

# **Gaze detection and following in primates: soul-gazing or a technique.**

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# Goals

- Address the argument about the existence of gaze detection in primates
- Analyze work by Povinelli, Hare, Santos and Tomasello
- Understand the concept of gaze set formal definitions of “gaze” and “visual attention” drawn from what we know about “gaze” in humans.
- Answer and expand the question posed by Keeley in [1] “Is it true that some animals follow gaze without attributing mental states to others?”

# ***Neurophysiological background***

- The structure of primate vision is not limited by the eye (or retina).
- Complex system:
  - *eye* (retina, cones/rods, bipolar cells, ganglions)
  - *midbrain* (optical fiber, LGN or lateral geniculate nucleus)
  - *cortex* (visual cortex with more than a dozen specialized areas, already singled out)

# ***Neurophysiological background***

- Highly specialized and evolved ability to reconstruct 3D information:
  - stereo-vision
  - visual parallax
  - comparing to the objects of known size

# ***Neurophysiological background***

- Highly developed *fovea* in combination with the frontal location of the eyes allows us, as all the predators to exercise a “smooth pursuit”.
- Primates are able to concentrate their “gaze” on a certain area and receive a stable image of this area even when undergoing through spatial perturbations (e.g. while running)

# Definitions

- The definition of *gaze* that I will use is “the act of fixating the eyes on the object”. Note however, that it is not required to “gaze at the gaze” to detect it, because it can be noticed by other means, such as using the peripheral vision or inferring its location using other cues, e.g. head orientation. Notice the mechanistic meaning of the gaze, as nothing more than a physical concentration of one’s eyes on some location in 3D world.
- Visual attention on the other hand is a psychological state “...taking possession of the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects...”

# ***Experiments: initial assumption***

- The base of the argument for the low-level interpretation of the gaze - Povinelli's tests on chimpanzees.
- **Observation:** lab animals put buckets over their head to “obstruct their vision” and run into things.
- **Initial belief:** intentional gaze detection is present in chimps

# *Experiments: gaze line*

- The experimenter looking at the object hidden behind the glass half of which is opaque.
- The animals don't seem to trace the human gaze past the obstacle
- **Conclusion:** “they understand that the person is looking at something, that they cannot see”.
- **Objection:** “taking the physiological model of primates' vision into account this can be explained simply by the visual ability to map the distances and reconstruct the 3D scene, followed by the occlusion map”



# ***Experiments: begging***

- Task: Make animals address their natural begging gesture to one of the two people in the room.
- One person's gaze is obstructed by the bucket, screen, blindfold or hand or the person is turned away.
- Results: all but one setting have made the subjects guess randomly, confirming the functional – low-level explanation.
- Almost all chimpanzees guessed right when the person was facing away ... (see next slide)

# ***Experiments: hierarchical model***

- Hierarchical model of chimpanzees gaze detection can explain the findings at this point
- Four levels of recognition/detection:
  - **body**
  - **head**
  - **face**
  - **eyes**
- The chimpanzees give a strong preference to the features at the body/torso level. Given those are the same, head orientation serves as an additional cue. The lowest weight is given to the smallest feature geometrically - the eyes.
- “Over the shoulder”, screens and “attended vs. distracted” test prove the hierarchical model.
- Open eyes vs. closed eyes produce the same result

# ***Experiments: training and retention***

- Training with rewards improved performance, but did not generalize to the blindfolds: covering the eyes vs. covering the mouth.
- A year after, and then 3 years after the subjects forgot almost all their skills
- Had to be presented 4 dozen screen tests and open/closed eyes test to develop the skill again.

# Experiments: humans

- Was the learning experience for infants and chimps comparable in its extensiveness and multitude of “seeing vs. non-seeing tasks?”
- Chimpanzee’s performance is compared to 18 months old infants
- “Unlike the apes, children were correct in most or all of the conditions from their very first trial period”

# Disproving initial assumption

- Earlier assumption about the presence of “seeing” concept in apes is reconciled with the general conclusion as follows:
- Chimps putting buckets over their heads have merely “place a bucket over their heads because it produces an interesting, pleasurable experience”.
- Conclusion: this does not necessarily imply that they have discovered the concept of seeing by obstructing their vision.

# Critique

- Allen argues, that “Povinelli’s chimps” differ from chimps in the wild in the fact that they lack a social experience in the natural setting
- Such a claim has place in the case of tool use, which occurs in chimpanzees’ natural life cycle
- With respect to “seeing experiments”, Povinelli’s chimps even had an advantage, because from their infant years they were exposed to the significant interactions with human beings, in which gaze plays an important role.

# Experiments by Santos et. Al

- Santos et al. show on a similar set of experiments that rhesus monkeys:
  - have more reliable eye-detection
  - eye detection has more weight over head detection and body tracking.

# Experiments by Hare et al.

- Experiments by Hare have confirmed the screen results obtained by Povinelli
- Chimps can discern the spatial location of the barrier in relation to the conspecifics' gaze.
- Note: some chimps were non-lab animals.



# Conclusions

- Primates do detect *gaze*
- *Visual attention* concept was not convincingly demonstrated in the reviewed work.
- Smooth gradation of skills in different species in terms of gaze detection was established.
- In order to prove that primates have the “theory of seeing” one has to consider, perhaps, experimentation to reveal more complex concepts that can be constructed based on seeing, e.g. guilt.
- Such an experiment is not likely due to the absence of language to express abstract concepts in animals