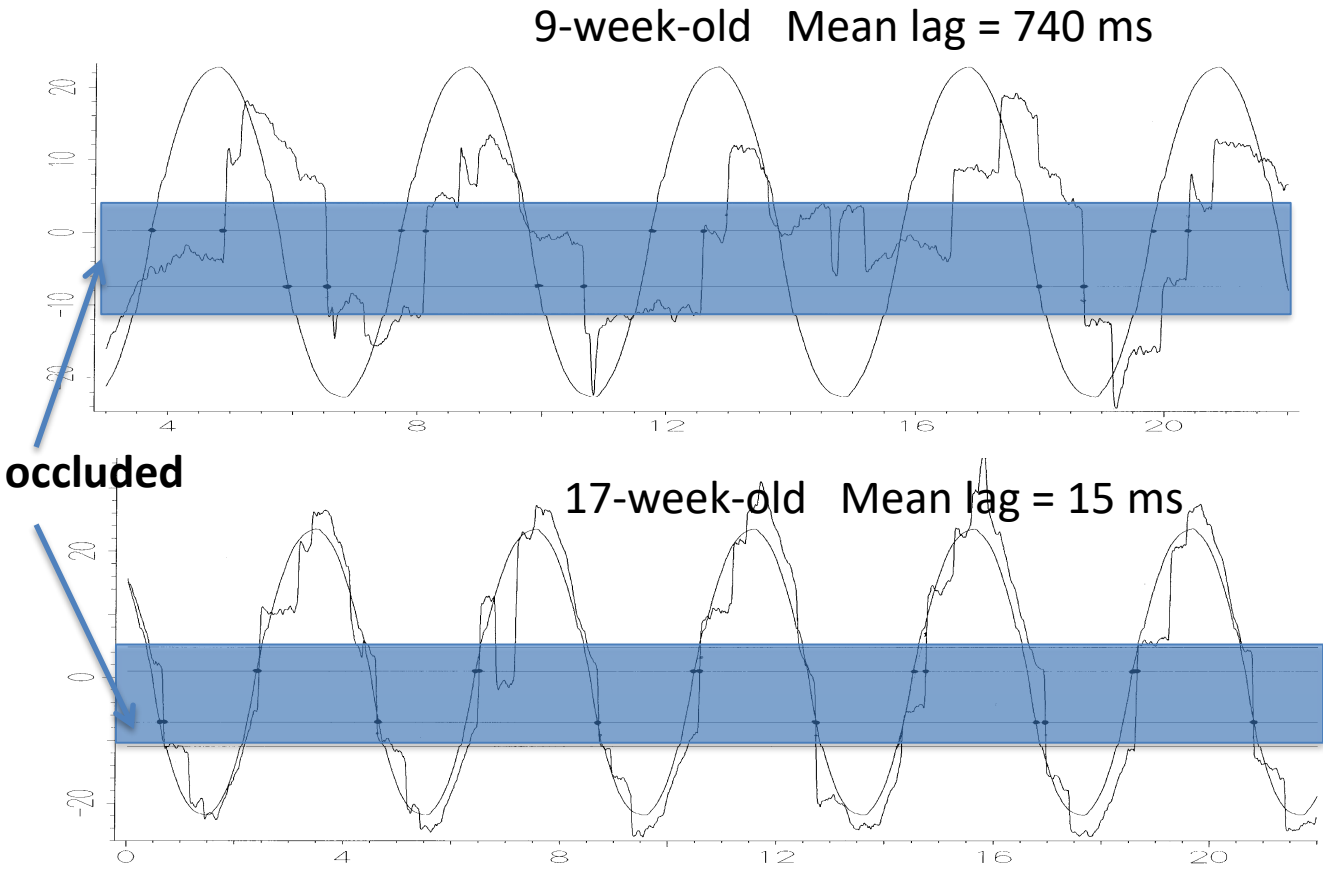
This ability is of great importance because it provides continuity to the perceived world.

At about 4 months of age, infants begin to expect objects that move behind other objects to reappear at the correct place and time.

Here is an example of two infants who observe an object that moves back and forth behind an occluder. *(Rosander & von Hofsten, 2004)*



- An 9-week-old infant who does not expect the object to reappear on the other side.
- A 17-week-old infant who clearly predicts every reappearance



**Where do infants predict the object to reappear?** The inertia principle states the it should appear along the continuation of its previous trajectory. Here is an example where a 6-month-old infant watches an object that disappears behind an occluder. It reappears 90° to its original path. *(von Hofsten, Feng & Spelke, 2000)*

- The onset of functional reaching opens up new possibilities for actions.
- By anticipating events and preparing actions for them, infants are able to successfully interact with the outside world.

# At the onset of functional reaching, infants show anticipatory adjustments.

1. **The grasping of an object is timed to the arrival of the hand to it.** from the onset of reaching.
2. **The opening of the hand is scaled to the size of the object**. from 9 months of age.
3. **The hands orient themselves appropriately to prepare grasping.** From the onset of reaching.
4. **The different fingers assume different roles in the preparation of grasping.** This is accomplished at the end of the first year of life.

Von Hofsten & Rönnqvist

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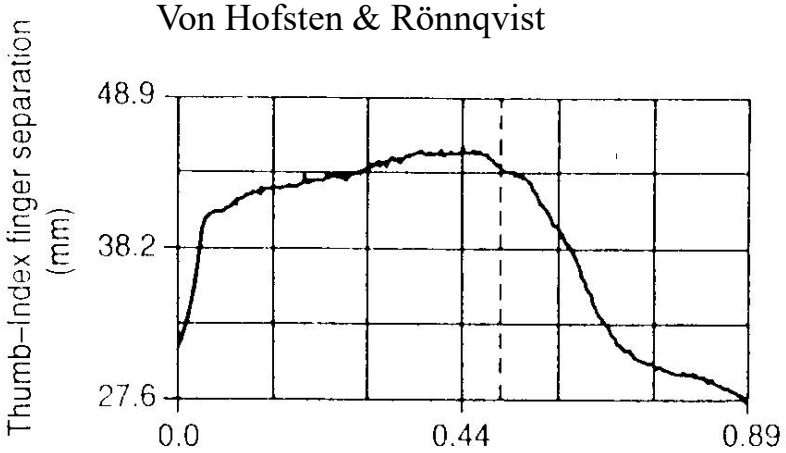


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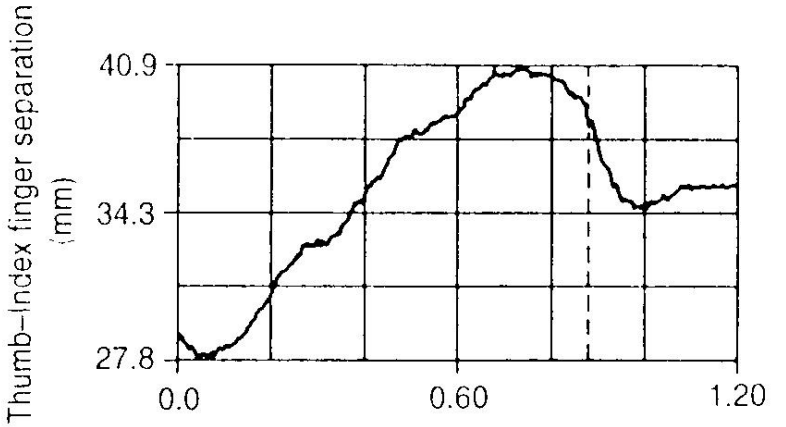


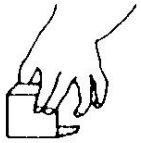

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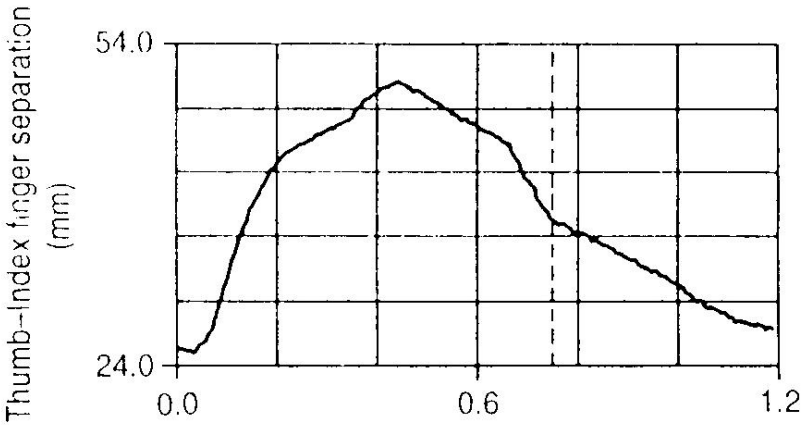

# Infants early catching

From the onset of reaching infants catch moving objects. The reaches are aimed at a future position of the object where the hand and the object will meet and **not** at the position where the object is seen at the onset of the reach.

# Summary

1. Actions are guided by perception at all ages, even in the neonate.
2. Motion introduces time into perception and makes it possible to prepare actions for future events.
3. Predictive control is an absolutely essential part of the development of action. It constitutes the foundation of any skill from eye tracking to manipulation of objects.
4. As infants come to control an increasing number of prediction problems, they become more skillful in their everyday activities. At 5-6 months of age, infants explore objects efficiently.

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