Training in social signals with a robot for adults with an ASC*

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ABSTRACT

This paper motivates robot-based work towards a training system in social signal recognition for high-functioning adults with an Autism Spectrum Condition. It summarises progress to date and discusses a projected study involving the target group.

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1 INTRODUCTION

In the UK, Autism Spectrum Conditions (ASC) affect 547,000 people over the age of 18 (1.3% of working age adults) according to the 2011 census. These adults encounter serious difficulties in their everyday life, particularly in securing and maintaining employment. The unemployment rate among adults with autism is higher than 85%, nearly double the unemployment rate of 48% for the wider disabled population and compares to an overall UK unemployment rate of 5.5%. Presently, it is estimated that only 16% of adults with an autism spectrum conditions (ASC) in the UK are in full-time employment

Individuals with an ASC often encounter problems associated with social interaction [5] and multi-tasking [21], leading to difficulties with communication and task completion in the workplace [1, 16]. So, developing innovative therapies that target potentially challenging employment scenarios could help these adults successfully integrate at work.

Behavioural Skills Training (BST) [11] is recognized as one of the most effective training approaches for the effects of an ASD. BST is a behaviourist training approach involving phases of instruction, modelling, rehearsal, and feedback in order to teach a new skill. It has been used to teach social skills to people both with and without disabilities [23]. However, BST is too labour-intensive to be widely applied. If robots could be used to help deliver BST, this could reduce the effort required by human trainers and lower the cost of BST application.

Interruptions are common at work [4] and are known to adversely affect individualâĂŹs workflow: causing delayed resumption time and reduced task accuracy [3]. Literature from related psychological concepts (e.g. multitasking, executive function; [10, 21] suggests that the necessity to break from routine and adopt a flexible strategy make interruptions especially challenging for autistic individuals. Of the few studies that have addressed interruptions with this group it appears that coping strategies can be developed through video-modelling and conversation based intervention [24]. Another option would be to roleplay workplace interruptions with a social robot.

Social robots are being deployed primarily for children with an ASC [12, 26], with preliminary evidence suggesting child-robot-interaction leads to increased social engagement in the classroom [25]. Conceptually, robots are ideal for therapy with this population due to their simplified appearance and predictive nature [6]; potentially combating over-sensory stimulation issues [15, 19]. So, while work with children focuses on the development of socio-communicative skills and understanding, here we extend work in this domain to adultâĂŹs workplace interactions.

This work is being carried out within the SoCoRo project [1], and has so far involved a set of experiments intended to test the impact of designed robot facial expressions of approval and disapproval and explore the use of neuro-typical participants as well as participants with an ASC diagnosis. The next projected experiment moves closer to a workplace scenario and engages with the target group.

2 EXPERIMENTS IN EXPRESSIVE FACIAL EXPRESSIONS

The robot being used for work in the SoCoRo project is the Flash mobile robot with the EMYS expressive robot head - see Fig. 1

Research on facial expressions has been dominated by two judgment procedures: categorical, involving basic emotion categories [7] where universality and discreteness are central; and dimensional, involving scales or dimensions (for example: Pleasure, Arousal, Dominance) that underlie the emotion categories [13, 18] where temporal dynamic is the focus. Given that a particular emotion can usually be represented by more than one facial expression with varying intensity, the discrete approach suffers from the flaw of rigidity with its one-to-one mapping. Moreover, anything that

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Figure 1: Alyx: a FLASH robot with an EMYS expressive head.

could be described as a static expression is very rarely observed in normal interaction where expressive behaviour is continuously modulated in the evolving context. The dimensional approach on the other hand is able to convey a wide range of affective messages seamlessly and supports such modulation in a natural way.

We have therefore taken this approach in the current work, focusing on two groups of expressions supporting important social signals: approval and disapproval. The aim is for Alyx to express continuous internal state so that the resulting social signals are more âĂŸhuman-likeâĂŹ, pose the advantage of increased ecological validity [27] and hence, enable transfer of learning from robot to human incrementally in line with the Reduced Generalisation Theory [20].

2.1 Initial experiments

A first set of experiments was designed to validate eight expressions designed for Alyx, four intended to express approval, and four intended to express disapproval.

A pilot study was conducted at the Glasgow Science Centre over two days, with passing visitors invited to participate. 77 participants were involved (M:39; F:38) with a mean age of 16.9 and a median age of 9. This reflects both the majority participation of children and the wide age range of adults. A basic issue with running a study in a public place like this is that it is entirely possible for participants to spectate before they take part and observe the reactions of other participants. This contagion risk was addressed by selecting a random sample of four expressions from the eight available. Since transporting the whole robot to Glasgow was not feasible at that time, the EMYS head was removed and participants interacted with that. Given the risks of autonomous operation in a public environment, this first experiment was conducted using a Wizard of Oz approach with the wizard sitting behind the screen visible to the right of Fig. 2.

Figure 2: Alyx setup in Glasgow experiment.

Participants were asked to offer Alyx items for its breakfast. These were plastic toy representations of fruit and other food items: six were laid out in front of the robot. While it is possible that food type may have influenced beliefs of the robot's food preferences (e.g. that Alyx likes ice-cream), our focus was the users emotion recognition, not the affect of food type. After an item was offered, Alyx was made to produce one of the eight designed expressions randomly by the 'Wizard' using a WoZ interface. Depending on whether they thought Alyx did or did not approve of the item, participants were instructed to place it in a box marked 'Like' or a box marked 'Dislike'. There was no relationship between the object presented and the expression generated.The setup can be seen in Fig. 2

The experiment was introduced by Alyx itself, using a female Scottish-accented unit-selection voice, with a pre-scripted statement. After each of the first three items Alyx would state that it was still hungry and would like another item; after the fourth item Alyx made a positive statement about having had an enjoyable breakfast. Other than the approval/disapproval expressions, the head did not move; in particular it did not visually track the presented object. Though this clearly made participants uncertain about whether Alyx had registered the object, nonetheless, they found the interaction easy.

The results demonstrated that of the eight designed expressions, two of those intended to express disapproval were widely interpreted as approval, while two of the expressions intended to communicate disapproval were interpreted by around half the participants as approval, making them ambiguous. Results are discussed in detail in our earlier paper [17]. This allowed us to run a second study under lab conditions with the remaining four expressions with some confidence that they were recognised as intended by neuro-typical participants. These can be seen in Fig. 3.

2.2 Second Study

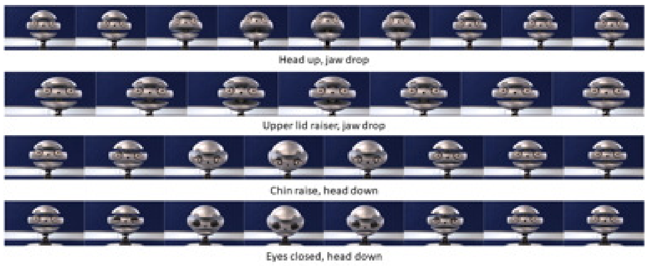

Figure 3: Filmstrip of EMYS head approval and disapproval facial expressions

Although still considered a ‘spectrum’ condition, research of neuro-typicals suggest Autism Spectrum Disorders (ASD) comprises a ‘continuum’, with phenotypic cognition and behavior expressed at varying sub-clinical levels in the broader population [9] - what is often referred to as the ‘broader autism phenotype’ [22]. Support for the broader autism phenotype comes from twin studies that report an increased risk of autism diagnosis in first degree relatives [22], as well as cognitive research of neuro-typical adults with high autistic traits levels showing similar social and perceptual processing. Furthermore, research measuring these traits in an HFA sample found a negative correlation between trait level and emotion recognition accuracy [8]. So, in line with other research of these traits, we propose that neuro-typical adults expression recognition accuracy is affected by their autistic trait level.

In order to organise a study around this issue, we used the widely applied Autism-Spectrum Quotient (AQ) questionnaire [2]. This allowed us to We assess autistic traits for neuro-typical individuals. This is a novel approach in the study of Human-Robot Interaction for those with an ASC. We suspect that one of the reasons there is so little work with adults with an ASC compared to children is the difficulty of assembling an acceptable number of participants for studies. If it is possible to use neuro-typical participants together with an AQ for preliminary work at least, this would assist such work greatly.

Fifty-seven university staff and students (Mean age = 25.84, SD = 8.60) participated, including 24 females and 33 males. The sample had a mixed demographic; 72% White, 19% Asian, 3.5% mixed, 3.5% Arab, and 2% African. Of the sample, 59.6% were native English speakers. Participants were recruited via lectures, university advertising boards, posters, and an internal news article. Participation criteria included being over the age of 18 years, having no diagnosed psychiatric condition, and normal or corrected vision.

The experiment setup can be seen in Fig. 4 and this time involved the whole robot and not just the EMYS head. Participants sat facing the robot and adjusted their seat to be at the robot’s eye-level. The experimenter told participants they would be offering food items to the robot and provided a full account of the experiment procedure. The procedure was explained meticulously as the pilot study had

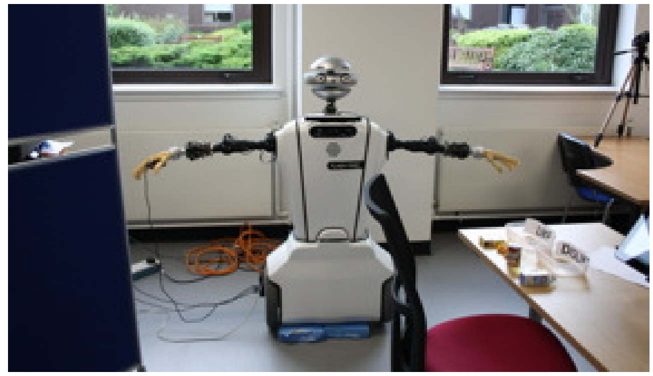

Figure 4: Emotion recognition task setup. RFID reader strapped to robots right hand. RFID tagged items on table.

demonstrated that verbal instructions from the robot alone often did not provide participants with adequate information. Participants were asked to place each food item near the robots right hand with the RFID tag facing the reader, one at a time, and only once the robot had offered its hand. A beep would indicate the RFID signal recognition. After the beep, the robot glanced at its hand, turned its head back to the user, lowered its hand, and produced an expression (latency 2 sec). Participants were told to keep hold of the object and to maintain attention on the robot’s facial expression after it had lowered its hand. Participants were asked to place the food item in the respective box on the table next to them depending on the observed expression.

However the outcome of this study, although it included some interesting results, failed to substantiate the idea that AQ score would correlate with emotional expression recognition. Summarizing the the accuracy data with the model revealed that the only statistically significant relationship in the data was between participant native language and the number of incorrect responses generated. This is unsurprising given that English speakers were correct on 88.24% of trials, compared to non-native English speakers 74.74% of trials. This suggests a cultural factor in the interpretation of facial expressions, and indeed recent work using dynamically generated agent faces [14], showed that Westerners attended more to the region of the mouth when observing expressions while their Eastern Asian counterparts focused more on the eye region [28]. While the project expects to work with a British group of adults with an ASC, there is interesting work to be carried out here relating adults with an ASC to their cultural milieu to establish whether they adhere to their cultural norms in recognising facial expression to the same extent as a non-ASC group.

3 A WORKPLACE-RELATED SCENARIO

The project’s next study will investigate how adults with and without an ASC task performance is affected by an interruption. In one condition, a human will interrupt the participant while they carry out a task, and in the other, the robot will carry out the interruption.

A human interruption condition has been included in the design as a baseline for responses since there is a dearth of literature examining peopleâĂŹs responses to robot interruptions.

Studies of interruptions with neuro-typical adults show that an initial task is often resumed at a lower intensity following an interruption, in terms of speed, sub-tasks completed, and accuracy (Altmann and Trafton, 2007; Borst et al., 2015). On occasion, the task is not resumed at all (OâĂŹConaill and Frohlich, 1995). Further, cognitive studies into âĂIJattention residueâĂİ demonstrate that information related to an initial task (Task A) can remain active while switching to a new task (Task B; Leroy, 2009; Leroy and Schmidt, 2016). This ihas been demonstrated by a reduction in response time (RT) and increase in accuracy to stimuli related to Task A whilst transitioning to Task B).

This study will use a modified version of the paradigm developed by Leroy (2009) to examine whether being interrupted by a robot or a human causes more or less attention residue while switching from Task A to Task B. Also, the speed, number of sub-tasks completed, and accuracy of Task A after completing Task B will give a general indication of how the interruption affected Task A performance.

The primary hypothesis concerns the interrupter type: robot or human. Given the aforementioned research, we propose that adults with an ASC will perform better when interrupted by a robot. This will be demonstrated by an attenuation of attention residue: responses to Task A related stimuli in the lexical decision task will not show reduced RT and increased accuracy relative to other stimuli. In the same condition, we also expect to observe a reduction in completion time, increase number of subtasks completed, and accuracy on Task A after completing Task B. For those in the neuro-typical group, we expect to see similar attention residue effects - reduced RT and increased accuracy for Task A related stimuli - for both interrupter types.

Our secondary hypothesis states that the ability to cope with interruptions is atypical in ASC, as shown in research from the related domain of executive functioning (Hill, 2004) and cognitive control (Geurts, Corbett, and Solomon, 2009) demonstrating document task switching and task disengagement difficulties. We expect autistic participants to take longer, be less accurate, and complete fewer sub-tasks after returning to Task A having completed Task B. Further support will come from the human interruption condition, where we expect autistic participants to show greater attention residue (i.e. reduced RT; increased accuracy to Task A related words) than the neuro-typical group due to difficulty disengaging from Task A.

3.1 Data collection

Data collection will take place over two sessions.

3.1.1 Intelligence Assessment. In the first session, participants IQ will be measured so as to allow us to balanced IQs across the ASC and non-ASC groups. For this we will use the WAIS-II: this includes four tasks, including Block Design, Vocabulary, Matrix Reasoning, and Similarities. Vocabulary and Similarities represent the Verbal Comprehension scoring component, whilst Block Design and Matrix Reasoning represent the Perceptual Reasoning component. Together, these tasks provide an indication of Full-Scale IQ.

3.1.2 Interruption Task. In the second session participants will complete the interruption task, as well as an abbreviated version of the AQ mentioned above. Finally they will fill in a post-test questionnaire. This session will be recorded by two tripod mounted HD video cameras. Participants will be randomly assigned to the human or robot interrupter version of the interruption task. Each group will be read a different version of the Participant Information sheet, stating that they will either âĂIJinteract with a robotâĂİ or âĂIJinteract with the experimenterâĂİ. Equal numbers of autistic and non-autistic adults will be assigned to each condition. Thus the study will have a 2 ÃŮ 2 between-subjects design, including the factors group (autistic, non-autistic) and interrupter (human, robot).

In the interruption task participants will first be asked to complete an emailing task (Task A). After 5 mins of engaging in this task, the interruption will occur (by either the human or robot). During the interruption the interrupter will direct participants to a word game on the computers desktop (the lexical decision task), then ask them to organise some papers (Task B) after the word game, before finally returning to Task A. Once the interruption is over the interrupter will move to a work station in the lab out of the participantâĂŹs way. The experimenter will cease the interruption task after a period of 15mins. To finish, participants will be asked to fill out the abbreviated AQ and post-test questionnaire on the computer.

The experimenter will read out the Information Sheet at both testing sessions to ensure participants are aware of the studies aims, that they are to be video-recorded, and that data concerning their eye behaviour will also be recorded. Initially, participants will be naive to the focus on interruptions and instead will be told that the experiment is part of a project developing a workplace multi-tasking training schedule (in the Information Sheet). However, the focus on interruptions and development a robot-based social skills training for adults with an ASC will be revealed during the debrief.

4 CONCLUSIONS

In this paper we have given an overview of work to date in the SoCoRo project, with the eventual aim of developing the basis for robot training systems to aid in social signal recognition. We have reported summaries of a pilot study in which we established robot facial expressions that were recognised as signals of approval or disapproval and a study in which we explored the use of AQ and uncovered cultural factors in facial expression recognition. Finally we have summarised a new study in which we hope to move to a more explicitly workplace-related scenario and explore the effects of interruptions to human task execution by a robot.

REFERENCES

[1] Susanna Baldwin, Debra Costley, and Anthony Warren. 2014. Employment activities and experiences of adults with high-functioning autism and aspergerâĂŹs disorder. *Journal of Autism and Developmental Disorders* (2014). DOI: http://dx.doi.org/10.1007/s10803-014-2112-z

[2] Simon Baron-Cohen, Sally Wheelwright, Richard Skinner, Joanne Martin, and Emma Clubley. 2001. The Autism-Spectrum Quotient (AQ): Evidence from Asperger Syndrome/High-Functioning Autism, Males and Females, Scientists and Mathematicians. *Journal of Autism and Developmental Disorders* 31, 1 (2001), 5–17. DOI: http://dx.doi.org/10.1023/A:1005653411471

[3] Jelmer P Borst, Niels A Taatgen, and Hedderik van Rijn. 2015. What Makes Interruptions Disruptive? A Process-Model Account of the Effects of the Problem State Bottleneck on Task Interruption and Resumption. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems - CHI '15* (2015). DOI: http://dx.doi.org/10.1145/2702123.2702156

[4] Mary Czerwinski, Eric Horvitz, and Susan Wilhite. 2004. A diary study of task switching and interruptions. In *Proceedings of the 2004 conference on Human*

factors in computing systems - CHI '04. DOI:http://dx.doi.org/10.1145/985692.985715

[5] Jessica de Villiers, Peter Szatmari, and Susan Yang. 2014. Autism and Asperger Syndrome: Language Use. In *Comprehensive Guide to Autism*. DOI:http://dx.doi.org/10.1007/978-1-4614-4788-7{_}194

[6] Joshua J. Diehl, Lauren M. Schmitt, Michael Villano, and Charles R. Crowell. 2012. The clinical use of robots for individuals with Autism Spectrum Disorders: A critical review. *Research in Autism Spectrum Disorders* (2012). DOI:http://dx.doi.org/10.1016/j.rasd.2011.05.006

[7] Paul Ekman and Wallace V. Friesen. 1982. Felt, false, and miserable smiles. *Journal of Nonverbal Behavior* (1982). DOI:http://dx.doi.org/10.1007/BF00987191

[8] O Golan, S Baron-Cohen, J Hill, and M Rutherford. 2007. The 'Reading the Mind in the Voice' test-revised: a study of complex emotion recognition in adults with and without autism spectrum conditions. *Journal of Autism & Developmental Disorders* (2007).

[9] Francesca Happé and Angelica Ronald. 2008. The 'fractionable autism triad': A review of evidence from behavioural, genetic, cognitive and neural research. (2008). DOI:http://dx.doi.org/10.1007/s11065-008-9076-8

[10] Elisabeth L. Hill. 2004. Executive dysfunction in autism. (2004). DOI:http://dx.doi.org/10.1016/j.tics.2003.11.003

[11] A. Hillier, H. Campbell, K. Mastriani, M. V. Izzo, A. K. Kool-Tucker, L. Cherry, and D. Q. Beversdorf. 2007. Two-Year Evaluation of a Vocational Support Program for Adults on the Autism Spectrum. *Career Development and Transition for Exceptional Individuals* (2007). DOI:http://dx.doi.org/10.1177/08857288070300010501

[12] Claire A.G.J. Huijnen, Monique A.S. Lexis, Rianne Jansens, and Luc P. de Witte. 2016. Mapping Robots to Therapy and Educational Objectives for Children with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders* (2016). DOI:http://dx.doi.org/10.1007/s10803-016-2740-6

[13] Rachael E. Jack, Oliver G.B. Garrod, and Philippe G. Schyns. 2014. Dynamic facial expressions of emotion transmit an evolving hierarchy of signals over time. *Current Biology* (2014). DOI:http://dx.doi.org/10.1016/j.cub.2013.11.064

[14] Rachael E. Jack and Philippe G. Schyns. 2017. Toward a Social Psychophysics of Face Communication. *Annual Review of Psychology* (2017). DOI:http://dx.doi.org/10.1146/annurev-psych-010416-044242

[15] David O. Johnson, Raymond H. Cuijpers, and David van der Pol. 2013. Imitating Human Emotions with Artificial Facial Expressions. *International Journal of Social Robotics* (2013). DOI:http://dx.doi.org/10.1007/s12369-013-0211-1

[16] Timo Lorenz, Cora Frischling, Raphael Cuadros, and Kathrin Heinitz. 2016. Autism and overcoming job barriers: Comparing job-related barriers and possible solutions in and outside of autism-specific employment. *PLoS ONE* (2016). DOI:http://dx.doi.org/10.1371/journal.pone.0147040

[17] McKenna Peter E, Lim Mei Yii, Ghosh Ayan, Aylett Ruth, Broz Frank, and Gnanathusharan Rajendran. 2017. Do you think I approve of that? Designing facial expressions for a robot. In *International Conference of Social Robotics (ICSR)*. Ninth International Conference of Social Robotics (ICSR): Embodied Interactive Robotics, Tsukuba, Japan.

[18] Albert Mehrabian. 1996. Pleasure-arousal-dominance: A general framework for describing and measuring individual differences in Temperament. *Current Psychology* (1996). DOI:http://dx.doi.org/10.1007/BF02686918

[19] Laurent Mottron, Michelle Dawson, Isabelle Soulières, Benedicte Hubert, and Jake Burack. 2006. Enhanced perceptual functioning in autism: An update, and eight principles of autistic perception. (2006). DOI:http://dx.doi.org/10.1007/s10803-005-0040-7

[20] Kate C. Plaisted. 2001. Reduced generalization in autism: An alternative to Weak Central Coherence. In *The Development of Autism: Perspectives from Theory and Research*. DOI:http://dx.doi.org/10.1017/CBO9781107415324.004

[21] Gnanathusharan Rajendran, Anna S. Law, Robert H. Logie, Marian Van Der Meulen, Diane Fraser, and Martin Corley. 2011. Investigating multitasking in high-functioning adolescents with autism spectrum disorders using the virtual errands task. *Journal of Autism and Developmental Disorders* (2011). DOI:http://dx.doi.org/10.1007/s10803-010-1151-3

[22] David H. Skuse, William P L Mandy, and Jane Scourfield. 2005. Measuring autistic traits: Heritability, reliability and validity of the Social and Communication Disorders Checklist. *British Journal of Psychiatry* (2005). DOI:http://dx.doi.org/10.1192/bjp.187.6.568

[23] Kelise K. Stewart, James E. Carr, and Linda A. LeBlanc. 2007. Evaluation of family-implemented behavioral skills training for teaching social skills to a child with Asperger's disorder. *Clinical Case Studies* (2007). DOI:http://dx.doi.org/10.1177/1534650106286940

[24] Lauren M. Turner-Brown, Timothy D. Perry, Gabriel S. Dichter, James W. Bodfish, and David L. Penn. 2008. Brief report: Feasibility of social cognition and interaction training for adults with high functioning autism. *Journal of Autism and Developmental Disorders* (2008). DOI:http://dx.doi.org/10.1007/s10803-008-0545-y

[25] Joshua Wainer, Ben Robins, Farshid Amirabdollahian, and Kerstin Dautenhahn. 2014. Using the humanoid robot KASPAR to autonomously play triadic games and facilitate collaborative play among children with autism. *IEEE Transactions on Autonomous Mental Development* (2014). DOI:http://dx.doi.org/10.1109/TAMD.2014.2303116

[26] Indika B. Wijayasinghe, Isura Ranatunga, Namrata Balakrishnan, Nicoleta Bugnariu, and Dan O. Popa. 2016. HumanâĂŞRobot Gesture Analysis for Objective Assessment of Autism Spectrum Disorder. *International Journal of Social Robotics* (2016). DOI:http://dx.doi.org/10.1007/s12369-016-0379-2

[27] Tanja S.H. Wingenbach, Chris Ashwin, and Mark Brosnan. 2016. Validation of the Amsterdam Dynamic Facial Expression Set ' Bath Intensity Variations (ADFES-BIV): A Set of Videos Expressing Low, Intermediate, and High Intensity Emotions. *PLoS ONE* (2016). DOI:http://dx.doi.org/10.1371/journal.pone.0147112

[28] Hui Yu, Oliver G.B. Garrod, and Philippe G. Schyns. 2012. Perception-driven facial expression synthesis. In *Computers and Graphics (Pergamon)*. DOI:http://dx.doi.org/10.1016/j.cag.2011.12.002