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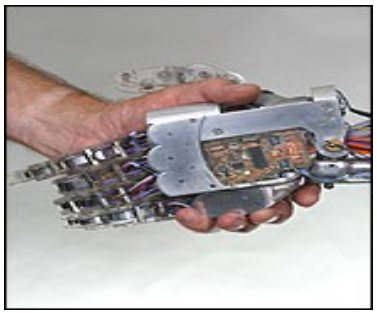
ICRA'07

2007 IEEE International Conference on Robotics and Automation

Full Day Workshop on Roboethics

Rome, April 14th, 2007

Human-robot interaction in autism



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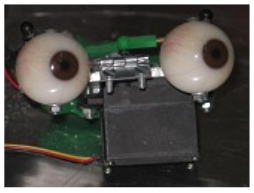
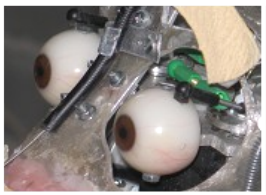
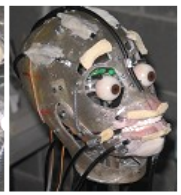
Facial Automaton for Conveying Emotions (FACE)




Human-machine interface for
non verbal communication within an umwelt

Believability: the embodied mind

Materials

- *Artificial vision and earing system*
- *Proprioception system*
- *Artificial muscles*
- *Motor control*

Control

- *Sensory and actuating data fusion*
- *Imitation strategy*
- *Neurocontroller*

Facial Automaton for Conveying Emotions (FACE)

The learning process in FACE will be based on imitating predefined stereotypical behaviours which can be represented in terms of FAPs (Fixed Action Patterns) followed by a continuous interaction with its umwelt, the epigenetic evolution of the machine

FAPs

action schemes, partly fixed on the basis of physical constraints and sensory-motor reflexes, partly subjected to a specialization on the basis of the experience

FACE

will continually learn, adapt and evolve within a simplified behavioural space in function of the umwelt and it will maintain spontaneous activity open to any innovative and intelligible behaviours arising which may then be interpreted

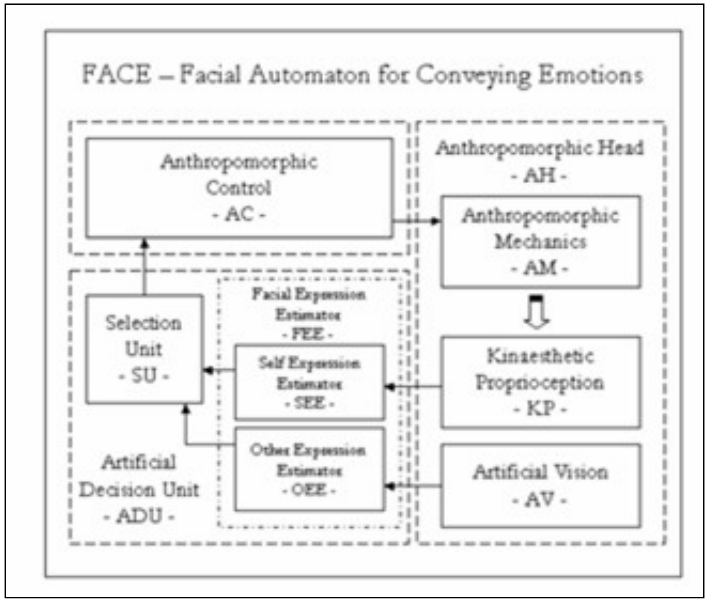
FACE Architecture

Man-machine interface for non-verbal communication

- Paradigms to develop a believable emotional display
- anthropomorphic mechanics
- science of materials

- Neuroscientific overview on neural message transmission
- Correlation between neural activity and emotional behaviours

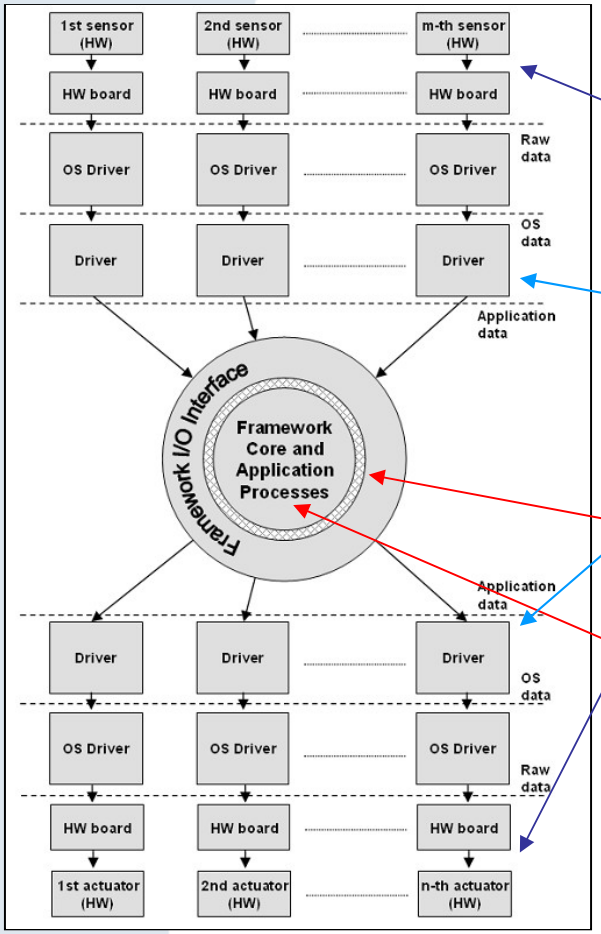
Emerging emotional behaviours



- **By behaviour we mean an emerging form of interaction with the environment FACE is engaged with.**
- **The problem we are currently setting ourselves is that of realizing a neural structure capable of creating its own representation of the surrounding environment in order to make it possible for innovative behaviours to emerge.**
- **Emerging behaviours could derive from an associative memory through which it may be possible to navigate within a behavioural space. These characteristics are typical of some areas of the central nervous system like the hippocampus, upon which the architecture for the neurocontroller of FACE will be based.**

• Pioggia et al., "*FACE: Facial Automaton for Conveying Emotions*", Applied Bionics and Biomechanics, 1(2), 2004
• Casalini et al., "*FACE e la sua mente*", in "La Bioingegneria del Sistema Cervello-mente", cap. 5., Biondi Ed., Collana di Bioingegneria, Patron, 2006

Framework Architecture



- Framework's base architecture is available to the researcher as a structured programming environment
- Filters can be redefined according to the particular device's technology
- The efficiency of filtering and buffering processes over the data coming from sensors and over the data directed to actuating devices is delegated to appropriate interfaces (drivers)
- The framework is responsible for dispatching transducer data to the control system through an indexing operation during the initialization step
- Specific processes are defined inside the control system, and their execution and synchronization are managed by the framework

Ferro et al., "*An Architecture for High Efficiency Real-time Sensor and Actuator Data Processing*", EUROSENSORS XIX, Barcelona, Spain, September 11th-14th, 2005

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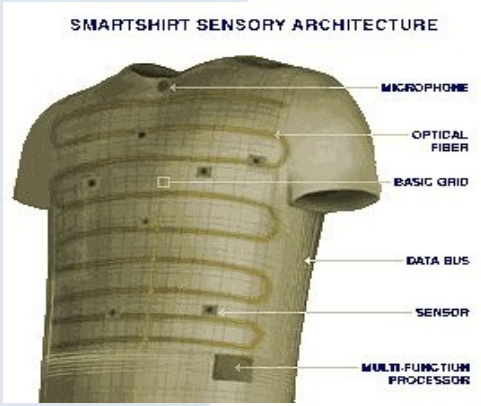
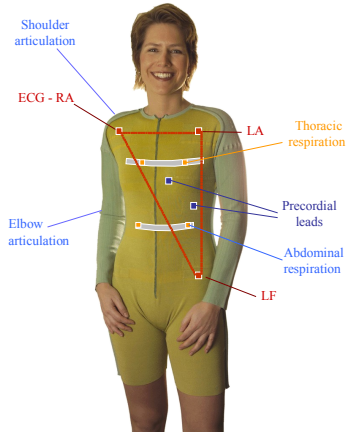
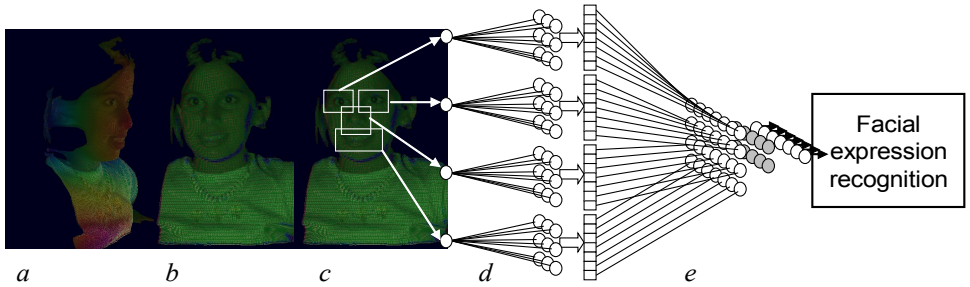
Acquisition of physiological and behavioural information

an unobtrusive sensorized wearable interface from the interlocutor.

to analyse the emotional reactions of individuals through optical analyses of facial expressions and tracking

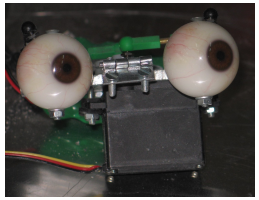






Future development

Gaze monitoring



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Facial Expression Recognition

Hierarchical Neural Network (HNN): 4 KSOMs + 1 MLP

Off-line training and test:

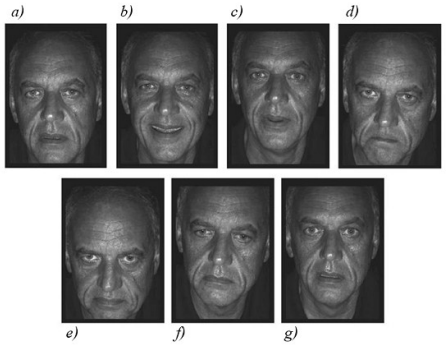
- **Facial Expression Databases JAFFE: 5 female subjects, 7 facial expressions, 154 total images)**

Center "E. Piaggio": 2 male subjects, 7 facial expressions, 308 total images)

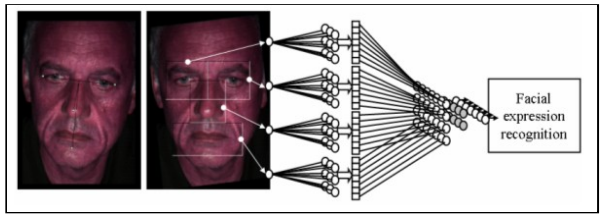
- **Splitter tool**

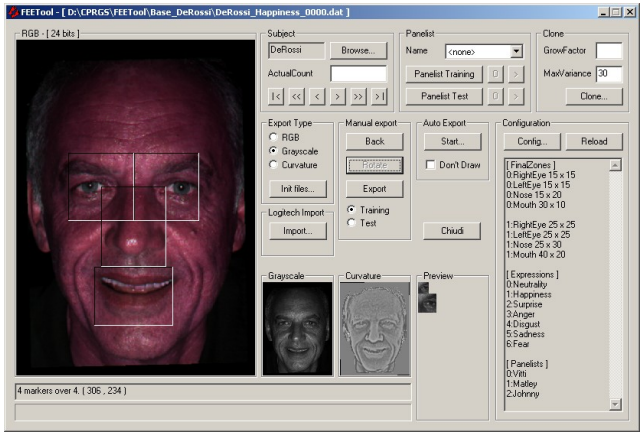
- **DataEngine ANN: 18 HNN configurations**

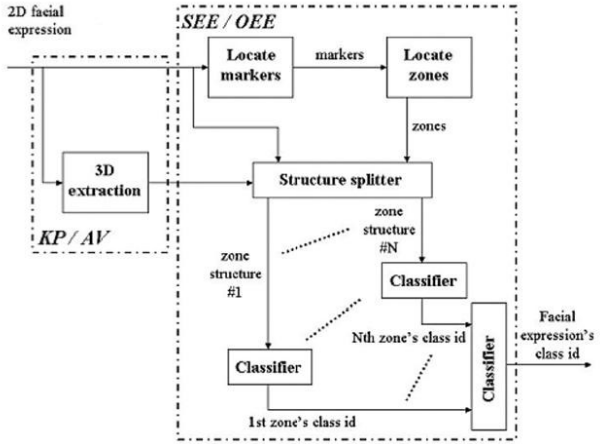
- **Panellist tool: 12 subjects at Center "E. Piaggio"**



Facial expressions of: a) *neutrality*; b) *happiness*; c) *surprise*; d) *anger*; e) *disgust*; f) *sadness*; g) *fear*







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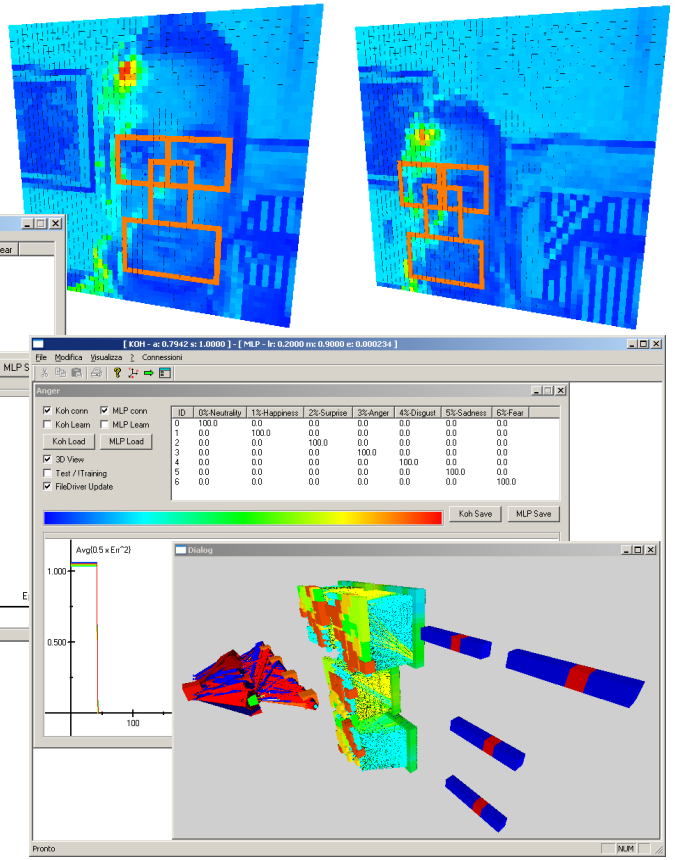
Facial Expression Recognition (2)

- **Off-line training: MLP and KSOM learning**

- **Real-time test: CameraSensorDriver, Face Tracking, Facial Zone Detection, MLP and KSOM running processes**



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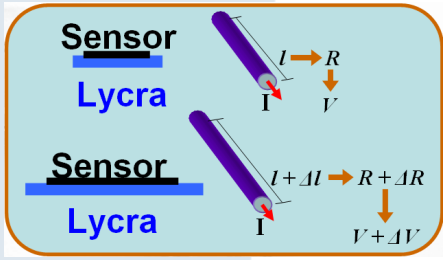
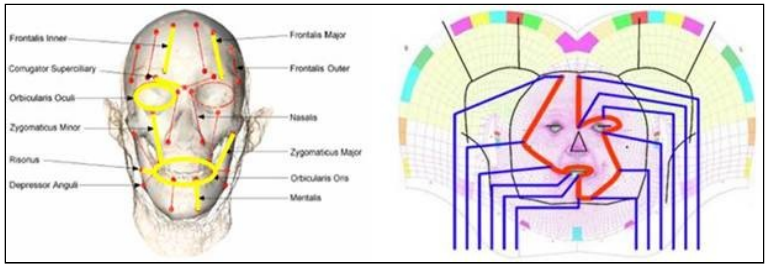
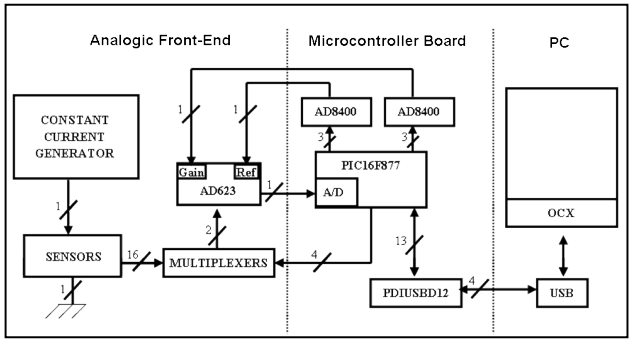
Facial Proprioception System



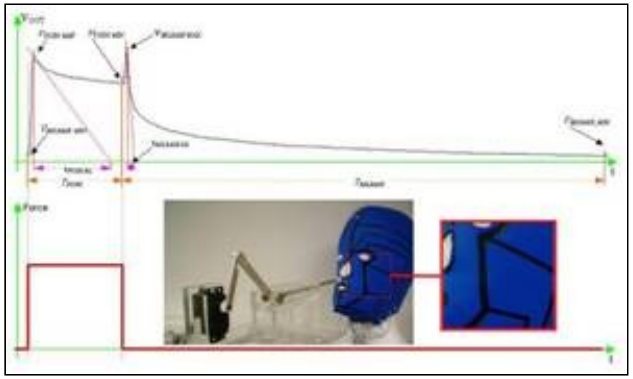




- **Sensors**
- **Connecting wires**

Directly printed on the fabric by using carbon filled silicone rubber.

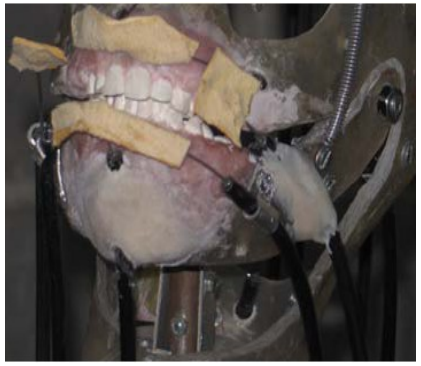
This mixture shows piezoresistive properties and can be used as a sensor. Moreover, no external wiring is necessary to interconnect the sensors on the fabric. Elastosil LR 3162 A/B is produced by WACKER Ltd which guarantees the non toxicity of the material

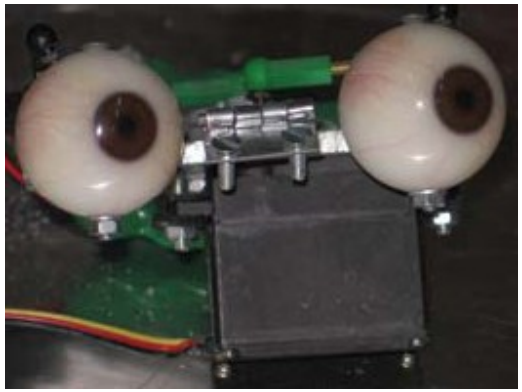


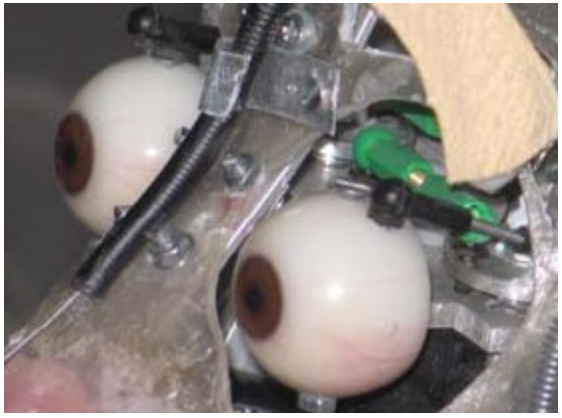
A module for the facial profile reconstruction is currently under development as an extension of the framework architecture

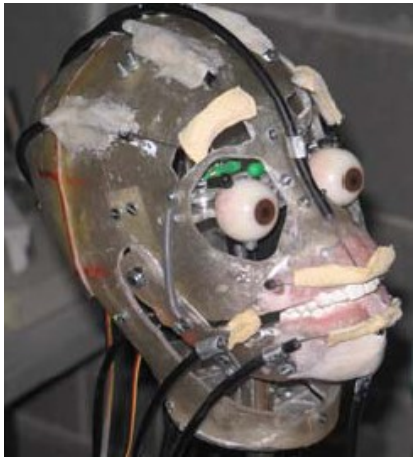
- Mazzoldi et al., "*EAP activity in Italy*", World Wide ElectroActive Polymers EAP (Artificial Muscles) Newsletter, Yoseph Bar-Cohen Editor, Vol. 6, No. 2, 2004.
- Pioggia et al., "*A biomimetic sensing skin: characterization of piezoresistive fabric-based elastomeric sensors*", in Sensors and Microsystems, 10th Italian Conference, World Scientific Publishing Co., Singapore, 2006.

FACE interacts with kinesics, a non verbal communication conveyed by body part movements and facial expressions









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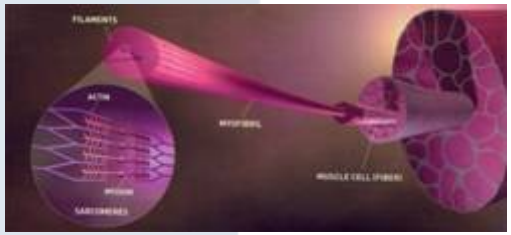
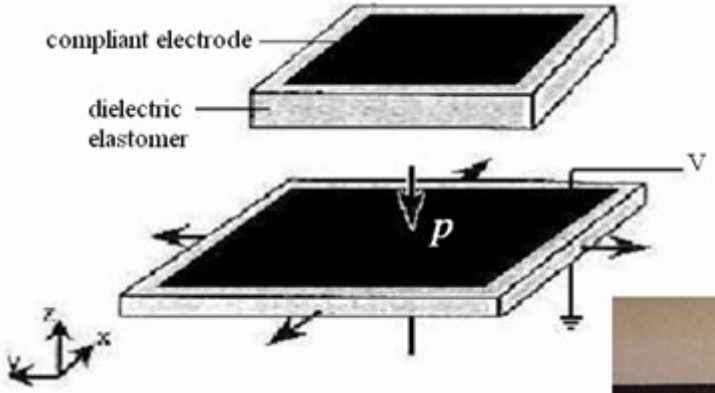
We believe dielectric elastomers are promising superior actuating materials for use in FACE



(Image from Pelrine, Kornbluh SRI, Stanford Research Institute)

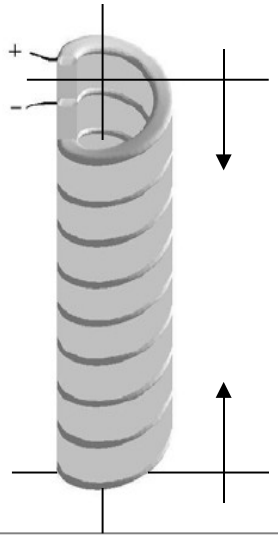


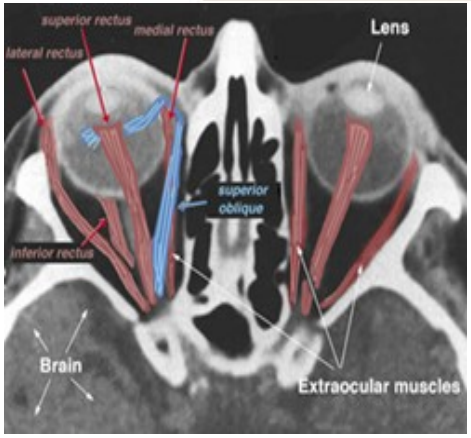
Voltage Off

Voltage On

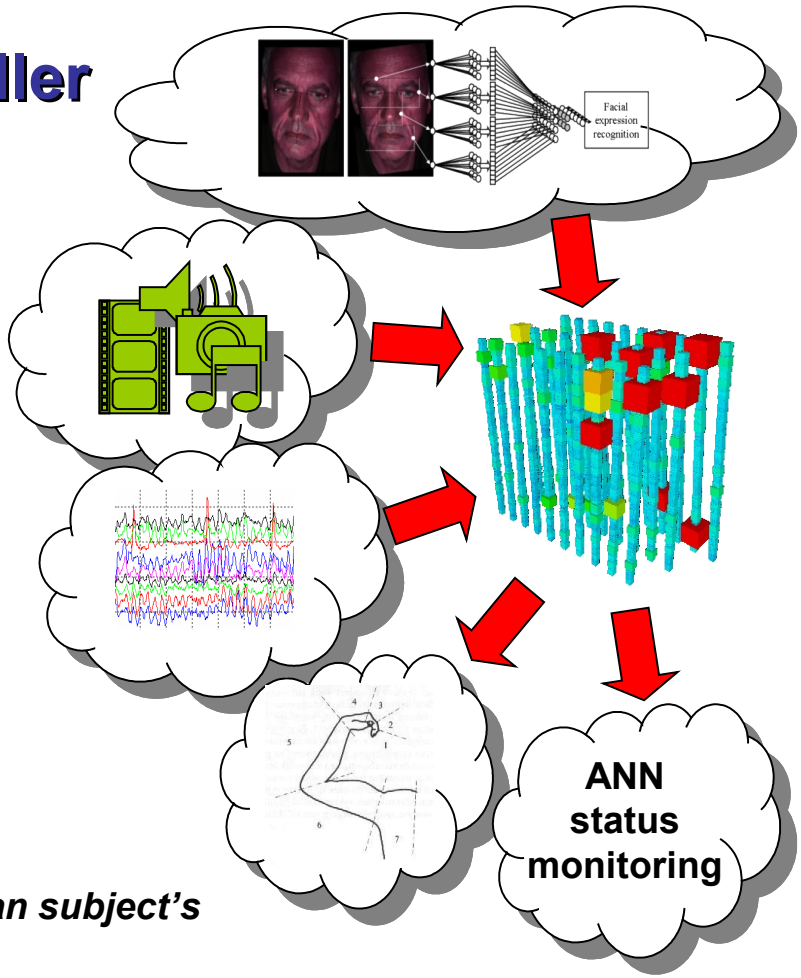
(b) Voltage on

Dielectric elastomers in double spiral configuration developed at Interdepartmental Research Centre "E. Piaggio"





Neuro Controller



A novel artificial neural network architecture

- *Epigenetic morphology: the geometrical configuration is taken into account as well as the topological architecture*
- *High-efficiency neuronal model: 1ms time resolution*
- *Selection strategy by means of the spike timing dependant plasticity rule (STDP)*
- *Real-time learning: the network can process continuous analog signals (camera and audio input, physiological signals, …)*

Application Scenarios

- *Simulation of central nervous system areas*
- *Model validation: comparing simulation results with human subject's behaviours and vice-versa*
- *Architectures for classification and prediction purpouses on etherogeneous and time-continuous signals*
- *Development of artificial brain areas as prothesis instruments*

FACE as a Therapeutic tool for people with autism (FACET)

Two distinct modalities are employed:

- **the first is based on a repertoire of pre-selected social situations**
- **the second allows the therapist to realise new situations as a consequence of the real time interaction between FACE and the child.**

A series of initial sessions are devoted to the familiarisation of the child with the robot, and to observe spontaneous reactions of the child when placed in front of FACE.

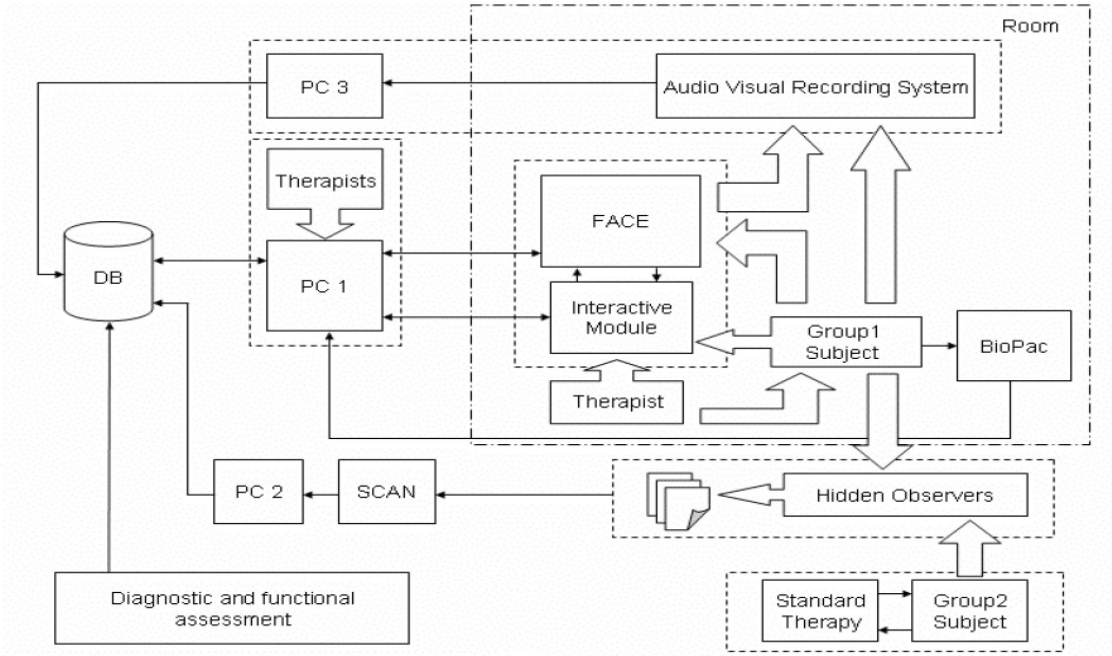
In the following we monitored the attention of four children towards FACE and then we checked if the android remains a restricted and repetitive interest or an object to share with the therapist.

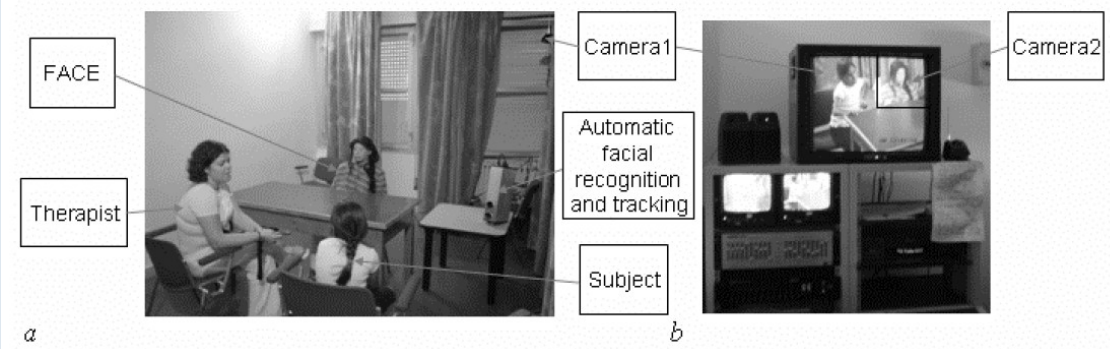
• Pioggia et al, "*An Android for Enhancing Social Skills and Emotion Recognition in Autistic Patients*", IEEE Transactions on Neural Systems and Rehabilitation Engineering, IEEE Transaction On Neural Systems And Rehabilitation Engineering, Vol. 13, No. 4, December 2005
• Pioggia et al., "*FACET: an android-based therapeutical approach for treatment of autistic disorders*", in Proceedings of 3th World Congress on Biomimetics, Artificial Muscles & Nano-Bio, Lausanne, Switzerland, 2006.
• Pioggia et al., "*Imitation and Learning of the Emotional Behaviour: Towards an Android-based Treatment for People with Autism*", in Proceedings of Sixth International Conference on Epigenetic Robotics: Modeling Cognitive Development in Robotic Systems, Paris, 2006.

FACE as a Tool for Autism (FACET) (2)

Experimental set-up

- Equipped room
- Therapist supervision
- The subject interact with FACE through an Interactive Module

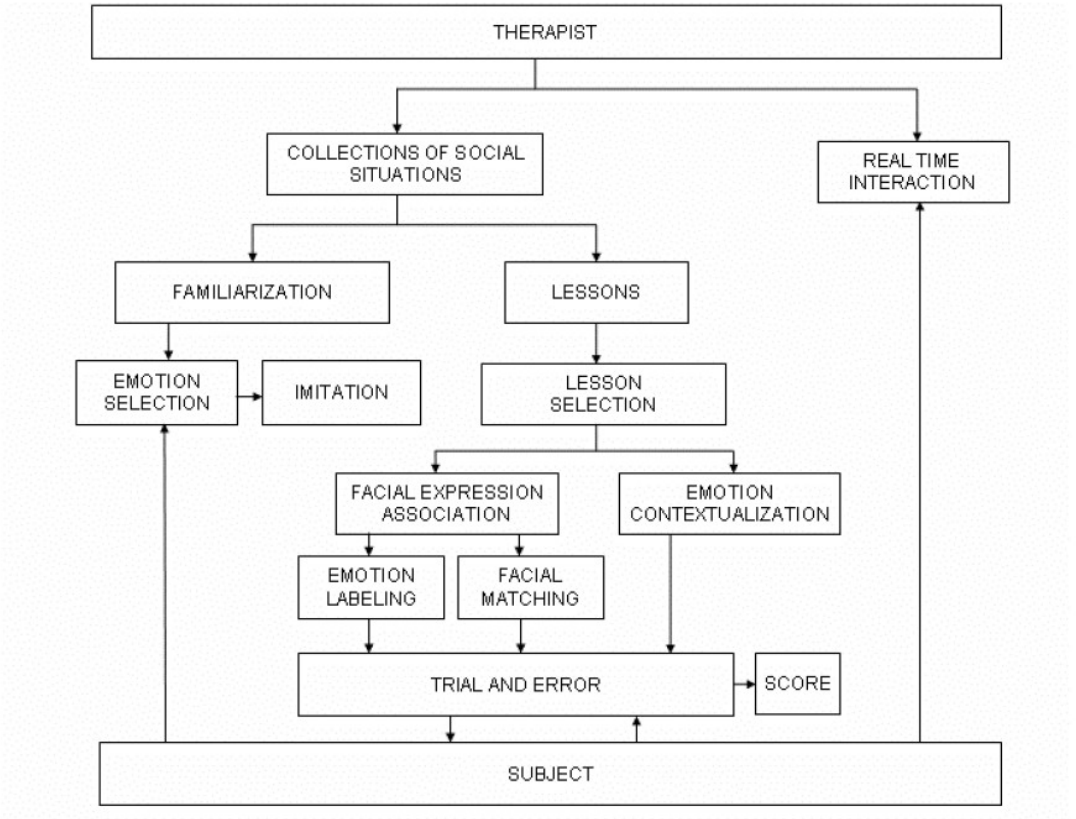




FACE as a Tool for Autism (FACET) (3)

Treatment Scheme

- **Modalities: Repertoire / Therapist control**
- **Face tracking, eye tracking, facial expression recognition**



C.A.R.S.
Childhood Autism Rating Scale

15-item behavioral rating scale developed to identify children with autism

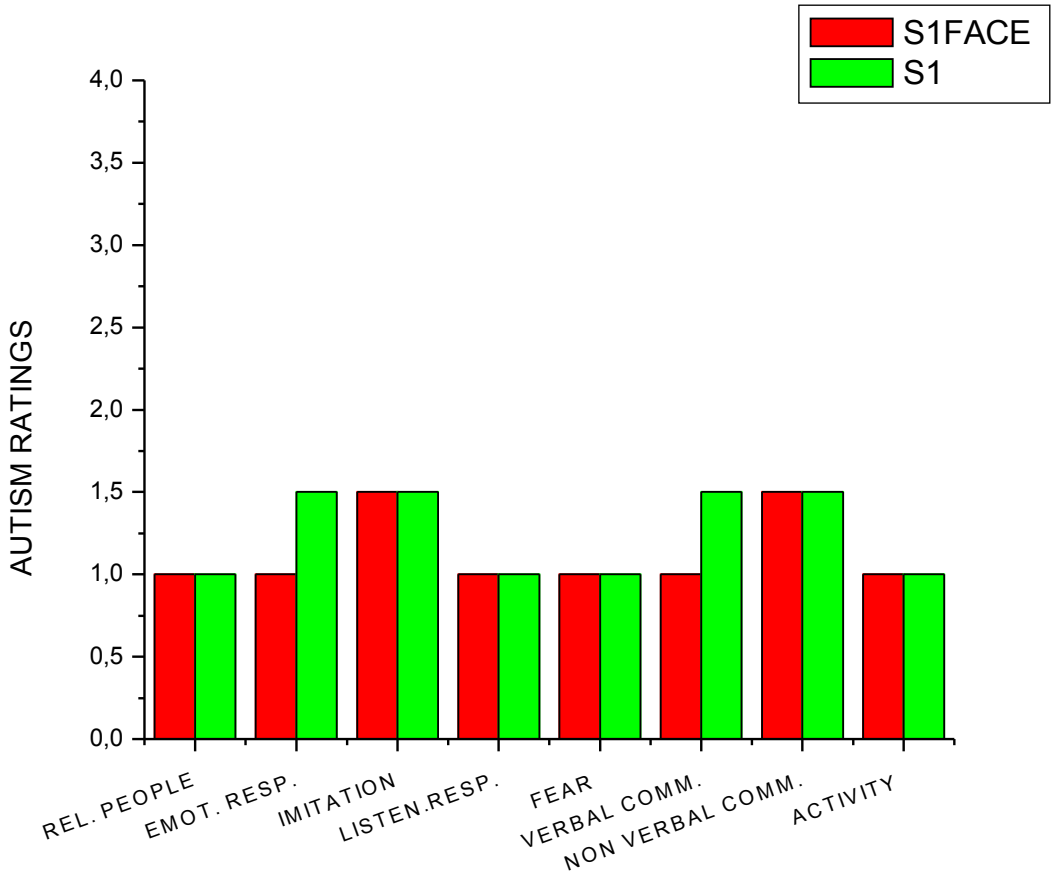
Advantages
-Items represent varied diagnostic criteria and reflect the broadened definition of the autism syndrome.
-Applicability to children of all ages including preschooers
-Replacement of clinical judgements with objective and quantifiable ratings Based on direct behavioural observations.

Limits
-Presence of subjectivity collecting data
-Classification of CARS is not an end point in assessment
-CARS does'nt consider the autisms's criteria of early onset

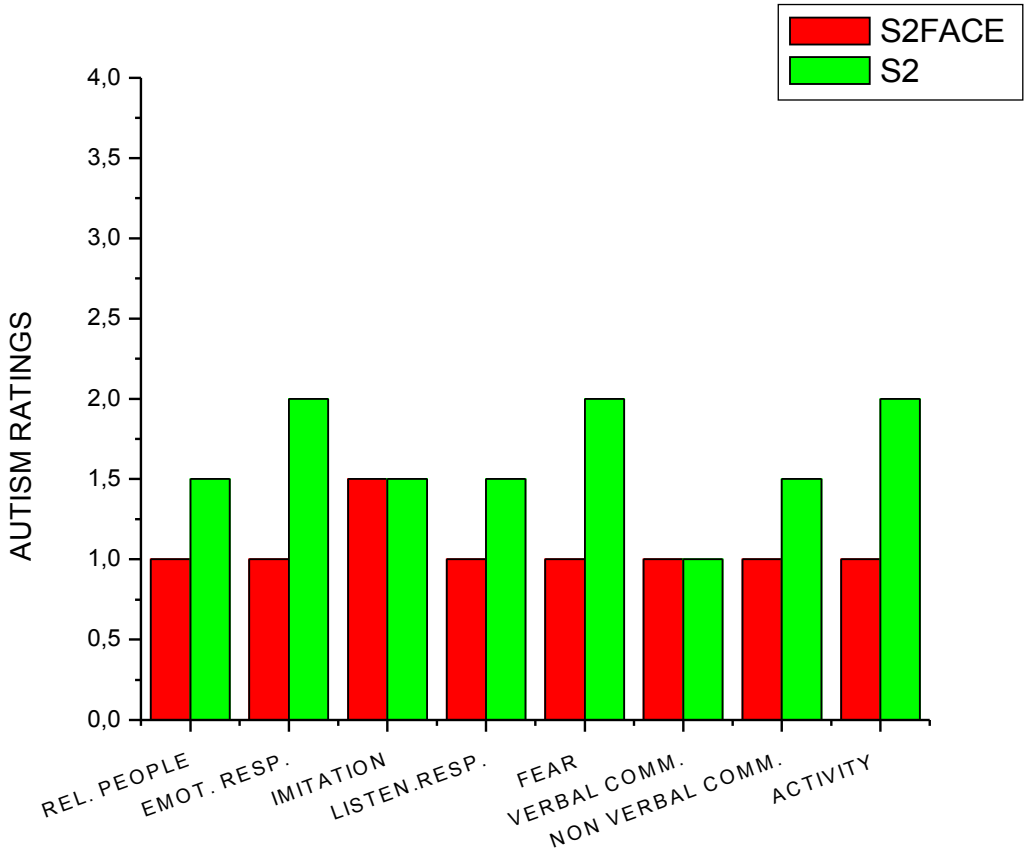
CARS ITEM

I- RELATING TO PEOPLE
II- IMITATION
III- EMOTIONAL RESPONSE
IV- BODY USE
V- OBJECT USE
VI- ADAPTATION TO CHANGE
VII- VISUAL RESPONSE
VIII- LISTENING RESPONSE
IX- TASTE, SMELL, AND TOUCH RESPONSE AND USE
X- FEAR OR NERVOUSNESS
XI- VERBAL COMMUNICATION
XII- NON VERBAL COMMUNICATION
XIII- ACTIVITY LEVEL
XIV- LEVEL AND CONSISTENCY OF INTELLECTUAL RESPONSE
XV- GENERAL IMPRESSIONS

S1 FACE = cars ratings made from experimental session with FACE
S1 = cars ratings made from observations during psychological testing



S2 FACE = cars ratings made from experimental session with FACE
S2 = cars ratings made from observations during psychological testing



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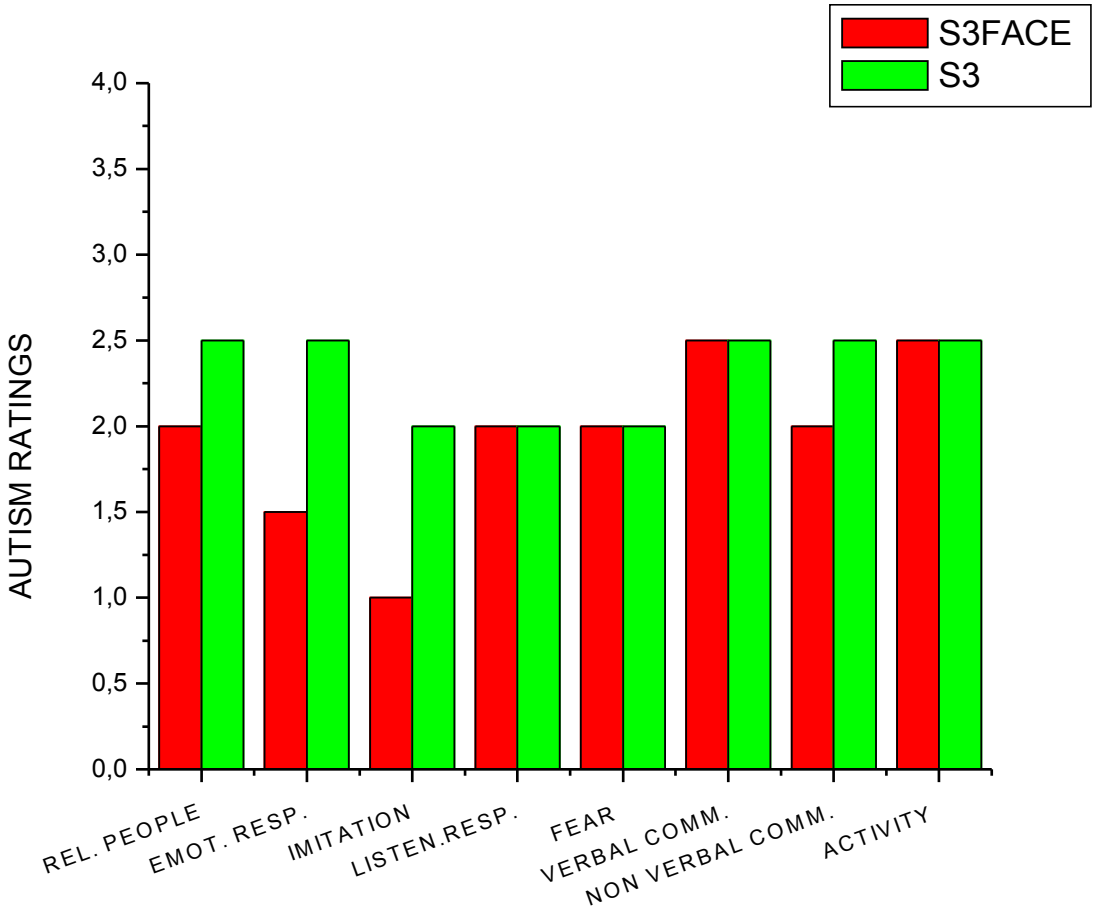
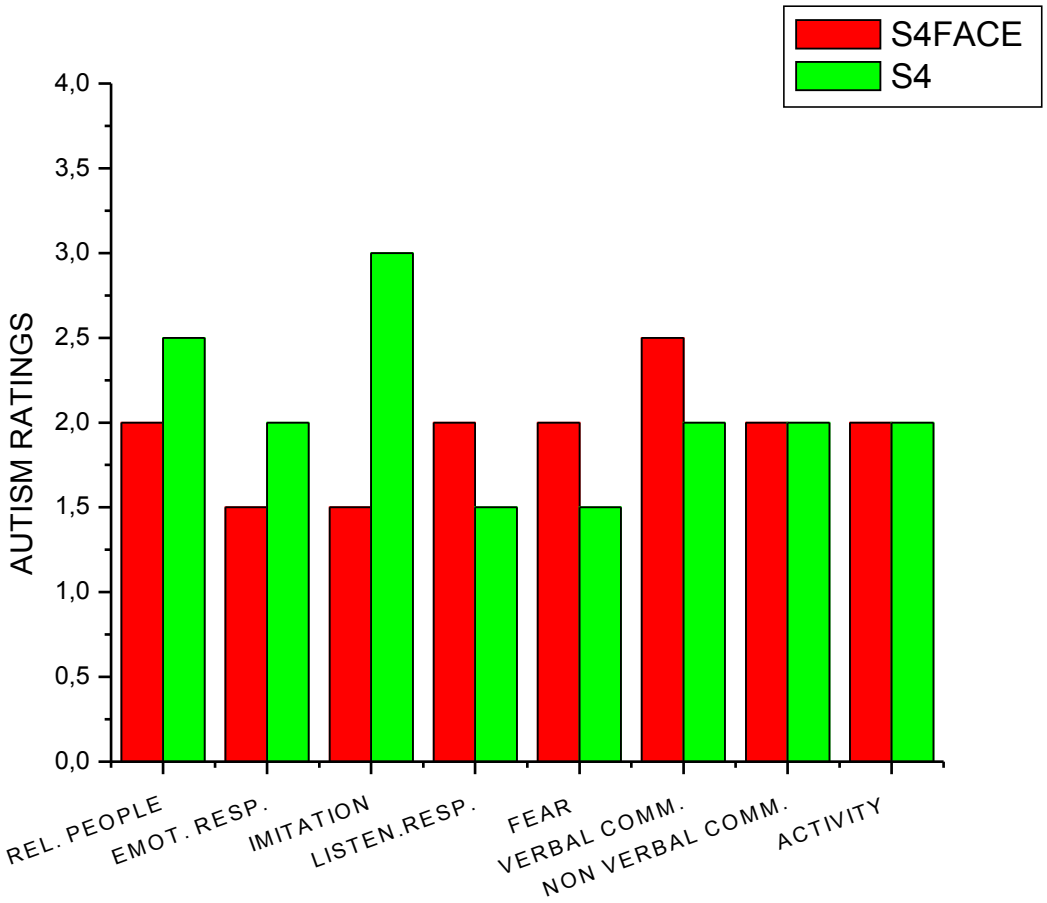
S3 FACE = cars ratings made from experimental session with FACE

S3 = cars ratings made from observations during psychological testing



S4 FACE = cars ratings made from experimental session with FACE

S4 = cars ratings made from observations during psychological testing



Experimental session: focus of attention on FACE (s4)

Experimental session: spontaneous approaching for eye contact with FACE (S4)

Experimental session: non verbal requesting through conventional gesture (S4)

S4 winks at FACE

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The "connectionist ethical stand point" and FACE Therapy Morality:

During the interaction between the autistic child and FACE, the therapeutic importance rests on the possibility to build an intellective-emotional bridge.

The importance of a therapeutic approach based on the interaction between autistic people and artificial devices being able to create a semplified model of a tipical emotional interaction is proved by sperimental evidencies.

References

K. Dautenhahn
Professor of Artificial Intelligence
University of Hertfordshire

K. Dautenhahn *Design issues on interactive environments for children with autism*
K. Dautenhahn, **and A. Billard**, *Games Children with Autism*
Can Play With Robota, a Humanoid Robotic Doll

Francois Michaud
Department of Electrical and Computer Engineering
Universite de Sherbrooke, Sherbrooke (Quebec Canada)

Francois Michaud, Pierre Lepage, Jean-Daniel Leroux, Matthew Clarke, Francois Belanger, Yannick Brosseau and David Neveu, *Mobile Robotic Toys for Autistic Children*

THE VALUE OF THE CONTEXT

The morality of the context in which the interaction between child and robot takes place is not based on a apriori construction rules.
It depends on the building subjects. It is due to the their ability to create an comunicative situation which is near at hand for autistic children.

That is based first of all on an assumption: the autistic child needs love as every child, ***because he or she is autistic and not despite his or her autism.***

Uta Frith in her book ***Autism. Explaining the Enigma***
(Blackwell, Oxford, UK & Cambridge, USA, 1989) says that the intuitions of sane people on their mental states and on the ones of the others, dominate our relationships.
All the people who want to relate with autistic subjects have to repress that domination if they want to understand them.

Sentences like “That child refuses my feelings” doesn’t make sense!!

If a child is not able to “mentalize”, a sentence like that can’t be supported!

Which is the relevance of autism knowledge and in what does the importance of FACE Therapy for autistic children consist?

It is clear that parents of autistic children must be well informed on the contents of FACE Therapy and on the expected results of an interaction between FACE and the child.

Aside from that, we must understand that every people willing to interact and communicate with an autistic child necessarily have to choose a different way. If people taking care of autistic children are “good teachers”, we can succeed in letting the child learn some aspects of social behaviour, scholastic abilities, and a lot of environmental data.

In that sense, FACE Therapy must be considered as a particular communicative step, aimed at yielding a behavioural help.

CONCLUSIONS

- FACE is an ongoing project
- imitation process will be based on imitating predefined stereotypical behaviours
- stereotypical behaviours will be represented i terms of FAPs followed by a continuous inter action with the android umwelt
- FACE framework is actually applied to investigate the interaction between a child with autism and a humanoid
- Our hypotesis is that this method will diminuish social impairment and increase expressiveness, facial mimicry and shared attention

Future work for the beyond

- The framework architecture will be improved and extended
- Edelman's "Theory of Selection of Neuronal Groups" is actually under study making use of the Izhikevich neuronal model
- The current neural models do not include the role of glia cells and in particular those of the astrocytes. Glia modulates the neural communication achieving a two-dimensional continuum in which calcium ion waves influence synaptic communication.
- Transducer devices and control modules of F.A.C.E. are currently being improved and extended

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DEFINING CRITERIA FOR AUTISM

(DSM-IV)

- Qualitative impairment in communication
- Social Impairment
- Restricted, repetitive and stereotyped patterns of behavior
- Early onset (3 years)
- Exclusion of other Pervasive Developmental Disorders (PDD)

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- 4 autistic subjects

=> Diagnoses according to criteria of DSM-IV :

- Autism Diagnosis Interview Revised (ADI-R) (Lord et al.,1989; 1994) administered by a trained clinician
- Autism Diagnostic Observation Schedule (ADOS), a semistructured assessment of social interaction, communication, play for individuals with PDD

⇒ Cognitive evaluation aimed to measure intelligence (WISC-R):

=> Normal MRI

=> Absence of epilepsy

=> Without chromosome anomalies

PDD	CA	PIQ
S 1	10y 6m	105
S 2	9y 6m	87
S 3	8y 11m	85
S 4	20y 6m	52

DIAGNOSTIC INSTRUMENTS: ADOS-G

Autistic Diagnostic Observation Schedule General
(Lord, Risi, Lambrecht, Cook, Leventhal et al. 2000)

Trad. It. Tancredi R., Saccani M., Persico A.M., Parrini B., Igliozzi R., Faggioli R.

- a semi-structured assessment of social interactions, communication, play and imaginative use of materials
- meet DSM –IV (Diagnostic and Statistical Manual of Mental Disorders)- and ICD 10 (International Classification of Diseases 10) criteria
- yield a quantitative diagnostic algorithm, which discriminates autistic from non-autistic subjects. They are also the sole instruments widely accepted for the diagnosis of autism.