# PhD Open Days

# Towards an Embodied Simulator of Autistic Child Behaviors

## Dual degree Carnegie Mellon University-Portugal PhD program

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## Introduction

Autism Spectrum Disorders (ASD) are a set of developmental disorders prevalent in 1 in 68 individuals in the USA, and affects core areas of a child's development including verbal and non-verbal communication, reciprocal social interaction, and repetitive behaviors. Because of their predictability and controllability, artificial agents such as robots are recently being introduced in the context of autism therapy. However, increasing the autonomy of such agents is challenging because the behaviors exhibited by children with ASD vary greatly. We believe that the ability to simulate the behaviors of these individuals in the context of a structured interaction can potentially greatly contribute to informing the decision-making of these robots. An embodied version of this simulator could also be used to enhance the diagnostic training of autism therapists.

In this work, we focus on the problem of simulating the occurrence of these behaviors in a structured interaction. The approach we take stems from the observation that diagnostic tools used by psychologist to diagnose children with ASD can be reversed to generate simulated child behaviors that could be useful to train an agent, such as a robot, expected to interact with such children. We exploit the standardized aspect of the Autism Diagnosis Observation Schedule (ADOS) to extract a behavioral model of ASD children, use this model to build a behavioral simulator, and finally visualize some typical ASD behaviors with different severities on an animated Nao humanoid robot.

## Data Analysis and Model Extraction

We used a clustering algorithm on the ADOS scores of 279 children obtained from the National Database of Autism Research (NDAR) and the Child Development Center at Hospital Garcia de Orta, and used a correlational model to generate additional synthetic data.
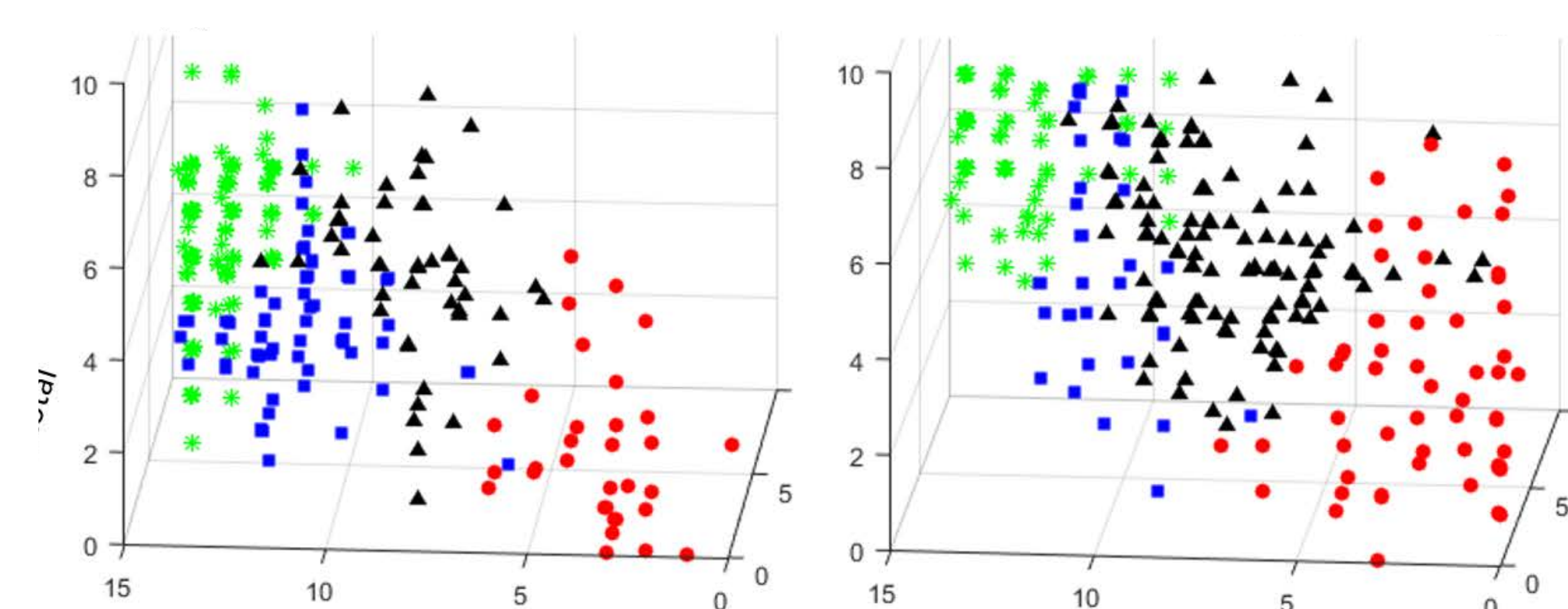


Fig. 1. Data visualization according to computed totals along Social Communication, Reciprocal Social Interaction and Restricted Repetitive Behaviors dimensions, with high-dimensional k-means clustering (color coded). **Left:** Real database; **Right:** Synthetic database generated according to correlational model.
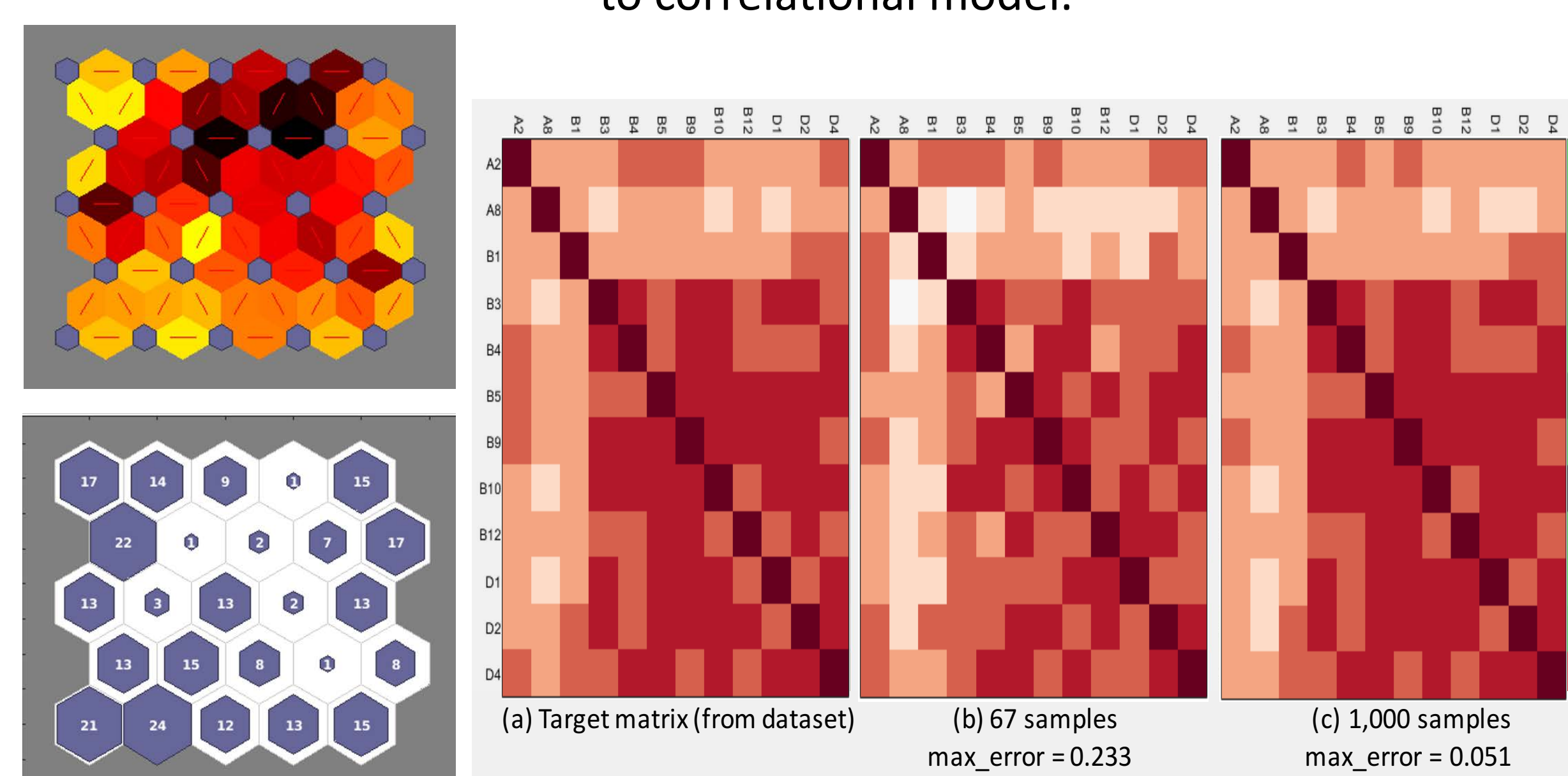


Fig. 2. Data distribution visualization in 2D using a Self-Organizing Map.

Fig. 3. Correlation matrices of synthetically generated feature values **(b-c)** matching that of the real dataset **(a)**.

(a) Target matrix (from dataset)
(b) 67 samples max_error = 0.233
(c) 1,000 samples max_error = 0.051

## ADOS-Based Autism Simulator (ABASim)

We built a simulator, named ABASim, based on ADOS. It algorithmically reverses the diagnosis pipeline to stochastically output behaviors starting from high-level descriptors of the child, namely the age (A), language ability (L), and ASD severity (S), as illustrated in Fig. 5. To generate a synthetic feature vector from the ADOS total score, it uses the correlation model of Fig.3. To select a set of behaviors to be outputted for a given activity we defined relevant features for each activity and use a smart algorithm that selects non-contradicting behaviors from a dataset of behaviors desribed in the ADOS manual. The ABASim user interface is shown in Fig. 4 on the right.



Fig. 4. ABASim user interface with input fields in green and output fields in blue



Fig. 5. ABASim pipeline from descriptors to behaviors

## Embodied Visualization using a Nao Robot

We designed and validated 16 selected behaviors along 4 different features with varying severities and implemented them on a NAO robot as part of an autonomous agent capable of interacting autonomously with a human playing the role of a therapist.



'Calling name' task    'Joint attention' task    'Snack preference' task
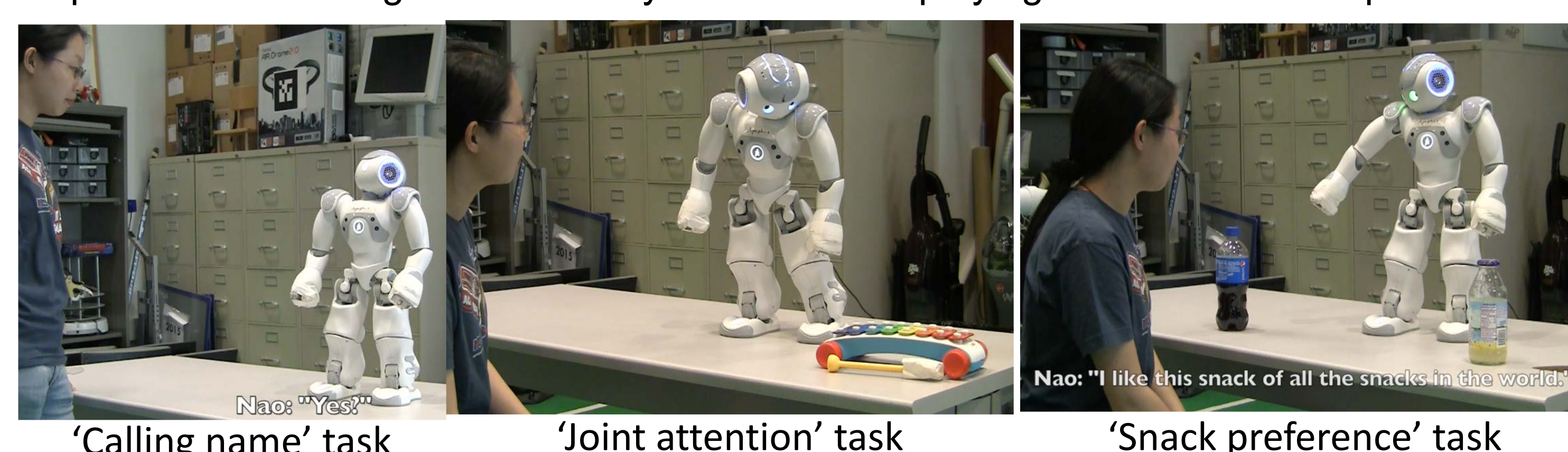
## For more information

Baraka, K., Melo, F. S., Veloso, M. *Data-Driven Generation of Synthetic Behavioral Feature Vectors Modeling Children with Autism Spectrum Disorders.* In: Development and Learning and Epigenetic Robotics, 2017 (to appear).

Baraka K., Melo F.S., Veloso M. In: Progress in Artificial Intelligence. EPIA 2017. Lecture N*Simulating Behaviors of Children with Autism Spectrum Disorders Through Reversal of the Autism Diagnosis Process.* Notes in Computer Science, vol 10423. Springer.

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