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

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Overview

- Introduction
- Participants
- Hypotheses
- Definition of Individual Visual and Proprioceptive Profiles
- Three complementary Human-Robot Social Interactions Tasks
  - Recognition of expressions of emotions
  - Greetings with Nao
  - Joint Attention Initiation by Nao
- Conclusions

Introduction
LIMSI > HCI > CPU

- Research Group « Cognition, Perception, Use » (Head J.-C. MARTIN)

Researchers in Psychology / Ergonomics / Computer Sciences

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

Grynszpan, O., Martin, J.-C., Nadel J. (2008) Multimedia interfaces for users with high functioning autism: an empirical investigation. International Journal of Human – Computer Studies (IJHCS), 66, 628-639

Grynszpan, O., Nadel, J., Martin, J. C., Simonin, J., Bailleul, P., Wang, Y., Gepner, D., Le Barillier, F., Constant, J. (2012). Self-monitoring of gaze in high functioning autism. Journal of Autism and Developmental Disorders (JADD), 42 (8), 1642-1650.

Courgeon, M., Rautureau, G., Martin, J.-C., Grynszpan, O. (2014) Joint Attention Simulation using Eye-Tracking and Virtual Humans. IEEE TAC (Transactions on Affective Computing) Issue 3 - July-Sept. (vol. 5), pp. 238-250

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

Participants

- 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)

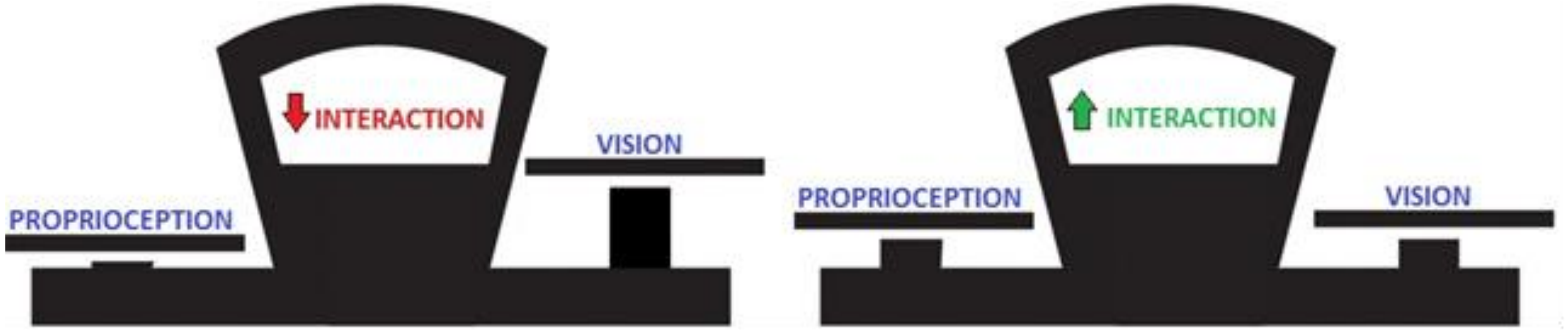
  - 7 adults with ASD
    - 3 women and 4 men
    - 26.8±7.9 years old

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

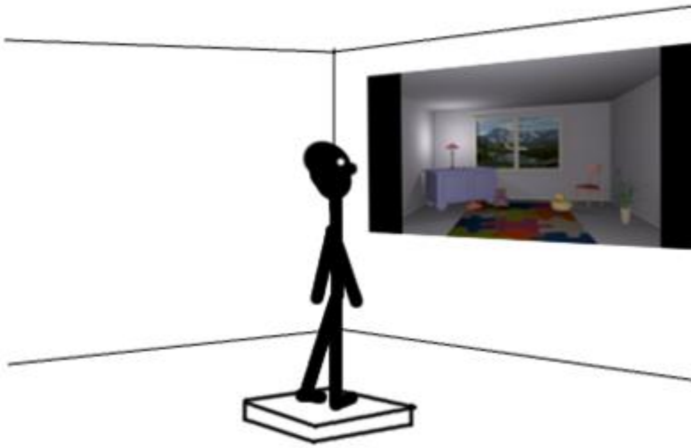
Individual Visual and Proprioceptive Profiles

- 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

- The AASP items and the data extracted from the CoP are used
- 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)

Chevalier, P., Tapus, A., Martin, J.-C., Bazile, C., Isableu, B. (2015) Social Personalized Human-Machine Interaction for People with Autism: A close look at Proprioceptive and Visual Orientation Integration. International Meeting for Autism Research, Salt Lake City, Utah, USA, May 2015

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

Chevalier, P., Tapus, A., Martin, J.-C., Bazile, C., Isableu, B. (2016) Impact of sensory preferences of individuals with autism on the recognition of emotions expressed by two robots, an avatar, and a human. Journal Autonomous Robots, vol. 40, issue 5, May 2016

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

  BODY: Use of the BEAST database [De Gelder B, Van den Stock J, 2011] for body animation + linear interpolation + dynamics [Wallbott, 1998]

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 withTypically 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 withTypically 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

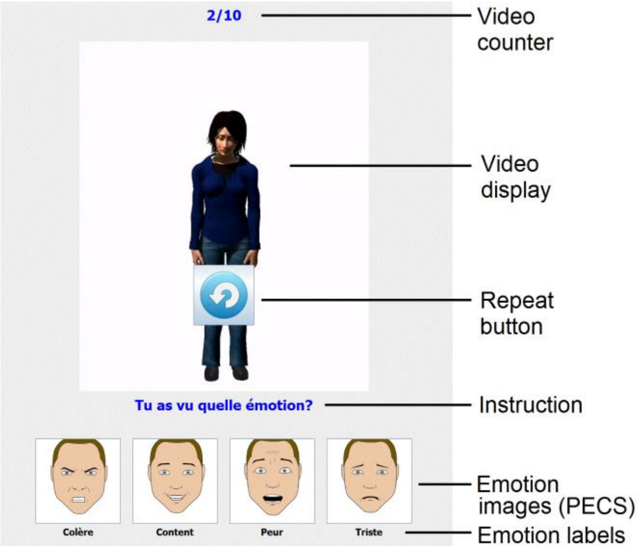
- 40 videos were selected among the best recognized by TD individuals

  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 depends 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

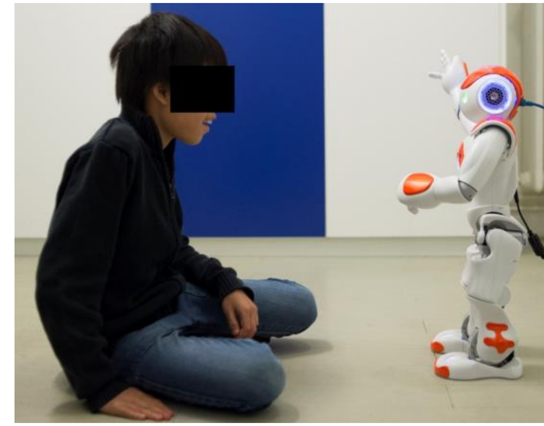
- Adults have difficulties to play the game

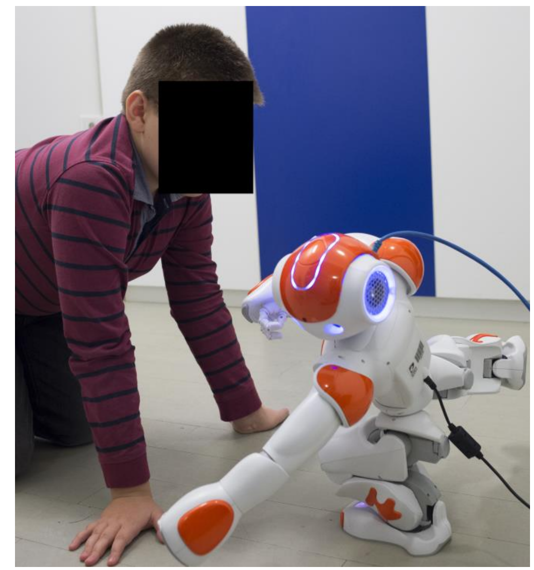
  Maybe because they do not do this kind of game with their caregiver, whereas children do play such games

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





Chevalier, P., Martin, J.-C., Isableu, B., Tapus, A. (2016) Individuals with Autism: Analysis of the First Interaction with Nao Robot Based on Their Proprioceptive and Kinematic Profiles"
International Conference on Robotics in Alpe-Adria-Danube Region, RAAD 2015, 225-233

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

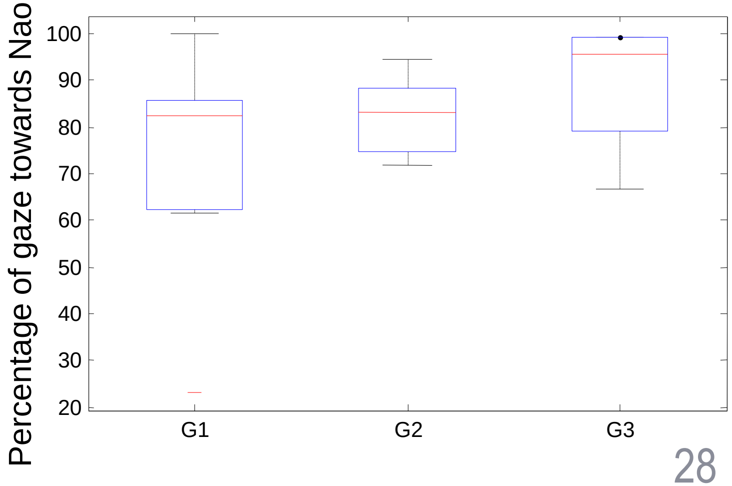
- Participants looked more than 60% of the time Nao, excepted for two participants from groups G1 and G2

- Numerous smiles observed

- Some participants showed to be slightly afraid and impressed by the robot at the beginning of the interaction

Task #2:
Greetings with Nao

- 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

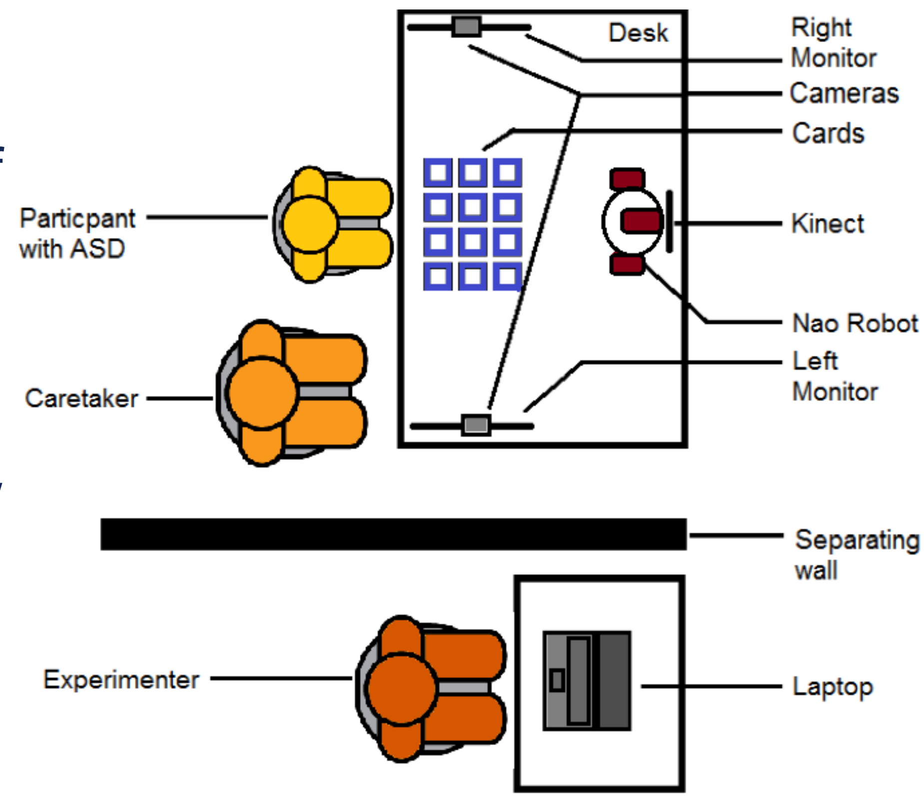
  2 monitors

- **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



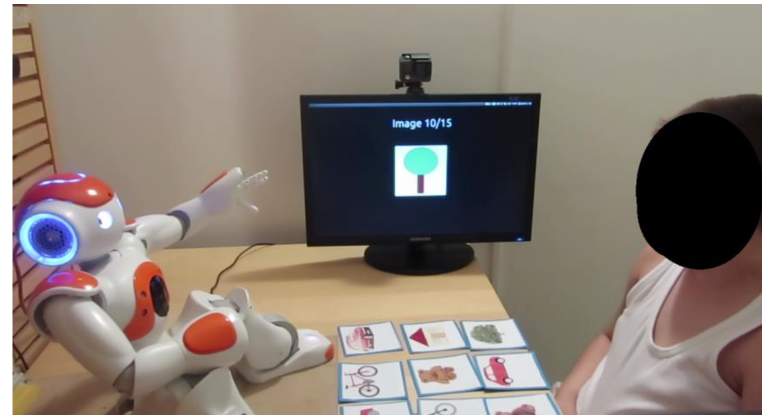
Task #3:
Response to Joint Attention Initiation

- 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

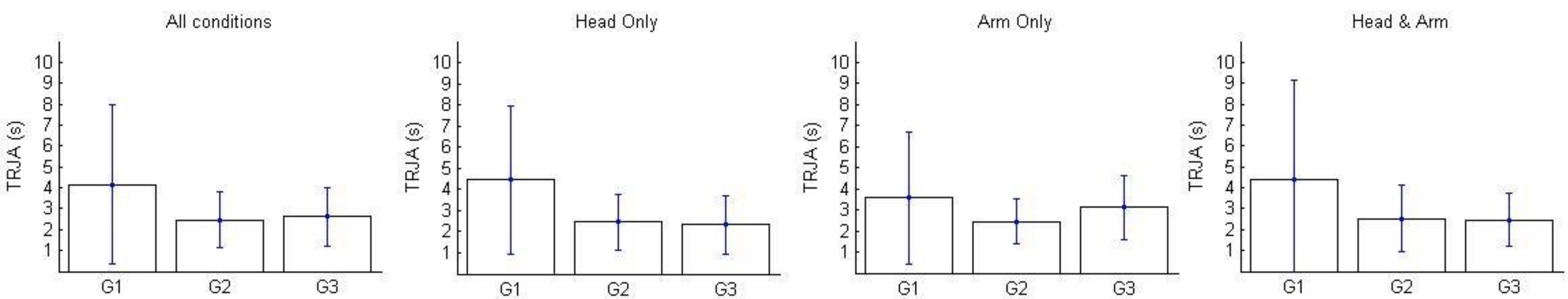


Task #3:
Response to Joint Attention Initiation

- 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

Aknowledgement

- We thank the participants, their families for accepting the participation of their children in our study, and the care centers' teams for their help.

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