Séminaire : « Le nourrisson : ce qu'il sait, ce qu'il apprend »
Seminar: « Core knowledge and learning in infants »
PARIS, Collège de France, January 31th 2012

Babies in society: perception of faces and biological motion

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htpp: //dpss.psy.unipd.it/iclab/

The origin of the sensitivity to social agents

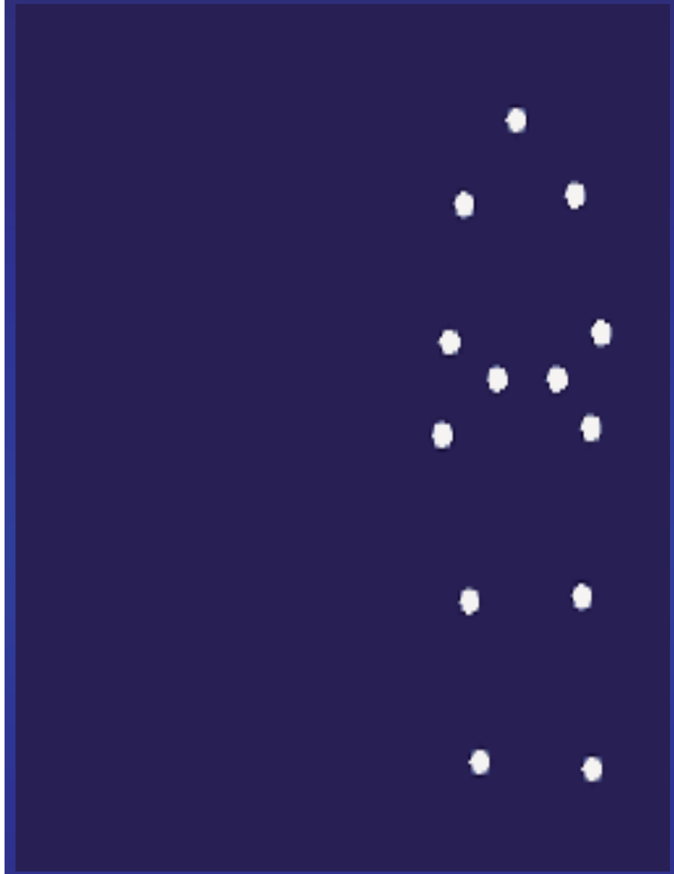
FACE PROCESSING

Adults are experts in processing faces in few milliseconds they can recognize

- Gender
- Age
- Emotion
- Identity

FACE PROCESSING : TO DETECT A FACE

IN ADULT HUMAN OBSERVERS



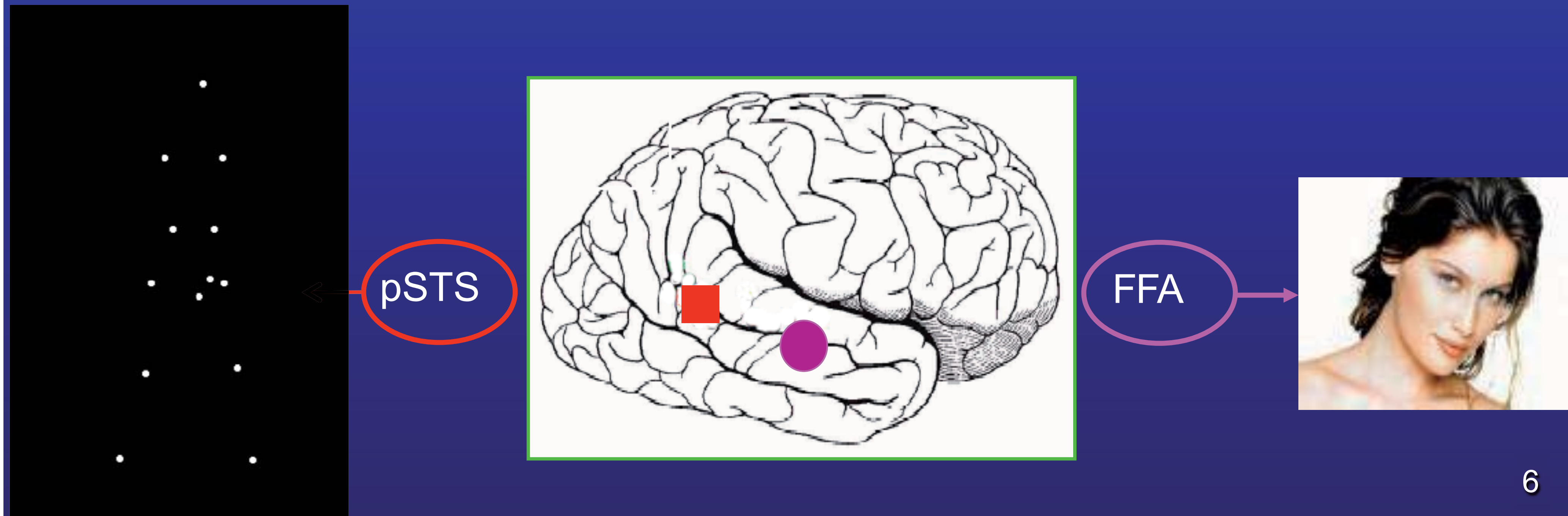
Several studies demonstrate that the human visual system is particularly sensitive to the movements of living creatures.

A dozen of point lights placed on the main joints of a walking person is sufficient to convey the vivid and instantaneous recognition of a human (Johansson, 1973)

THE SOCIAL BRAIN

Evidence from behavioral, brain lesion and neuro-imaging studies suggest that, in adults, both FACE processing and BIOLOGICAL MOTION perception involve specific processes carried out by dedicated brain areas.

(Farah *et al*., 2000; Kanwisher, 2000; Grossmann *et al*., 2000)



Evolutionary perspective

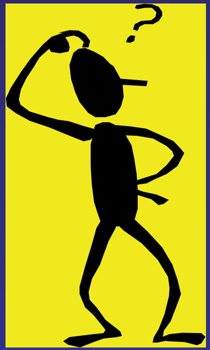
The capacity to identify and separate biological agents from nonbiological events plays a critical role for the adaptive behaviour

THESE ABILITIES ARE CONSERVED ACROSS SPECIES AND ARE CRITICAL FOR

FILIAL ATTACHMENT

DETECTION OF PREDATORS

Which is the origin of the brain specialization for social stimuli ?



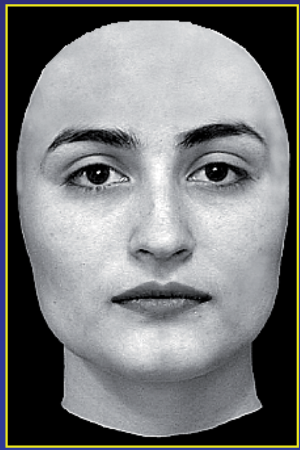
Does the human system possess inborn predisposition that ensure specialization?

How **innate mechanisms and perceptual experience** contribute to the development of a social brain

STRUCTURE OF THE TALK

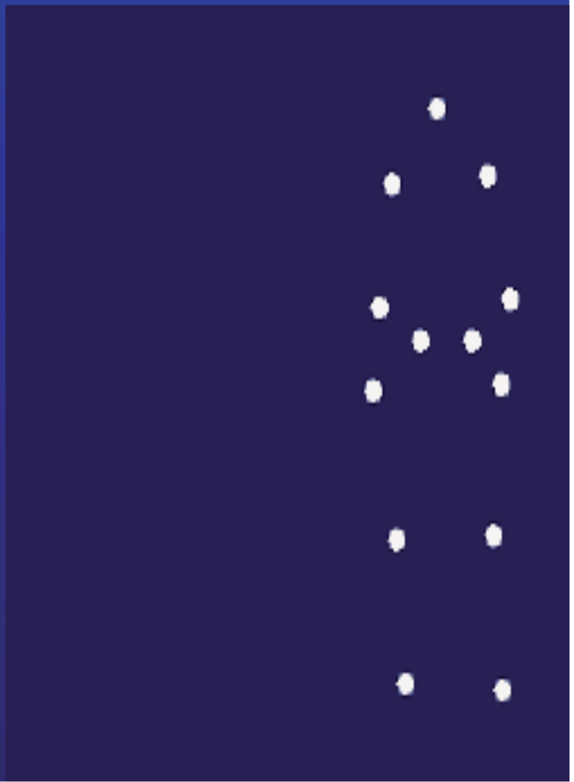
FACE

- Mechanisms for face detection
- The development of face specificity



BIOLOGICAL MOTION

Detection of social stimuli through the dynamic of their movement:



Face detection involves a decision as to whether or not a given stimulus is a face and implies the capacity to detect that all faces share the same relational features with two eyes above a nose that is above a mouth (FACE GEOMETRY)

Face recognition or delayed matching involves a judgement of previous occurrence and thus whether a face has been seen earlier

Familiarization phase

Test phase

Habituation tecnique

Newborns ‘recognition of their mother face

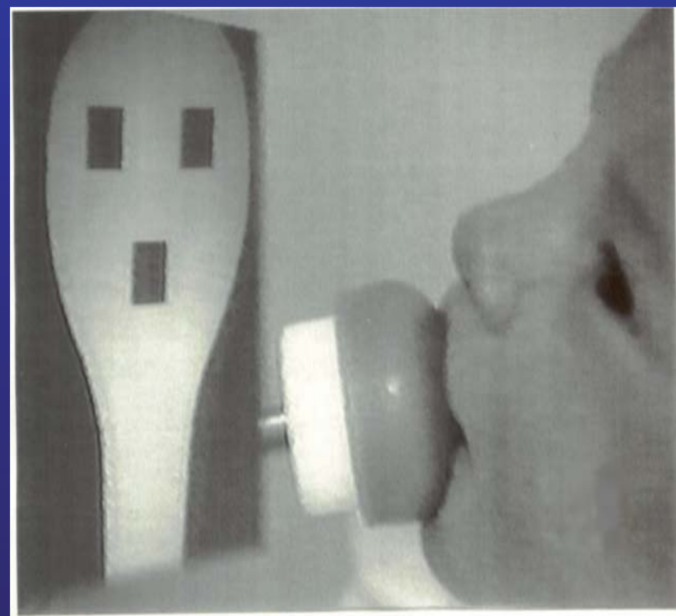
(e.g., Bushnell, 2001; Field et al., 1984; Pascalis et al., 1995)

Face recognition implies a face learning system that processes different features at different ages

De Schonen & Mathivet (1989)
Deruelle & De Schonen (1998)
Acerra, Burnoud & De Schonen (2007)

Face detection

- IS THE HUMAN SYSTEM SPECIALIZED TO DETECT SOCIAL STIMULI SINCE BIRTH ?



EXPLANATIONS OF THE FUNCTIONAL AND NEURAL SPECIALIZATION FOR FACES IN ADULT

INNATE (experience independent) SPECIALIZATION

- recruits specific mechanisms (Kanwisher, 2000)
- is determined before any postnatal experience (Farah et al., 2000)

EXPERIENCE DEPENDENT SPECIALIZATION

- recruits general mechanisms (Tarr & Gauthier, 2000)
- results from the fine-tuning by expertise of parts of the visual system (Gauthier & Logothetis, 2000)

DEVELOPMENTAL MODELS

EXPERIENCE-EXPECTANT VIEW

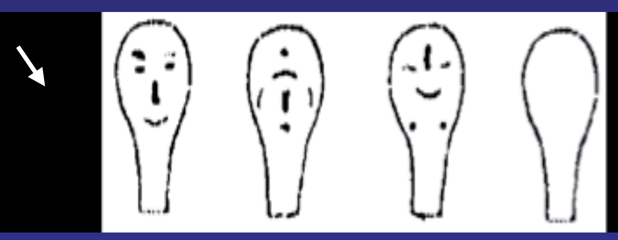
Face processing…

- **results from the interaction between innate predispositions and the extensive experience with faces**

(de Schonen, 2002; Greenough & Black, 1992; Nelson, 2003)

Newborns prefer face configurations, rather than other, equally complex, non face stimuli

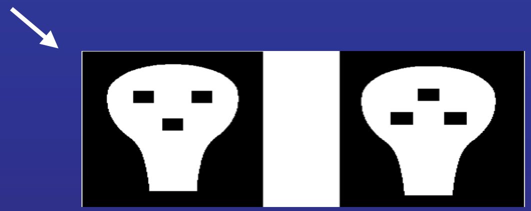
Visual tracking



Goren, Sarty, & Wu, 1975

Morton & Johnson, 1991

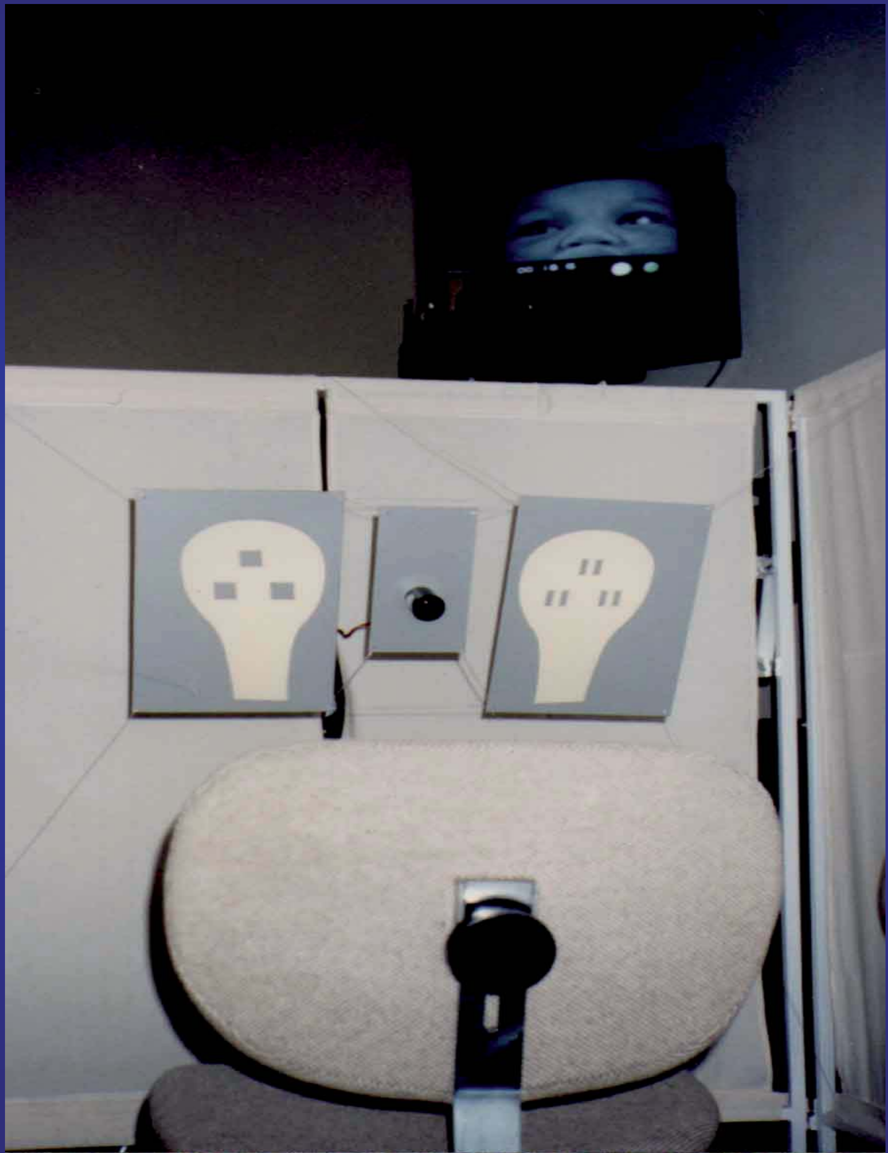
Visual preference



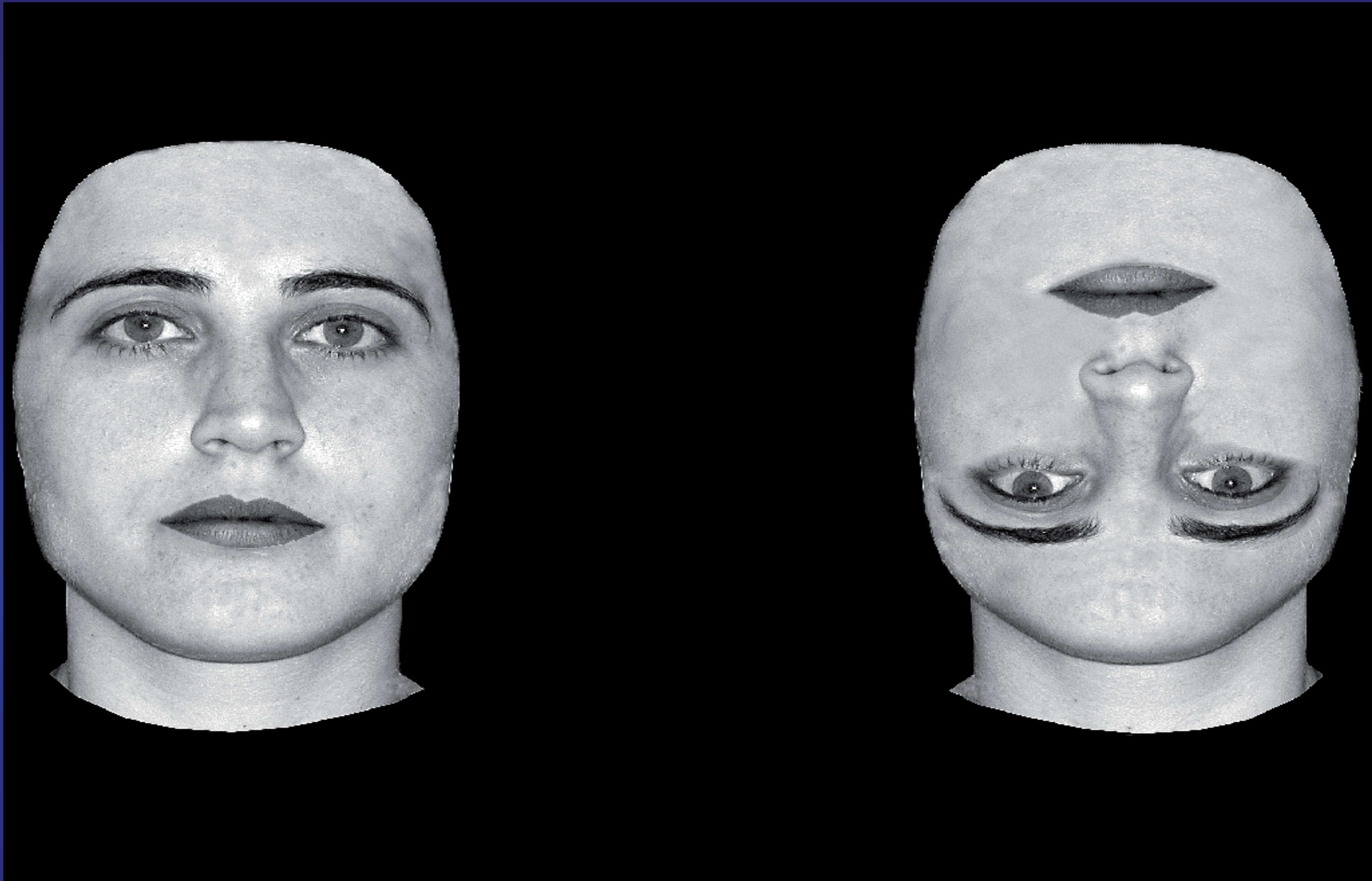
Valenza, Simion, Macchi Cassia, & Umiltà, 1996

Macchi Cassia, Turati, & Simion, 2004

PREFERENTIAL LOOKING TECNIQUE



Valenza, Simion, Macchi Cassia, & Umiltà, JEP (HPP) 1996



Macchi Cassia, Turati, & Simion, *Psychological Science*, 2004

MECHANISMS UNDERLYING FACE PREFERENCE

This preference has been interpreted as due to:

LSF face detector system (CONSPEC), provided by the evolutionary pressure (Johnson, 2005)

Non-face-specific attentional biases toward general high level structural properties embedded in a face (Simion et al., 2004)

FACE PROCESSING SYSTEMS (Johnson)

DETECTION

A sub-cortical route responds to non-face-specific structural properties

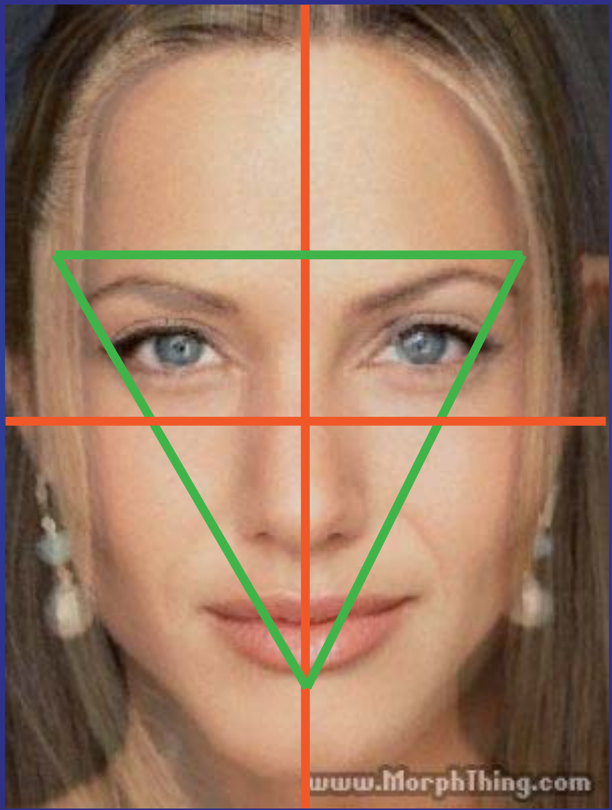
RECOGNITION

GENERAL PATTERN LEARNING MECHANISM:
acquires information about any visual pattern not specific for faces (De Schonen & Mathivet,1989)

at about 2 months, specific cortical circuits specialized for identifying faces and responsible for adult-like face recognition develop

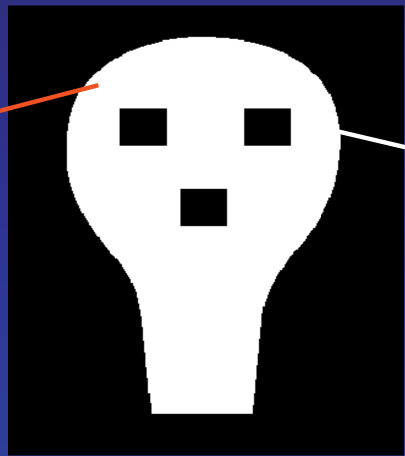
Do structural properties induce newborns to prefer a face ?

- Symmetry of inner elements
- Congruency between the disposition of the inner elements and the shape of the outer contour
- Top-down asymmetry of the inner elements



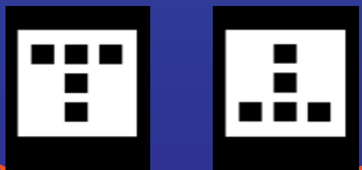
Faces can be described as a collection of general "structural" and "configural" properties

(see Johnson & Morton, 1991, p.135, Box 6.1)



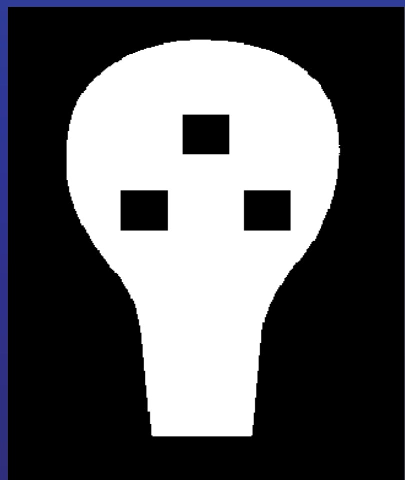
A congruent spatial relation between the distribution of the inner features and the shape of the outer contour

Up-down asymmetry in the distribution of the elements within the contour (more elements in the upper vs lower part)



Macchi et al 2008 Child Devel.

Simion et al. 2002
Developmental Science



These properties are not present in the typical inverted facelike stimulus

Other stimuli, besides faces, are preferred by newborns on the basis of their structural configurations

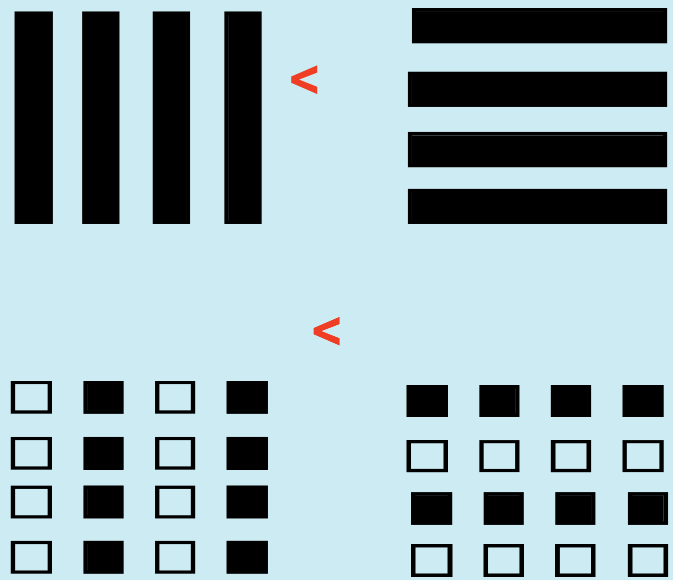
(Farroni *et al.*, 2000; Slater, 1977, 1985)

Technique

• visual preference

Dependent variables:

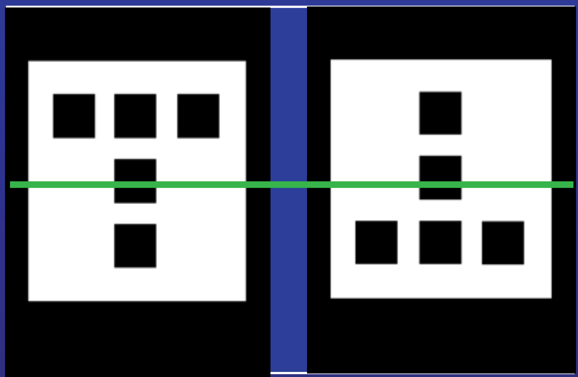
• number of orienting responses
• total fixation time



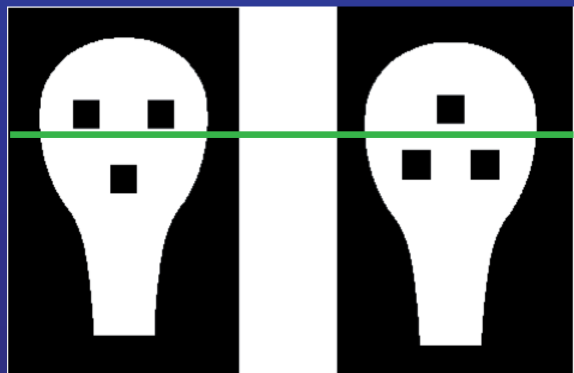
Farroni, Valenza, Simion & Umiltà (2000).*Perception.*

THE ORIGIN OF FACE PROCESSING

In line with this latter hypothesis we explored whether newborns' face preference may be ascribed to non-face -specific attentional biases : up-down asymmentry, congruent disposition



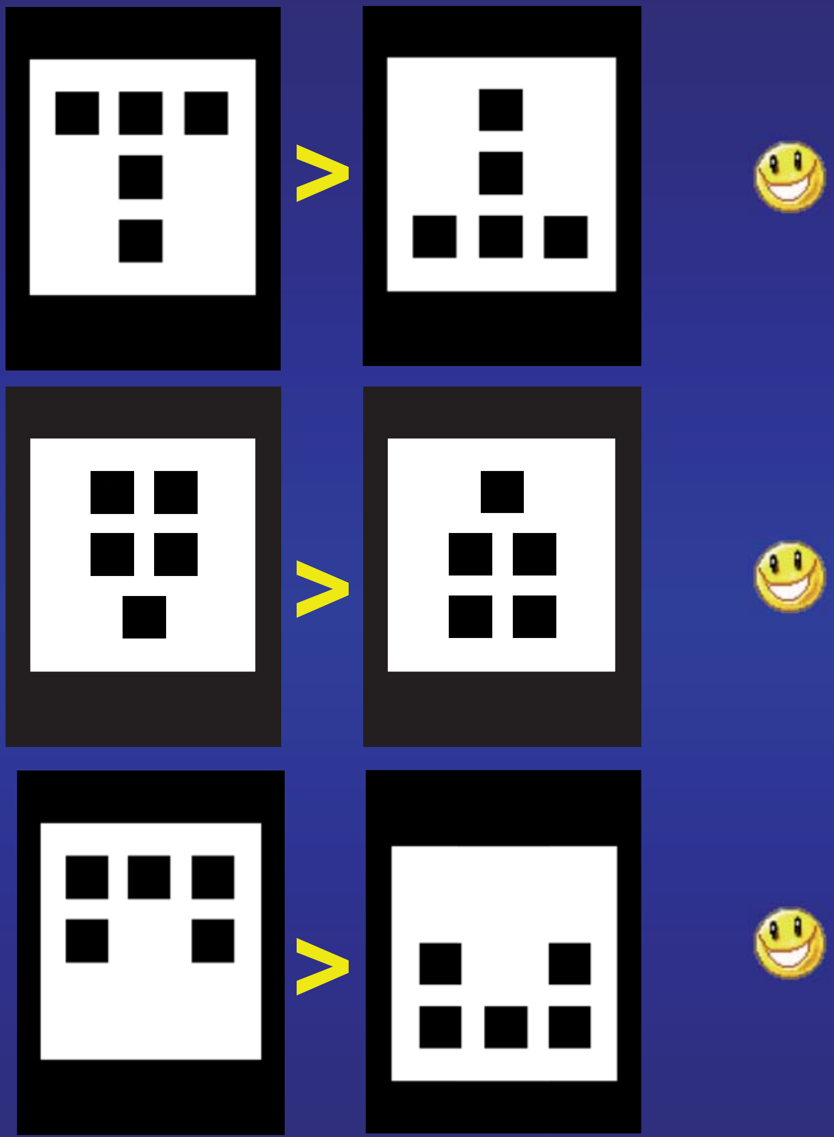
Simion, Valenza et al. (2002)
Developmental Science

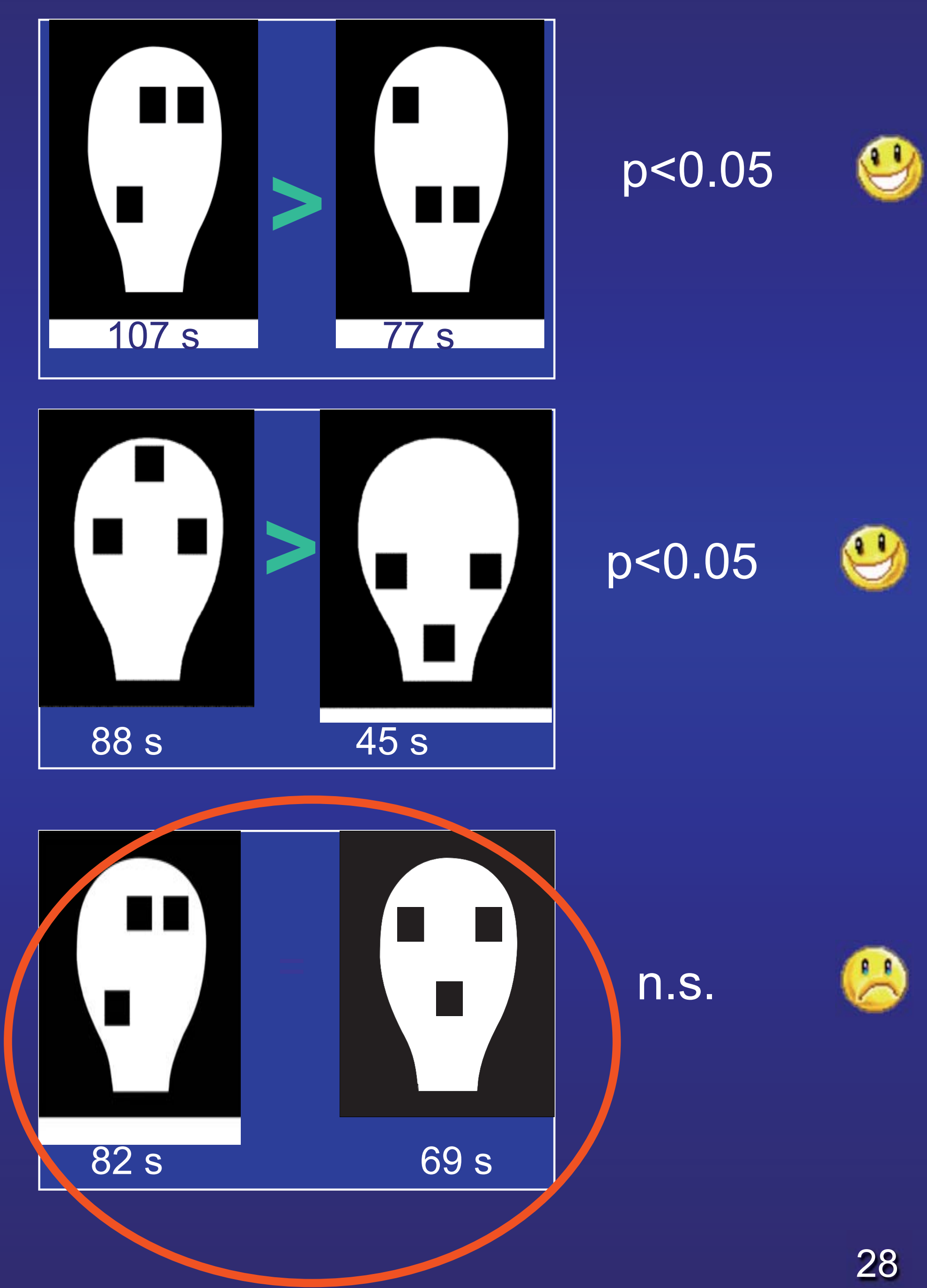


Turati et al. 2002.
Developmental Psychology

Macchi Cassia et al. , 2008.
Child Development

RESULTS





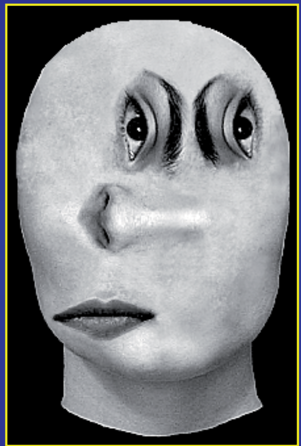
Num. of orienting responses: $F(2,44) = 7.73$ $p<0.01$

Total fixation time: $F(2,44) = 19.20$, $p<0.005$

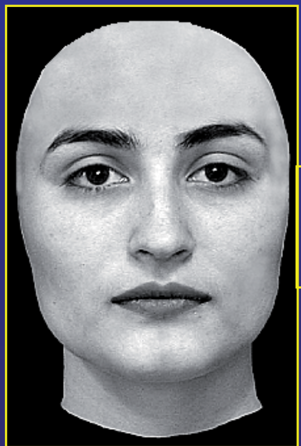
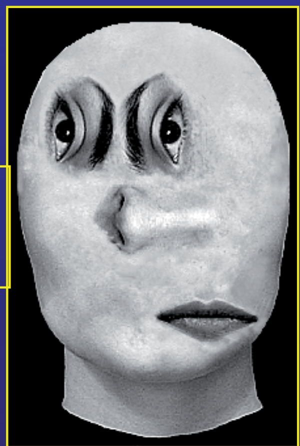
Dependent variables: → Number of orienting responses | Total fixation time (sec)

 > 

	Number of orienting responses	Total fixation time (sec)
UPRIGHT FACE	**16**	**101**
INVERTED FACE	12	71
	$p<.02$	$p<.03$

 > 

	Number of orienting responses	Total fixation time (sec)
TOP-HEAVY CONFIG.	**16**	**115**
BOTTOM-HEAVY CONFIG.	12	80
	$p<.01$	$p<.001$

 = 

	Number of orienting responses	Total fixation time (sec)
UPRIGHT FACE	13	78
TOP-HEAVY CONFIG.	13	**91**
	n.s.	n.s.

FACE

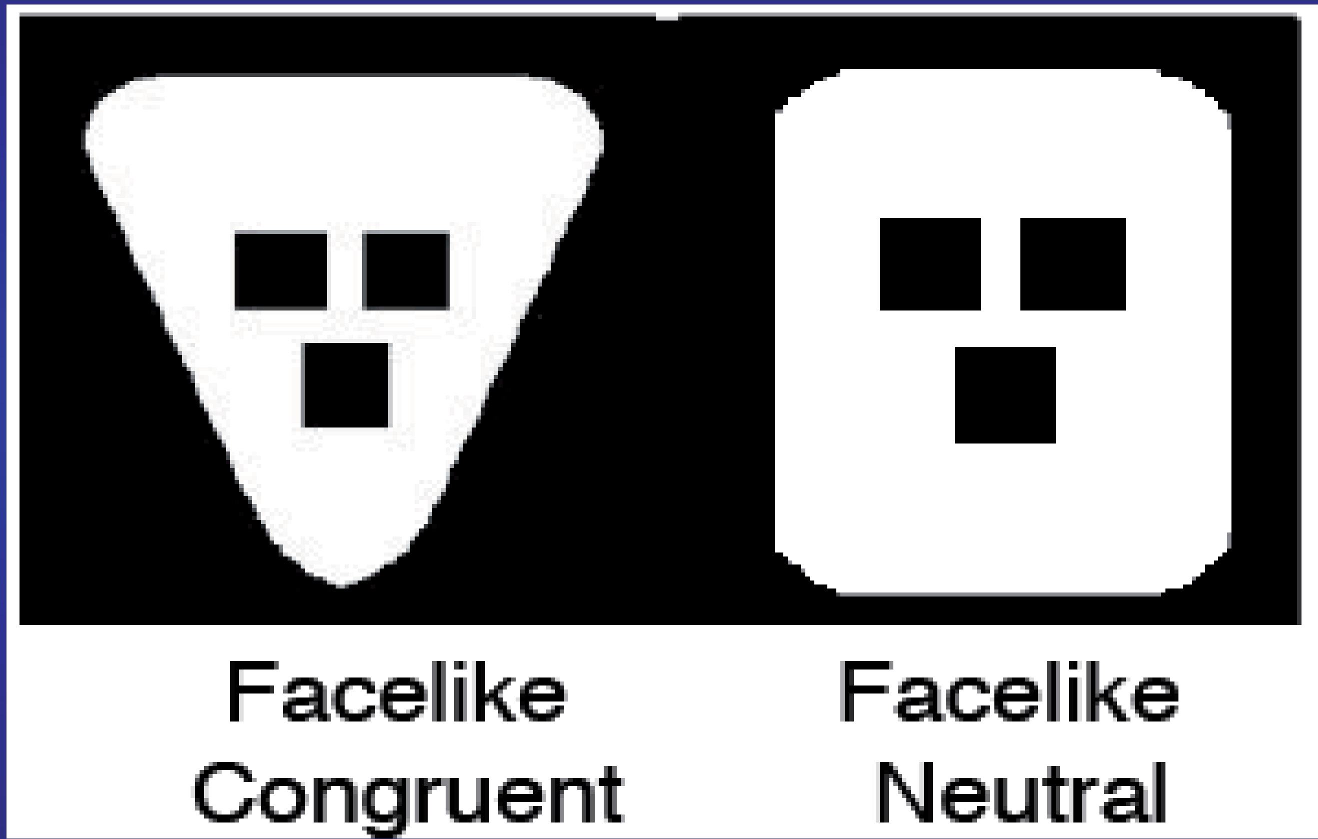
TOP-HEAVY NON FACE

<

Newborns are sensitive to the number of elements in the upper part more than to face geometry

	Number of Orienting Responses		Total fixation time	
REAL FACE	12.50	$p < .01$	45.5 s	$p < .001$
TOP-HEAVY NON FACE STIMULUS	17.58		111.86 s	

Are newborns sensitive to the congruent disposition of the elements within the contour ?



52 sec

36 sec

Macchi, Simion et al.Child Dev. 2008

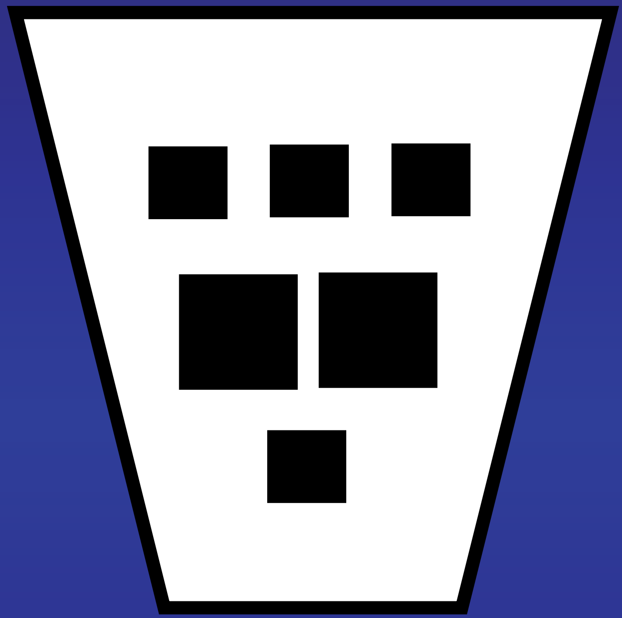
Are newborns sensitive to the congruent disposition of the elements within the contour ?

104 sec

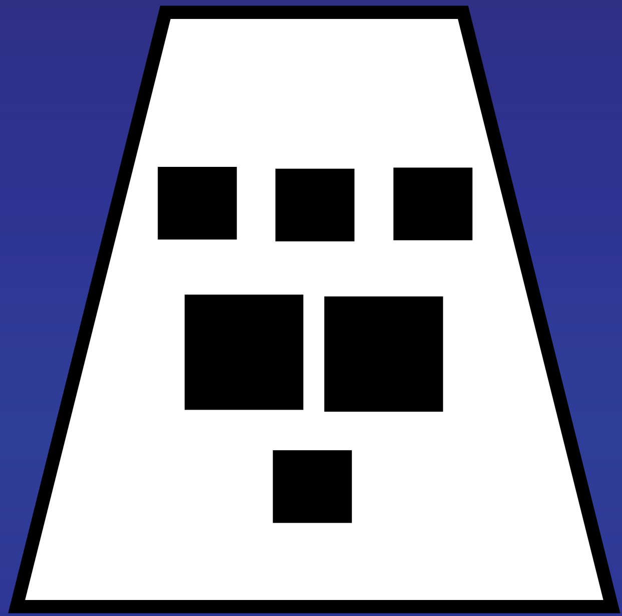
84 sec

Macchi et al. Child Development, 2008

A second structural property that trigger newborns' attention is the presence of a congruent spatial relation between the shape of the contour and the disposition of the inner elements



Top-heavy congruent stimuli



Top-heavy non-congruent stimuli

Macchi, Simion et al.Child Dev. 2008

FACE DETECTION AT BIRTH :

- A preference for stimuli with more elements in the upper part and/or a congruent disposition of the elements within a contour is present at birth.
- In newborns' visual world, faces are the patterns that most likely display such fetaures .
- At birth, the preference for faces is in fact a preference for certain non-face specific perceptual attributes.

Nature's trick

In order to induce the too crude superior colliculus to prefer faces,

a preference for non face-specific perceptual attributes has been created.

FACE PROCESSING SYSTEMS

DETECTION

A sub-cortical route responds to faces because of the presence of non-face-specific properties

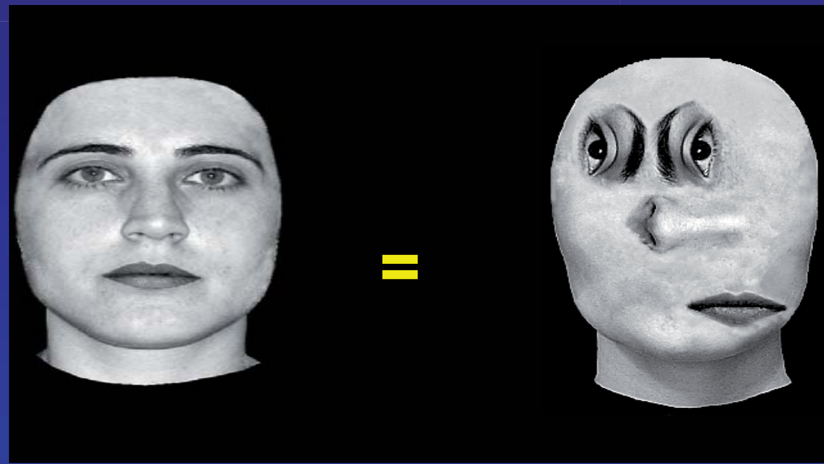
RECOGNITION

GENERAL PATTERN LEARNING MECHANISM:
acquires information about any visual pattern not specific for faces (De Schonen & Mathivet. 1989)

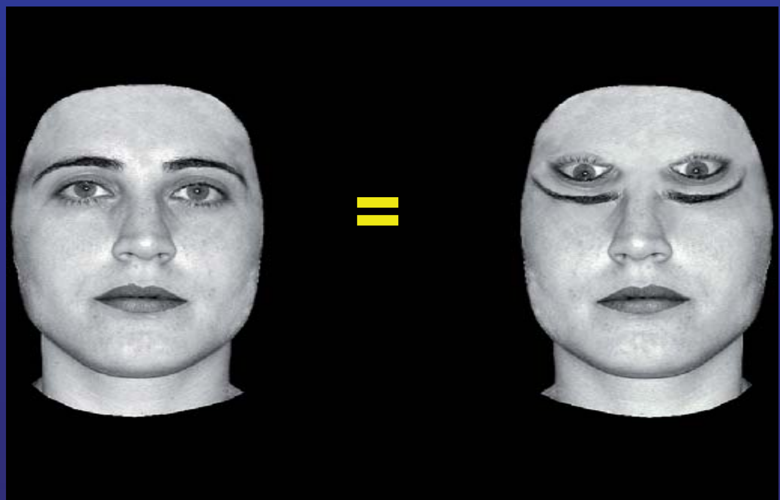
at about 2 months, specific cortical circuits specialized for identifying faces and responsible for adult-like face recognition develop

Optimal stimuli for the sub-cortical route at birth

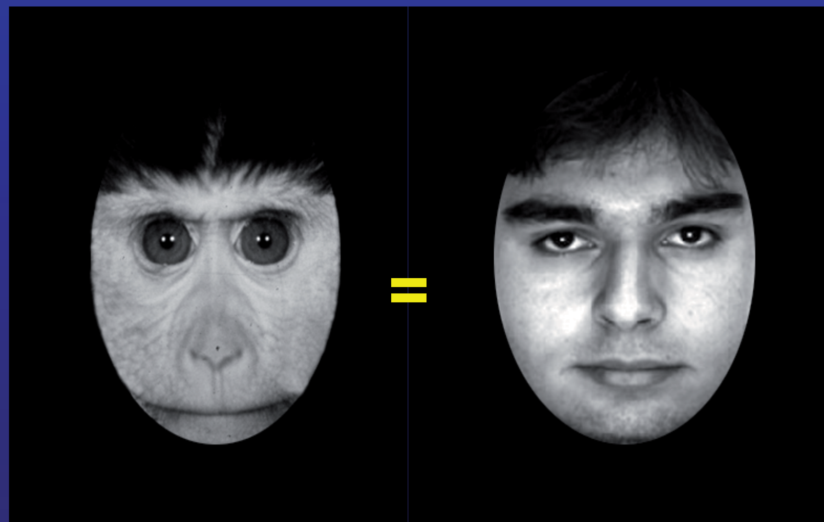
- A coarse template of face is present at birth



78 s 91 s



31 s 33 s



33 s 32 s

How do newborns process a face ?

newborns process faces holistically

69 sec

36 sec

p <.01

The visual system processes these faces as a Gestalt

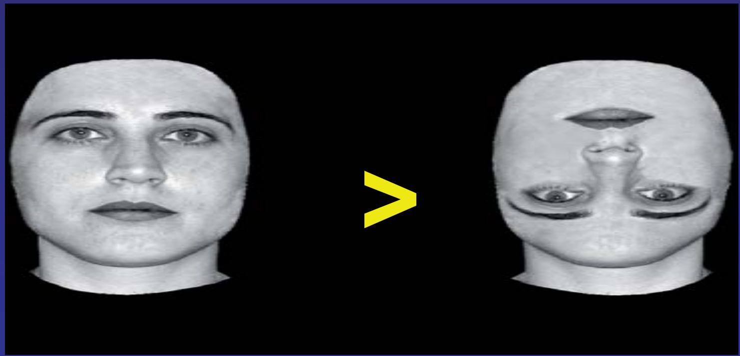
Leo & Simion, ***Developmental Science*** 2010

Perceptual narrowing

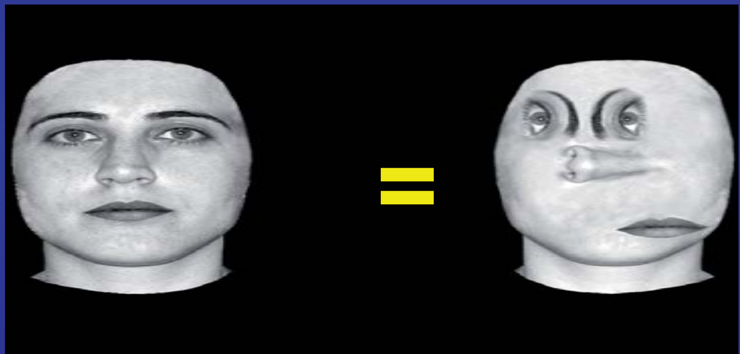
"Face space" becomes narrowed and attuned in the first months of life

EYE TRACKER SYSTEM

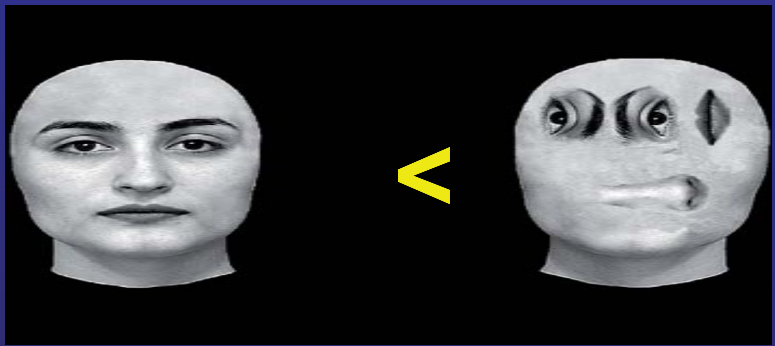
newborns



101 s 71 s

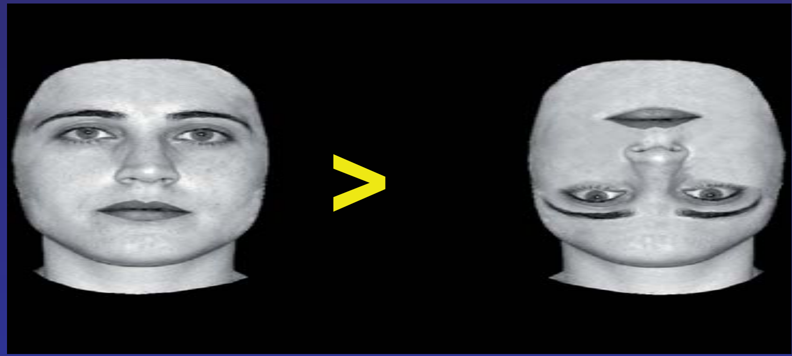


78 s 91 s

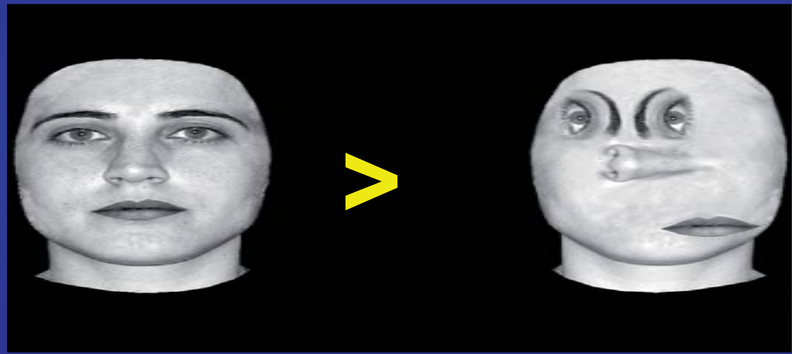


45 s 112 s

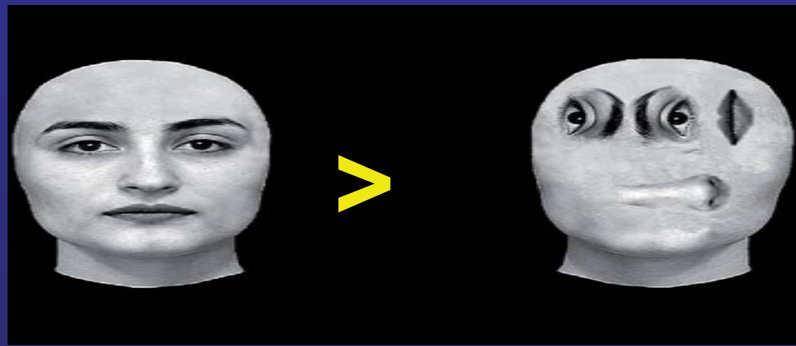
3-months-old infants



196 s 147 s



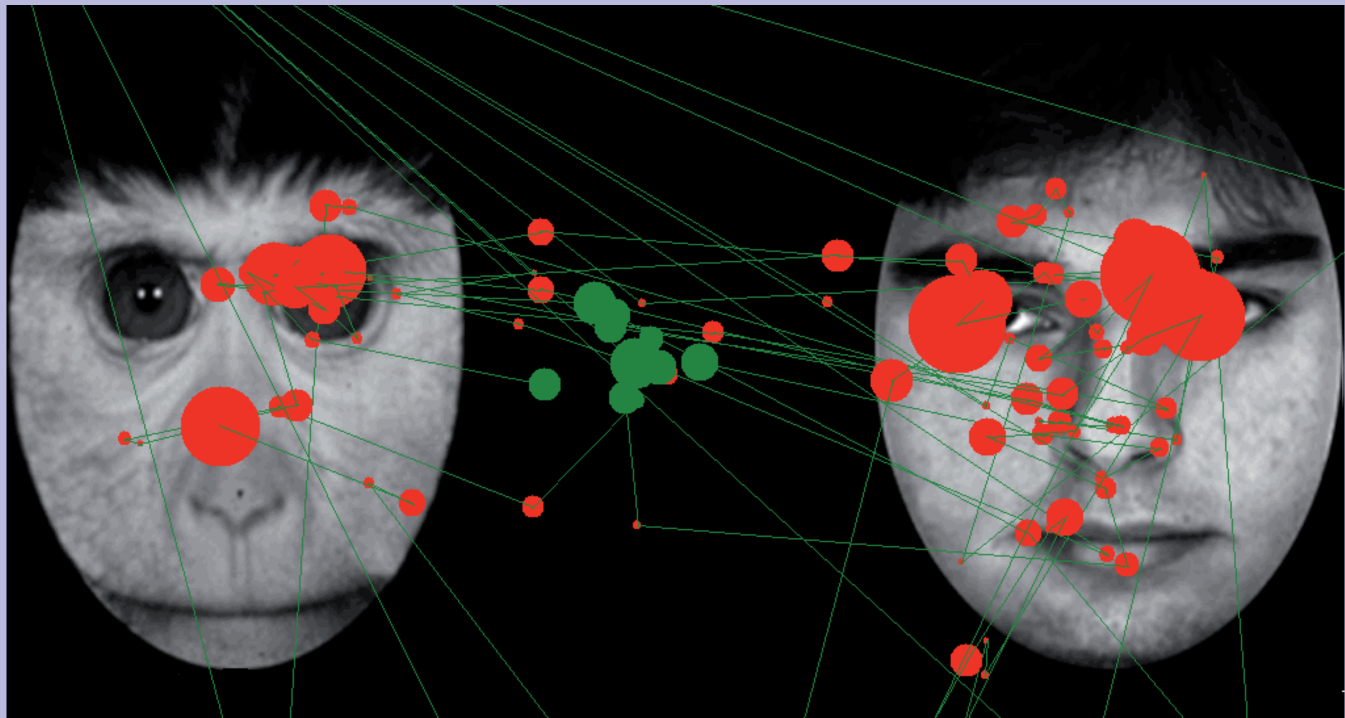
240 s 190 s



230 s 148 s

3-month-old infants

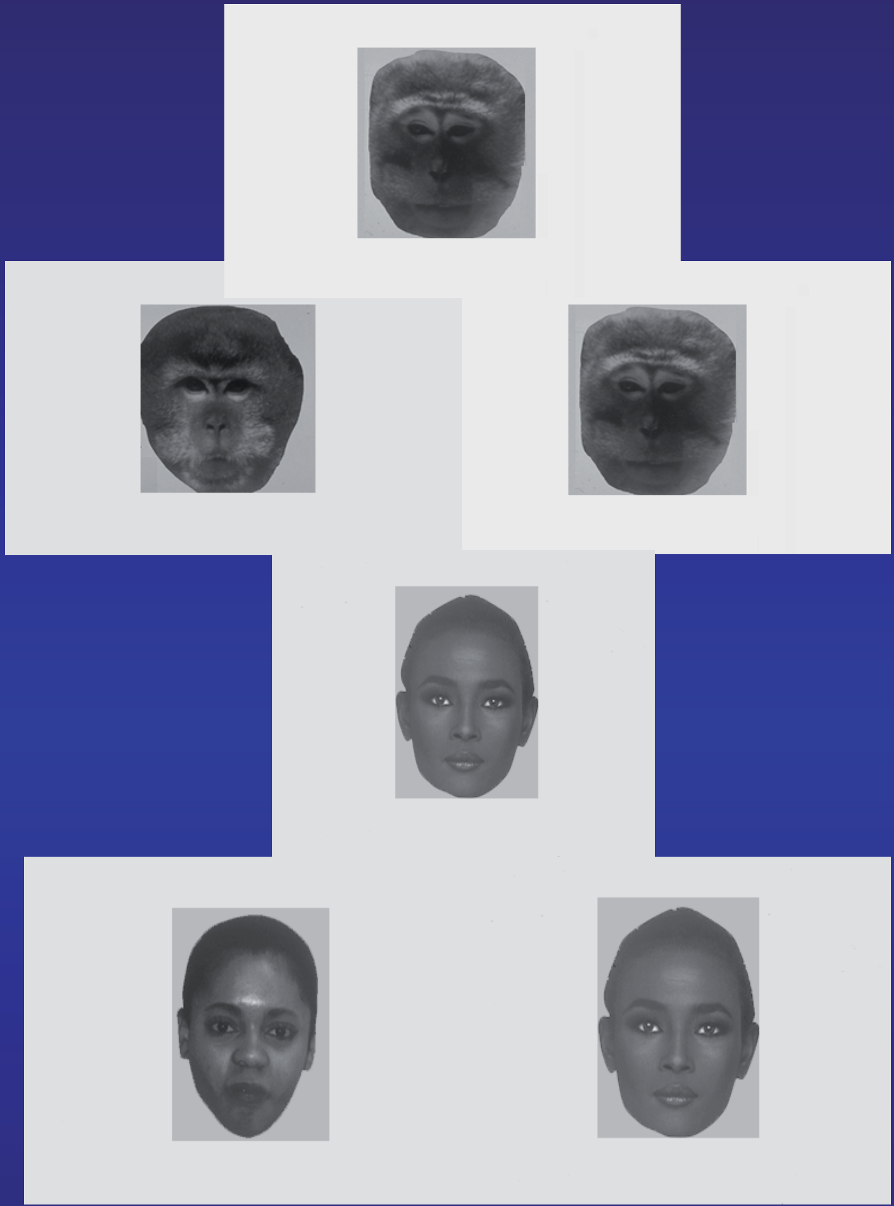
20.4 s 36.7 s



PERCENTAGE OF LOOKING
TO THE MAN

62.5%

t (11) = 2.3, *p* < .01 (d = .67)



SPECIES-EFFECT

de Haan, Pascalis & Johnson (2002)

J. of Cognitive NeuroScience

OTHER-RACE EFFECT

Sangrioli & de Schonen (2004) J. of Child Psych. and Psych.

Kelly et al. (2007) Psychol. Science

Quinn et al. (2008) Journal of Neuropsychology

Conclusions:

- Infants at birth are sensitive to the additive effect of perceptual properties present in faces

- The same general constraints active in newborns cannot explain face preference at 3 months of age.

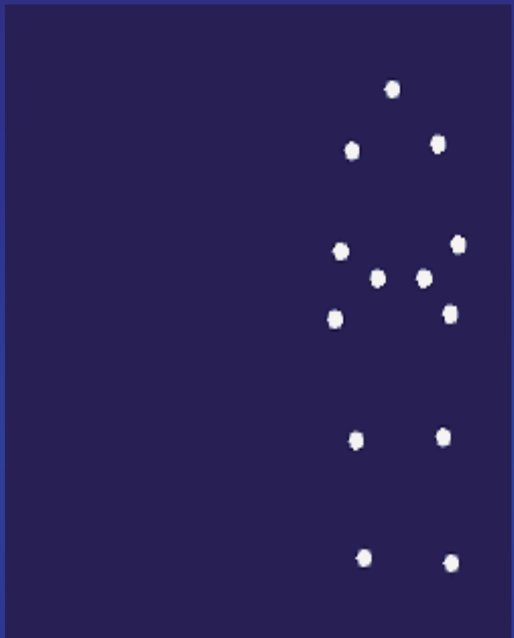
ORIGINS OF FACE SPECIALIZATION

1. **As a function of experience the processes responsible of infants' face preference shift from being broadly tuned to a wide range of visual stimuli to being increasingly tuned to human faces**

2. **Face specialization emerges gradually as a product of the interaction between innate constraints and the structure of the input provided by the species-typical environment.**

DETECTION OF SOCIAL STIMULI
Sensitivity to Biological Motion at birth

Is the human system able to detect social stimuli on the basis of other specific properties such as the way they move ?



IN ADULT HUMAN OBSERVERS

Several studies demonstrate that the human visual system is particularly sensitive to the movements of living creatures.

A dozen of point lights placed on the main joints of a walking person is sufficient to convey the vivid and instantaneous recognition of a human (Johansson, 1973)

Human studies on Biological Motion

200 ms of observation are sufficient in order to recognize a moving human being

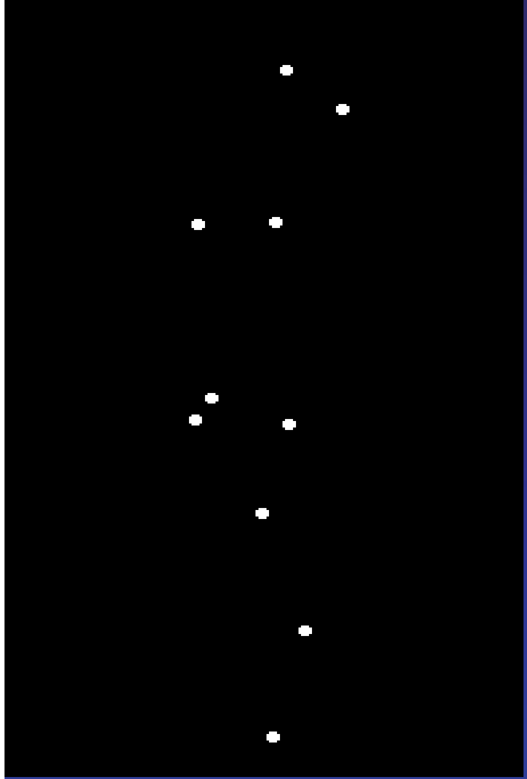
400 ms are enough in order to recognize the kind of action represented

(Johansson, 1975)

The perception of Biological Motion has been hypothesized to be an intrinsic capacity of the vertebrate visual system, guided by an

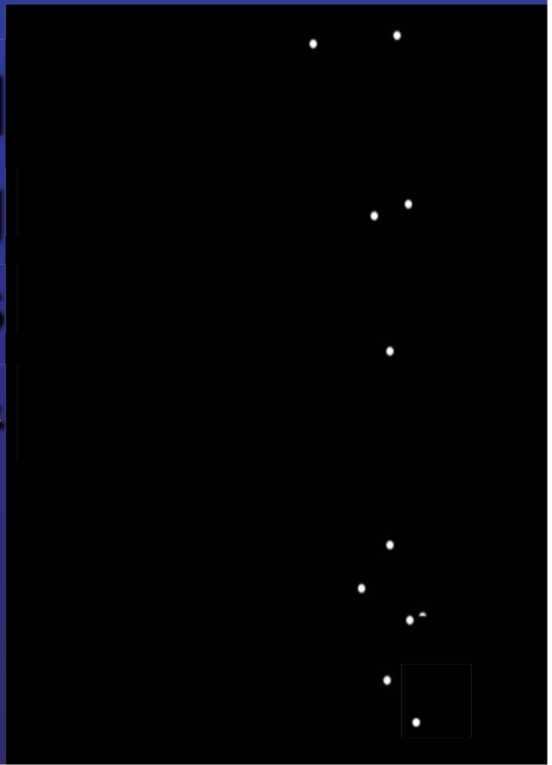
INNATE PREDISPOSITION

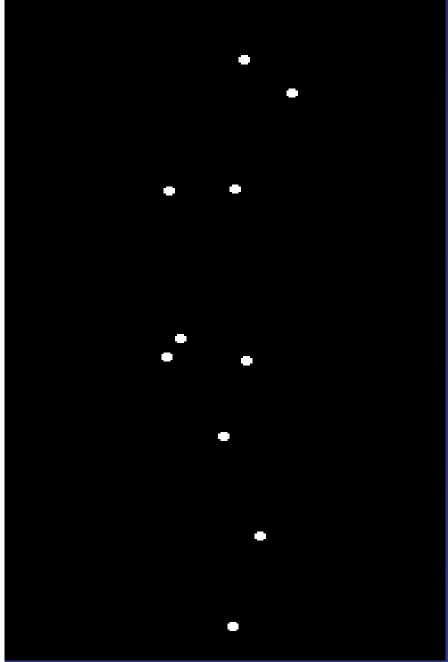
(Johansson, 1973)



In adults sensitivity to biological motion is **orientation-dependent** :INVERSION EFFECT

Similarly to faces, **detection and recognition** of a point-light walking person are **distrupted** when the display is turned upside down. (Sumi, 1984; Pavlova & Sokolov, 2000).



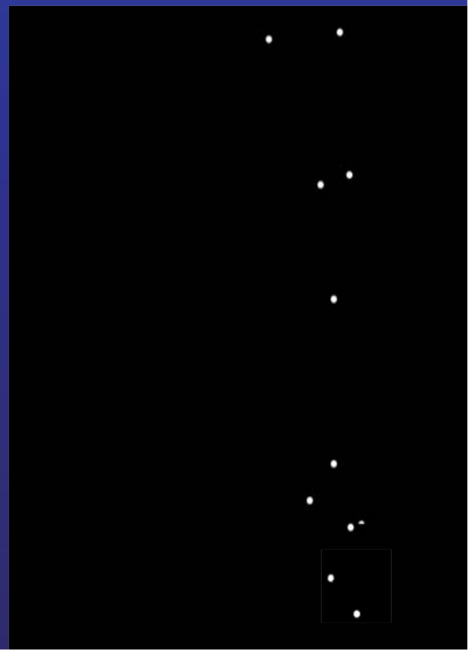


Explanations of the inversion effect

Inversion impairs:

- the **configural processing** of the familiar shape (Bertenthal & Pinto, 1994; Reed et al, 2003).
- the **perception of dynamic relations** that relies on the natural direction of the gravity force. (Shipley, 2006; Troje and Westhoff, 2006).

Explanations



With respect to its evolutionary importance, it is an interesting question whether the **sensitivity to biological motion** and the underlying neural specificity are

Inborn

Experience dependent

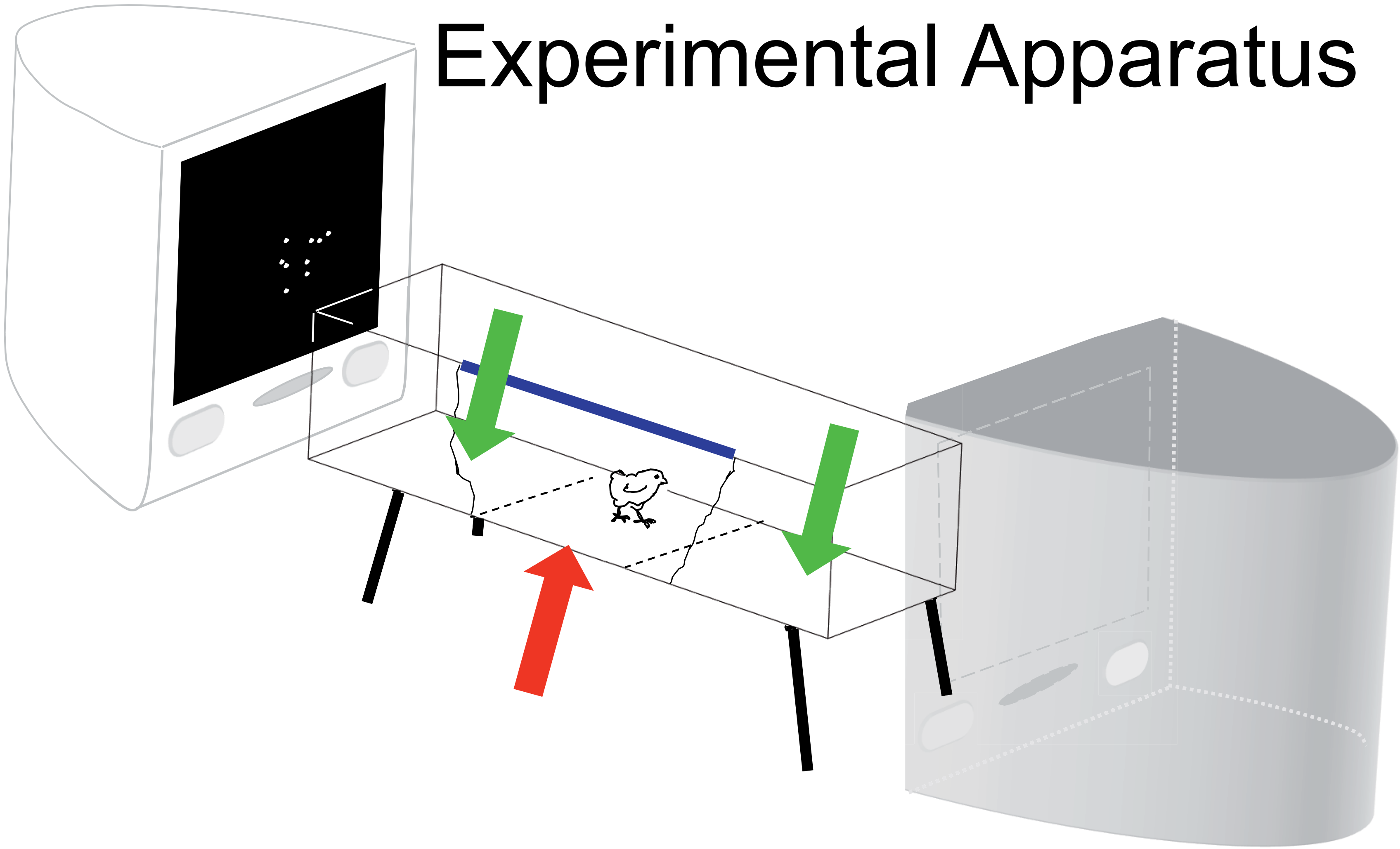
Results with newly hatched chicks, at their first exposure to point-lights animations, support the hypotheses:

- of an **inborn** predisposition for the dynamics of biological motion (Vallortigara e Regolin 2006)

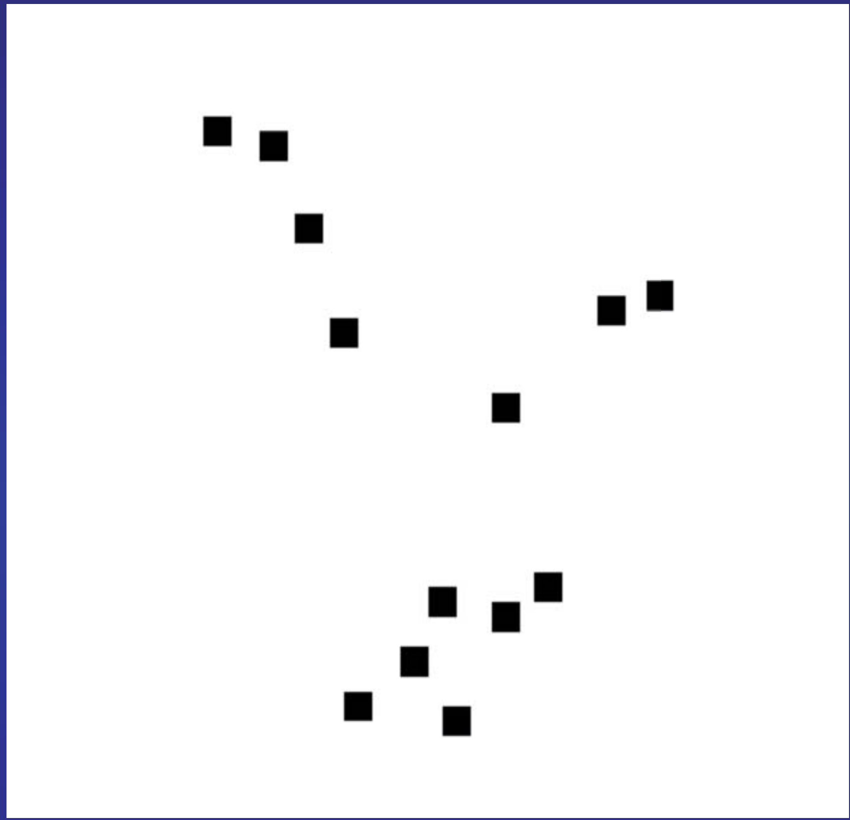
- of an inborn mechanism to detect the motion of legged vertebrates Life detector system (Troje and Westhoff, 2006; Johnson, 2006).

What about humans at birth ?

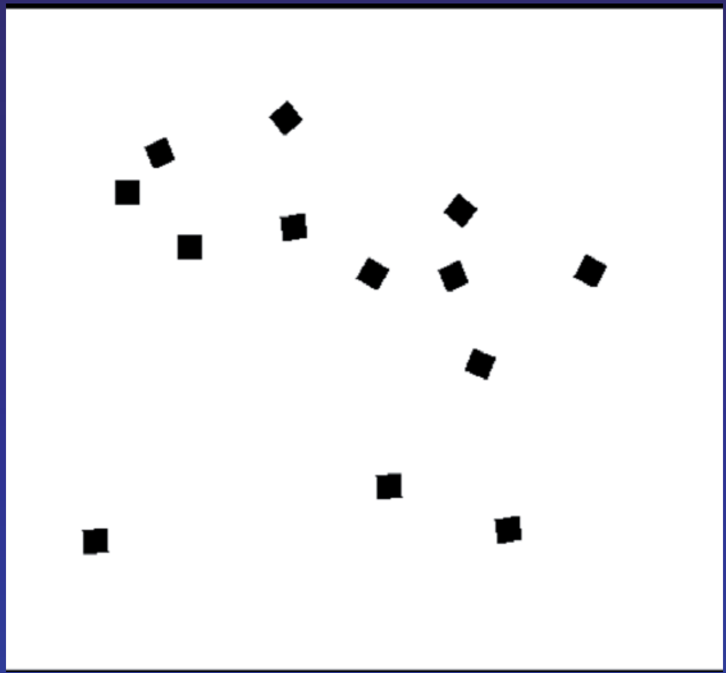
Experimental Apparatus



Stimulus "Walking Hen"

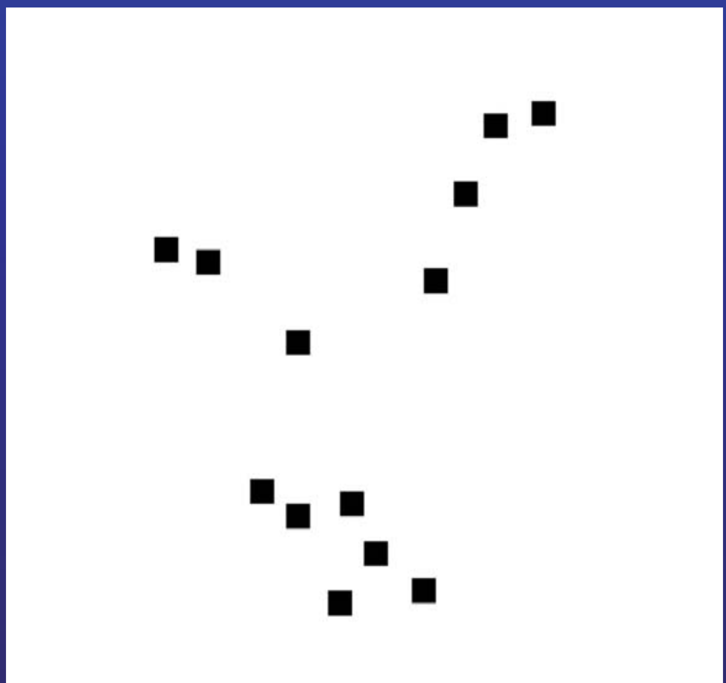


… to rule out the possibility that newborns utilize a representation derived from previous experience, the same stimulus used with chicks was utilized.



Random non biological motion

Each dot moves in arbitrary direction
Same average velocity of the point of the hen



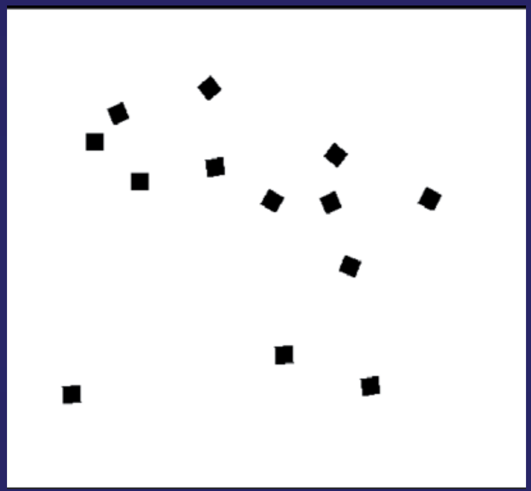
Walking hen

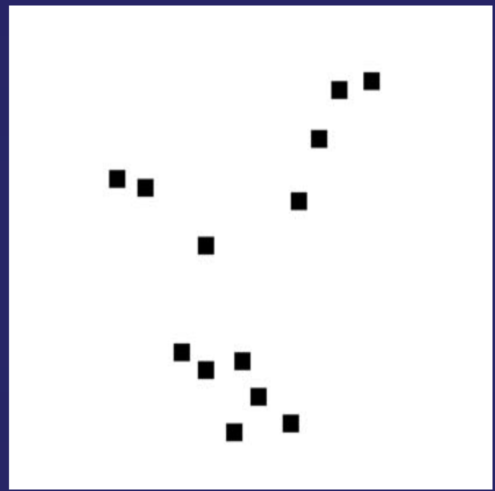
Simion,Bulf, Regolin, PNAS 2008

EXPERIMENT 1

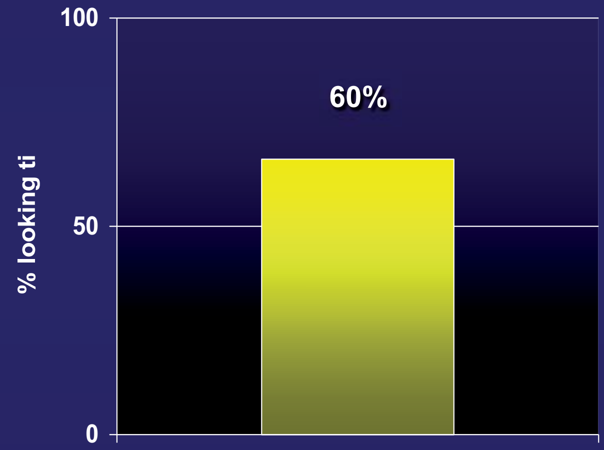
Newborns' preference for biological vs random motion displays

Partecipants: 12 newborns
Procedure: preferential looking


Random


Biological

Results



Biological motion

$t_{11} = 3.75 \quad p < 0.01$

Newborns exhibit a spontaneous preference for the biological motion display.

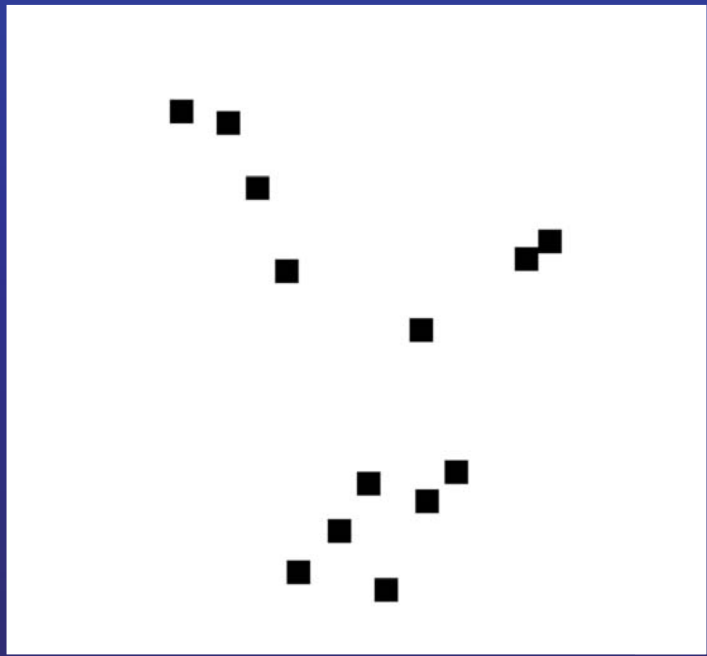
The preference might be due to the presence of figural coherence among the point-lights that is absent in the random motion sequence.

Exp. 2

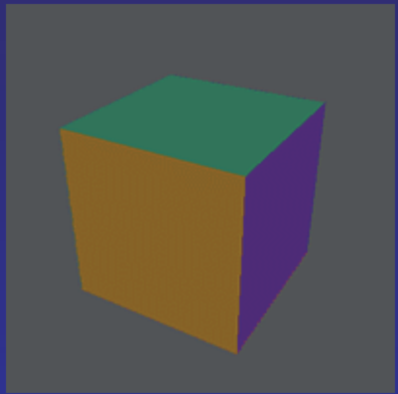
Is aimed at testing the specificity of the preference for biological motion by contasting two **structured arrays with different motions**:

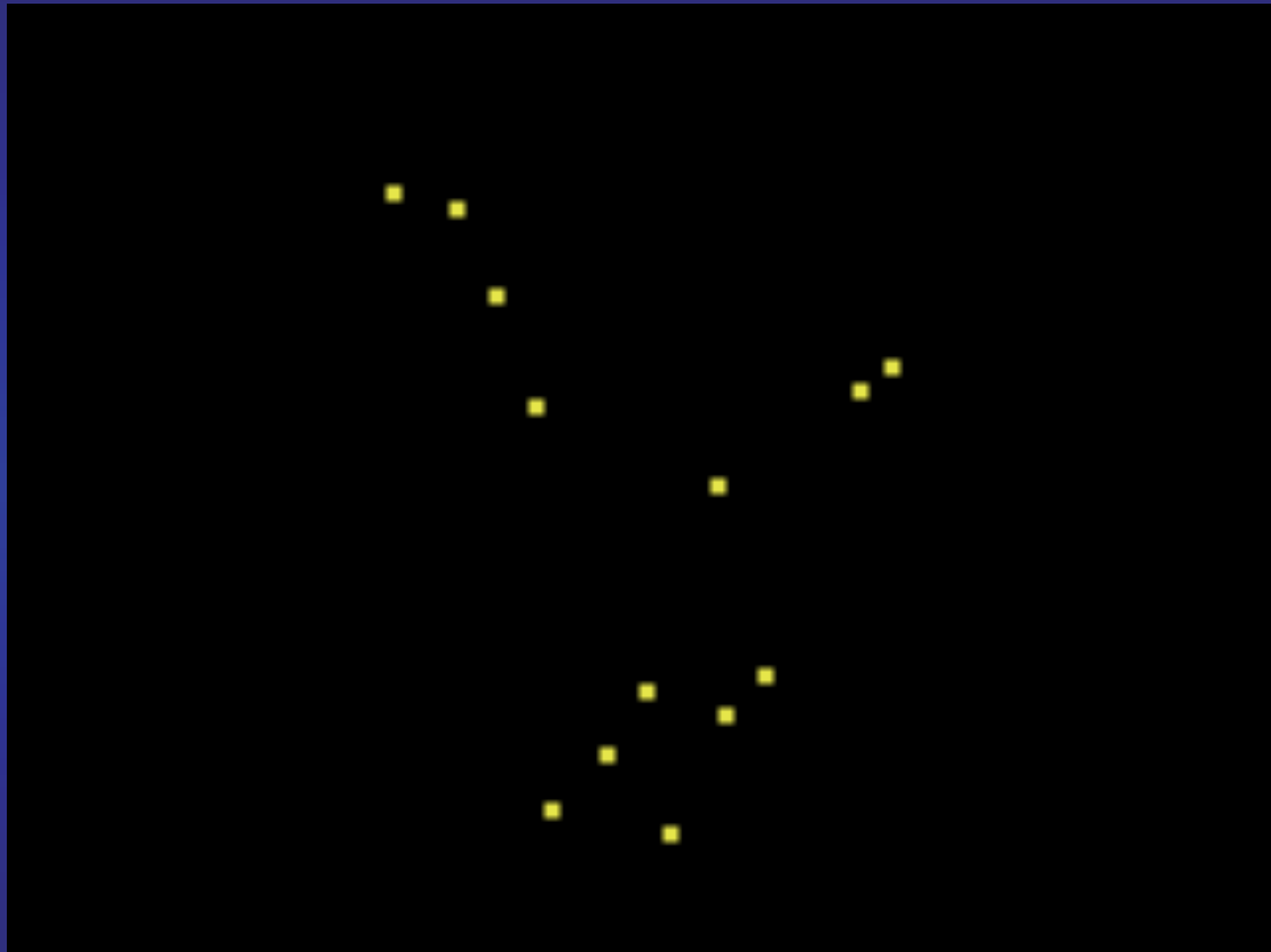
walking hen	vs	hen-like rotating object
biological motion		rigid motion

Rigid motion: a single frame of the hen moves rigidly about the vertical axis



Stimulus “Rigid motion”





EXPERIMENT 2

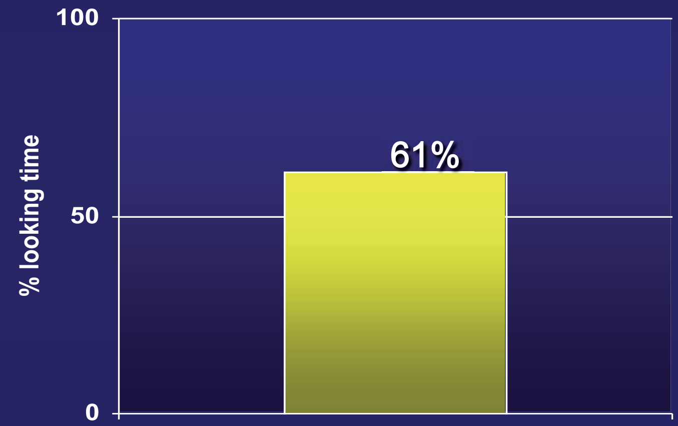
The stimuli are both structured and of comparable form

Partecipants: 12 two-days-old newborns
Procedure: Preferential looking tecnique

Rotating Rigid hen-like motion

Walking hen

Results



Biological motion

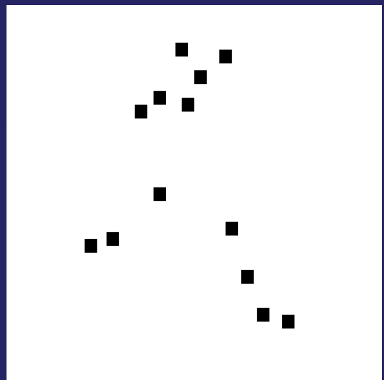
t(11)=3.44 p=0.006

Newborns STILL prefer the biological motion display

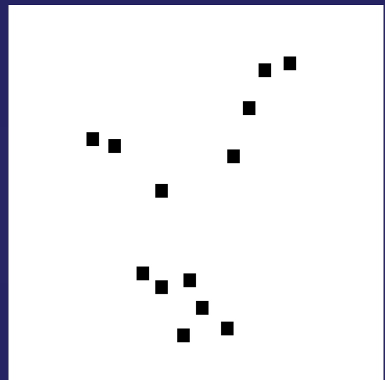
Bardi, Regolin, Simion, Developmental Science 2011

Preference for Upright vs Upside down walking hen.

Partecipants: 13 two days old newborns
Procedure : Preferential looking

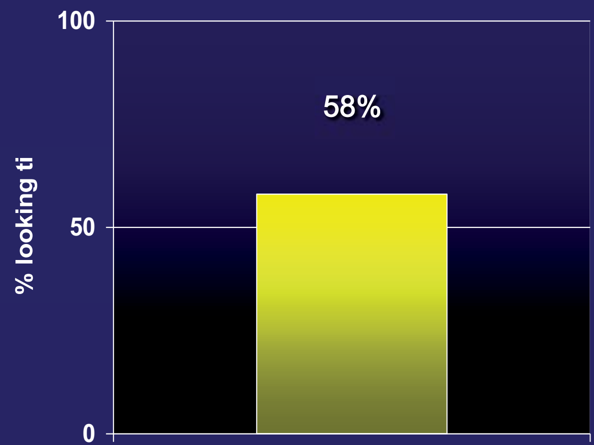


Upside down
Walking hen



Upright
Walking hen

Results



Upright stimulus

$t_{12} = 2.43 \quad p<0.05$

The results suggest the presence of an inborn predisposition to be sensitive to the dynamic relation specified by the direction of gravity.

Simion, Bulf,Regolin, PNAS 2008

Explanations of the inversion effect,

- An **inborn predisposition for the dynamics** of biological motion that relies on the direction of the gravity force (Vallortigara and Regolin,2006).

- A **visual filter tuned to the motion of limbs** of an animal (Life detector) (Troje and Westhoff, 2006).

Detection of perceptual cues present in biological motion

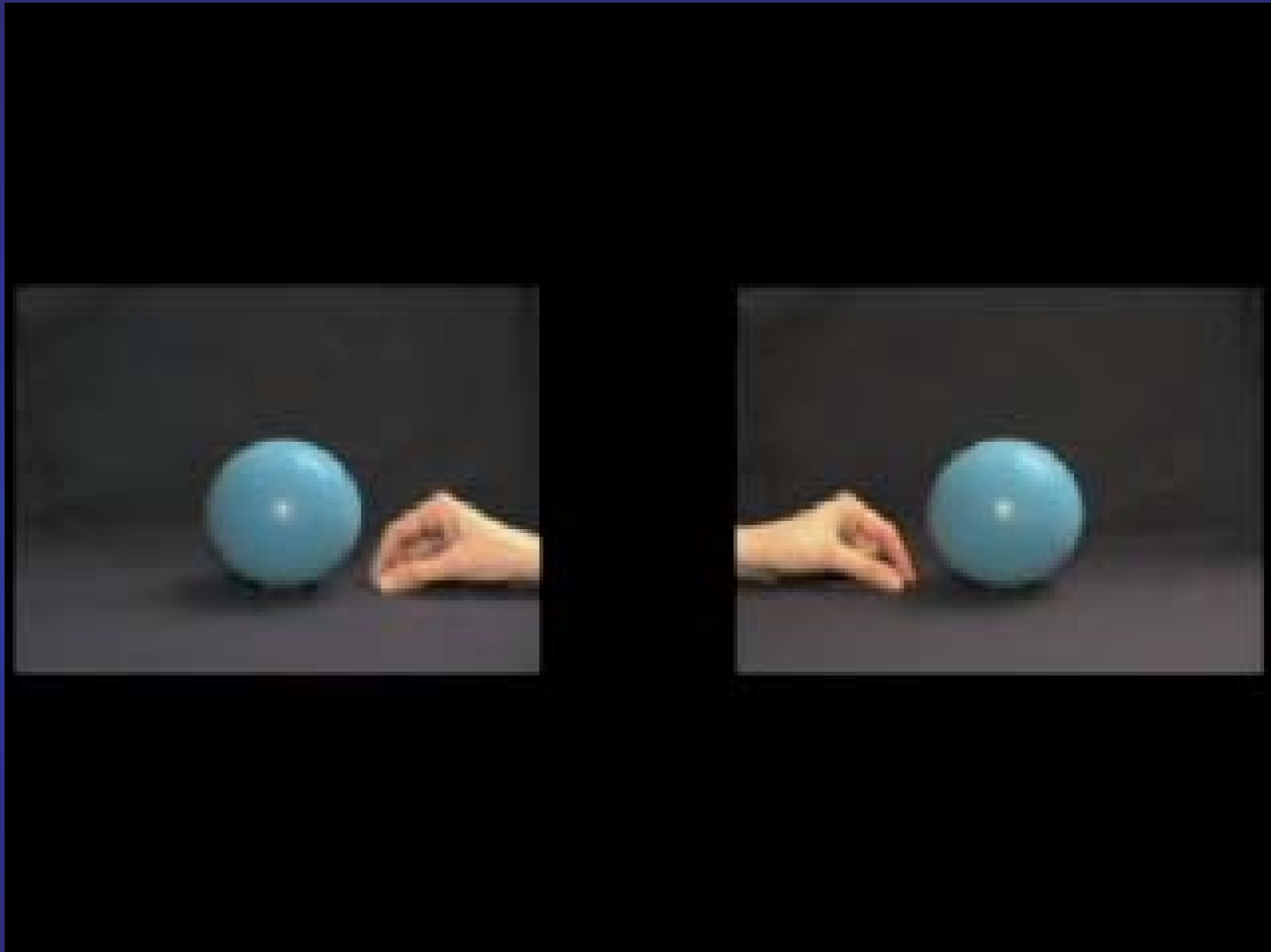
What do newborns process ?

Are newborns able to process:

Type of movement ?

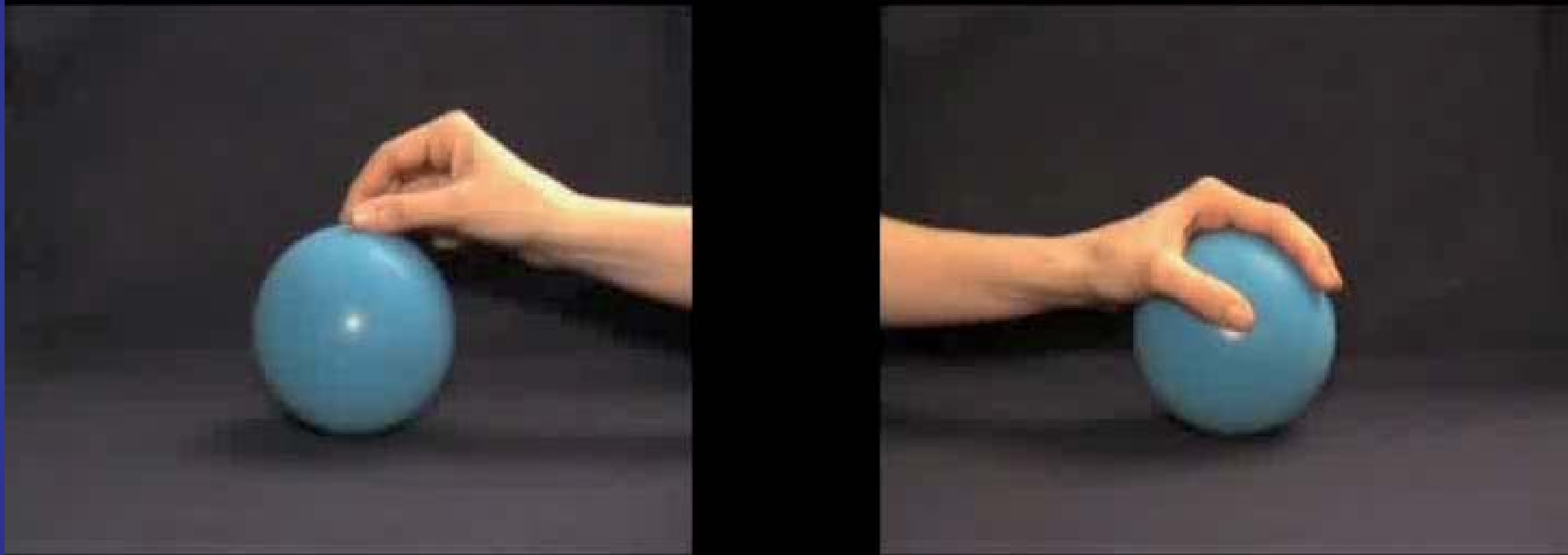
Direction of movement ?

Away from the body

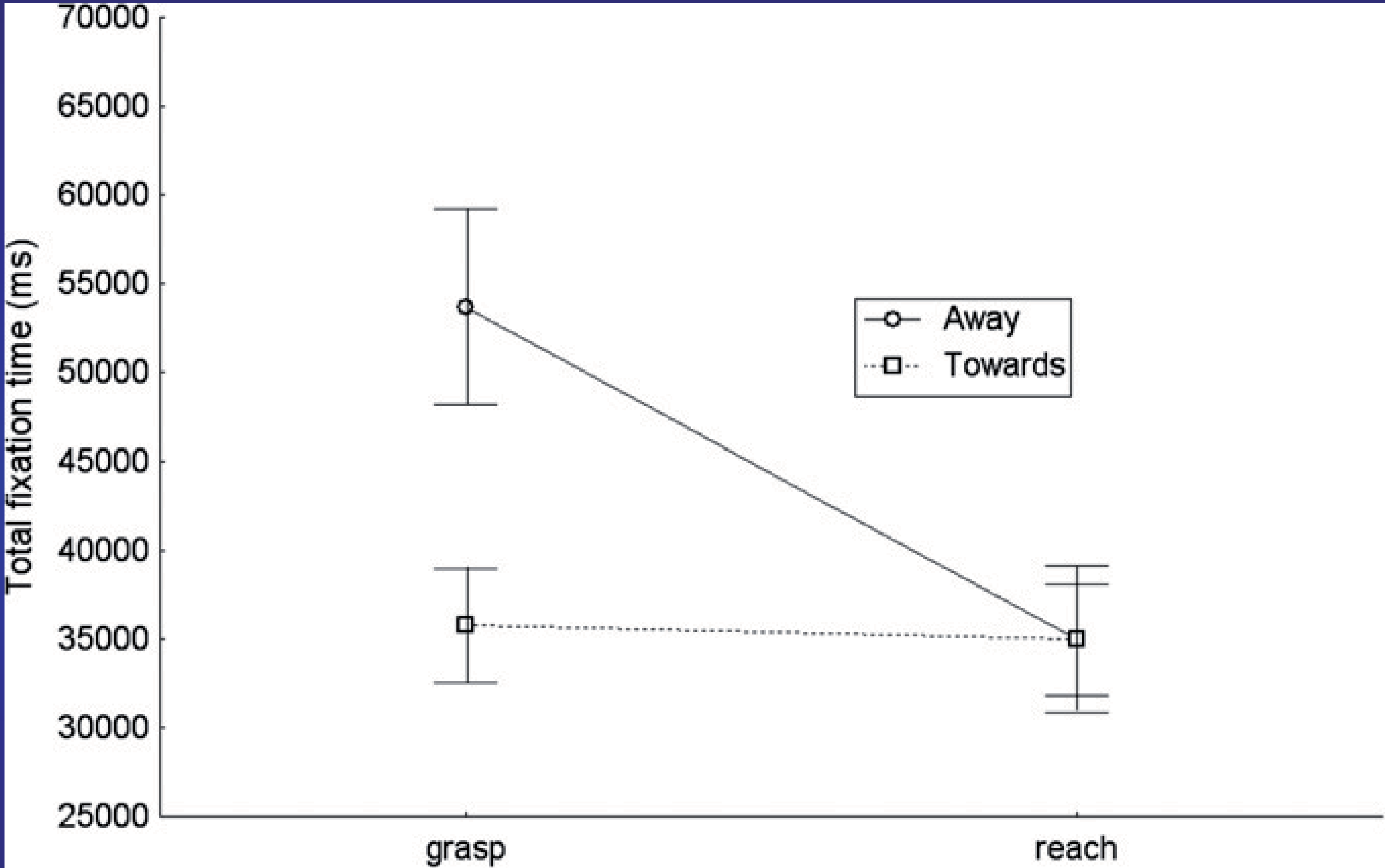


Craighero,Leo,Umiltà, Simion, COGNITION 2011

TOWARD THE BODY



Type of Movement x Direction of Movement, $F(1, 52) = 11,00$, $p = 0.002$,



Newborns preferred to orient to and to look longer at Grasping only when the movement was directed Away from the body

Overall…

- newborns prefer biological motion vs non biological motion display (exps. 2 and 3)

Overall these data are consistent with the existence in humans, at birth, of a predisposed and experience–independent perceptual mechanism for the detection of biological motion.

This predisposed system might enable newborns to preferentially attend to the movement of biologically relevant signals of their own environment.

The human system at birth

- Broadly tuned to detect low level perceptual cues embedded in social stimuli

As a function of experience the human system becomes **Expert and Specialized** in the identification of social stimuli

THANK YOU
FOR
YOUR ATTENTION

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