Development of Robot-enhanced Therapy for Children with Autism Spectrum Disorders

Project No. 611391

DREAM
Development of Robot-enhanced Therapy for Children with Autism Spectrum Disorders

Agreement Type: Collaborative Project
Agreement Number: 611391

D2.3.2 Tasks for social robots (supervised autonomous version) on developing social skills

Due Date: 01/04/2018
Submission date: **04/04/2018**

Start date of project: **01/04/2014** Duration: **54 months**

Organization name of lead contractor for this deliverable: **Babes Bolyai University**

Responsible Person: **Daniel David**

Revision: **1.0**

Project co-funded by the European Commission within the Seventh Framework Programme		
Dissemination Level		
PU	Public	**PU**
PP	Restricted to other programme participants (including the Commission Service)	
RE	Restricted to a group specified by the consortium (including the Commission Service)	
CO	Confidential, only for members of the consortium (including the Commission Service)	

Table of contents

Executive Summary

The deliverable *D2.3 Tasks for social robots (supervised autonomous version) on developing social skills* provides the primary results of the evaluation of Robot-enhanced Therapy (RET) in clinical settings. This preliminary version of the deliverable will focus on the randomized clinical trial, including preliminary findings concerning the effectiveness of RET using a supervised autonomous version (*T2.3*). The main outcomes for which the effectiveness of RET is being tested are: joint attention, imitation, and turn-taking skills. Thus, in this deliverable (*D2.3*) we will present the theoretical background, objectives, design, procedure, environmental setup, preliminary results from the experiments carried in task *T2.3*, conclusions and discussions.

Principal Contributors

The main authors of this deliverable are as follows (in alphabetical order):
Daniel David, Babes-Bolyai University
Anca Dobrean, Babes-Bolyai University
Silviu Matu, Babes-Bolyai University
Radu Soflau, Babes-Bolyai University
Aurora Szentagotai, Babes-Bolyai University

Revision History

Version 1.0 (23-03-2018)
First draft, describing the rationale of the task and the methodology
Version 2.0 (25-03-2018)
Second draft, results included

Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder defined by persistent deficits in social communication and social interaction and restricted, repetitive patterns of behavior, interests, or activities (APA, 2013). ASD children commonly experience difficulties with social interactions. Thus, impairments in imitation, joint-attention and turn-taking skills are common in ASD (Dawson et al., 2004). These impairments are particularly problematic given that imitation, joint-attention and turn-taking are important prerequisites for developing social communication skills. For example, it was found that improvements in imitation can facilitate the recognition of peers and caregivers as "social others", the hand-eye coordination, and the later development of communication skills (Ricks & Colton, 2010). Imitation also enables children to learn new information from his/her social environment (Cabibihan, Javed, Ang, & Aljunied, 2013). Similarly, joint-attention (i.e., the ability to focus simultaneously on the same object/activity with another social partner) is particularly important for perceiving the social others, for a successful learning (Ricks et al., 2010) and for the acquisition of language (Dawson et al., 2004). In what turn-taking skills are concerned, it appears that they play a fundamental role in regulating conversations (Ricks et al., 2010, Cabibihan et al., 2013) and social interactions. Due to these impairments in social skills, ASD children have difficulties sustaining a conversation or playing a game in which the partners' roles constantly alternate. As a consequence, the three social skills are often targeted by various interventions that have been developed for ASD.

Applied Behavioral Analysis (ABA) / Cognitive Behavioral-Therapy (CBT) has extensive support for its effectiveness (e.g., Peters-Scheffer, 2011; Virués-Ortega, 2010) for ASD. More recently, ABA / CBT techniques have been adapted in order to be delivered by a social robot to address the difficulties displayed in autism. The use of a social robot in the therapy of ASD children has received increasing attention in the last years, given that social robots are considered to be of potential added value in the interventions developed for children with ASD (Cabibihan et al., 2013; Thill et al., 2012). Still, a relative reduced number of studies have focused on testing whether such robots could ameliorate the social interaction and communication deficits that are characteristic to this population (David, Matu & David, 2014). Although the results are promising (see also Pennisi et al., 2016), most of the available studies implemented single case experiments or had reduced sample size. Moreover, RET has been seldom compared with standard therapist-delivered interventions.

The main aim of this study is to the test the effectiveness of RET in improving performance of children with ASD by supervised autonomous behavior of the robot. We investigate if a social robot can improve the social abilities of children with ASD and whether RET produces similar or better results than a standard therapist-delivered intervention. The social abilities targeted by our intervention program are: imitation, joint-attention and turn-taking.

Methods

Design

A blinded, randomized, equivalence clinical trial was designed to attain these aims. Participants are randomly assigned to receive one of the two interventions: the standard therapist-delivered intervention (SHT) or the robot-enhanced intervention (RET). The randomization procedure was carried out by an independent researcher using a digital random number generator. The information regarding the allocated condition for each child was communicated to the research team, which has subsequently informed the parents. The protocols of the two interventions are identical (i.e., identical tasks for both groups). The only difference between the two intervention groups is at the level of the interaction partner who delivers the intervention: in one case a therapist and in the other case a social robot (Nao).

Participants

So far, participants were recruited form different organizations and institutions which provide educational and/or psychotherapeutic services to children with autism, located in Cluj-Napoca and Baia Mare. All included participants need to have an age ranging between 3 to 6 years old and to have a previous diagnosis of ASD that is confirmed based on the scores obtained at *Autism Diagnostic Observation Schedule (ADOS),* corroborated with the scores form *Social Communication Questionnaire (SCQ)*. All children with scores that are not in the clinical range are being excluded. An informed consent is signed by the parents/caregivers of each included child. Forty nine potentially eligible children have been assessed for eligibility so far. Of those, eight have been excluded from the study for various reasons. Twenty seven children went through the entire intervention protocol, other four completed at least half of the intervention protocol, while the remaining 10 included children underwent at least one intervention session up till now.

Procedure

All recruited participants are required to attend 12 sessions: 2 initial evaluation sessions (i.e., pre-intervention), 8 intervention sessions, and 2 final evaluation sessions (i.e., post-intervention). The 45 minutes sessions are hold bi-weekly. The overall structure of the 12 sessions is described below.

Sessions 1 and 2 are designed to undergo a comprehensive psychological evaluation and to determine the baseline level of the three social abilities (i.e., imitation, joint-attention and turn-taking abilities). The *Autism Diagnostic Observation Schedule (ADOS)* and *Raven's Progressive Matrices (RPM)* are administrated to each child in order to assess the social and communicative behavior associated with autism and respectively the general cognitive ability. In addition, the ASD screening instrument *Social Communication Questionnaire (SCQ)* is completed by the children's parents/caregivers. The baseline levels of the three targeted social abilities are determined through a series of subtasks that are similar to those designed for intervention (as detailed below).

Sessions 3 to 10 are used for training imitation, joint-attention and turn-taking abilities.

Sessions 11 and 12 firstly aim to determine the level of the three abilities after the interventions. (i.e., through tasks in which the targeted behaviors are preceded by a stimulus but are not followed by any feedback). As it is the case for the initial evaluation sessions, in the post-

intervention assessment the standard psychological instruments (*ADOS, RPM, SCQ*) are also applied, aiming to determine if the benefits of the interventions are generalized.

Intervention protocol

As previously specified, the intervention protocol is identical in the two interventions, concerning the involved tasks. Thus, we will present the shared protocol. The tasks that have been developed for the training of the imitation, joint-attention and turn-taking abilities follow a structured behavioral approach called discrete trial training (DTT). According to Smith (2001), DTT can be particularly useful for the acquisition of new behaviors and for teaching discriminative behavioral responses. Working from the assumptions of this approach, the training tasks take place in a highly structured learning environment and are being directed by the interaction partner (i.e., the Softbank Robotics' Nao robot *OR* a psychotherapist). Thus, all training tasks are organized around a table, which in the case of joint attention and turn taking tasks incorporates a large touch-screen. During training, each targeted behavior/action is preceded by the partner's discriminative stimulus or instruction (e.g., "Do as I do!") and followed by a contingent reinforcement (e.g., "Try again!", "Well done!"). The behaviors are presented over multiple and successive trials and explicit prompting is giving when the child doesn't succeed to accomplish the targeted behavior after several trails. Each action is repeated three times. The intervention protocol is personalized for the needs of each child. Thus, the training of each ability starts from the baseline level (i.e., the level determined in the first two evaluation sessions). As the child's performance improves, the training moves to the next level (i.e., a sub-task of an increased level of difficulty is approached). The goal of the intervention is to reach the highest level possible for each child, on each of the three social abilities. In the following section we will briefly describe the levels of difficulties, as well as the structure of the tasks used to train imitation, joint attention, and turn-taking abilities

A. Imitation

Both the child and the therapist are sitting at a table during the imitation task. If the robot provides the intervention, then the robot is placed on a table in front of the child. Each child is asked to imitate the actions made by the interaction partner (therapist or robot). The imitation ability is trained though the following sub-tasks:

- level 1 of difficulty: imitation with objects (e.g., moving a car, pretending to drink from a cup);
- level 2 of difficulty: imitation of gestures (meaningful movements; e.g., waving one hand and say "bye-bye");
- level 3 of difficulty: imitation of movements without a meaning.

Table 1. The structure of the imitation task.

Instruction
Provided by the interaction partner (robot or human)

"Do as I do!"

Response
Provided by the child Moving arms/objects in similar ways as the interaction partner.
Consequence
Provided by the interaction partner (robot or human) Depending on the child's answer: *If the child executes the requested movement correctly, he/she receives positive feedback: "Well done!"* *If the child doesn't execute the requested movement, he/she receives encouraging feedback: "Try again!"*

B. Joint-attention

The task is presented to the child in a context (e.g., "Now, we will play another game. In this game I will show you the objects I've seen in an office"; see Table 2). Then, two pictures are displayed simultaneously on a big touch-screen incorporated in the table: one on the left side and the other one on the right side. In this task the child has to look at the picture indicated by the robot/therapist. There are different ways of indicating one of the two displayed images, the number of modalities used to indicate the picture determining the task's level of difficulty:

- level 1 of difficulty: simultaneously looking at one picture, pointing to that picture and saying "Look!";
- level 2 of difficulty: simultaneously looking at one picture and pointing to that picture;
- level 3 of difficulty: looking at one picture.

Table 2. The structure of joint-attention task.

Instruction
Provided by the interaction partner (robot or human) "Please, pay attention to what am I looking at!"
Response
Provided by the child Looking at the picture indicated by the robot/human.
Consequence

Provided by the interaction partner (robot or human)

Depending on the child's answer

If the child looks at the picture indicated by the robot/human, he/she receives positive feedback: "Well done!"

If the child doesn't look at the picture indicated by the robot/human, he/she receives encouraging feedback: "Try again!"

C Turn-taking

The turn-taking ability involves different activities during which the child and his partner have to play by taking turns. The sub-tasks were designed to be implemented on a big touch-screen tablet (Sandtray) and include: sharing information, assigning items to categories and continuing repeating patterns activities. As it can be seen in Table 3, in all subtasks the interaction partner provides an instruction / question before the targeted behaviors and administers a consequence depending on the child's response / behavior.

- sharing information: On the screen of the tablet are displayed simultaneously 5 pictures. In this task the child has to choose a picture from a series of 5 pictures displayed on a touchscreen (when it is his turn) and wait when the robot chooses a picture (when is interaction partner`s turn).
- categories:
    - level 1: 3 pictures are displayed simultaneously on the screen of the tablet (two of them represents categories and the third one is the item that has to be categorized). In this task the child has to categorize the items (when it is his turn) and wait when the robot categorizes (when is interaction partner`s turn). At this level, the categories are familiar to the children between the ages of 3 to 7 years (e.g., fruits vs. vegetables) and the items that have to be categorized appear one by one;
    - level 2: 10 pictures are displayed simultaneously on the screen of the tablet (two of them represents categories and the rest of eight are the items that have to be categorized). In this task the child has to categorize the items (when it is his turn) and wait when the robot categorizes (when is the interaction partner`s turn). At this level, the categories are more complex and the child has to choose one picture at a time from a larger number of pictures that are simultaneously displayed (ground vehicles vs. water vehicles).
- patterns
    - level 1: 6 pictures are displayed simultaneously on the screen of the tablet (2 of them in the middle of the screen and the rest of them arranged in a string). The child has to continue the pattern illustrated by the string (when it is his turn) and wait when the robot adds a picture to the string (when is robot`s turn). At this level of difficulty the repetitive pattern consists of two or three repetitive items and the only relevant criterion for categorization is the geometrical shape (e.g., rectangle, rectangle, triangle, rectangle, rectangle, ...);

- level 2: 10 pictures are displayed simultaneously on the screen of the tablet (4 of them in the middle of the screen and the rest of them arranged in a string). The child has to continue the pattern illustrated by the string (when it is his turn) and wait when the robot adds a picture to the string (when is robot`s turn). At this level of difficulty four items repeat and there are two relevant criterions based on which the categorization has to be made: the geometrical shape and its color (e.g., green squire, star, orange squire, circle, green squire, star, ...; see Table 3).

Table 3. The structure of turn-taking task

Sharing information
Instruction
Provided by the interaction partner (robot / human) *a. "It's your turn first! What's your favorite [...]?"* *b. "Now it's my turn!"*
Response
Provided by the child a. The child chooses a picture that represents what he/she likes the most. b. The child waits his turn (doesn't move his/her hands above the touchscreen of the Sandtray when is the partner's turn)
Consequence
Provided by the interaction partner (robot / human) Depending on the child's answer *a. If the child chooses a picture from those shown on the touch-screen, he/she receives positive feedback: "You showed me very nicely what you like!"* *If the child doesn't choose a picture from those shown on the touch-screen, he/she receives no feedback.* *b. If the child waits his/her turn (doesn't move his/her hands above Sandtray), he/she receives positive feedback: "You have waited very nicely!"* *If the child doesn't wait his/her turn (he/she moves his/her hands above the Sandtray), he/she receives an encouraging feedback: "You have to wait! It's my turn."*

Categories

Instruction

Provided by the interaction partner (robot / human)

a. ”Let’s sort [...]! It’s your turn first.”

b. ”Now it’s my turn.”

Response

Provided by the child

a. The child categorizes the items.

b. The child waits his/her turn (doesn’t move his/her hands above the touchscreen of the Sandtray when is the partner’s turn).

Consequence

Provided by the interaction partner (robot / human)

Depending on the child’s answer

a. If the child categorizes correctly, he/she receives positive feedback: “You sorted the picture correctly. Well done!”

If the child categorizes incorrectly, he/she receives encouraging feedback: “You sorted incorrectly. Try again!”

b. If the child waits his turn (doesn’t move his hands above the Sandtray), he/she receives positive feedback: “You have waited very nicely!”

If the child doesn’t wait his/her turn (he/she moves his hands above the Sandtray), he/she receives an encouraging feedback: “You have to wait! It’s my turn.”

Patterns

Instruction

Provided by the interaction partner (robot / human)

a. ”Let’s continue the string!”

b. ”Now it’s my turn.”

Response

Provided by the child

a. The child continues the pattern illustrated by the string.

b. The child waits his/her turn (doesn't move his/her hands above the touchscreen of the Sandtray when is the partner's turn).

Consequence
Provided by the interaction partner (robot / human) Depending on the child's answer *a. If the child continues the pattern correctly, he/she receives positive feedback: "You matched the picture correctly. Well done!"* *If the child continues the pattern incorrectly, he/she receives encouraging feedback: "You've matched the picture incorrectly. Try again next time!"* *b. If the child waits his/her turn (doesn't move his/her hands above the Sandtray), he/she receives positive feedback: "You have waited very nicely!"* *If the child doesn't wait his turn (he/she moves his hands above the Sandtray), he/she receives an encouraging feedback: "You have to wait! It's my turn."*

Outcomes and measures

Primary outcomes

The primary outcomes correspond to the three social skills that are being targeted by this randomized clinical trial: imitation, joint-attention, and turn-taking abilities. To determine the level of imitation, children's performance in the imitation task is coded with a score of "1" when the children execute the requested movement correctly and with a score of "0" when children do not execute the requested movement. Similarly, the level of joint-attention is determined based on the performance from the imitation tasks that is coded with a score of "1" – when the children look at the picture indicated by the interaction partner and with a score of "0" - when the children do not look at the indicated picture. In the case of turn-taking, a score of "1" is given when children wait for their turn (don't move their hands above the touchscreen of the tablet when it is the partner's turn) and score of "0" is assigned when the children do not wait for their turn (they move their hands above the tablet).

Secondary outcomes

In addition, we are also investigating some secondary outcomes that are of relevance for ASD interventions. Thus, we also compare the two interventions on engagement in the task, verbal utterances, and knowledge/cognitive abilities. Eye-contact and the reported positive emotions are used as indicators for task engagement, given that this outcome refers to the child's interest and enthusiasm for performing the task. The assessment of verbal utterances targets both initiations and contingent responses (i.e., meaningful verbal productions of child) in this trial.

The knowledge/cognitive abilities refer to the extent to which the children are able to share information, sort items, and to continue a repetitive pattern correctly during the turn-taking subtasks. Thus, when the children choose the right picture, share information or sort the items correctly a score of "1" is assigned. Otherwise, a score of "0" is assigned.

Standardized instruments

A number of standardized instruments are being used in order to determine the eligibility of the participants as well as to assess the generalization of results. *Autism Diagnostic Observation Schedule* (*ADOS*; Lord, Risi, Lambrecht et al., 2000), *The Social Communication Questionnaire* (*SCQ*; Rutter, Bailey & Lord, 2003), and *Raven's Progressive Matrices (RPM)* are administrated to evaluate the social and communicative behaviors associated with autism and the general cognitive ability.

Statistical analysis

The data analysis strategy presented in deliverable D2.3.2 is exploratory in nature, considering that the sample is too small at this point to adequately test equivalence criteria. Data for the primary outcomes are available and have been included in the analysis: performance on imitation, joint-attention, and turn-taking. We also included analysis for some of the secondary outcomes in this deliverable: knowledge/cognitive abilities during the three tasks under turn-taking training (information sharing, patterns, and categories). The data for task engagement and verbal utterances are not readily available at this point. Some exploratory data analysis concerning the impact on standardized instruments was also conducted. First, a MANOVA was run to test for potential differences at pre-test. Second, we run a number of univariate within-between ANOVAs for each level of task difficulty in order to detect possible time (i.e., changes in performance within each level of difficulty), group (i.e., differences between intervention groups at each level of difficulty), and group*time interactions on both primary outcomes and knowledge/cognitive abilities. Third, we computed per-level univariate ANCOVAs in order to compare post-test scores on primary outcomes and knowledge/cognitive abilities, while controlling for their baseline level scores. Fourth, a MANOVA was run to compare the two interventions on the progress in the levels of difficulty that have been reach in each tasks (imitation, joint attention, and turn taking). Finally, paired sample *t* tests were computed to investigate improvements within each intervention group on standardized scales. At post-test, only data for *SCQ* and *ADOS* was readily available for computation at the time when data analysis was conducted, for a reduced number of subjects. Some of the data is still being scored.

Results

Pre-test comparison

MANOVA indicated that there are pre-test differences between the two intervention groups on the assessed outcomes (F (8, 16) = 3.19, p = .023, $_{partial}Eta^2$ = .62, Wilks' Lambda = .62), but only concerning joint attention (F (1, 23) = 6.66, p = .017, $_{partial}Eta^2$ = .23) and the subscore of knowledge/cognitive abilities concerning categorization (F (1, 23) = 7.681, p = .011, $_{partial}Eta^2$ = .25; see *Figure 1*).

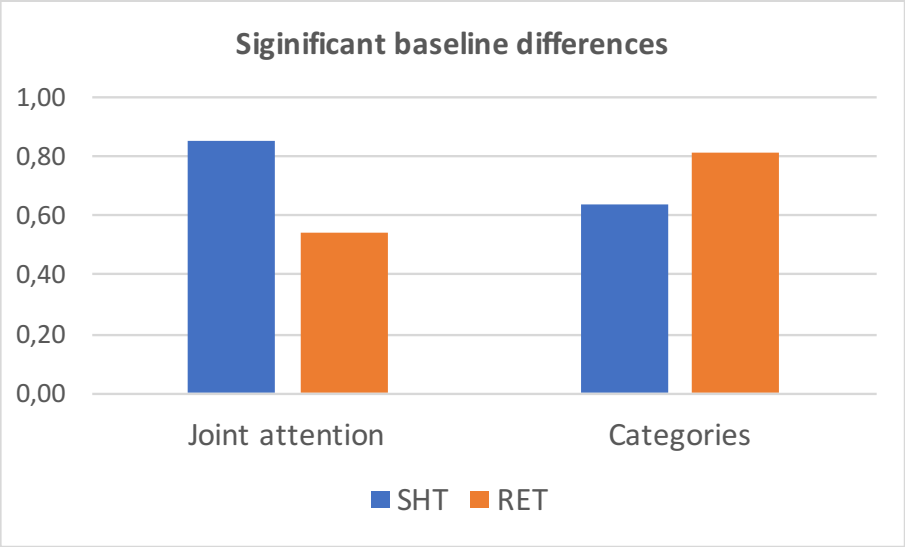

Figure 1. Baseline differences

Primary outcomes

The univariate within-between ANOVAs revealed significant time effects for imitation (F (1, 25) = 21.79, p < .001, $_{partial}Eta^2$ = .47) and turn-taking performance in information sharing (F (1, 25) = 4.50, p = .044, $_{partial}Eta^2$ = .15), categorization (F (1, 25) = 11.61, p = .002, $_{partial}Eta^2$ = .32) and filling pattern subtasks (F (1, 25) = 10.22, p = .004, $_{partial}Eta^2$ = .29) at the first level of difficulty. All significant results indicated that overall there were improvements in the aforementioned primary outcomes. No other significant time, group or group*time effects emerged on this level of difficulty or any other level (i.e., levels 2 and 3) for the primary outcomes. The lack of statistically significant differences between the two intervention groups were confirmed by per-level univariate ANCOVAs that found no significant group effect at post-test (p > .05), regardless of the level of difficulty taken into account.

The MANOVA for the progress in each task yielded significant differences between groups on the combined outcomes (F (3, 23) = 5.08, p = .008, $_{partial}Eta^2$ = .40, Wilks' Lambda = .40). However, no significant univariate difference was found concerning the progress in levels of difficulty on imitation, joint-attention or turn-taking tasks (p > 0.5; see *Figure 2*).

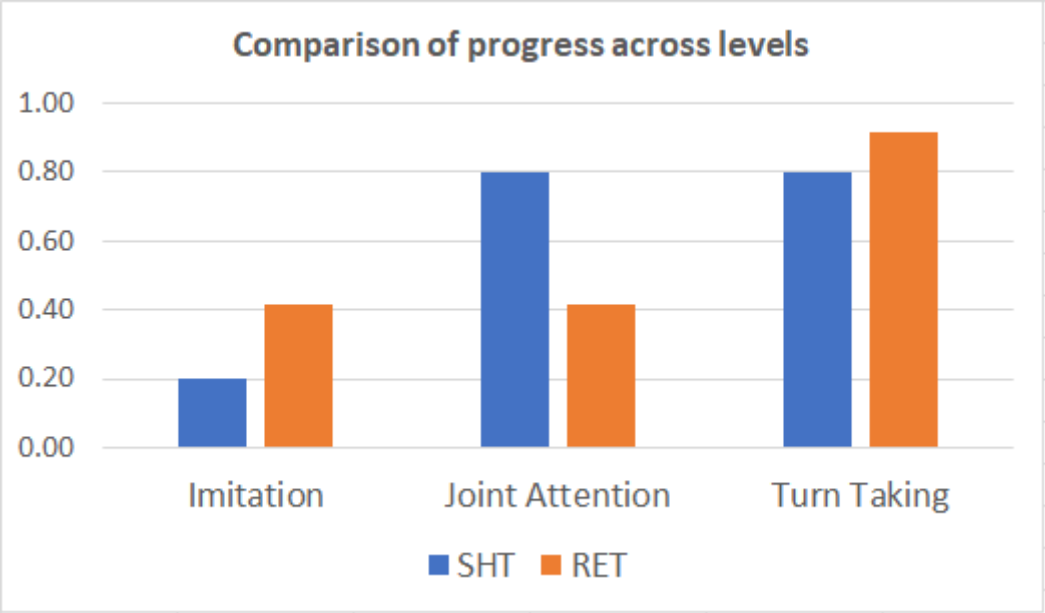

Figure 2. Comparison unadjusted for baseline differences

Secondary outcomes

The univariate within-between ANOVAs revealed that no significant time, group or group*time effects emerged on the secondary outcomes, on any of the three levels of task difficulty ($p > .05$). In comparison, per-level univariate ANCOVAs indicated one significant group effect on the subscore of knowledge/cognitive abilities concerning categorization (F (1, 20) = 4.87, p = .039, $_{partial}Eta^2$ = .20; see *Figure 3)* at level 2, favoring RET. No other comparison yielded significant differences.

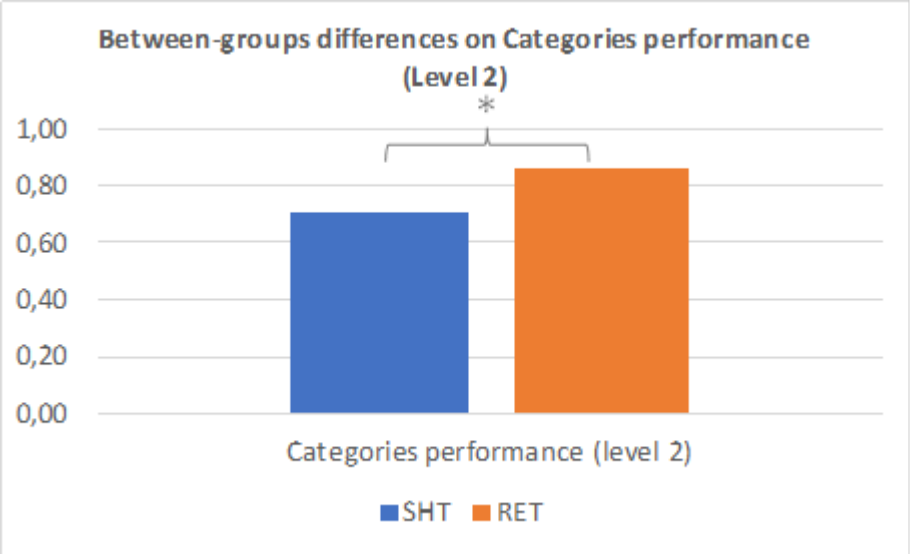

Figure 3. Knowledge/cognitive abilities concerning categorization per intervention group

The exploratory paired sample *t* tests showed improvements for all scores on standardized instruments in the SHT group (i.e., scores decreased), except for the scores on restrictive behaviors sub-scale of *SCQ*. There were significant improvements on ADOS total score (t (5) = 3.50, p = .017) and ADOS - social interaction (t (5) = 3.37, p = .02). In the RET group all scores decreased following intervention, with significant improvement on ADOS total score (t (4) = 3.25, p = .031) and ADOS - social interaction (t (4) = 3.37, p = .034).

Conclusion

The task *T2.3* comprises the first randomized clinical trial that compares an intervention delivered by a supervised autonomous robot with standard therapy delivered by a human agent, within a high-power rigorous study, following the standard procedure in evidence-based psychotherapy. The primary outcomes are standard in the field and comprise imitation, joint attention and turn taking performance. These outcomes reflect key abilities that are trained by therapeutic interventions for ASD children. Thus, it is expected for this randomized clinical trial to provide clear evidence assessing the efficacy of RET by the end of the *T2.3* task.

It is noteworthy that the data presented in this deliverable are based on a somewhat small sample and exploratory data analysis. The preliminary results suggest that all outcomes follow the expected trend, with improvements following treatment. These positive results are visible on both social skills and more general ASD standardized instruments. Still, not all of these results are statistically significant. In what the comparison between the two intervention groups is concerned, preliminary data appear to indicate that overall they have a similar impact on ASD-related outcomes. However, firm conclusions cannot be drawn until the sample size required for an adequate statistical power is completed.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Association.

Cabibihan, J. J., Javed, H., Ang, M., & Aljunied, S. M. (2013). Why robots? A survey on the roles and benefits of social robots in the therapy of children with autism. *International journal of social robotics*, *5*(4), 593-618. doi: 10.1007/s12369-013-0202-2.

David, D., Matu, S. A., & David, O. A. (2014). Robot-based psychotherapy: Concepts development, state of the art, and new directions. *International Journal of Cognitive Therapy*, *7*(2), 192-210. doi: 10.1521/ijct.2014.7.2.192.

Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., & Liaw, J. (2004). Early social attention impairments in autism: social orienting, joint attention, and attention to distress. *Developmental psychology*, *40*(2), 271. doi: 10.1037/0012-1649.40.2.271.

Lord, C., Risi, S., Lambrecht, L., Cook, E. H., Leventhal, B. L., DiLavore, P. C., ... & Rutter, M. (2000). The Autism Diagnostic Observation Schedule—Generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of autism and developmental disorders, 30*(3), 205-223. doi: 10.1023/A:1005592401947.

Pennisi, P., Tonacci, A., Tartarisco, G., Billeci, L., Ruta, L., Gangemi, S., & Pioggia, G. (2016). Autism and social robotics: A systematic review. *Autism Research*, *9*(2), 165-183. doi: 10.1002/aur.1527.

Peters-Scheffer, N., Didden, R., Korzilius, H., & Sturmey, P. (2011). A meta-analytic study on the effectiveness of comprehensive ABA-based early intervention programs for children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *5*(1), 60-69. doi: 10.1016/j.rasd.2010.03.011.

Ricks, D. J., & Colton, M. B. (2010, May). Trends and considerations in robot-assisted autism therapy. In *Robotics and Automation (ICRA), 2010 IEEE International Conference on* (pp. 4354-4359). IEEE.

Rutter, M., Bailey, A., & Lord, C. (2003). *The social communication questionnaire: Manual*. Western Psychological Services.

Thill, S., Pop, C. A., Belpaeme, T., Ziemke, T., & Vanderborght, B. (2012). Robot-assisted therapy for autism spectrum disorders with (partially) autonomous control: Challenges and outlook. *Paladyn, 3(4*), 209-217. doi: 10.2478/s13230-013-0107-7.

Virués-Ortega, J. (2010). Applied behavior analytic intervention for autism in early childhood: Meta-analysis, meta-regression and dose–response meta-analysis of multiple outcomes. *Clinical psychology review*, *30*(4), 387-399. doi: 10.1016/j.cpr.2010.01.008.