Exotic Sensory Systems

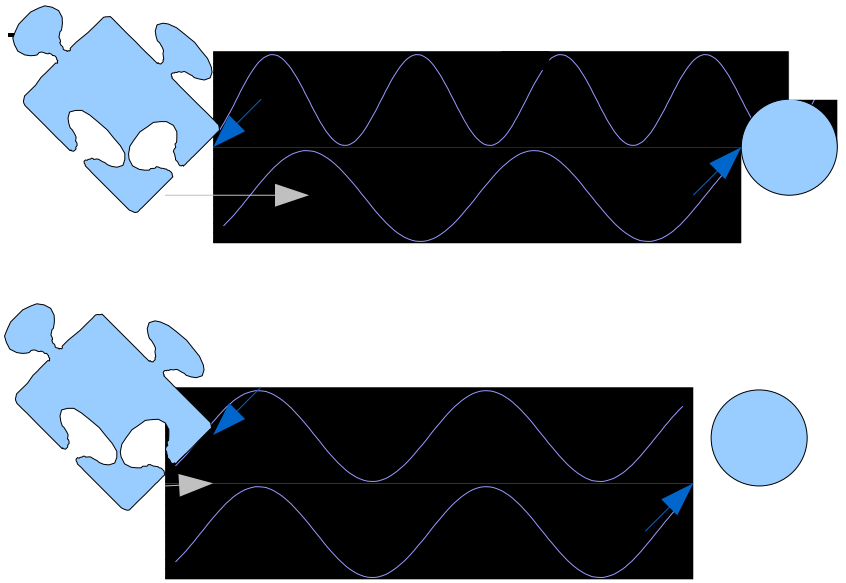
Much material taken from *Sensory Exotica* by Howard C. Hughes, 1999, MIT press.

Bats:The Big Bug Scourge of the Skies

- How do we know bats navigate with their ears?
  - 1794: Spallanzani; series of experiments
    - Bats can fly in near-total darkness. They must have very good vision, right?
    - Place hoods over bat heads (result: mixed, but hoods do seem to interfere with bat navigation). Is the “good vision” theory confirmed?
    - Destroy bat eyes (result: bats navigate just fine.)
  - Jurine: Placing simple plugs in bat **ears** renders them unable to fly in darkness
  - Spallanzani: If the ears are doing the work, how come we don't hear anything?
    - Further experiments forced Spallanzani to agree with Jurine, even though there's no audible noise during bat flight.

- . . . bats navigate with their ears (cont.)
  - 1795, Cuvier: “You guys are cruel to bats. Hearing can't be right. Bat movement in darkness depends on an elaborate system of touch.”
  - For some reason, Cuvier's became the accepted theory until the 1930s, when technology enabled us to detect bat calls in darkness.
  - Donald Griffin (undergrad at Harvard, later under Lashley) was aware of Spallanzani's experiments.
    - Asked a physics professor, G. W. Pierce, to borrow his newly-developed high-frequency sound detector.
    - Found bats emit high-frequency noises, outside the range of human hearing.
    - When bat mouths are tied shut, preventing the high-frequency cries, navigation in darkness is impaired.

- What information can bats acquire via sonar?
  - Size of target (corresponds to amplitude of wave)
  - Distance to target (time it takes signal to return)
  - Target up/down, right left (similar to humans)
  - Target receding or approaching, how quickly? (information contained by Doppler effect)
    - Approaching a target quickly yields a higher-pitched echo than the cry emitted
    - Approaching slowly yields an echo similar in pitch to the cry



- Humans can use echolocation, too, but it takes practice
- Famous recent practitioner: Ben Underwood (although we've known since the 50's that humans have this ability.)
- Although Underwood can use tongue clicks to produce the signal, many humans use a cane.
- Seem to still be able to perceive size and distance

- Electroreception
- Parker and van Heusen (1917): a blindfolded catfish will respond when a metal rod is put in the water – but will not respond when a glass rod is.
- They knew an electrical field was generated by the metal rod in water – but why did the fish sense it?
- Sharks are similar – eyeblink to weak electric fields – if you sever some nerves coming from the ampullae of lorenzini, you prevent the eyeblink.
- (It's been known for a long time there are animals that can produce electric fields – like eels – but some have a very weak electric discharge. Why?)
  - Active sense (like echolocation) vs. passive sense (like just hearing)

- Electroreception
- Dijkraaf and Kalmjin (1962)
  - Shark will attack a well-camouflaged flounder.
  - Shark will attack a flounder in agar, opaque, but electrical currents pass through it.
  - Shark will not attack a dead flounder in agar.
  - Shark will attack an electrode producing a similar electrical field to that produced by the flounder.

Perceptual Development

Methods of studying perception in infants (Fundamental problem in infant perceptual studies - we can't tell them what to do, or ask them what they think!)

1)Orienting reflex - eye movements, head turns, tracking behavior as a response to a stimulus that suddenly appears or moves around.

Methods of studying perception in infants:

2) Preferential looking – infant in a seat or on his or her back (or sometimes just sitting in mommy or daddy's lap), two stimuli in front of infant.

Methods of studying perception in infants:

2) Preferential looking (cont.)

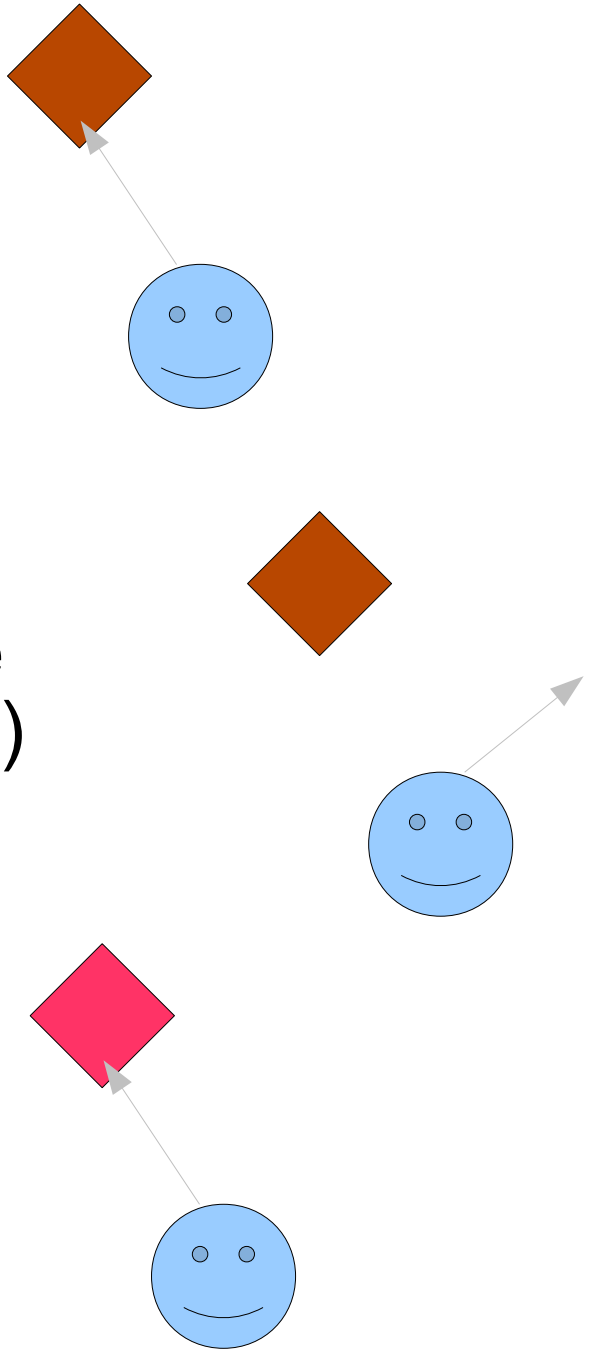
a)Experimenter viewing (and recording) infant through an aperture in the wall.
b)Experimenter tracks infant's head and eye movements, keeping track of the amount of time the infant is looking at each stimulus.
c)If the infant looks at one stimulus more than the other, this suggests infant has a preference for that stimulus – which implies that he or she can tell the difference between the two.
d)Lack of preference does not imply the infant *cannot* detect the difference – just that he or she *didn't* that time.

Methods of studying perception in infants:

3)Forced choice preferential looking
  a)Experimenter viewing (and recording) infant through an aperture in the wall.
  b)Only one stimulus presented to the infant at a time, and only in one location. The experimenter viewing the infant does not know where that stimulus is.
  c)If the experimenter viewing the infant can tell where the stimulus appeared, based on his or her observations of the infants responses (usually eye movements), the infant is capable of at least detecting the stimulus.

Methods of studying perception in infants:

4)Habituation and dishabituation
  a)Only one stimulus presented at a time. When the stimulus is first presented, the baby will orient towards it, and pay it some attention.
  b)After a while, the infant will get bored with the stimulus (will *habituate* to it) and the orientation behaviors will stop. (That is, the infant is just randomly looking around now.)
  c)Now the first stimulus is removed, and another stimulus, with only one change, is presented to the infant. If the infant *dishabituates*, it will orient to the new stimulus, because it's no longer boring to look at. This implies the infant can detect the difference between the stimuli.



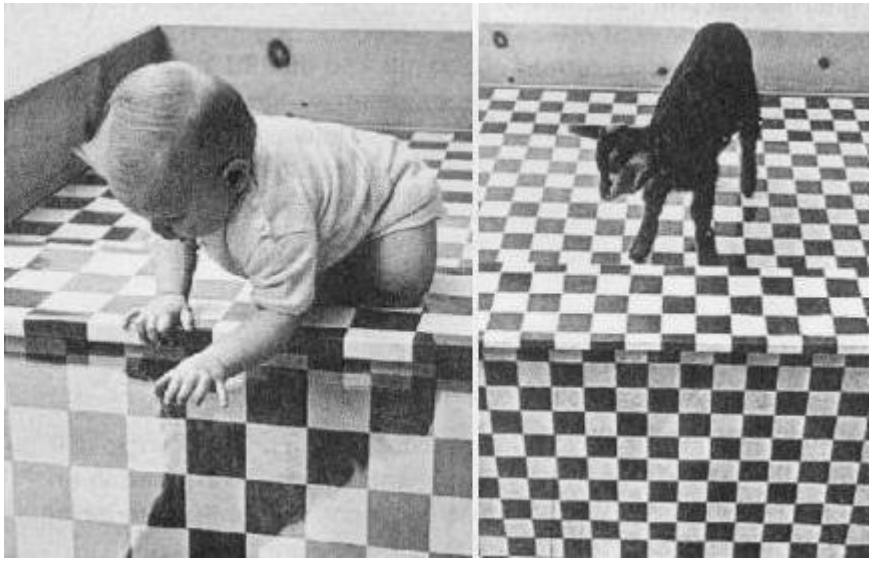
Approaches to perceptual development

1)life-span approach (long-term): knowing a person's age will tell you a lot about how that person's perceptual processes work. (“at one, your perceptual experience will be x, but at 20, your perceptual experience will be y.")

- Example: holism/reductionism. Elkind (1978) showed children large objects made up of smaller objects (e.g., a vegetable bird) and asked what it was.

Approaches to perceptual development

- Example 2: visual cliff. Gibson & Walk(1960)
  - Infant placed near a "cliff"
  - Parent (on the other side of the cliff) either acts afraid, or motions the child toward them.

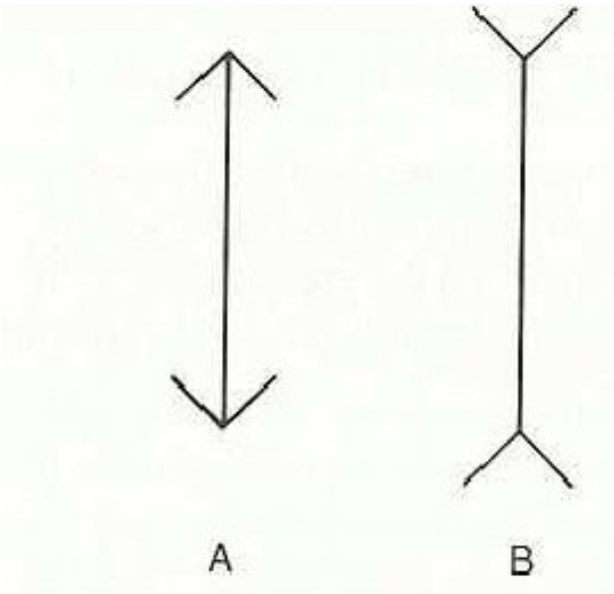


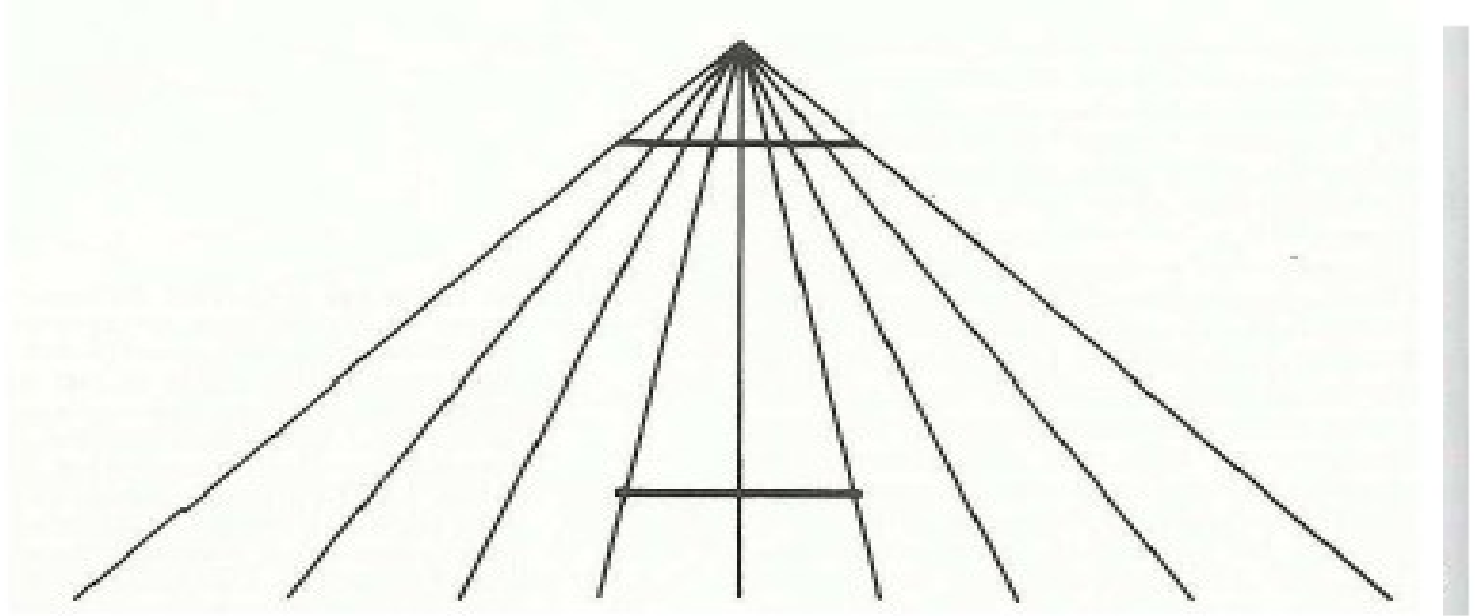
- In the classic study, the child does the reverse of what they normally do – if the parent acts afraid, the infant usually wants to go to them, but with the cliff in between them, they stay away.
- Young kids placed directly on the "deep" end – older infants (9 months or so) - are afraid and have increased heart rate. Younger infants (5 months or so) experience no change in heart rate.

Approaches to perceptual development

2)Perceptual learning approach (short-term): particular experiences will change our perceptual abilities in particular ways.

a)Ex: Attentional weighting - learning to pay attention to the things that matter, and ignore the things that don't. Recall Muller-Lyer and Ponzo illusions.





Approaches to perceptual development

- Presumably, the better you're able to ignore the extraneous parts of the stimulus (that is, the wings in the M-L and the converging lines in the Ponzo), the less susceptible you'll be to the illusory effect.
- Children, we know, are generally poorer at filtering out extraneous stimuli (it's hard for them to ignore something)
- Children old enough to understand what you're asking and give you an answer show a stronger effect for both illusions. The strength of the effect gradually tapers off until about age 25, presumably as we get better at our ability to use attentional weighting.

Approaches to perceptual development

2)Perceptual learning approach (cont.)

Example: Differentiation. Experience with a set of stimuli improves your ability to tell two (previously indistinguishable) stimuli apart.

- People are better able to identify faces belonging to races with which they have more experience (O'Toole et al, 1996; Meissner and Bringham, 2001)
- Chicken sorting by gender – difficult to do because genitalia of a chick are not easily seen – but important to do, because female chickens are more economically valuable.
- People can learn to use echolocation!
- Gibson (2001) suggested that anything we call perceptual learning is basically a form of differentiation.

Approaches to perceptual development

2)Perceptual learning approach (cont.)

Example: Selective rearing. Raise an animal in an environment that is restricted in some way.

- Raising an animal in the dark for the first months of its life results in reduced responding in visual cortex, including both orientation and motion sensitive cells (E.g., Brown, 2001).
- Hirsch and Spinelli (1971) raised kittens in an environment in which the kitten could only see vertical stripes. Afterward, simple cells in the kittens cortex, normally responsive to oriented lines of all directions, were now only responsive to vertical or near-vertical lines. If you help a pencil vertically, the cat could see it and would bat at it, but if you help the pencil horizontally, the cat could not see it, and would ignore it.

List of terms, section 11

Exotic sensory systems

- Spallanzani/Jurine experiments
- Donald Griffin experiments
- Information attainable through echolocation
- Electroreception
- Dijkraaf & Kalmjin experiments
- Active vs. passive perception

Perceptual development

- Orienting reflex
- Preferential looking
- Forced choice looking
- Habituation/dishabituation
- Life-span approach
- Elkind(1978) experiment
- Gibson & Walk (1960) experiment
- Perceptual learning approach
- Differentiation
- Selective rearing, Brown (2001), Hirsch & Spinelli (1971) experiments