PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Ersilia Vallefuoco

XXXII Cycle

Training and Research Activities Report – Third Year

Tutor: Alessandro Pepino

Information

Ersilia Vallefuoco, MSc in Biomedical Engineering, cum laude, in 2016 – University of Naples Federico II.
XXXII Cycle - University of Naples Federico II.
DIETI (University of Naples Federico II) and SInAPSi University Centre (University of Naples Federico II) finance my fellowship.
Tutor: Prof. Alessandro Pepino.

Study and Training activities

In my third year of PhD program, I attended the following seminars and courses:

Courses:

1. ***Strategic Orientation for STEM Research & Writing*** (15/3/2019; 18/3/2019; 22/03/2019; 25/03/2019; 1/04/2019; 8/04/2019), ad hoc module, Lecturer: Chie Shin Fraser, 6 CFU.

2. ***Internet censorship: enforcement, detection, and circumvention*** (7/5/2019; 8/5/2019; 9/5/2019), ad hoc module, Lecturer: Prof. Giuseppe Aceto, 2 CFU.

Seminars:

1. ***Presentazione ADI: Vittorie, Sfide, Obiettivi*** (9/5/2019); Lecturer: Mirella Paolillo, Edoardo Baldaro, Vittorio Di Somma, Lorenzo Fattori; Organizer: ADI-Napoli, 0.2 CFU.

2. ***Control of multi-robot systems: from rendez-vous to long-duration autonomy*** (14/5/2019); Lecturer: Gennaro Notomista; Organizer: Prof. Bruno Siciliano. 0.3 CFU.

Credits Summary

	Credits year 1								Credits year 2								Credits year 3									
		1	2	3	4	5	6			1	2	3	4	5	6			1	2	3	4	5	6			
	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Total	Check
Modules	20	4	3			3	6	**16**	15		3			0,4	3,2	**6,6**	21		6	2				**8**	**31**	30-70
Seminars	8	2,8	1,4	0,2	0,2	0,4	0,4	**5,4**	6			2	0,8	0,9	0,4	**4,1**	12		0,5					**0,5**	**10**	10-30
Research	32	5	5	7	7	5	6	**35**	39	10	7	8	9,2	9	6,6	**50**	30	10	6,5	8	10	10	10	**55**	**139**	80-140
	60	12	9,4	7,2	7,2	8,4	12	**56**	60	10	10	10	10	10	10	**61**	63	10	13	10	10	10	10	**63**	**180**	180

Research Activity

A serious game to improve daily living skills in people with Autism Spectrum Disorder

The majority of people with Autism Spectrum Disorder (ASD) are not autonomous, presenting difficulties in various daily living activities, such as cooking, shopping or managing finances. Serious games are innovative computer-based interventions to support children and adults with ASD. However, research on interventions for people with ASD through SGs reveals severe limits, such as the restricted range of topics and genres for SGs, the frequent use of non-standardized tools for outcome assessments, a lack of multidisciplinary approaches in SG design, a lack of personalization in SG-based intervention and, most of all, little evidence of skills being generalized from the virtual world of SGs to real-life contexts.

In my PhD, I study new methodologies and techniques to support rehabilitation intervention of people with Autism Spectrum Disorder (ASD) through personalised serious games. In particular, I investigated and assessed the effectiveness of a personalised SG-based intervention aimed at helping young subjects with ASD learn and train skills, specifically, daily living skills.

Research Description

Autism Spectrum Disorder (ASD) encompasses a set of neurodevelopmental disorders clinically characterised by two main categories of symptoms: deficits in social communication and social interaction; restricted patterns of behaviours [1]. There is a high heterogeneity in the ASD clinical presentation due to the variability of the intellectual ability, of the severity levels of disorder, and of the associated psychiatric comorbidities [2]. ASD symptoms appear in early childhood [1] and can change over the years with diverse developmental pathways [3]. However, the symptoms generally persist throughout life, so ASD is considered a lifelong disorder.

Among the several technological applications for people with ASD, serious games – that is, digital games specifically designed to achieve characterizing goals through entertainment [4] – have been developed [5]. Serious games (SGs) usually consist of at least three factors: (1) simulation, because they can reproduce real events or some aspects of real events; (2) the learning, because the main purpose of SGs is to acquire skills and knowledge; (3) the game itself, because SGs have the structure of actual videogames, and the gaming elements motivate the player and get them involved in the selected activities [6].

Nevertheless, despite the inherent potentiality of serious games, few studies have evaluated the effects of SGs on the generalisation process in people with ASD [7-9]. According to different reviews [9-14], these applications were developed mostly for children with ASD or high-functioning youths, often not considering the heterogeneity of the disorder and the different functioning profiles of individuals with ASD. In addition, the key themes are emotion recognition, social conversation, and word learning. These limitations do not aid the spread of serious games in rehabilitation contexts and increase the gap between research and practice.

During this year, the aim of my research was to assess the efficacy of a rehabilitation intervention for people with ASD through an individualised serious game developed for improving skills related to a specific daily living activity: shopping in a supermarket. The underlying hypothesis of this study was that training with an individualised serious game can improve performance in a real-life environment. In order to prove this hypothesis, a sample of 10 subjects with ASD played an individualised serious game, *ShopAut*, for ten sessions. Subjects underwent real-life experiences in a supermarket pre- and post-virtual training to determine whether there had been a generalisation of skills from the virtual environment to the real environment. Improvements in skills and performance in the real shopping activity were evaluated using specific tools.

10 children and teenagers with ASD were recruited from the medical centre “Centro Medico Riabilitativo Pompei” (Strada Statale 145, 64, 80045 Pompei NA, https://centropompei.webnode.it/), which is specialized in the rehabilitation of people with ASD. Inclusion criteria were: (1) clinical diagnosis of ASD, in keeping with the diagnostic criteria of DSM-V[1]; (2) chronological age between 8 and 16 years; (3) no physical impairments; (4) a rehabilitation plan already underway in accordance with the study’s goals. The participants’ IQ was estimated via the Wechsler Intelligence Scale for Children IV (WISC-IV) [15] and a diagnostic screening was conducted via Autism Diagnostic Observation Schedule-Second Edition (ADOS-2) [16] in order to evaluate their severity level in compliance with the DSM-V [1]. The participants’ parents gave their informed consent to let them participate in the study. The study was in accordance with the declaration of Helsinki.

The research involved a multidisciplinary team, namely a neuropsychiatrist, a psychologist, biomedical engineers, neuro and psychomotor therapists, speech therapists, and occupational therapists. The research team developed a specific experimental protocol for this study identifying three main phases:

1. *Pre-intervention*: first real-life experience to evaluate the participants' performance in a real environment.
2. *Intervention*: virtual training with the individualised serious game to train, experiment, and practice behaviours and actions.
3. *Post-intervention*: second real-life experience to evaluate the improvements achieved by the participants after the training.

In the real-life experiences, the participants went to a supermarket accompanied by a therapist, while a researcher recorded the experience with a traditional camera. The therapist guided the participant, providing him or her with a shopping list that included three tasks to complete: (1) pick up the ingredients to cook a dish (pasta with tomato sauce); (2) pick up personal care products; (3) pick up a product to organize a party. The tasks in the shopping list were both written and explained with representative images. The therapist helped the participant only where necessary (for example, by reading the tasks of the shopping list or by demonstrating the actions to perform if the participant did not know them). The videos were analysed independently by two research members, a psychologist and a neuropsychiatric, who had not been previously involved in the real-life experiences.

The virtual training with the serious game took place during the therapy session of the participants at the Centro Medico Riabilitativo Pompei. The game sessions were led by each participant's therapist, who chose the game options according to each participant's needs, while a researcher supervised in case of a technical issue with the game. Each participant played 10 game sessions, one per week, for no more than 30 minutes.

I developed *ShopAut* in the previous year of my PhD. *ShopAut*, is a three-dimensional game that was conceptually inspired by classic 3D life simulation games. It was developed as a computer application and provides two input devices: a joystick controller and a keyboard with a mouse. The game provides a realistic shopping experience where the player can specifically practice and engage with several kinds of shopping activities, as well as experiment their problem-solving skills, take on unexpected events, and interact with others. In particular, the game aims to teach the procedure of a shopping activity; to reinforce object categorization and recognition in a supermarket; to improve attention, orientation, and problem-solving skills; and to help the player engage in simple economic transactions. The game consists of ten levels of increasing difficulty, the first one being a tutorial level meant to introduce the player to the game. Before launching the game, the main menu allows the player to select the game level, their own ASD severity level, and the type of player (i.e., third- and first-person view). In particular, the option for the ASD severity level provides different facilitators – such as images or directions – in the game. After setting up the different game options, each game level starts by introducing the main character, Nello, who asks the player to help him buy certain products. If a third-person view was previously chosen, the player controls Nello directly. The game takes place in the supermarket chosen for the real-life experience and includes two environments: the supermarket and its parking lot. The player can move into these two scenarios and they can interact with all the objects that can be useful for shopping. The shopping game experience is interactive and the player can select the products through a fictional barcode scanner positioned on the shopping cart. The game score is calculated based on the accuracy of the game actions, and the player can be awarded a gold, a silver or a bronze medal at the end of each game level. The player has access to the subsequent level from the main menu only if they have earned a medal; otherwise, they have to play the same level again in order to advance. A feedback system is present in the game in the form of sounds and textual messages based on the accuracy of the player's actions. When the player makes a mistake, they can repeat the action to understand where they went wrong. The game was developed using Unity as a game engine and ran on Windows 10 Home 64-bit, 32 GB RAM and Intel Core i7 7th Generation.

The assessment of real-life experiences should involve clinical, psychological, and social aspects and should be connected to the real environment; there are no specific assessment tools helpful to describe the functioning of the participant. Therefore, I elaborated an ad hoc evaluation form based on *the International Classification*

of Functioning, Disability and Health: children and youth version (ICF-CY) [17]. However, the form we devised evaluated qualitative variables derived from both behavioural observations and the actions performed in the real-life experiences. For this reason, the real-life experiences were analysed by two expert raters to establish the consistency of the ICF-CY scores. Furthermore, the intervention efficacy clinically assessed via the *Vineland Adaptive Behavior Scale II* (VABS-II) [18].

The inter-rater reliability of the ICF-CY scores was calculated from the data obtained from the two independent raters via weighted Cohen's kappa. Cohen's kappa was calculated with 95% confidence. Items that scored 8 in the ICF-CY scale were considered missing values in the statistical analysis. The comparison of paired data (pre- and post-intervention) was analysed via the Wilcoxon signed-rank test. The statistical analysis was conducted using R Software and a P-value < 0.05 indicated statistically significant differences.

The inter-reliability analysis showed an almost perfect level of agreement between the raters. This result highlights the reliability of the elaborated form, which appropriately identified the activities and behaviours involved in the shopping experience. In the first real-life experience, the majority of participants were disoriented, insecure and, above all, distracted, being unable to focus their attention throughout the shopping activity. In particular, almost all of participants showed different levels of difficulty (ICF-CY scores between 2-4) in almost all ICF-CY codes. Moreover, 4 of the participants did not complete their shopping as they encountered various difficulties, especially in directing their attention, understanding the tasks, and managing their own behaviour; in these cases, the experience was interrupted not to upset the participant.

After the training with *ShopAut*, all participants completed the shopping experience, showing increased attention, orientation ability, self-confidence, and knowledge of the shopping procedure. In fact, all participants presented improvements in the monitored ICF-CY codes and the analysis of paired data confirmed statistical improvements for each ICF-CY code. The VABS-II analysis confirmed the effectiveness of the SG-based intervention. More specifically, the paired samples Wilcoxon test showed a statistically significant increment in the domains mainly involved in the intervention.

I am registering this study as clinical trial in the WHO International Clinical Trial Registry Platform.

During this year, I collaborated within a national research project - SUPER - aimed to propose efficient methodologies and tools to support the interventions planning for people with ASD. This project involves different Italian universities (University of Campania Luigi Vanvitelli, University of Milano Bicocca, University of Trento) and research institutes. More specifically, I supported the design and the development of web-platform that facilitates scientific understanding of Autism Spectrum Disorder and provides shared tools to help the different figures involved in a rehabilitation programme of an individual with ASD. Furthermore, based on the form elaborated for my research, a new form was created to define the ICF-CY functioning profile of an individual with ASD in rehabilitation and educational contexts. This form was elaborated in collaboration with Dr. Giovanna Gison (University of Campania Luigi Vanvitelli) and Prof. Paola Venuti (University of Trento); it has become a rehabilitation-educational tool, registered with copyright.

Collaborations

For my research, I collaborated with the medical centre "Centro Medico Riabilitativo Pompei" and the Department of Translational Medical Sciences, University of Naples Federico II.

Products

Publications

1. Gison, G., **Vallefuoco, E**. and Pepino A. (2019). Piattaforma digitale per la progettazione degli interventi nel Disturbo dello Spettro Autistico. SUPER (Sistema Unitario in una Piattaforma Educativa e Riabilitativa). IL TNPEE, Erickson, vol. 1, n. 1.
2. Pepino, A., Ronchetti, M., Peron, A., Freda, C. and **Vallefuoco, E**. (2019*). The lecture video recording in university: A case study*. EMOOCs-WIP 2019, vol. 2356, pp. 175-180.
3. **Vallefuoco, E.,** Mele M., Pepino A. (2019). *A Serious Game to Support Decision Making in Medical Education*. In: Cristani M., Prati A., Lanz O., Messelodi S., Sebe N. (eds) New Trends in Image Analysis and Processing – ICIAP 2019. ICIAP 2019. Lecture Notes in Computer Science, vol. 11808. Springer, Cham.
4. **Vallefuoco, E**, Gison, G., Bravaccio, C. and Pepino, A. *Improving daily living skills in people with Autism Spectrum Disorder through a personalised serious game*. Nature Scientific Reports (under review).

Conferences and Seminars

I attended the following conference:

- ***20th International Conference on IMAGE ANALYSIS AND PROCESSING***.
  Trento, 9-13 September, 2019.
  1 paper with oral presentation

I held the following seminars:

1. ***Personalised Serious Games for people with Autism Spectrum Disorder***
   Observational, Diagnosis and Education Lab. (ODFLab), Department of Psychology and Cognitive Science - University of Trento. Organized by Prof. Paola Venuti. 31/05/2019

2. ***SUPER: Web Platform to support interventions for people with Autism Spectrum Disorder***
   [SUPER: Piattaforma Digitale per la Progettazione degli interventi nel Disturbo dello Spettro Autistico] Department of Medicine and Surgery, University of Milano Bicocca. Organized by Prof. Fiorenza Broggi. 14/12/2019

Moreover, I was invited as a speaker at event: ***Cangemi for Autism*** in the World Autism Awareness Day, 2 April. I held a speech about the role of the technology-based interventions in the rehabilitation-educational programmes of people with Autism Spectrum Disorder. Boscoreale, 2 April 2019.

Activity abroad

- ICIAP, 20th International Conference on IMAGE ANALYSIS AND PROCESSING – Trento, Italy – 9-13 September, 2019
- visiting at Observational, Diagnosis and Education Lab. (ODFLab), Department of Psychology and Cognitive Science - University of Trento – from 31/05/2019 to 3/06/2019

Tutorship

I supported my tutor (Prof. Alessandro Pepino) in exercises lessons for the Sistemativi Informativi Sanitari module [12 hours].

I held the following seminars for the “Simulazione in medicina” course:

1. Serious games in healthcare [2 hours]
2. The game engine Unity and its tools [12 hours]
3. Develop a serious game [4 hours]

Tutorship for the course of “Simulazione in medicina”, “Sistemi informative sanitari” and “Tecnologie per la Valutazione, l'Assistenza e il Recupero Funzionale”.

Exam assistant to the MSc (Biomedical Engineering) course of “Sistemi Informativi Sanitari”, MSc course of “Tecnologie per la Valutazione, l'Assistenza e il Recupero Funzionale” and MSc course of “Simulazione in medicina”.

Support activity for the MSc candidate Raffaella Nocerino and Claudia Ottaviano.

References

1. American Psychiatric Association. Diagnostic and statistical manual of mental disorders (American Psychiatric Association, 2013), 5th edn.
2. Lenroot, R. K. & Yeung, P. K. Heterogeneity within autism spectrum disorders: what have we learned from neuroimaging studies? Front. Hum. Neurosci. 7, 733 (2013).
3. Fountain, C., Winter, A. S. & Bearman, P. S. Six developmental trajectories characterize children with autism. Pediatrics 129, e1112–e1120 (2012).
4. Dörner, R., Göbel, S., Effelsberg, W. & Wiemeyer, J. Serious Games. (Springer, 2016).
5. Zakari, H. M., Ma, M. & Simmons, D. A review of serious games for children with autism spectrum disorders (ASD). In International Conference on Serious Games Development and Applications, 93–106 (Springer, 2014).
6. Garris, R., Ahlers, R. & Driskell, J. E. Games, motivation, and learning: A research and practice model. Simul. & Gaming 33, 441–467 (2002).
7. Whyte, E. M., Smyth, J. M. & Scherf, K. S. Designing serious game interventions for individuals with autism. J. Autism Dev. Disord. 45, 3820–3831 (2015).
8. McCleery, J. P. Comment on technology-based intervention research for individuals on the autism spectrum. J. Autism Dev. Disord. 45, 3832–3835 (2015).
9. Tang, J. S. Y., Falkmer, M., Chen, N. T. M., Blte, S. & Girdler, S. Designing a serious game for youth with asd: Perspectives from end-users and professionals. J. Autism Dev. Disord. 49, 978–995, DOI: 10.1007/s10803-018-3801-9 (2019).
10. Zakari, H. M., Ma, M. & Simmons, D. A review of serious games for children with autism spectrum disorders (ASD). In International Conference on Serious Games Development and Applications, 93–106 (Springer, 2014).
11. Ke, F., Whalon, K. & Yun, J. Social skill interventions for youth and adults with autism spectrum disorder: A systematic review. Rev. Educ. Res. 88, 3–42 (2018).
12. Grossard, C. et al. Serious games to teach social interactions and emotions to individuals with autism spectrum disorders (ASD). Comput. & Educ. 113, 195–211 (2017).
13. Tang, J. S., Chen, N. T., Falkmer, M., Blte, S. & Girdler, S. A systematic review and meta-analysis of social emotional computer based interventions for autistic individuals using the serious game framework. Res. Autism Spectr. Disord. 66, 101412 (2019).
14. Grynszpan, O., Weiss, P. L., Perez-Diaz, F. & Gal, E. Innovative technology-based interventions for autism spectrum disorders: a meta-analysis. Autism 18, 346–361 (2014).
15. Wechsler, D. Wechsler intelligence scale for children. 4th edition. (2003).

16. Lord, C. et al. Autism diagnostic observation schedule–2nd edition (ADOS-2). Los Angeles, CA: West. Psychol. Corp. (2012).
17. World Health Organization. International Classification of Functioning, disability and health: Children and Youth version: ICF-CY (2007).
18. Sparrow, S. S. Vineland Adaptive Behavior Scales, 2618–2621 (Springer New York, New York, NY, 2011).