Foundations Of Mind

Today: End of Depth
Next Time: Objects

Unconscious computation: Distance from blur & contrast

Weakly electric fish

Max Amplitude

Distance From Body = 0.5698 Max Slope ~1.0899

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The New view: From Descartes (& others)
The idea of unconscious computations (inferences)

Unconscious computation:
- Takes information from the environment through causal connections with the senses
- The computation transforms this information.
- The output is a new representation of information not given explicitly by the input.
- Some important unconscious computations may be present at birth, innately specified, and not require specific learning.

Weakly electric fish
- Nocturnal
- Can "see" in the dark using an electric pulse

Special thanks to Ben Dirlikov for electric fish information
Unconscious computation: Distance from blur & contrast

**Human**

**Weakly electric fish**

Special thanks to Ben Dirlikov for electric fish information.
Depth Perception

• We experience the visual world as 3-D from information on our 2-D retina.
• Mathematically, this is equivalent to foreseeing the future by looking at the present.

Depth Perception

How far is apple in dimension 3 (depth)?
How rich is Justin in dimension 4 (time)?

E = distance between eyes measured in dimension X (in XYZ coordinates)
d = angle of eyeball measured by strain of the eye muscle to turn the eye
An “angle” requires two sides
In order for there to be an “angle” of the eye there must be E AND some distance in the Z dimension (depth) that the eye has turned through

E = opposite / adjacent
Tan d = D / .5E
D = .5E(Tan d)

J$ = J$

Depth Perception

The Old view:
Perception is a causal connection between mind and world, no computation involved. Cognition is the conscious thinking reasoning mind.

Berkeley’s critique and alternative theory (1709)
“In vain shall all the mathematicians in the world tell me, that I perceive certain lines and angles which introduce into my mind the various ideas of distance; so long as I myself am conscious of no such thing.”

To us perception (of depth, of phonemes etc) appears to be immediate and without effort. As if no computation or inferences required
Depth Perception

The New view:
Perception too may use, in deed require, computation and unconscious inferences (e.g. Descartes view of convergence)

NB Kellman’s quote:
“How size constancy develops is a classic topic in infant perception research. Because real size depends on distance information and projective size, size constancy illustrates the need for inference in perception. Furthermore, if distance perception itself must develop by learning (as Berkeley suggests), size constancy might be predicted to be an elaborate developmental construction. Learning to interpret projective size in relation to distance would require the scaffolding of learning to perceive distance in the first place. Against this background, the outcomes of research on infant size perception are nothing short of astonishing.”

If Infants CAN compute depth, what can they DO with that knowledge?

Difficult problems like depth may require specially designed dedicated unconscious representations and computations (i.e. Core Knowledge). The importance of Core Knowledge to the cognitive system increases when this knowledge is used by us to solve other challenges.

Rationale:
Test for depth perception by asking whether infants can use a representation of depth to compute other properties of the array.

Examples:
Size constancy
Shape constancy

The Problem of Depth

A small nearby object projects the same retinal image…
as a large far-away object!

Size constancy

The true size of an object is computed from information about its retinal size and its distance.

If babies perceive true size, this too would be evidence for innate perception of depth.
Do newborn infants have size constancy?

Slater’s experiment

Habituation display: Small or large cube at 6 different distances

Retinal sizes:

Test displays: Small cube near and large cube far, side by side at new distance

Equating retinal size, infants prefer novel real size.

Evidence for size constancy in newborn infants.

Do newborn infants have shape constancy?

Another Slater experiment

Habituate to rectangle or trapezoid at various slants.

Test with rotated rectangle vs. frontal trapezoid.

Result: Babies prefer the new REAL shape not a new retinal shape. Newborns have shape constancy, therefore newborns have depth perception.

True shape is computed from retinal shape + slant

What do these studies show?

--Newborn infants perceive the true sizes and shapes of objects, not their retinal sizes and shapes.

--True size and shape must be computed from information about retinal size and shape, combined with information about distance and slant.

--Newborn infants therefore must perceive distance and slant.

Size and shape constancy experiments provide indirect evidence for depth perception in newborn infants.

Questions

(1) If newborn infants perceive depth, does that mean that early experience isn’t important?

• No! Early experience may be needed to support, maintain, or extend initial capacities.
Psychophysics: Put stereo glasses on babies

Longitudinal study
Stereopsis begins at 3-4 months. Acuity rises rapidly thereafter.

Questions
(1) If newborn infants perceive depth, does that mean that early experience isn’t important?

• No! Early experience may be needed to support, maintain, or extend initial capacities.

An example: stereopsis in adults who were deprived of binocular vision as children (“strabismus”)

Helmholtz’s Problem
To decide between nativist & empiricist theories, we need to study space perception in newborn human infants:

Why?
Because infants are the only human beings with a visual system and no prior visual experience.

Problem: If we can’t ask infants what they see, what can we do?

3 Approaches
1. Study the plasticity of visual space perception in human adults. (prism studies)
2. Study innate capacities for visual space perception in non-human animals. (Gibson visual cliff)
3. Study human infants with other methods. (Habituation etc.)
Studies of Babies

Three lines of research provide evidence that young infants perceive a 3D, visible surface layout before they learn to reach for and manipulate objects:

• Psychophysical studies probing the signatures of stereopsis
• Studies of the perceived equivalence of different depth cues (motion & stereo)
• Studies of size and shape constancy

Evidence for core perceptual knowledge of space.