

Core Knowledge

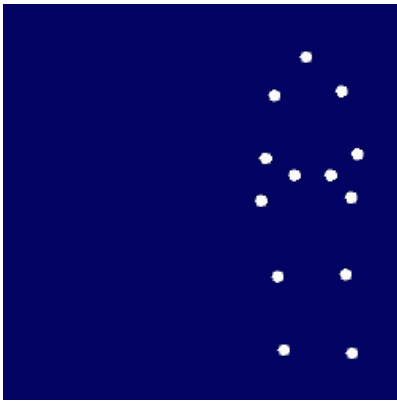


Biological motion

1. The biological motion

- it is a semi-rigid pattern of movement
- it canalizes the attention toward the most probably interesting stimuli
- it is part of the mechanisms that support the perception of basic social signals
- it seems to be compromised in infants with autistic syndrome

Biological motion – Johansson, 1973

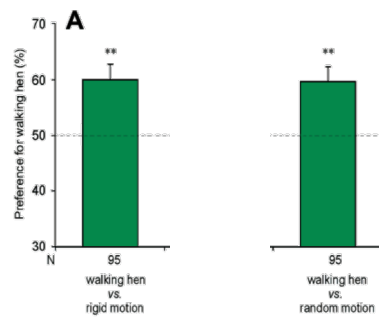


- in 200 ms we recognise the movement of a human body
- in 400 ms the peculiar activity in which he/she is engaged
- we discriminate the gender, the emotional state, the degree of familiarity, the weight that is lifted up and several complex motor acts
- different animal species

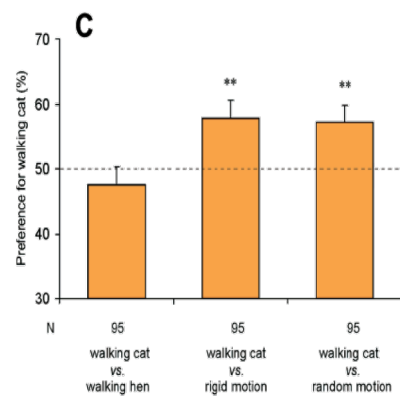
Biological motion

- It is so automatic
 - that we can expect it to be an innate mechanism (as Johansson hypothesized)
- domestic chicks are the most suitable animal model to investigate this issue, «God's organisms» [Rose, 2000]
 - precocial
 - rapid sensory-motor development
 - tested immediately after hatching in the absence of previous visual experience

Biological motion



Biological motion





Biological motion

- There seems to exist a spontaneous preference for the patterns of biological motion of a vertebrate
 - this is a **first mechanism** to direct attention toward the most appropriate class of objects
 - very likely they will be the mum or at least the conspecifics
 - such preference seems to be extended to the general movement, common to other vertebrates (raw mechanism)
- a **second mechanism** would make the learning possible – of peculiar features of a specific object



Biological motion

- infants show a preference for biological motion at about 4–6 months of age
- you could argue that, at that age, they could have had already massive experience of such kind of motion

Biological motion

A predisposition for biological motion in the newborn baby

Francesca Simion^{1*}, Lucia Regolin², and Hermann Bulth¹

¹Dipartimento di Psicologia dello Sviluppo e della Socializzazione and ²Dipartimento di Psicologia Generale, Università di Padova, Via Venezia 8, 35131 Padova, Italy

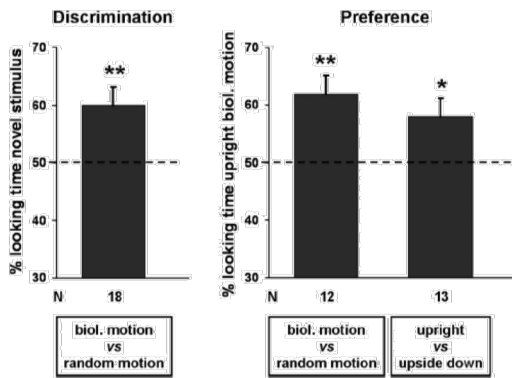
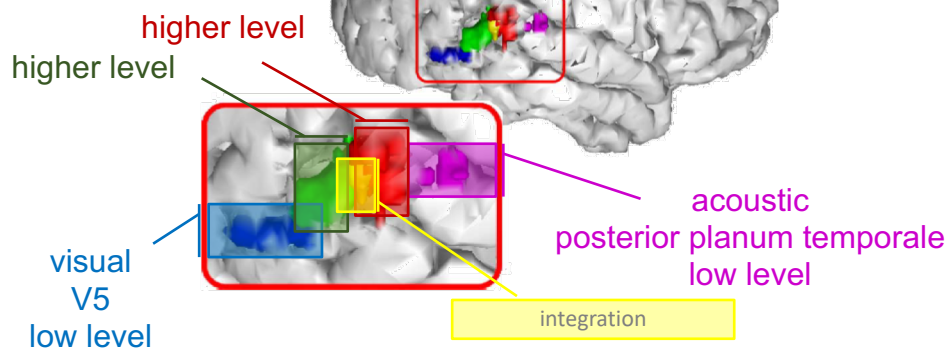


Fig. 2. Results of the three experiments, expressed as the percentage of time (mean ± SEM) spent looking at the biological motion stimulus. Dashed lines indicate chance level. *, $P < 0.05$; **, $P < 0.01$.

- we can test infants immediately after birth (max within the first 48h)
- by using the very same stimuli adopted with chicks (hence not species-specific)
 - infants prefer to attend biological motion stimuli, even if there is a walking hen and not a walking human-being

Agents

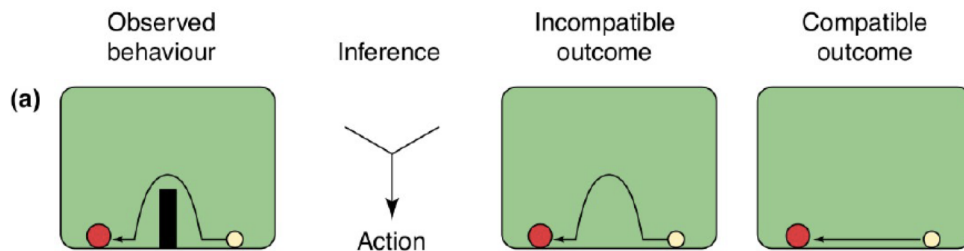


Animacy

2. Animacy

Spontaneous motion (endogenous)

- It does not require that the stimuli resemble organisms or show parts of an organism (like a leg or a face) in order to obtain such impression of **psychological causality**
 - The causality depends only on spatial-temporal features specific of the kinematics of the event



Animacy

- The perceived causality depends uniquely on spatial and temporal variables of the event kinematics
- There is a sort of hypersensitivity to intentional signals, especially for those conveyed by movement
 - Changes in direction (especially in front of another object) => intentional agency
 - Changes in speed (especially the acceleration)
 - Self-propulsion
 - Arrest + motion



Faces

There is a further hyperactive mechanism:

3. the face-detector



Faces

- In evolutionary terms, the ability to detect, even with just a few essential cues, that in close proximity there is potentially another organism is fundamental
- Being hyperactive, it subserves agent recognition also when the visibility is reduced or when only a limited number of cues are available
- By studying and understanding these universal and basic mechanisms we can explain the reason why people sometimes refer about magical manifestations...

Faces

- Faces are special:
 - Universally important
 - Provide infos about gender, age, health state...
 - and emotions



Primary emotions

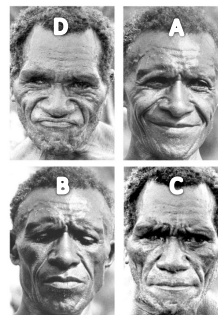
- Ekman & Friesen (1967) asked to the members of a tribal population of Papua New Guinea to show a feeling with the facial mimic
- How would you express

A) The arrival of a friend and you are happy

B) Your baby has died

C) You are angry and ready to fight

D) You see a died pig (long since)





Faces

- Faces are special:
 - Universally important
 - Provide info about gender, age, health state
 - And emotions (whether to initiate a social interaction or not)
- Allow the visual identification of individual conspecifics
- Mouth: understanding of the verbal message
- Eyes: direct the attention toward specific parts of the environment (joint-attention)

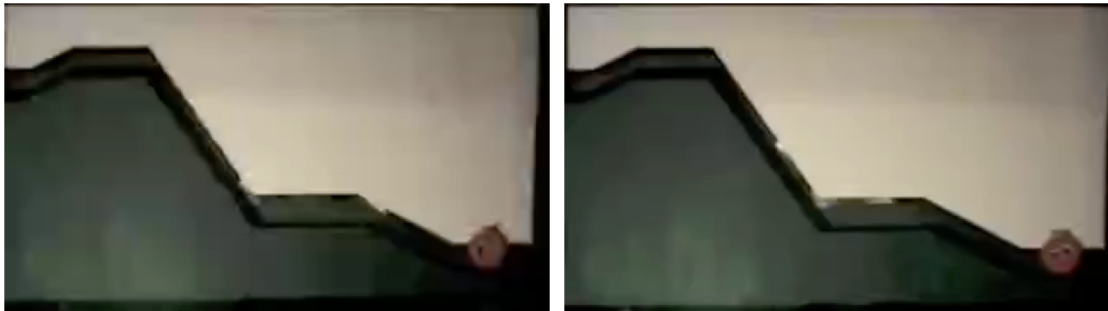


Faces

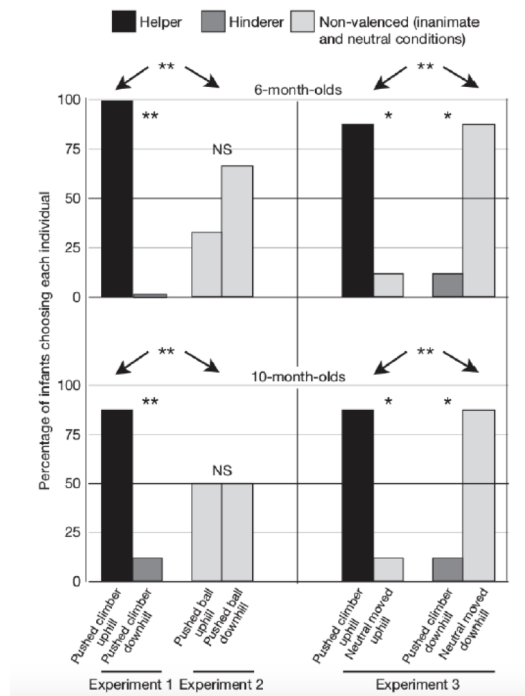


Faces

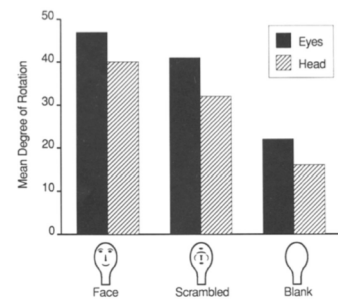
- Agents' actions are efficiently directed toward goals
- Agents interact with other agents, contingently and reciprocally
- Agents need not to have faces/eyes (see Heider & Simmel), but these cues are useful



Faces



Face-like stimuli



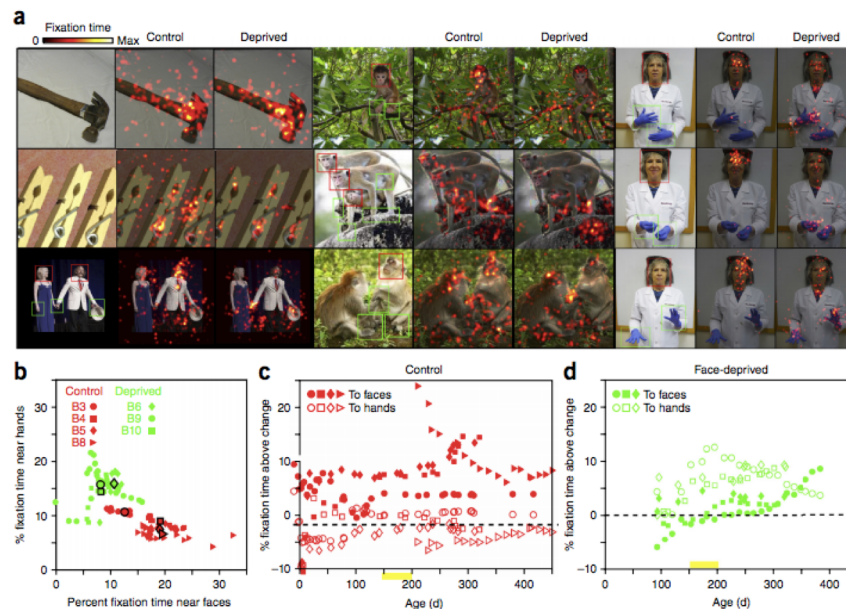
Johnson, Dziurawiec, Ellis, & Morton (1991)

Faces

- According to the core knowledge hypothesis, core systems would be available at birth. This is, of course, difficult to prove in humans. Human newborns are very immature at birth; hence, developmental studies suffer from the unavoidable limitation of a lack of precise control on the effect of early experience.
- Are mechanisms that preferentially orient neonates' attention to human faces inborn? It is virtually impossible to provide a complete absence of face stimulation even in neonates studied a few hours after birth.
- Note, however, that similar limitations are also apparent with altricial non-human species.

Faces

- Two distinct groups of macaques, for a year
 1. Reared by their mother living with other siblings and seeing humans (control)
 2. Cared for by humans with masks and bottle-fed
- At the end of the period, they are maintained in social groups comprising macaques and monkeys
- the fMRI scanning reveals that:
 - Control macaques show areas for the recognition of objects and faces
 - Experimental macaques shows areas for all categories except faces



Arcaro et al., 2017



Faces

- The results show that deprivation has a selective effect on how the brain organizes itself
 - The brain is good at recognising the things an individual often sees and it has a bad performance for things it rarely encodes
 - [...] environmental importance influences viewing behavior, viewing behavior drives neuronal activity, and neuronal activity sculpts domain formation [...]



Faces

- Red light is the most effective in passing through the tissues
- The 3 dots have been arranged in two triangular shapes in order to replicate the original study with newborns
- 39 healthy fetuses in the last trimester have been tested 5 times each
- *“The study doesn’t tell us much about how a fetus naturally develops. The circumstances are very much unlike anything that would happen in the real world. But it’s interesting that these predispositions might be there from earlier on to prepare the infant for birth,”* Mark Johnson

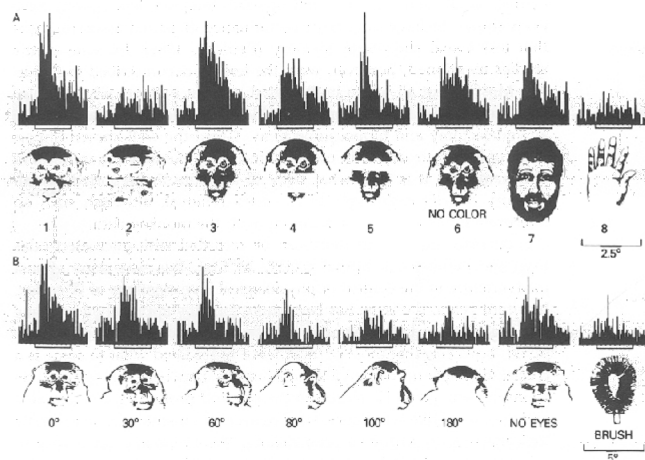
Faces



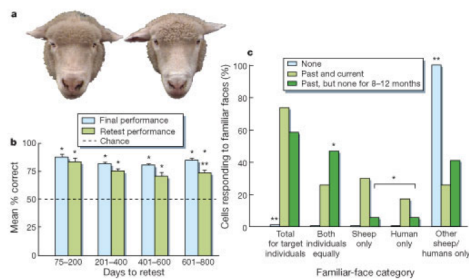
- an unlearned representation (CONSPEC), shared among vertebrates, that directs the animal's attention toward stimuli whose internal features are arranged according to a triangular face-like configuration
- starting from this template, one can encode and memorize specific features of a specific individual

Are faces special? Single-unit recording

- Face cells have been recorded in the macaque brain



Are faces special? Single-unit recording



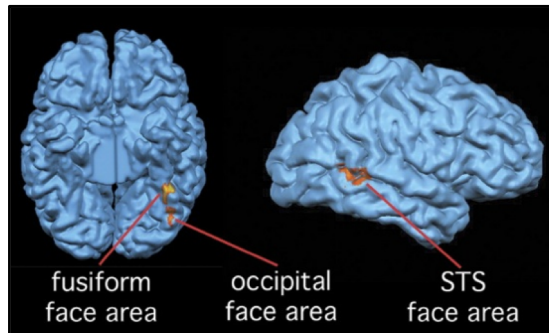
- Sheeps recognize up to 50 different faces of conspecifics
- With the 80% of accuracy
- And remember them for more than 2 years

Are faces special? Single-unit recording

- Face cells have been recorded in the macaque brain as well as in the sheep brain
- Their specificities:
 - for the face of the sheep
 - for the face of the sheep of the same breed
 - for the human face
 - for the direction of the gaze
 - for the rotation of the head
 - there are also horn-sensitive cells



Are faces special? fMRI



- Fusiform gyrus
- Other areas are involved in face processing:
 - Temporal superior sulcus
- The FFA seems to encode invariant features, the STS dynamic features

FFA: faces vs competence

- Whether the FFA is domain specific for the faces, is not yet completely clarified
- One alternative hypothesis concerns the possibility that it is activated whenever the individual has to make a perceptual discrimination between well-known stimuli → **level of competence**
 - Faces vs Flowers
 - We are all face experts, only a few are experts about roses; we see the FFA more often enrolled for faces because they are important for interactions and survival





Agents

- A known network responds selectively to faces with respect to other objects
- We encode familiar and unfamiliar faces differently
 - Very good with pictures, even rotated, of familiar ones
 - Vary bad if faces are unfamiliar
- Landi e Freiwald (2017), with fMRI, measured the cerebral response to macaque conspecifics:
 - personally familiar ones belonging to monkeys that the macaques had lived with for years;
 - visually familiar ones whose pictures they had seen hundreds of times;
 - totally unfamiliar ones
- The same 3 categories were presented also for objects as a control

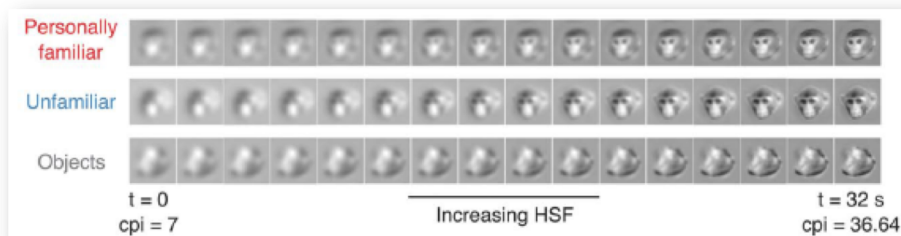


Agents

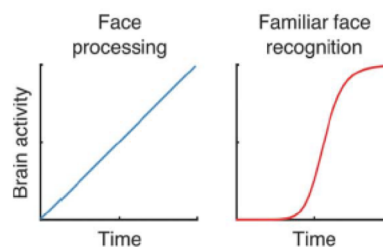
- The idea was that the face-specific network would have responded for categories 1 and 2 and not, or badly, for category 3;
- Conversely, the network activated especially for the 1st
- With a reduction in such activation for the 2nd

Agents

- the faces of animals whom the macaques had known for years prompted the activation of two previously unknown face-selective areas
 - Associated to declarative memories
 - Associated to social aspects (ranking, hierarchy, etc.)
- When presented blurry → to → defined...

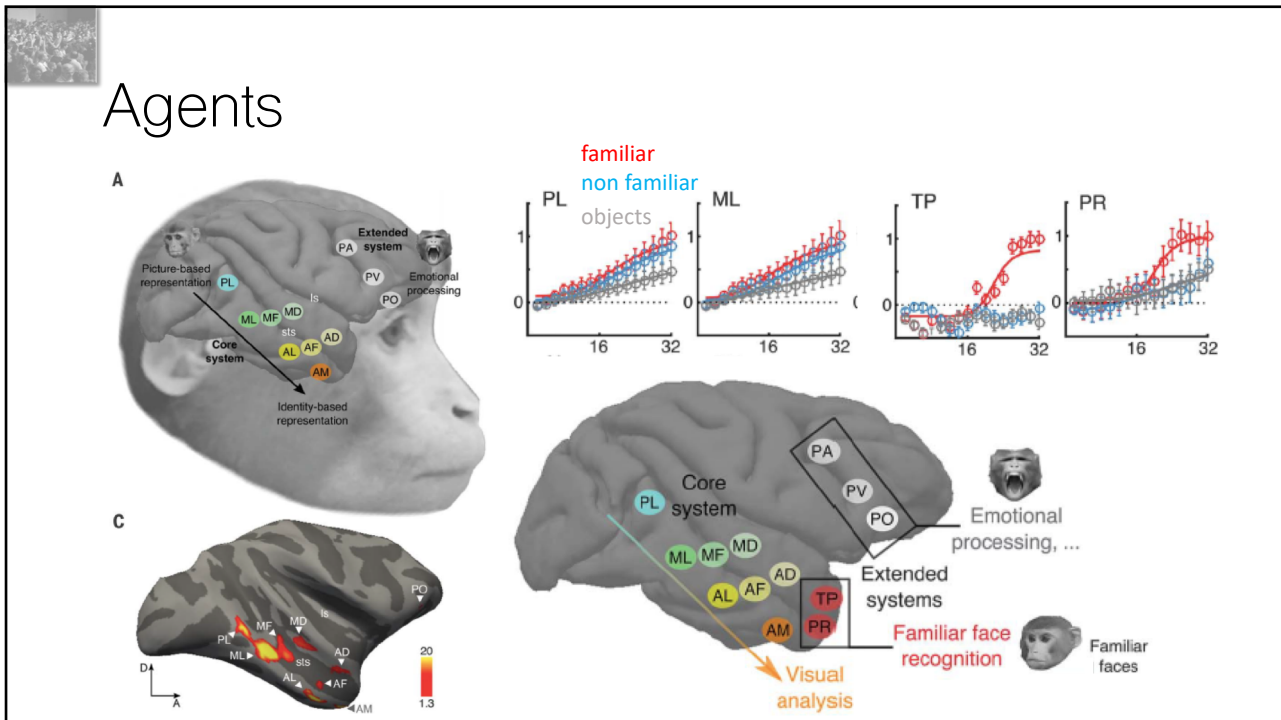


Agents



- When the researchers showed the macaques blurry images of personally familiar faces, which gradually became sharply defined over the course of half a minute or so, the activity of previously known face-processing areas increased steadily over time
- The new areas first showed little or no initial increase in activity, followed by a sudden surge – an all-or-nothing response that evokes "the sudden 'aha' moment" we experience when we recognize a familiar face

Agents

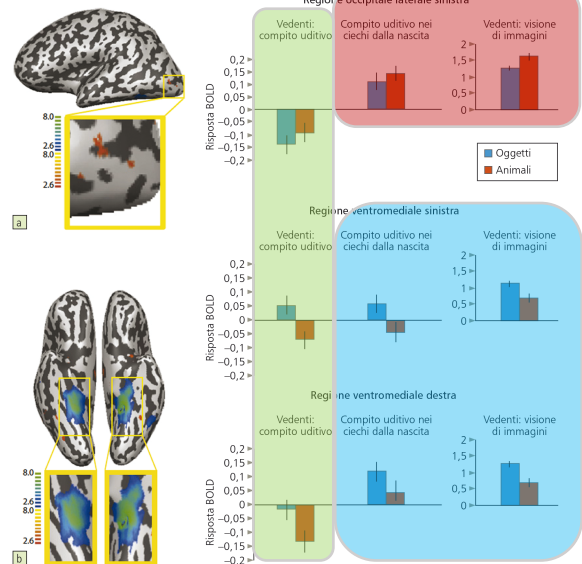


Other areas category-specific

- Other cerebral areas seem to be domain-specific (e.g., PPA), but the question is whether the organization of the visual pathways for the processing of specific categories depends on experience or rather this is an intrinsic property of the system
 - Between agents and physical objects there are different cerebral specializations:
 - AGENTS – medial regions of the ventral pathway (medial fusiform gyrus, paraippocampal cortex)
 - OBJECTS – lateral regions of the ventral pathway (lateral fusiform gyrus, inferior temporal gyrus)

Other areas category-specific

- Congenital blindness people are an optimal model study:
 - If the specialization is not experience-dependent, we should find the same organization found in control people
- Visual experience is not necessary
- To discriminate between objects and agents is a more fundamental ability

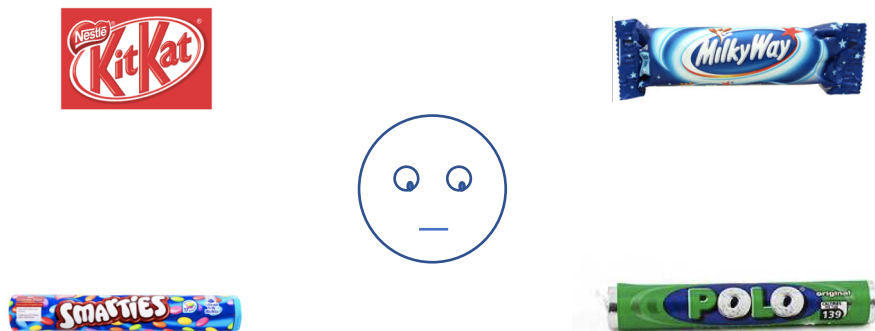


Atypical development

- Those that we have just seen are behaviors that unfortunately show deficits in infants with an atypical development, as for instance in the case of autistic spectrum disorder
 - These children show deficit in social interactions that are often compromised because
 - There is insufficient eye-contact
 - They hardly understand the facial expressions
 - They are unable to follow the gaze by others

Gaze – autism

- Baron-Cohen et al. 1995, the four-sweets task
 - What will Charlie go for?



Reading the mind in the eyes

- the *reading the mind in the eyes* is a test in which adults identify a complex mental state from the eyes only: «relaxed» or «sarcastic» [Baron-Cohen et al., 2001]



a preliminary attribution of a mental state

Who's Afraid of Virginia Woolf ?

- A beautiful movie, 1966
- There are complex dynamics and interactions between the 4 people and we try to understand the emotional reactions in the eyes/on the faces of the other non-speaking character

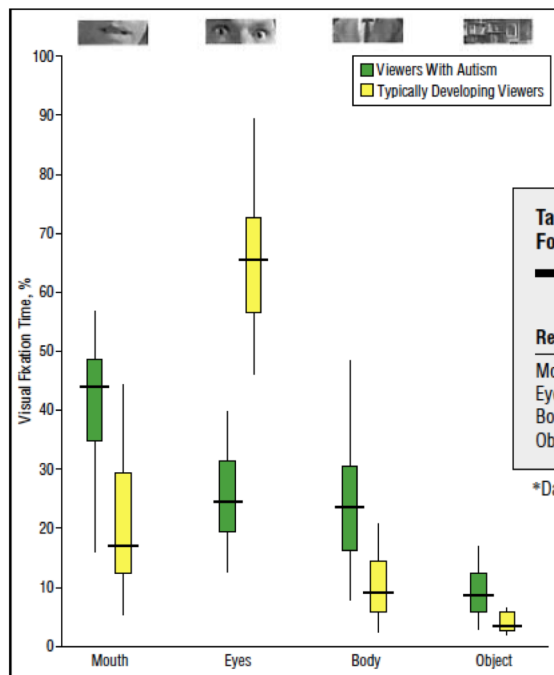
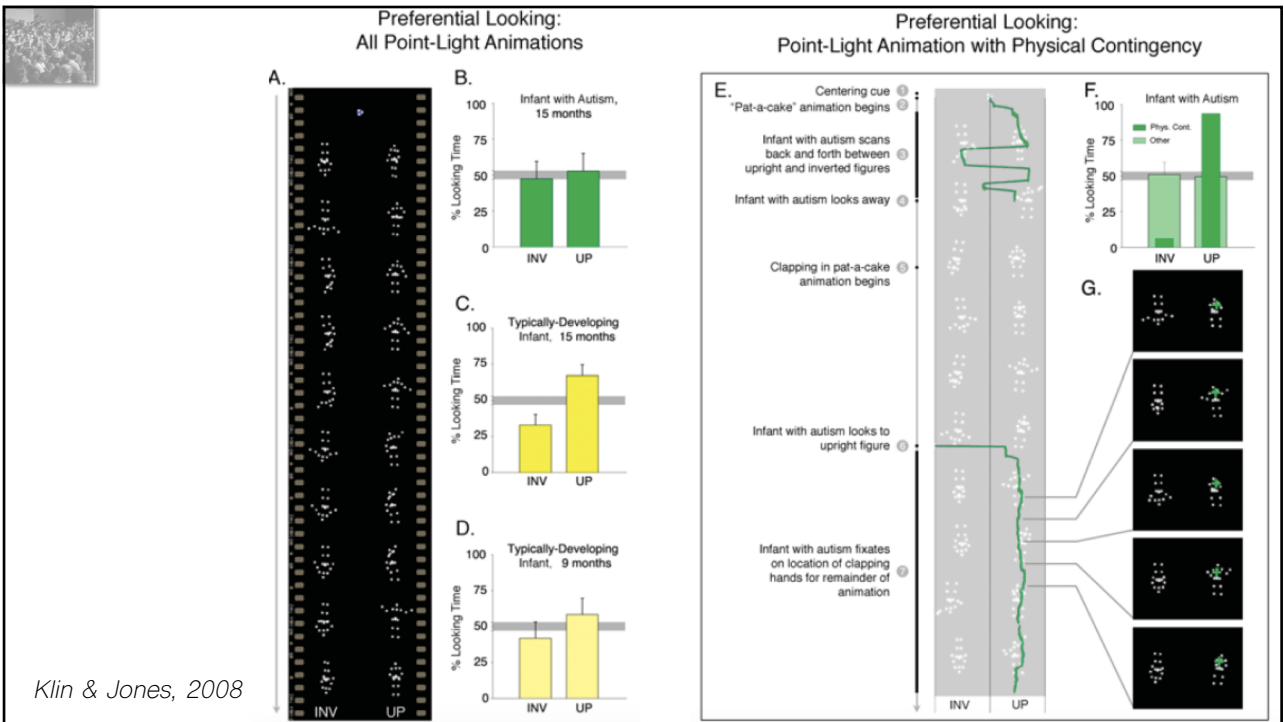
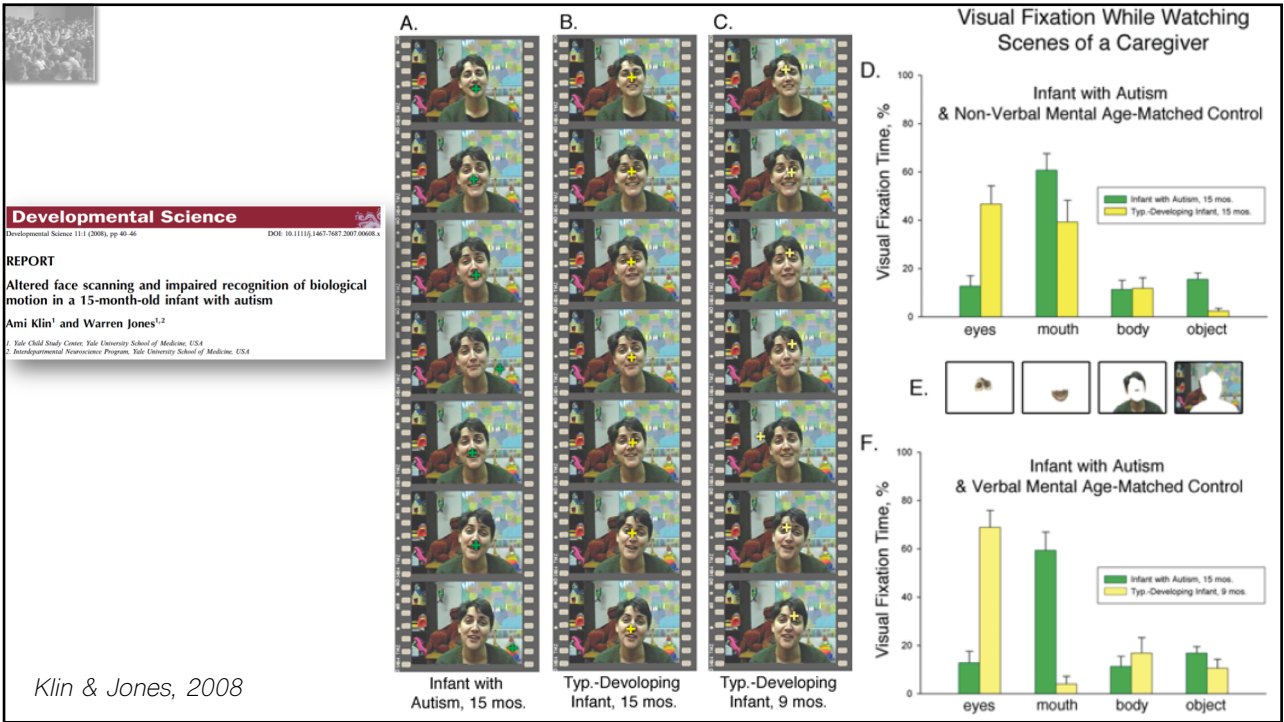


Table 2. Percentage of Viewing Time Spent Focused on Mouth, Eyes, Body, and Object Regions*

| Region | Autism Group (n = 15) | Control Group (n = 15) | t Value | P Value |
|--------|-----------------------|------------------------|---------|---------|
| Mouth | 41.2 (15.0) | 21.2 (12.1) | 4.026 | <.001 |
| Eyes | 24.6 (8.1) | 65.4 (12.8) | -10.455 | <.001 |
| Body | 24.6 (12.4) | 9.7 (5.7) | 4.226 | <.001 |
| Object | 9.6 (6.5) | 3.7 (2.4) | 3.286 | <.003 |

*Data are given as mean (SD).

Klin et al., 2002





Eye movements – autism

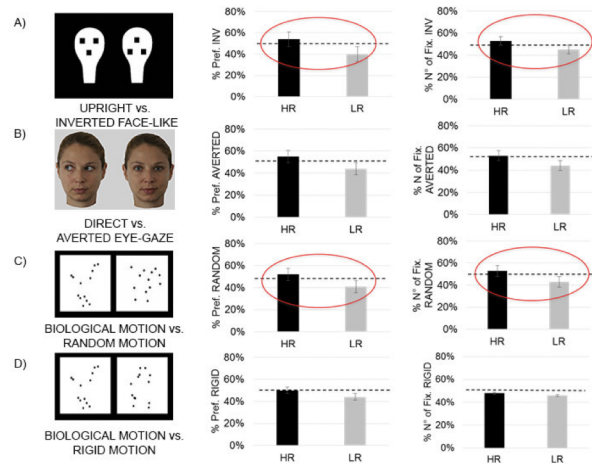
- Within a face, while speaking, the point in which there is the higher audio-visual contingency is the mouth (lip motion and speech sounds) as in the clapping of the hands of the previous movie
- Less attention to the eyes which are the most significant part
- By 2 years, they seem already on a different developmental trajectory: they have already learnt that the coincidence of light and sounds is more salient than other social info
- Eye fixation correlates with the level of social disability
 - The lesser the eye fixation, the higher the disability (Jones et al., 2008)



Eye movements

- Some researchers tested newborns with high risk of familiar autism (i.e., sisters/brothers of autistic children) on
 - Face-like stimuli
 - Gaze orientation
 - Biological motion

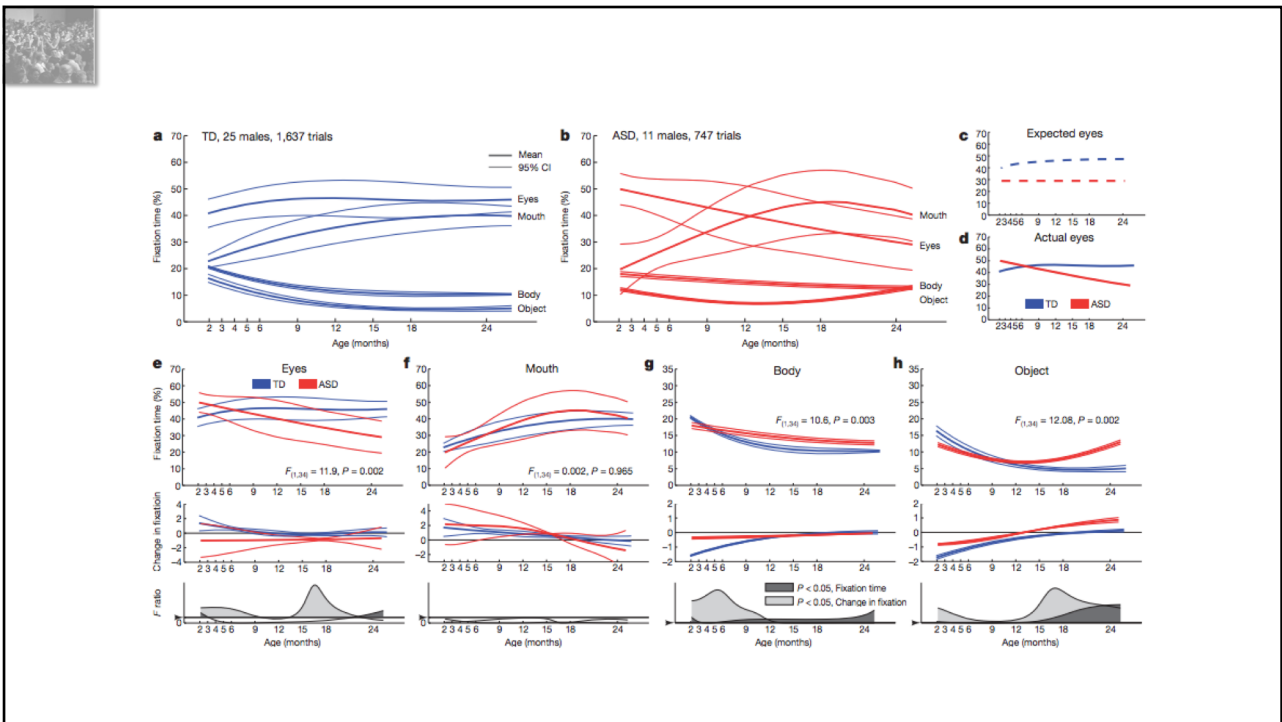
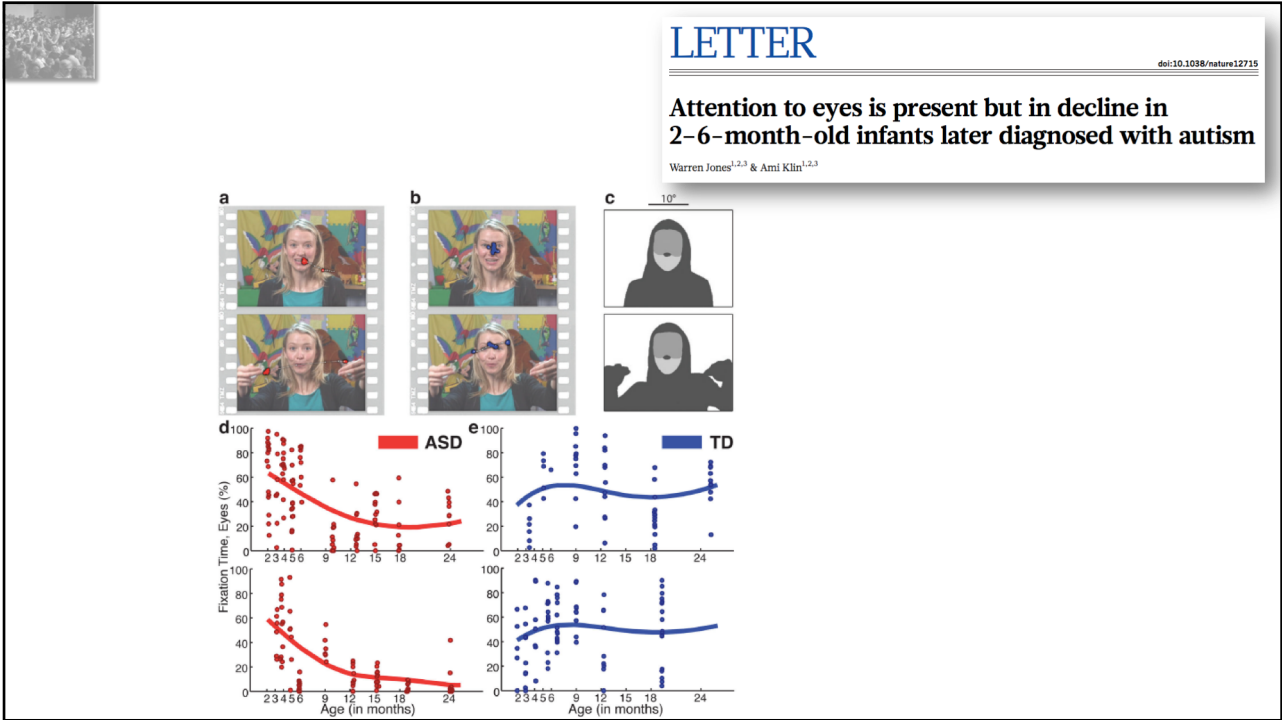
Eye movements



Di Giorgio et al., 2016

Eye movements

- The results show that
 - Both the % of looking
 - And the number of fixations
 - Is higher for the version of the stimuli that are not attractive to typically developing children (Di Giorgio et al., 2016)
- This is a first demonstration that deficits in orienting mechanisms toward socially relevant stimuli can be found very early in children at high risk of autism





Eye movements

- The results show that
 - Eye gaze/fixation is an important signal
 - The previous hypothesis is falsified
 - There is a brief temporal window during which the process details
- This is a first demonstration that deficits in orienting mechanisms toward socially relevant stimuli can be found very early in children at high risk of autism



Core knowledge

The criteria hypothesized by Spelke (2000) seem to be satisfied as for the system of knowledge that support our reasoning on the behaviour of agents:

- Given at birth
- Independent from experience and formal culture/acclturation
- Largely shared between species
- At the basis of learning processes