Considering Sensory Preferences in the Design of Human-Robot Interactions for Autistic Users

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Overview

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+ Definition of Individual Visual and Proprioceptive Profiles
+ Three complementary Human-Robot Social Interactions Tasks
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  - Greetings with Nao
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+ Conclusions
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Nonverbal Affective Interaction

PhD Thesis of Ouriel GRYNSZPAN (Co-supervised by Jacqueline NADEL) 2002-2005

Virtual characters ; Facial and bodily expressions of emotions ; Eyetracking ; Joint Attention


Introduction

Related Work

No virtual characters

Mobile Affective Computing [Picard 2009], Innovative technologies [Grynszpan 2013], Gaze Tracking [Lönnqvist 2016]

Virtual Characters

Gazing at facial expressions [Grynszpan 2012]

Social Attention Job interview [Mundy 2013]

Authorable Virtual Peer [Cassell 2015]
Introduction

Socially Assistive Robotics (SAR) a growing research area
[Feil-Seifer and Mataric, 2005; Tapus et al. 2008; Dautenhahn et al, 2009]

People suffering of Autistic Spectrum Disorders (ASD) are relevant users
Impaired skills in communication, interaction, emotion recognition, joint attention, and imitation [Charman 1997; Celani 1999]
Affinity with robots, computers [Hart 2005 ; Nadel 2007]

Individuals with ASD show strong individual differences
Introduction

Research Goals

- **Step 1:**
  Define individual profiles based on sensory preferences

- **Step 2:**
  Observe if an individual’s profile impacts social skills
  (communication, interaction, emotion recognition, joint attention, and imitation)

- **Long Term goal**
  personalized human-robot interactions to improve social skills
19 Participants with ASD from 3 care facilities

IME MAIA (Paris, France)
IME Notre Ecole (Sainte-Geneviève-des-bois, France)

12 children and teenagers with ASD
2 girls and 10 boys
11.7±2.6 years old

FAM La Lendemaine (Limours, France)

7 adults with ASD
3 women and 4 men
26.8±7.9 years old
Hypothesis

Researchers have observed a link between integration of proprioceptive and visual feedbacks and communication, interactions skills, emotion recognition [Haswell 2009]

• **Hypothesis**

  Hyporeactivity to visual motion and overreliance on proprioceptive information lead to difficulties in social interactions
Individual Visual and Proprioceptive Profiles

Questionnaire
Adolescent and Adult Sensory Profile (AASP) [Dunn, 1999]
Evaluates each individual's sensory processing preferences
Scores assessing Movement, Visual, Touch, Auditory processing

Experimental setup [Isableu et al., 2011]
Assess the effect of a moving virtual visual scene (VVS) on postural control

Assess an individual’s capability
to use proprioceptive inputs provided in dynamics of balance
to reduce visual dependency
Individual Visual and Proprioceptive Profiles

+ Analysis of the Center of Pressure (CoP) displacement with a force platform while exposed at visual stimulus [Isableu 2011]

+ Visual stimulus
  a virtual room rolling at 0.25Hz from line of sight with an inclination of 10°

+ Participants asked to stand on a force platform (FP) in front of a virtual room in 3 conditions
  C1 - stable position with static Visual Scene
  C2 - stable position with moving Visual Scene
  C3 - tandem Romberg position with moving Visual Scene
Individual Visual and Proprioceptive Profiles

Clustering analysis by Dendrogram

1. The AASP items and the data extracted from the CoP are used
2. Three groups were computed by the clustering analysis

- **G1**: no postural response to the visual stimulus, high movement sensitivity, low visual sensitivity

- **G2**: postural response to the visual stimulus, high movement sensitivity, medium visual sensitivity

- **G3**: postural response to the visual stimulus, low movement sensitivity, high visual sensitivity
Individual Visual and Proprioceptive Profiles

Our participants were classified into 3 groups characterizing their visual / proprioceptive integration

Hypothesis
belonging to a group impacts the social skills of the participant

Individuals from group G1 will have less successful interactions than individuals from groups G2 and G3 (they display proprioceptive preferences)

Individuals from group G3 will have the most successful interactions (they display visual preferences)

Task #1
Recognition of expressions of emotions

Research Question:
Is there a relationship between sensory profiles and recognition of expressions of emotion?

- Face + Body
- Expressions of emotions are often multimodal
- Different robotic platforms are available

Different embodiments
- Different robotic platforms are available
- Enables comparisons

Task #1
Recognition of expressions of emotions

+ We did not find any available database that fits our needs

+ => We collected a database of expressions of emotions
  + Emotions expressed by 4 different embodiments, real and virtual, with different complexity
  + Emotions displayed by the face and/or the body
Task #1: Recognition of expressions of emotions

Full database available on
http://perso.ensta-paristech.fr/~tapus/eng/media/EMBODI-EMO.zip

Video samples
Task #1: Recognition of expressions of emotions

Creation of the EMBODI-EMO Database

- Selection of 4 basic emotions: Anger, Happiness, Fear, Sadness
  Emotions « easier » to understand by individuals with ASD than more complex emotions
  Their expression is documented in the literature
- Design of animations
  FACE: Use of combination of Action Units (AU) [Ekman and Friesen, 1984] for one prototypical expression for each emotion
Task #1: Recognition of expressions of emotions

Creation of the EMBODI-EMO Database

+ Four embodiments
  - Nao, humanoid robot
  - Zeno, humanoid robot with a silicon-made actuated skin face
  - Mary, female humanoid virtual agent
  - Pauline, female human
Task #1: Recognition of expressions of emotions

Creation of the EMBODI-EMO Database

Three modalities

- Face Only
  (1 animation by emotion, Nao excluded)

- Body Only
  (3 animations by emotion, Nao included)

- Body and Face
  (3 animations by emotion, Nao excluded)
Task #1: Recognition of expressions of emotions

Collection of the EMBODI-EMO Database

96 videos

12 videos of facial expressions
   (4 emotions x 3 embodiments)

48 videos of body expressions
   (3 animations x 4 emotions x 3 embodiments)

36 videos of body and facial expressions
   (3 animations x 4 emotions x 3 embodiments)
Task #1: Recognition of expressions of emotions

Validation of the database with Typically Developed Adults

- Participants were asked to evaluate for each video the recognized emotion
- 64 participants
  - 31 females
  - age: 28.23 +/- 8.31 years old
  - 62.5% with a technological background
- Internet questionnaire
Task #1: Recognition of expressions of emotions

Validation of the database with Typically Developed Adults

- Emotion recognition results were higher in conditions in which the face expressed emotion than in the condition where only the body expressed the emotion.

  Importance of facial expressions for recognizing the category of emotion [Buisine et al., 2014; Meeren et al., 2005]

- Emotion recognition was more difficult on Zeno than on other platforms.
Task #1: Recognition of expressions of emotions

Emotion Recognition in individuals with ASD

- 40 videos were selected among the best recognized by TD individuals
  Divided in mini-sessions of 10 videos each

- Graphical interface implemented as a tactile computer game
  Participant had to press a button to chose the recognized emotion
  Video can be repeated
Task #1: Recognition of expressions of emotions

Emotion Recognition in individuals with ASD

- The results of the task depend on the motivation and/or condition of the participant
- Adults showed recognition scores around 25% for each emotion
- Analysis with only children participants suggests that:
  - Children in group G1 display the lowest scores
  - Children in group G3 display the highest scores

- No effect of the embodiment was found, differently to TD individuals.

- Children from G3 relied more on facial features than on body features, differently to children from G1 and G2
Task #1: Recognition of expressions of emotions

Emotion Recognition by individuals with ASD

- Visual and proprioceptive profile predicts emotion recognition score

- Adults have difficulties to play the game
  Maybe because they do not do this kind of game with their caregiver, whereas children do play such games
Task #2: Greetings with Nao

A first Human-Robot Interaction was conducted with all our participants (up to 2 minutes)

The robot presents itself and dance for the participant

Task #2: Greetings with Nao

+ Objective
  To introduce Nao to the participants: remove stress and present Nao as a social partner [Meltzoff et al. (2010)]
  Test if sensory preferences impact social behavior

+ Manual annotation and analysis of the participants' gaze direction and gestures towards the robot, the caretaker, and all the other directions
Task #2: Greetings with Nao

- Participants looked more than 60% of the time at Nao, except for two participants from groups G1 and G2.

- Numerous smiles observed.

- Some participants showed to be slightly afraid and impressed by the robot at the beginning of the interaction.
Participants from G3 showed more free speech than participants from G1 and G2; Participants from G1 showed less free speech than participants from G2 and G3 (p < 0.05)

Suggests that visual participants’ interaction is more successful?

A tendency suggesting that visual participants might look at Nao more often than proprioceptive participants (no statistical significance)
Task #3: Response to Joint Attention Initiation

Joint Attention Task

- Joint Attention appears to be impaired in individuals with ASD (Johnson 2007; Mundy 2007)
- Matching game involving Joint Attention
  - Similar game used in ASD care
  - Easy to adapt to individuals
  - Involve social interaction
  - Use of communication cues
- Design of the task with the help of the caregivers
Task #3: Response to Joint Attention Initiation

+ **Objective:** find a link between Joint Attention and Visual and Proprioceptive integration of cues

+ **Observation of the Time of Response to Joint Attention (TRJA) and social behaviors**

+ **Hypothesis:**

An individual with an overreliance on proprioceptive cues and a hyporeactivity to visual cues will have difficulties reading the intention of the robot.

- Participants from G1 will have more difficulties/will answer more slowly to JA than participants from G2 and G3
- Participants from G3 will have more facilities/will answer more rapidly to JA than participants from G1 and G2
Task #3: Response to Joint Attention Initiation

- **Set up**
  Nao seated on a table, in front of the participant
  15 cards
  2 monitors

- **Different levels of prompting by the robot Nao**
  Head only; Arm only, Both

- **Task**
  An image appears on monitor, Nao points to it and asks the participant to grab the matching card
Task #3: Response to Joint Attention Initiation

Video
Task #3: Response to Joint Attention Initiation

Except for CH5 and CH11 (G1), all participants understood the matching game.

The matching game was difficult for participants with low cognition, even if we discussed prior with the caregiver about the task.
Task #3: Response to Joint Attention Initiation

+ We did not find statistical differences in TRJA between conditions or groups

  Groups too small? Not enough repetitions? Great variability?

+ Descriptive statistics suggest that visual participants (G1) are slower than proprioceptive participants (G2 and G3)
Conclusions and future directions

Goal: define user profiles thanks to integration of visual and proprioceptive cues for personalized therapy for children with ASD

We tested our hypothesis on different communication and social skills

We obtained promising results
Conclusions and future directions

+ Defining such individual profiles could provide promising strategies for designing successful and adapted Human-Robot Interaction for individuals with ASD.

+ Methodological challenges
  
  Due to small subject pools and/or short-term experiments, generalized results in the improved skills are often questionable (Scassellati 2012)
  
  Adapt to the individual needs of children over longer periods of time (Thill 2012)

+ Current work: design an interaction adapted for each participant, in regards of their profiles
  
  Imitation task: observation of statistically significative results
  
  Repetitive sessions
  
  Adaptation to each participant
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