Gaze interaction

Corso di Interazione uomo-macchina II

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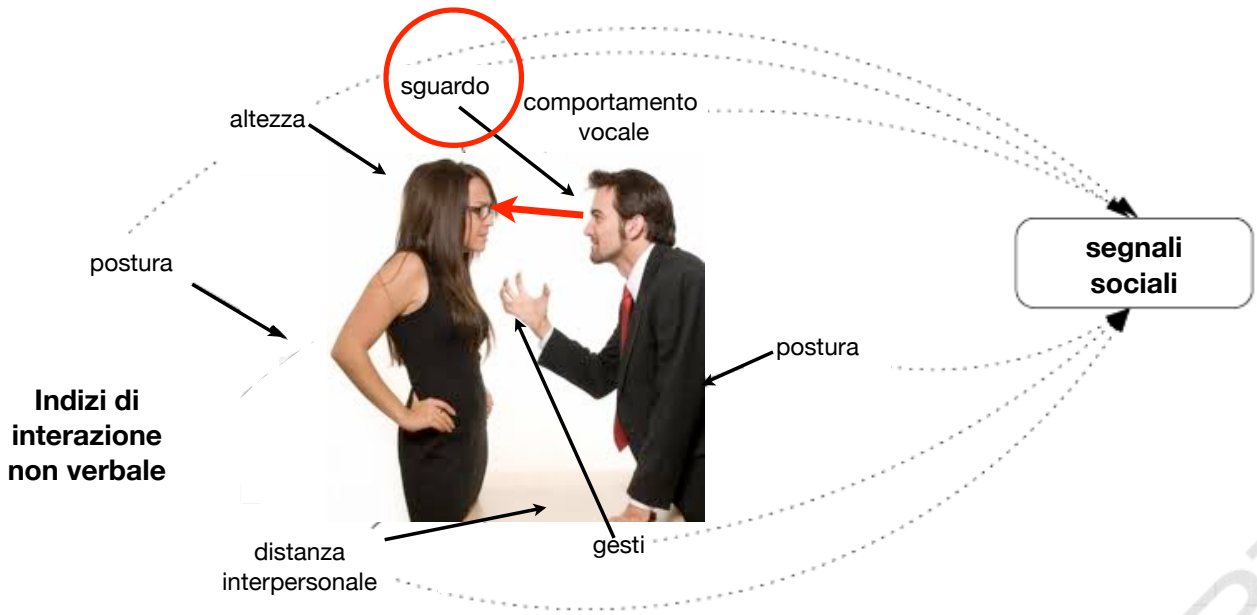
Gaze interaction



Gaze interaction

	Example Social Behaviours							Tech.		
Social Cues	emotion	personality	status	dominance	persuasion	regulation	rapport	speech anlysis	computer vision	biometry
Physical appearance										
height			√	√					√	√
attractiveness		√	√	√	√		√		√	√
body shape		√		√					√	√
Gesture and posture										
hand gestures	√	√			√	√	√		√	√
posture	√	√	√	√	√	√	√		√	√
walking		√	√	√					√	√
Face and eyes behaviour										
facial expressions	√	√	√	√	√	√	√		√	√
gaze behaviour	√	√	√	√	√	√	√		√	
focus of attention	√	√	√	√	√	√	√		√	
Vocal behaviour										
prosody	√	√		√	√		√	√		
turn taking	√	√	√	√		√	√	√		
vocal outbursts	√	√		√	√	√	√	√		
silence	√		√				√	√		
Space and Environment										
distance	√	√	√		√		√		√	
seating arrangement				√	√		√		√	

A. Vinciarelli, M. Pantic, H. Bourlard,
Social Signal Processing: Survey of an Emerging Domain,
Image and Vision Computing (2008)

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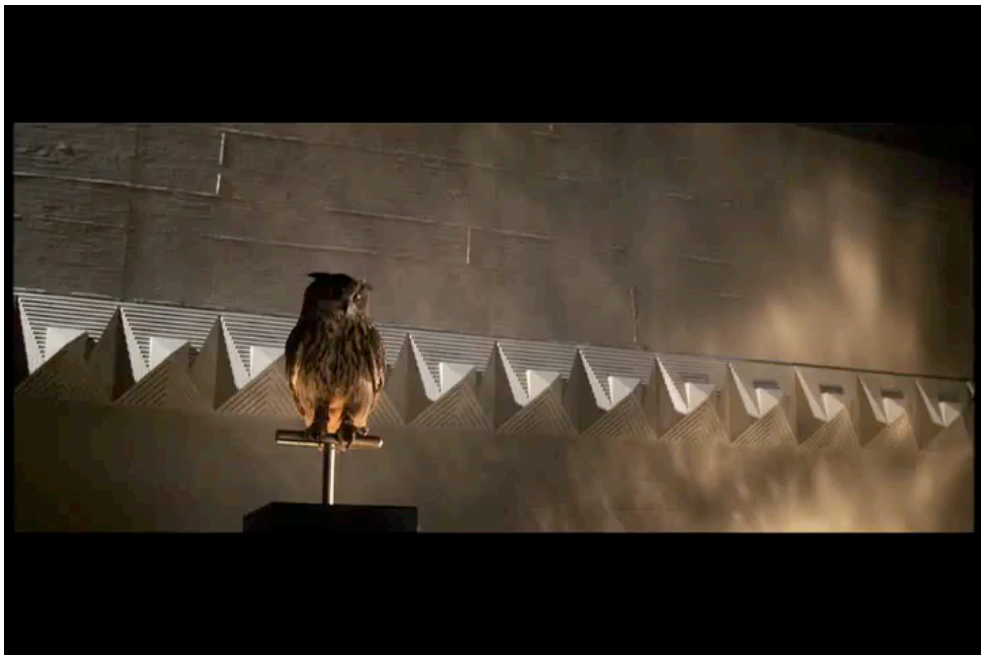

Gaze interaction

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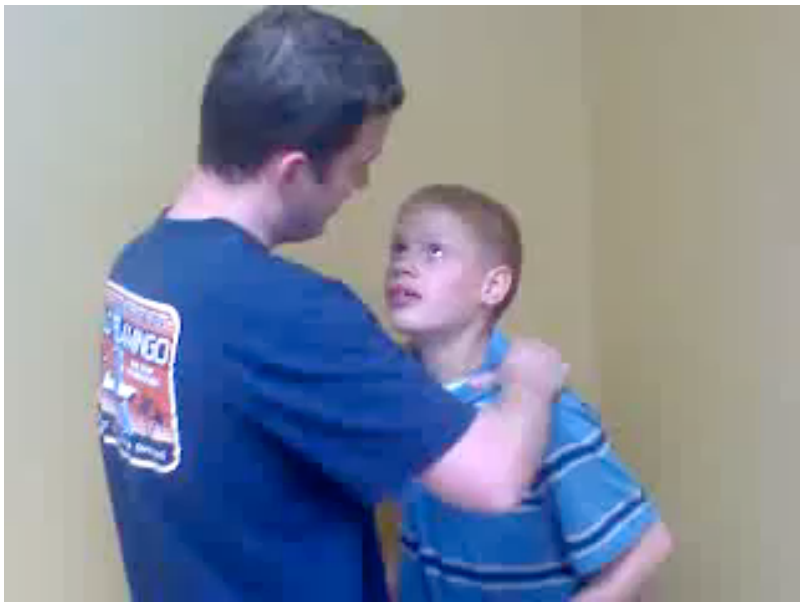
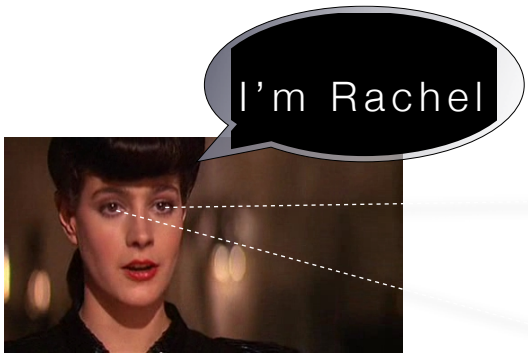


Gaze interaction

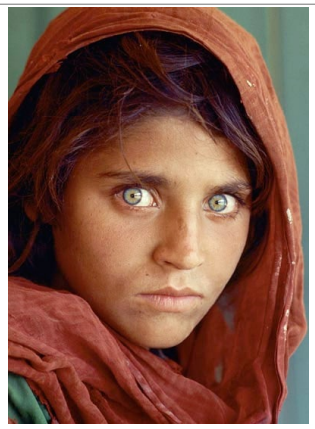
Situated action



Social interaction

Importance of the Eyes

- Eyes play an important role in social interaction
- Looking is noticeable
  - Social hierarchies and attention structure for cohesion



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Importance of the Eyes

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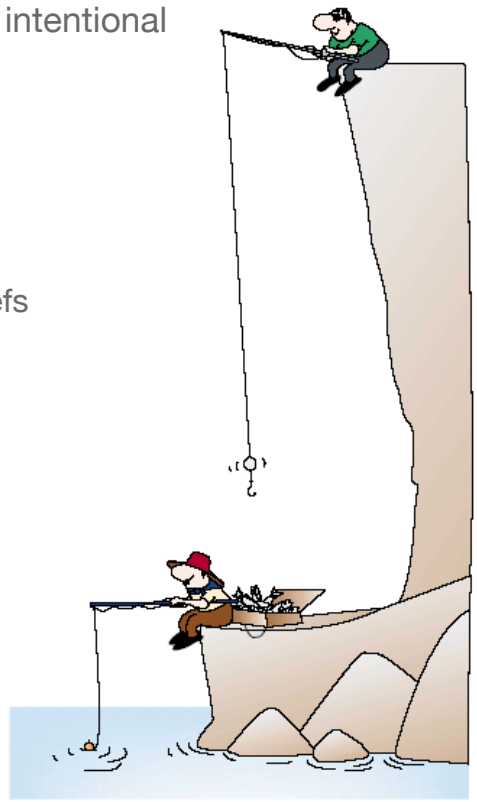
- Psychological Arousal
  - Aggressive cue
    - Threatening displays in many non-human primates
    - Dominance
  - Affiliative cue
    - Youngsters who can secure eye contact …
    - Gain attention of their parent
    - Being fed or having other needs satisfied

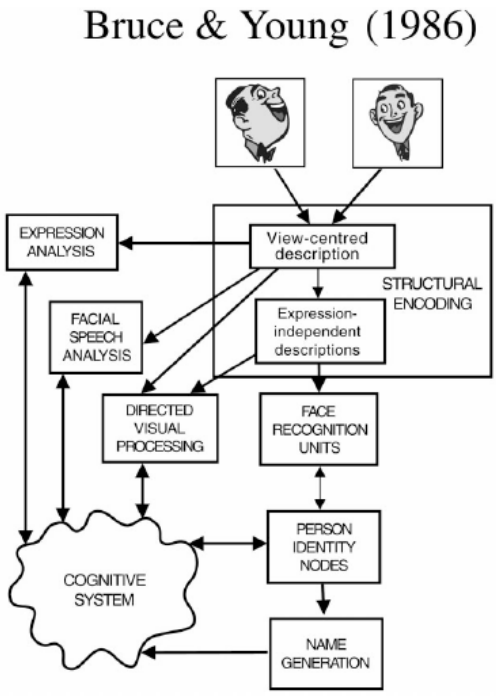
An important step for the Theory of Mind (TOM)

- Specific cognitive ability to understand others as intentional agents
  - Interpret their behaviour
  - Attribute mental states
  - Form theories of their intentions, desires and beliefs
  - Allows prediction



Importance of Gaze

- Face communicates an impressive amount of visual information. We use it to identify its owner, how they are feeling and to help us understand what they are saying.
- Bruce and Young:
  - identity
  - expression
  - facial speech
- are extracted in parallel by functionally independent processing systems, a suggestion for which there is now converging empirical support



Importance of Gaze

- Models of face processing have considered how we extract such meaning from the face but have ignored another important signal – eye gaze
- Gaze – has been widely studied by social psychologists who have long known that it is used in functions such as the regulation of turn-taking in conversation, expressing intimacy, and exercising social control
- Interest in the perceptual and cognitive processes underlying the analysis of gaze and gaze direction has only emerged in recent years, particularly stimulated, perhaps, by the work of Perrett et al and Baron-Cohen et al.

Baron-Cohen (1994)

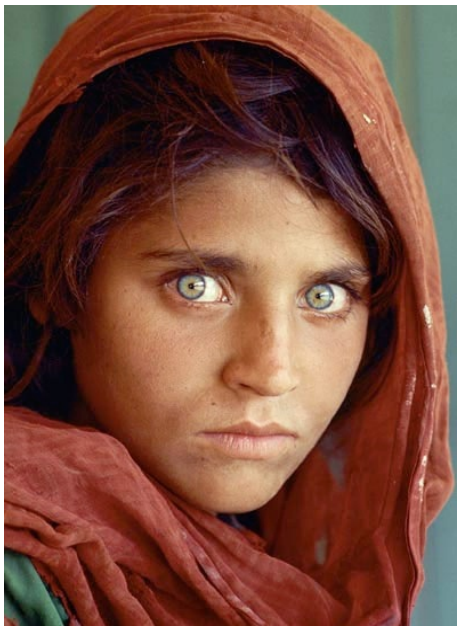
- Eye Direction and Intentionality Detectors
- Theory of Mind Module

Perrett and Emery (1994)

- Direction of Attention Detector
- Mutual Attention Mechanism

The perception and detection of gaze

- Humans and many other species tend to look at things in their environment that are of immediate interest to them
  - You might be the recipient of another's gaze, for instance, because you are a potential meal, a mate or simply because you are someone with whom they would like to interact
- Individuals who are able to detect rapidly when they are the object of another's attention, and who can analyse exactly where another's gaze is directed therefore have considerable **adaptive advantage**



The perception and detection of gaze

- How might evolution have equipped us to deal with this problem?
  - may have evolved dedicated brain mechanisms for recovering the relevant information from another's eyes early in visual processing

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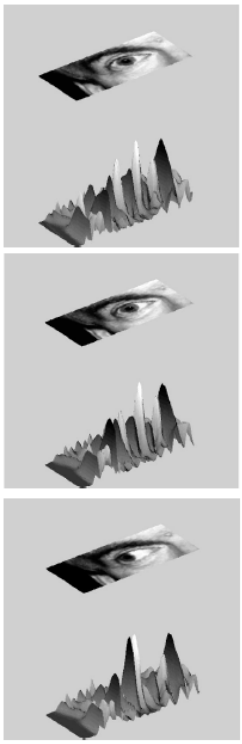
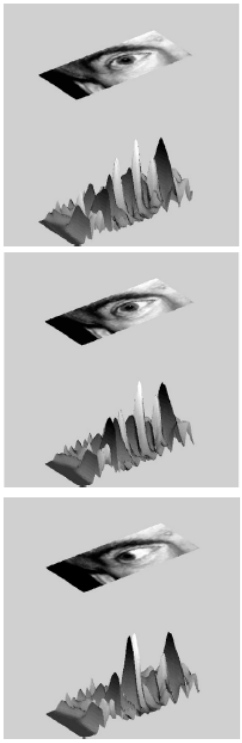
  - may have evolved dedicated brain mechanisms for recovering the relevant information from another's eyes early in visual processing
  - the physical structure of the eye may have evolved in such a way that eye direction is particularly easy for our visual systems to perceive



The perception and detection of gaze

- How might evolution have equipped us to deal with this problem?
  - The response of cortical simple cells to eye direction.
    - When the eye is looking straight ahead (left), the outputs of the cells responding to the area of sclera on either side of the eye are roughly equivalent (the two highest white peaks shown in the image below the eye).
    - As the eye begins to turn (centre and right), the area of sclera to the right of the iris increases relative to the area to the left of the iris. The relative strength of the cells' outputs corresponds to this change. This can be seen as one of the white peaks increases in height relative to the other as the eye turns.



The perception and detection of gaze

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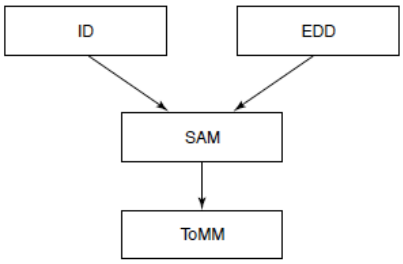
  - may have evolved dedicated brain mechanisms for recovering the relevant information from another's eyes early in visual processing
  - the physical structure of the eye may have evolved in such a way that eye direction is particularly easy for our visual systems to perceive
  - Viewpoints are not necessarily mutually exclusive: the eye might well be a special stimulus and we may have evolved brain mechanisms to perceive it

The perception and detection of gaze //Baron-Cohen model

- Proposed the existence of an eye-direction detector (EDD) in humans, a functionally specialized ‘module’ devoted to the task of detecting eyes, and for computing where eye-gaze is directed in the environment

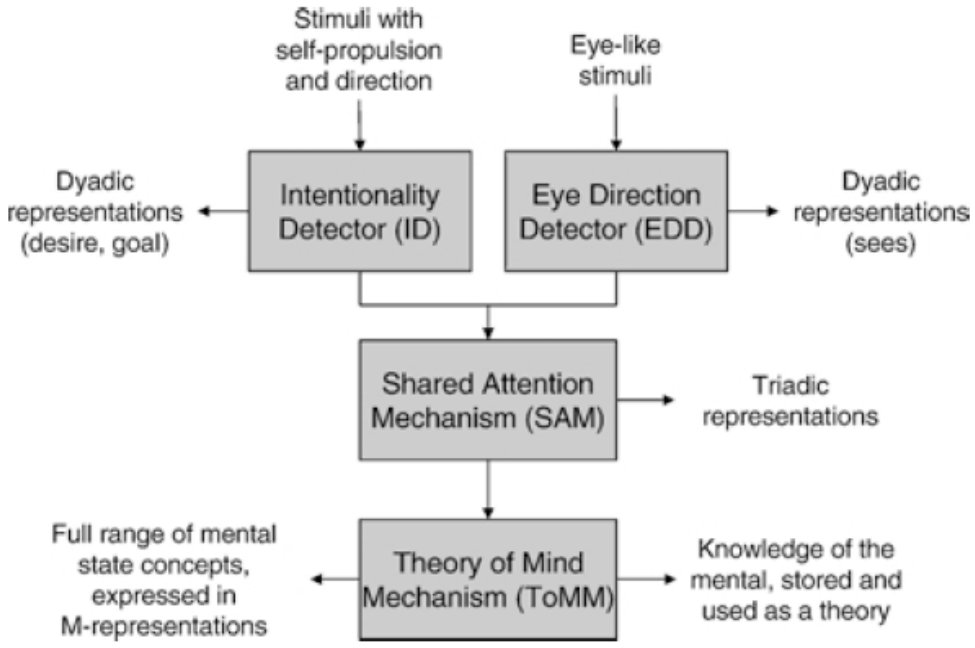
- Four component model

  - the intentionality detector (ID),
  - the eye-directiondetector (EDD),
  - the shared-attention mechanism (SAM),
  - the theory-of-mind mechanism (ToMM).



- Each is considered to be a cognitive ‘module’ sharing many, though not all, of theproperties of modularity described by Fodor work

The perception and detection of gaze //Baron-Cohen model



Evolutionary approach to theory of mind

Intentionality Detector (ID)

- A primitive perceptual mechanism that interprets self-propelled motion stimuli in terms of its desires and goals.
  - it is this mechanism which allows us to infer that a cat chasing a mouse ‘wants’ to eat the mouse
- Represents behaviour in terms of volitional states (goal and desire) Based on visual, auditory and tactile cues
- Attributes *intentionality* characteristic to objects based on the presence of certain cues
  - Goal-desire relationships with objects
- Process dyadic representations

Eye Direction Detector (EDD)

- Three tasks:

  - detects the presence of eyes or eye-like stimuli,
  - computes the direction of gaze based on the position of the iris in the surrounding sclera
  - attributes the mental state of ‘seeing’ to an agent whose eyes are directed towards itself ortowards another object or agent.
- Present in a large number of species
- Process dyadic representations
  - Agent-relation-Self, Agent-relation-Object
  - Agent[1]-relation-Agent[2], Self-relation-Object

Eye Direction Detector (EDD)

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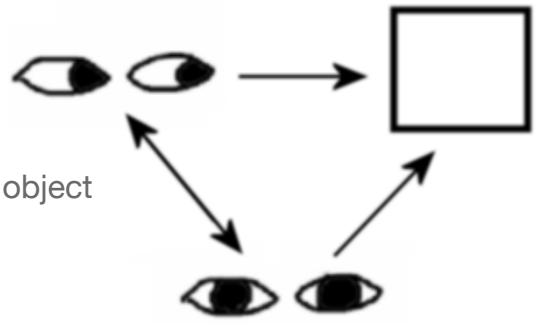
- By the age of about 9 months when the ID and EDD are considered to be fully functioning, an infant is able to
  - read another individual's behaviour in terms of their goals and desires
  - understands that these individuals 'see' the things to which their eyes are directed

Shared Attention Mechanism (SAM)

- What the infant cannot do at this stage is link the two mechanisms: understand that people often look at the things they want or are about to act on
  - achieved by the SAM: fully developed between 9 and 18 months
- Represent if the Self and another agent are attending to the same object or event
- Triadic relationships
  - Agent and self are both attending to same object
  - Self-relation-(Agent-relation-Object)
  - Self-relation-(Agent^1-relation-Agent^2)



- Links ID to EDD
  - Allows eye direction to be read in terms of volitional states

Shared Attention Mechanism (SAM)

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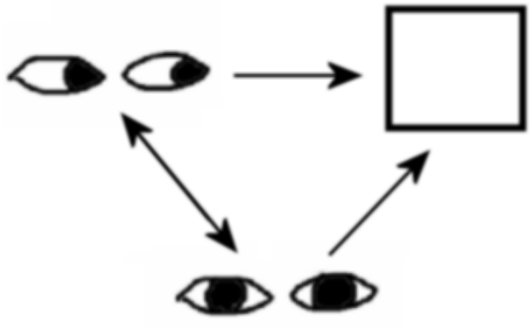
  - achieved by the SAM: fully developed between 9 and 18 months
- 'meeting of minds': the recognition that you and another are sharing the same mental state
  - that of 'attending to', 'seeing', 'wanting'
  - the state of having a particular goal



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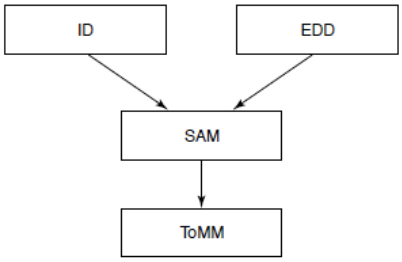
Theory of Mind Mechanism (ToMM)

- Represent the full range of mental states including the epistemic ones
  - triggered by SAM between 18 and 48 months
- two major functions:
  - infer the full range of mental states from observable behaviour. These include pretending, thinking, knowing, believing, imagining, and deceiving.
  - integrate this mental state knowledge into a useable theory which the child or adult can use to explain and predict other's behaviour.
- Allow one to:
  - Make sense of an agents current behaviour
  - Predict an agents future action
- *Interpretation* of behaviour in mentalistic ways

The perception and detection of gaze //Baron-Cohen model: evidence

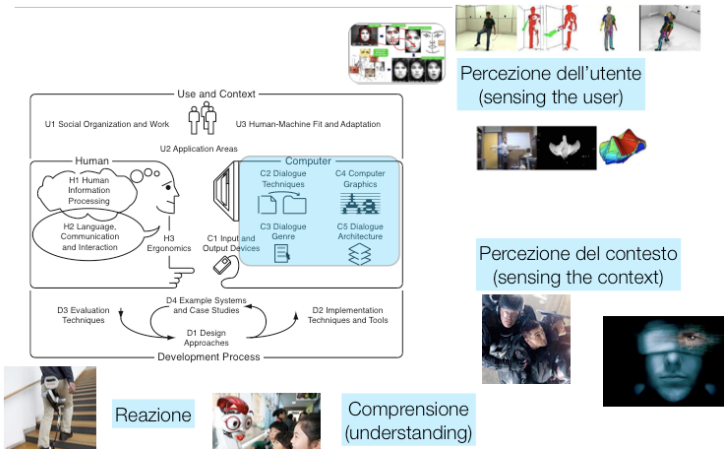
- Modules are *special purpose computational systems* in the social brain
- All four modules (ID, EDD, SAM, ToMM) are functioning by 4 years of age in humans
- EDD most basic and found in many vertebrates as a sensitivity to predators looking at the animal
- ID appears to be present in many primates
- SAM only partially in great apes
- Much less evidence for ToMM outside of humans



- Gaze cues do therefore seem to be processed obligatorily and cause viewers' attention to be shifted towards the cued region. This has the effect of facilitating the processing of any target that subsequently appears in that location, and also primes an infant's eye-movement response in that direction, although the mechanism for this is not know

The perception and detection of gaze //Baron-Cohen model: usability

- Information processing approach
- Modular
- Emphasis on the eyes and direction of attention of the agent
  - Special relationship between EDD and SAM
  - Triadic representations built more easily in the visual modality
  - When the goal of an action is uncertain, first place young children and adults look for information to disambiguate the goal is the eyes



The importance of other cues

- Where someone is perceived as directing their attention might depend, not only on the direction of eye gaze, but on the orientation of their head, the posture of the body and other gestures, such as where they are pointing their finger.
    - It has been suggested that these cues are all processed automatically by observers and all make contributions to decisions about another individual's social attention

The importance of other cues

- As long ago as 1824, William Wollaston noted that judgements of gaze direction are not based solely on the position of the iris and pupil relative to the whites of the eyes.
- Face (b) seems to be gazing directly at the viewer
- Face (a) appears to be looking slightly to the viewer's right.

(a) (b)

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- Face (b) seems to be gazing directly at the viewer
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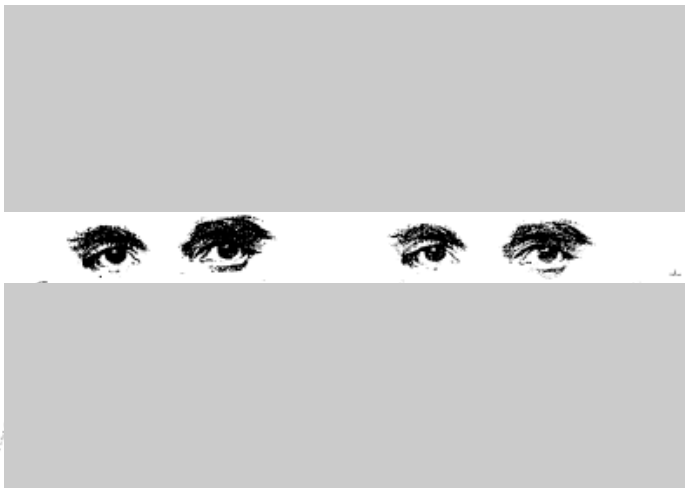
- By covering the lower and upper parts of each face you can see that the eye regions of both are, in fact, identical.



(a) (b)

The importance of other cues

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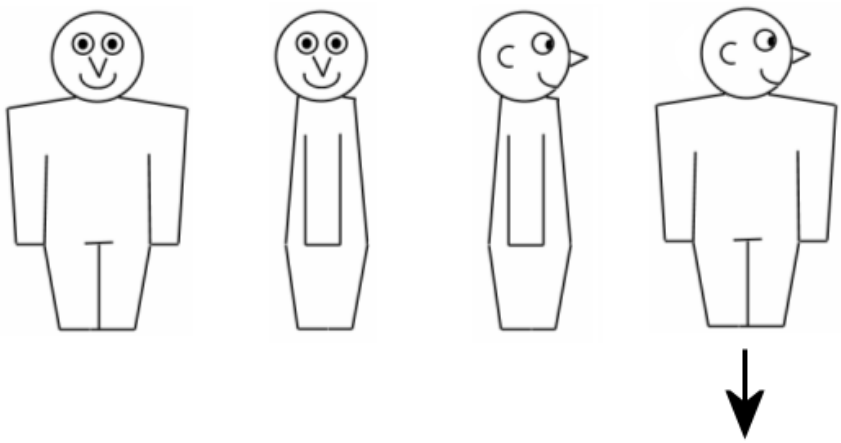
- Perception of gaze: based on some combination of information extracted from the eyes and information extracted from the orientation of the head
- Later stages of information processing: the computation of where another individual is directing their attention depends on a number of other social cues.
- Certain cells in the macaque temporal cortex respond strongly to particular gaze orientations.
  - Same cells: found to be sensitive to conjunctions of eye, head and body position,
    - all of these cues might contribute to the processing of attention direction
  - Perrett and his colleagues have suggested how these cues might contribute to the computation of attention direction

The importance of other cues //Perrett and Emery (1994)

- Their single-cell studies have indicated that individual cells in the superior temporal sulcus (STS) region of the macaque temporal lobe are sensitive to conjunctions of eye, head and body position
- More general Direction of Attention Detector (DAD)
  - Eye, head, body and locomotion direction



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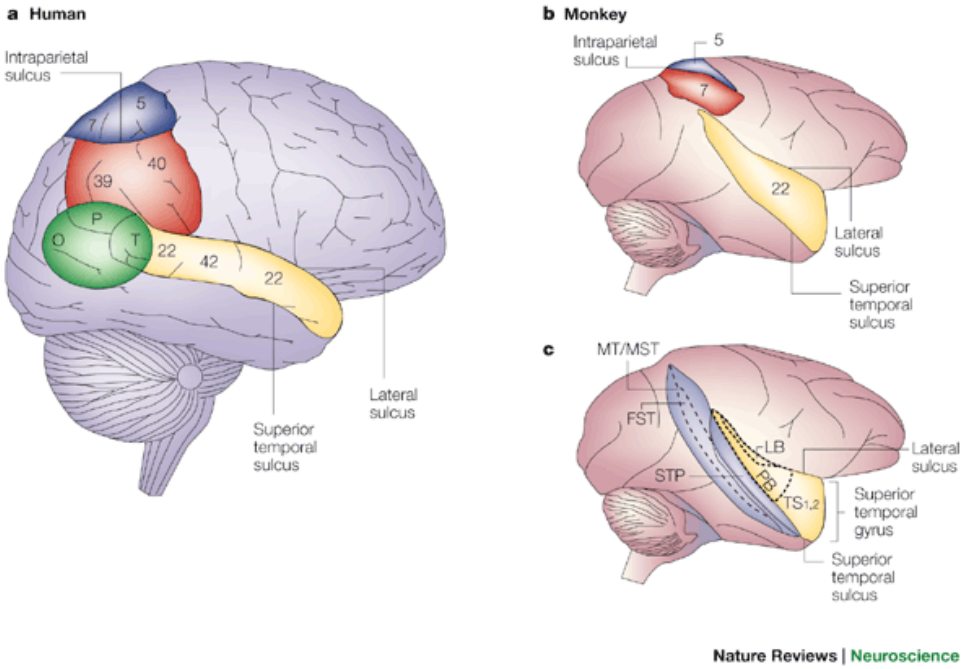

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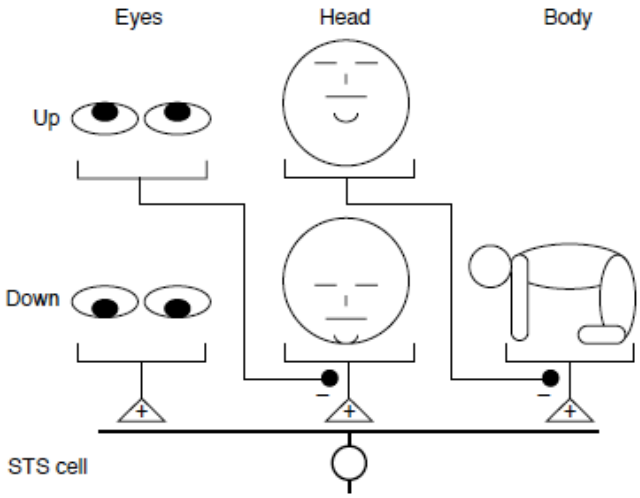
    - DAD is organized such that information from the eyes will override any information provided by the head, and in turn, information provided by the head can override directional signals from the body



A schematic representation of the connections and visual input to an STS cell (open circle) that signals that another's attention is directed downwards.

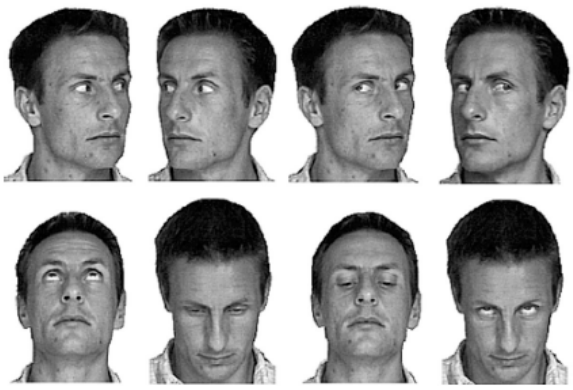
The cell receives excitatory connections (triangles) from cells selective for the appearance of eyes, head and body directed downwards.

Should the gaze be directed upwards, inhibitory connections (filled circles) prevent any response to the downward directed head and body cues

The importance of other cues //Perrett and Emery (1994)

- Social attention can also be computed under a variety of viewing conditions.
    - For instance, if the face is viewed at a distance, or if the eyes are obscured by shadow, the system defaults to signalling the direction of attention from the orientation of the head,or if this too is obscured, from the orientation of the body
- Recent evidence (Langton) suggests that information from the orientation of the head is not completely suppressed when it conflicts with the line of regard of the eyes.
    - rather than providing a blocking inhibition, information from the eyes may well simply attenuate the output of the head orientation detector.
    - This would ensure that head orientation contributes some information to the computation of attention direction even when the head angle conflicts with the direction of gaze

The importance of other cues //Perrett and Emery (1994)



In one study, participants were shown the stimuli illustrated i, one at a time on a computer screen, and (in one block of trials) they were asked to press a button on a keyboard contingent on the direction of the eye gaze. Although participants were asked to ignore the orientation of the head, the results indicated that they were unable to do so.

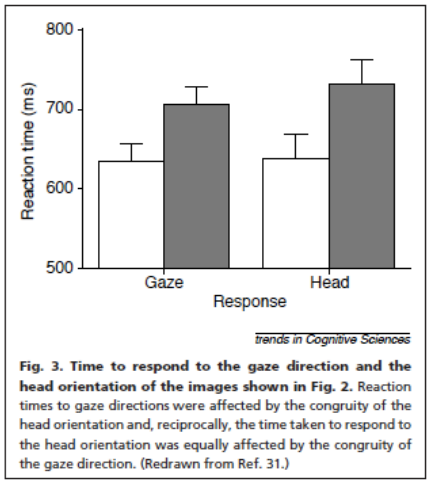


Fig. 3. Time to respond to the gaze direction and the head orientation of the images shown in Fig. 2. Reaction times to gaze directions were affected by the congruity of the head orientation and, reciprocally, the time taken to respond to the head orientation was equally affected by the congruity of the gaze direction. (Redrawn from Ref. 31.)

Reaction times (RTs) were faster when the eye-gaze and head were oriented in the same direction than when they were oriented in opposite directions

Langton, S.R.H. The mutual influence of gaze and head orientation in the analysis of social attention direction. *Q. J. Exp. Psychol.*

Developmental studies

- Baron-Cohen contends that eyes form a particularly salient feature for the developing infant.
  - A number of studies with young children have shown that secondary cues, such as head orientation and pointing gestures, might provide more salient signals to the direction of another's attention than eye-gaze direction alone.
- Experiments have shown that infants as young as 3–6 months are able to follow a combination of head and eye cues, but it is not until 14–18 months that they show any indication of following eye cues alone
  - Prior to 14–18 months it seems as though children actually ignore the orientation of the eyes and simply use the position of the head as an attention-following cue
  - A recent study by Hood et al. has suggested that adult gaze cues might trigger shifts of visual attention in infants as young as three months

Developmental studies

- What is not clear from many gaze-following studies is whether or not the child actually understands the mental experience of their mother
    - Can the child who follows their mother's gaze to a target object actually represent the fact that the mother 'sees' that particular object, or is the behaviour simply an example of the kind of reflexive attentional orienting mechanism?
        - It is not until around 4 years of age that children are able to infer the mental state of 'seeing' from another's gaze direction
- In summary:
    - children are able to follow an adult's head cues and use information from the orientation of the head to select which object is being looked at before they are able to perform these tasks on the basis of eye direction alone.
    - although sensitive to gaze from an early age, young children are most influenced by information from other individuals' gestures and head orientation in order to engage in joint visual attention and gather information about the world

The perception of gaze by non-human primates

- Comparative research with non-human primates also suggests that the orientation of the head might provide a stronger cue to another individual's attentional direction than eye-gaze alone

- Capuchin monkeys failed to orient spontaneously to eye, head or pointing cues of the experimenter in gaze-following experiments similar to those used with human infants, but were able to follow eye-plus-head cues of another individual of the same species
- There is evidence that chimpanzees are able to make use of eye-gaze cues in in the same task

The perception of gaze by non-human primates

- In general then, it seems that, at least for monkeys, turns of the head are more important cues than movements of the eyes alone.
- This conclusion is perhaps not all that surprising given what we now know about the external morphology of primate eyes
- We humans may have evolved eyes with a greater contrast between iris and sclera precisely because the risk of predation is minimal, and the benefits of an enhanced gaze signal in terms of communication and cooperation far outweigh the cost of an inability to deceive

Conclusion

- Baron-Cohen and Perrett:
  - proposed somewhat different models, but in both, the detection of eye-gaze and gaze direction plays a pivotal role
  - Such cues cannot be ignored even when they are irrelevant to the task in hand, and can create reflexive shifts in visual attention
- Experimental work with adults, children and non-human primates has suggested that the orientation of the head makes a larger contribution tothe processing of another's direction of attention than these models allow

We should think about new models