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Virtual Environment for Autism. Drawing Space for Connection and Inclusion: an Open Debate

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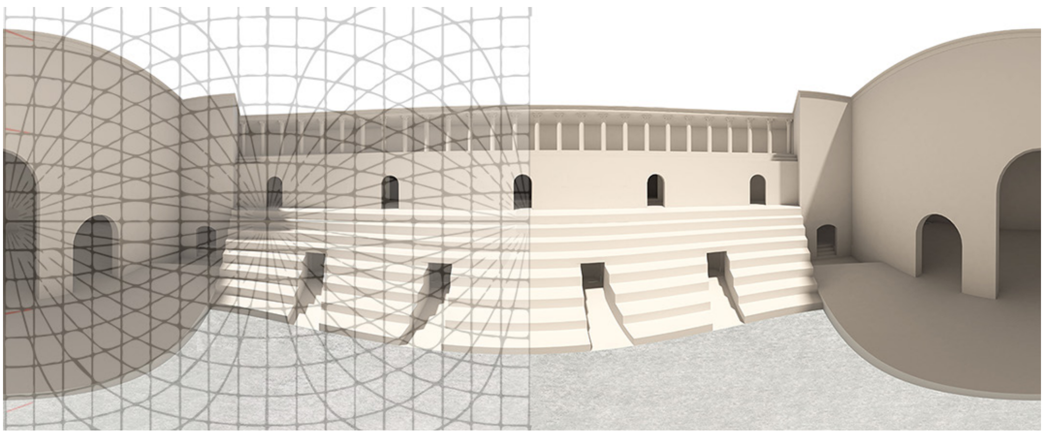
Abstract

The use of Virtual Reality (VR) in special education is still at an experimental stage, therefore it is important to test and explore many features of this technology. For this reason, it represents a growing sector of studies raising in research and debates. The sense of optimism, which encourages the experiments about ICT for Autistic disorder, is driven by some positive results of the experiences using VR, since those applications are showing the potential for education and rehabilitation in cognitive disorder. In this context, the ICAR 17 disciplines embody the multidisciplinary connective texture to investigate, read and understand the drawing space in order to become a knowledge medium for ADS people and their achieving to cultural contents. The present paper looks back to previous researches to compare different opinions and, in conclusion, to consider potentials and opportunities of this field of studies. Otherwise, analyzing publications about VR and autism, it stands out the lack of reference to perceptual contents and about the way they can influence the knowledge process. My attempt will not be only a comparison between different opinions about the use of immersive technology for autism, but also trying to fill in some of the details regarding spatial representation (when documents allow) related to their perceptual resonance.

Keywords
representation, Virtual Reality (VR), Virtual Environment (VE), Autism (ASD), learning.



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We often talk about inclusion, but hosting disability is not enough in order to allow everybody to gain the same knowledge targets and the same approach to the surrounding environment. Notably, the interaction with the environment, in cognitive disabilities, may assume a specific rule to enhance social and cultural skills involving perceptual stimuli. Romano Del Nord, talking about interaction between autism and architecture, claims: "Since the fact that the environment […] generates sensitivities to the organs of perception has now been universally acquired and shared, we cannot help but consider, in planning decisions, aspects that go beyond the pure and simple 'spatial functionality' and that involve the disciplines of proxemics, interpersonal visual communication as well as psychology and environmental psychology" [Del Nord 2010, p. 5]. In the recent years the representation disciplines, supported by the widespread of new technologies progress, play a fundamental role in the interdisciplinary mediation of educational field. If drawing has the potential of a language, at the same time universal but also specific in the message translation, the ICT can be a versatile instrument to control various communicative levels adapting itself to personal user needs. Referring to Hermelin and O'Connor studies, the difficulties involving the autistic clinical frame are connected especially to perception deficiency, with effects similar to blind people [Bogdashina 2015]. Frequently, visual distortions lead impairment in deep sense perception, *diplopia*, changes in shapes, dimensions and movements. VR system gives the opportunity to customize visual framework, acting on tools related to each of these aspects, becoming a valid support, for people with ASD, in understanding physical space. Referring to the first experiments in 1993 by Chen and Bernard-Optis, the first evidence is the capability of stimulating attention and focusing on information trough an appealing instrument, raising emotional involvement and, therefore, with new potentiality in educational training. It's a considerable benefit, for people with languages impairment, because the stimulus can be conveyed on figurative instead of verbal contents, modifying the cognitive dynamics. But, since the perceptual system in ASD react to different stimuli than neurotypical, the design of VE must be properly set up, considering the atypical answer concerning relation between vision and motion. Despite the visual system is not impairment in autism, the perceptual incoherence leads to a sensorial agnosia that inhibits the ability to confrere the right semantic meaning to environment figurative signs [Bogdashina 2015]. In addition, problems with proprioceptors can complicate the understanding of space dimensions and relations between objects, space and body [Williams, 1994]. All these aspects must be considered in designing virtual environment that integrate the vision perceptual modalities with the motion apparatus. In fact, the virtual navigation system is based on 360 degrees pictures (renderings, photos or videos) and, as soon as the limits of the observed image exceed the human visual field, the experience involves the body motion (even if just for rotating the head) turning from a static view to a dynamic perspective [Rossi et al. 2019]. Usually this relation helps the knowledge of the space features, while in autism it can create confusion or stress caused by a disorder of the 'efferent copy' phase [Russell 1994]. In this cases, to enhance wayfinding, navigation and understanding surround world, the VE must be structured considering speci-

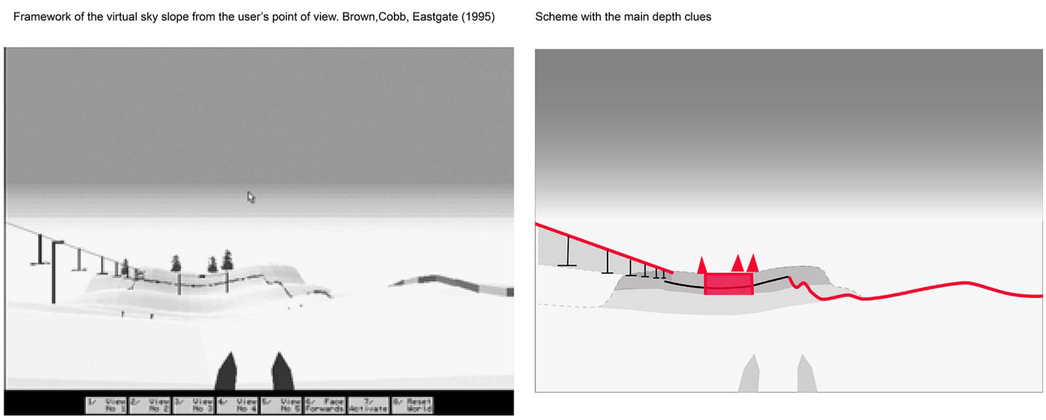

Fig. 1. VIRART's experiment. Image of the Virtual Environment. Photo published in Cobb Sue Valerie Gray, 2007. Virtual Environments Supporting Learning and Communication in Special Needs Education. Top Lang Disorders. No. 3, 2007, Vol. 27, pp. 211–225; a) VIRART (1995). Frame of the virtual ski slope from the user's point of view; b) Anna Lisa Pecora. Scheme with the main depth clues and target elements.

fic issues as: minimal distraction [Chen Li, 2018], simple visual patterns and colors [Strickland 1997; Saiano 2015], visual guide for motion and clear spatial reference [Mostafa 2014] concerning distances, positions and deep effects. However, it is difficult to set general guidelines because of the variety of behavioral difference between autistic users. For example, an Italian research of Genoa University exploring the effectiveness of VE in special education, confirms that people with ASD easily learn actions triggered by simple color stimuli [Saiano 2015] but, at the same time, a visual target can become a distraction from the main goal due to a long eye gaze fixation [Wade 2015]. Therefore, it's important to provide visual guidelines without triggering overstimulation. Referring to this aspect, an example is one of the first experiments led by Sue Cobb and the VIRART team. There are no descriptions about the virtual environment, but watching the published photo, it is possible to deduce some visual aspects interfering in the perceptual process. The VE represents a ski slope characterized by simple framework where objects have basic geometries easily recognizable (fig. 1). The highly prevalent white produces a flat configuration where it's difficult to understand the perspective. For this reason, the use of some graphic depth cues is crucial: a curb on the right and a schematic ski lift on the left side, provide two linear clues that, converging toward the frame center, become an important depth gradient. In fact, the angle of graphic signs on the vertical and horizontal axis, is a key element for tridimensional perception [Arnheim 1997]. The distances and dimensions reduction of ski-lift elements offer others depth gradients in the observed image; acting in the same direction, they enhance each other because "the more the gradient is regular, the stronger their effect acts" [Arnheim 1997, p. 227]. Moreover, the motion target, represented by the finish area, is emphasized with different graphic solutions (an horizontal line, some trees, a strong shade) representing a slope visual closure. In addition, the visual frame allows the view of the tip of the skis. This is another important detail enhancing embodiment and wayfounding because it gives a cue on self position and direction motion in the virtual space. As I introduced, the issues connected to the motion modalities involve many crucial aspects in our topic. Holden, Almeida, Park, Lewis, Griffin introduce the problem of cybersickness [Ravasio 2011]. Related to this point, there are many doubts: For example Park [Park et al. 2017], Almeida [Almeida et al. 2017] and Reiners [Reiners et al. 2014] reported high levels cybersickness in their HMD studies. Similarly, Bashiri [Bashiri et al. 2017] suggest that: "studies have indicated that cybersickness is a barrier to the use of training or rehabilitation tools in virtual reality environments" and

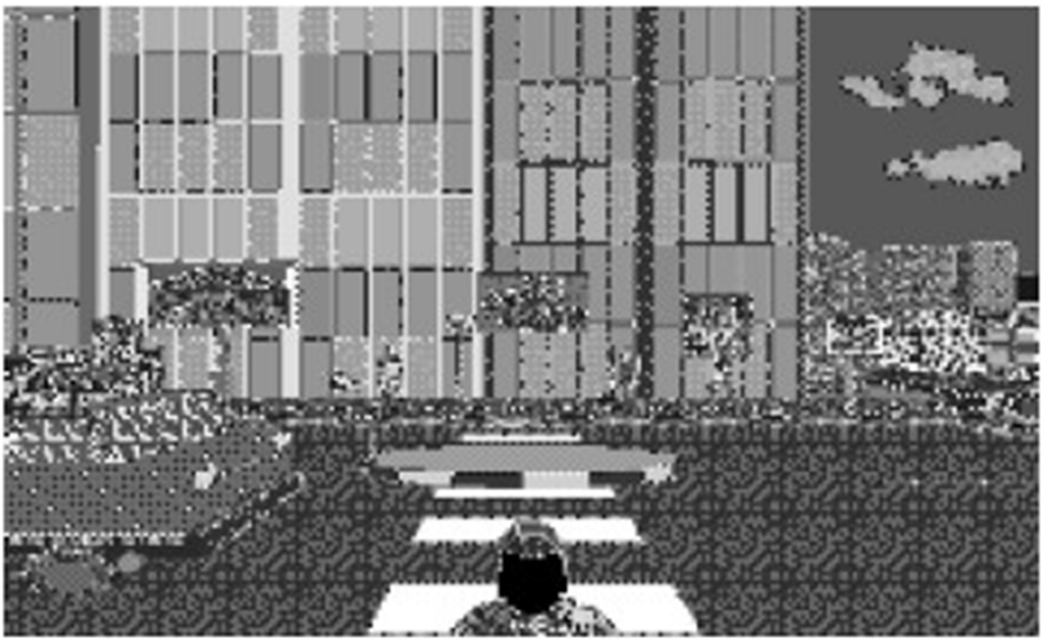

Fig. 2. Josman's experiment. Image of the Virtual Environment. Photo published in:Josman, Weiss 2008.

Polcar and Horejsi [Polcar, Horejsi 2015] reported that when present, cybersickness influenced learner attitudes towards technology negatively" [Bradley, Newbutt 2018, p. 6]. The symptoms, as well as the seasickness (oculomotor disorders, neurovegetative problems, vestibular disorders) are usually related to the period of the experience and to the age of the users, with more effect on women. In Ravasio opinion, the cybersickness is due to an incongruence between the movements perceived by the eyes and the information caught by the body and therefore: "between visual information indicating body movement and the proprioceptive and kinaesthetic vestibular information suggesting a static position" [Ravasio 2011, p. 65]. Such discomforts are also related to software and hardware [Newbutt et al. 2020], in fact they decrease when the high quality of devices allows adjusting the focal distance in relation to the individual interpupillary distance [Newbutt et al., 2016]. In 2018, the University of Camerino leads a research on neurotypical people to test the developing of motion sickness during virtual navigation. They understand that the modality of interaction

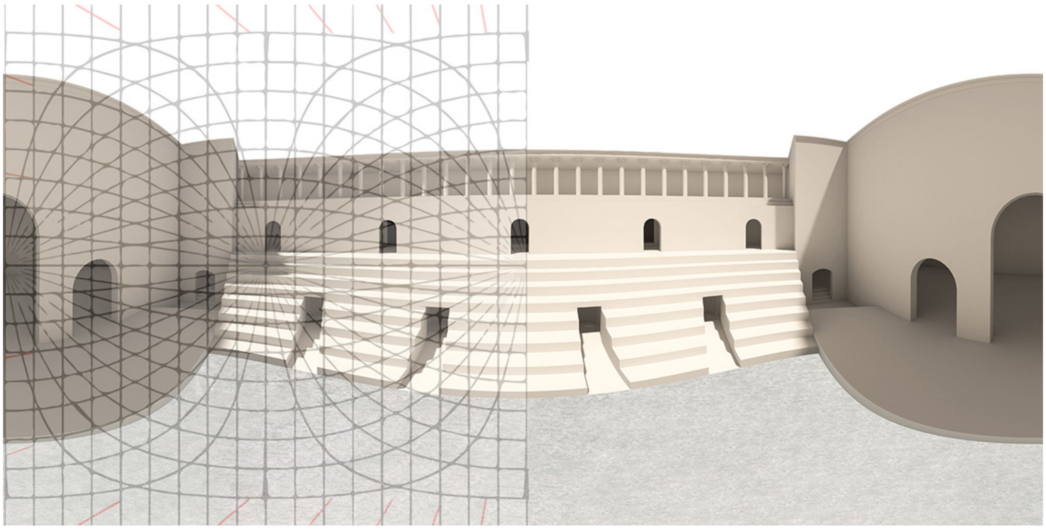

Fig. 3. Example of a rendering 360 degrees. Draft of a video related to a starting research about an autism friendly virtual archeological tour. The image represents the first step of a progressive building transformation over the centuries (graphic elaboration by Anna Lisa Pecora).

with the environment can influence the sense of motion sickness [Rossi, Olivieri 2019]. So that, the continuous navigation, even if supports the understanding of the virtual space, at the same time it occurs a longer detachment between visual and body stimuli raising the discomfort. At the opposite, the *Point and Teleport* exploration removes these problems but complicates the wayfounding and the memory of the environment, particularly for beginners or people with cognitive impairment. Moreover, the low resolution or the lack of ambient light can increase the sense of tiredness and visual fatigue interfering in performances. For example, an experiment lead by the University of Israel in 2008, with an old technology (a Pentium 3), reported some difficulties in understanding the virtual environment and its operation. Here, the pixels size is too large to define the graphic elements in the scene, thus, they work like visual distraction more than like uniform coatings. For the same reason, the object borders and different surfaces are not recognizable, complicating the perception of the three-dimension; this way the represented space appears flat, lacking in effective depth cues, without visual hierarchies and, therefore, sensorial confused (fig. 2). As Arnheim explains: "the whole layout is unreadable, because each possible relation is soon broken by a contrary and non-describable action. […] The result is confusion" [Arnheim 1994, p. 194]. Rather, if customized on specific user's need, the representation path allows the process of synthesis, communication and explicitation of the physical space necessary for decoding and subsequent learning its cultural contents. This is the attempt of a starting research lead by the Federico II University, focused on the so called *Sepolcro di Agrippina* in the Campi Flegrei archeological site (figs. 3-4). The future research will attempt to produce an autism friendly virtual tour showing the progressive structural transformation of the theatre building and how its relationship with the coastline changed throughout history. The short video in VR will act as a sensorial medium between the ASD user and the final in vivo tour. In particular way, the virtual space has the important role to decode with a simple and schematic graphic language, the complex theoretical and morphological contents of the real architecture. This way, the drawing shows relations between different elements that, only through their figurative configuration, can be understood thanks to graphic choices. Setting the detail level, the chromatic and luminous qualities, the quantity and the value of graphic signs in the VE, are essential features to define the sense of immersion and presence and therefore the communicative power driven by perceptual inputs. This way, the consciousness of living a

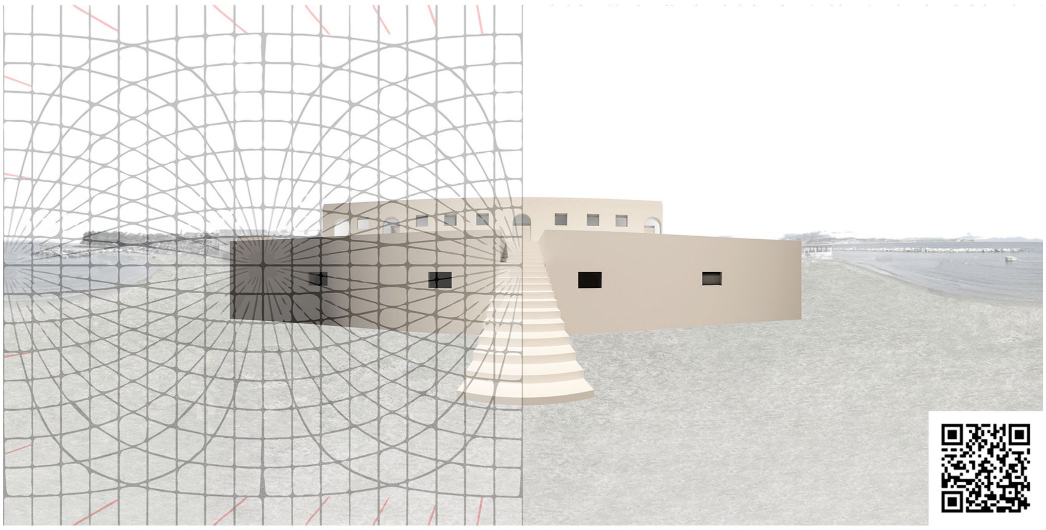

Fig. 4. Example of a rendering 360 degrees. Draft of a video related to a starting research, of Federico II University, about an autism friendly virtual archeological tour. The future research will attempt to produce a virtual tour showing the progressive structural transformation of the theatre building; the image represents the current state. Here the viewer can turn his view toward the coastline in order to take confidence with the main spatial references of the surrounding environment, before starting the in vivo tour. The QR code links to an example of the virtual tour. The video is under development (Anna Lisa Pecora).

virtual condition with the same perceptions of real life can be a support to transfer life skills and to improve autonomy of the ASD people more effectively than in real experiences. In fact, the sense of security given by the consciousness of living a space without dangers, removes the frequently unlikely symptoms occurring during unknown experience, as, for example, anxiety and stress [Gorini et al. 2008; Freeman et al. 2017], point out on the safe condition of the virtual environment "where consequences are not real" [Gorini et al. 2008, p. 5]. Usually, neurotypical children raise their knowledge trough experiments, training, errors, while students with autism use to avoid these experiences because they could be dangerous or frightening, since their impairment of sensorial system and low proprioceptive awareness. In 1996 Strickland publishes one of the first immersive experiments using an RV-HMD with the aim of teaching autistic children how to across a street alone. The experiment relevance lays on two main aspects: on one hand, it puts in evidence how the miscommunication with ASD can affect the data result, on the other hand it shows the potential of a safe environment providing the user, sense of comfort and safety. For this reason: "The virtual world was a simplified street scene consisting of a sidewalk and textured building shapes. All motion objects such as people, animals, and objects in the sky were removed. Periodically one car, whose speed could be changed, would pass the child standing on a sidewalk. The contrast was kept low in the scenes with gray being the dominant color. The low quality of the headset screens provided a less detailed environment automatically. The cars, the focal point of the test, were presented in bright, contrasting colors […] red and blue" [Strickland, 1997, p. 4]. Only later, another visual stimulus is introduced: a stop sign is moved to different parts of the tracking area during the later tests and the children are asked to find it and stopping there (figs. 5, 6). In this kind of configuration, the environment works like a neutral background helping to focus on visual targets, otherwise the oversimplification of morphological spatial signs creates difficulties in evaluating distances. For example, in the last exercise: "it was difficult to judge the sign's distance because of the lack of comparison cues" [Strickland 1997, p. 4]. Here, the graphical elements of the VE, are characterized by linear continuity: the sidewalk, the road, the long buildings sequence; so that, even if they contribute to perspective vision and to the dept sense they don't provide a taxonomy of the space elements neither a visual pattern helping the understanding of mutual object location. The depth effects depend by physiological qualities as well as by some perceptual gradients related to shapes, colors, dimensions, motion, recorded by the retina [Arnheim 1997]. The more these characters are explicit and the stronger the space structure is understood. So, the Strickland's experiment is useful to analyze visual aspects in order to understand how they can influence the space perception in autistic people, but also the potential of VR as learning environment for special education. It opens the way to many other studies that, for over 25 years, have extended the fields of observation, the technologies employed and the behavioral target for treatments. "Whilst there has been some progress in testing the relevance and applicability of VR for children on the autism spectrum in educational contexts, there remains a significant challenge in developing robust and usable technologies that can really make a difference in real world" [Parsons 2017 p. 356].

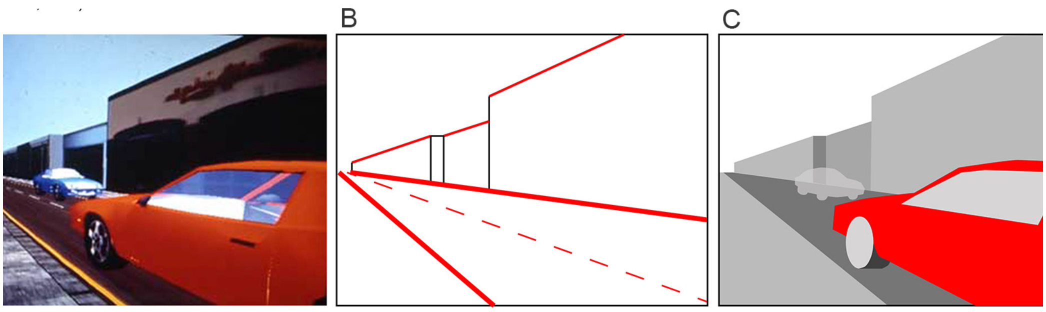

Fig. 5. Dorothy Strickland's experiment (1997). Image of the Virtual Environment and graphical schemes.
A) Dorothy Strickland (1997). Street scene of the Srtickland's experiment. http://www.virtualgalen.com/virtualhealing/autism.htm
B) Scheme with the main depth clues (Anna Lisa Pecora).
C) Scheme with the main target element highlighted in red (Anna Lisa Pecora).

Fig. 6. Strickland's experiment. Image of the Virtual Environment. Photo by Dorothy Strickland from: <http://www.virtualgalen.com/virtualhealing/autism.htm>.

Conclusions

The range of disciplines and technologies engaged in studies about autism and VR, show an increased interest and potential of this issue with a growing interdisciplinary approach, but without the contribute of representation disciplines. For the sake of narration, we are unable to argue here about a broader series of the experiments observed, which are therefore summarized in the attached table. In the taxonomy of data, priority has been given to the aspects of spatial figuration, although the publications rarely describe details of the settings. They often remain vague about some aspects useful to understand the perceptive response to the stimulus coming from the designed space. In spite of difficulties given by the atypical response of autism and by communication impairment, the studies have claimed that virtual reality can provide a valid support in special education, creating mental bridges between individual perceptual world and real scenarios. Referring to specific autistic frame, related to perception impairment, we suggest a need of investigating about customized technologies. Particularly, trough the specific intervention of drawing disciplines, actually lacking, it would be possible to fill the gap between the VR design and the cognitive reaction to visual stimuli, providing a relevant effect on cultural and social inclusion.

Acknowledgement

Thanks to Caterina Borrelli for the 3D model of the so called Sepolcro di Agrippina.

A.

PUBLICATIONS ABOUT RESEARCHES ON VR AND AUTISM
Field of study: **USABILITY TEST**

Autors	Project	Users	VE/ Technologies	Conclusions
Mineo B. A. et al., 2008. University of Delaware. USA	STAGES: • Observing a self video • Observing video about other people making VR experience • Self VR experience	n.42 6-18 years old	• No description or photos • Videoclip/ TV/ VCR	• Improvement of attention • Improvement of appeal during VR experience • No significant differences between self VR and self video condition relative to gaze. • No graphic aspects are reported in order to understand relation between results and VE representation.
Wallace S. et al. 2010. University of Oxford, UK, University of Birmingham, UK	AIM: Explore how people with ASD respond to VE STAGES: • Preliminary videos into CAVEs called BLUE ROOM • Training videos • Feedback trough a Social Attractiveness Questionnaire	n.10 ASD High function 12-16 years old. n.14 TD 12-16 years old	• Virtual roads, school corridor, playground • Third eye technologies, CAVE (screened room)	• Strongly realistic scenes • Richness of graphic details • Children with ASD respond with similar levels of presence as the typically developing children. • The high quality of design raises the sense of immersion providing a veridical experiences in VR.
Nigel Newbutt et al. 2015. University of the West of England	AIM: Tolerance of HMD for Autistic people STAGES: • Judging the willingness of participants to wear the HMD • Measuring the presence, immersion and negative effects of the HMD and VE as well as pre- and post- HMD anxiety levels	n.32 DSA. 17-52 years old	• A 3D VE cinema • A VE café • Safari adventure explored in a Jeep • Space adventure • Tuscan house in/out • VRT- HMD (oculus rift)	• Strong textures, saturated colors, low luminosity • The reported data don't allow to understand relations between the results and the representation elements of the space • Good willing to wear the HMD and experience two of the virtual environments (VEs). • A total of 95% were willing to view/experience all three scenes • In Phase II, anxiety levels not increase after the HMD VE experience. • Low Negative effects (feeling dizzy, sick, etc.) • High sense of presence, immersion and feeling natural in the space
Ramachandiran R. C et al. 2015. University Lakeside Campus, Malaysia	AIM: • Identifying an appealing design for ASD STAGES: • Interviews and questionnaires about favorite VE design using PECS (a communication method that does not require speech) • Objects images classification and association to the rooms. • Designing the prototype • Testing the partecipants' liking	n.41 ASD children and their parents	• House rooms, classroom, hospital, shop, autobus, café • Monitor	• Strongly saturated colors. • The reported data don't allow to understand relations between the results and the representation elements of the space • Cultural aspects and the age of parents influence preferences in graphic design
Chen Li R. et al. 2018. City University of Hong Kong	STAGES: • Training task performance related to daily life in VE. • Questionnaires for feedback	ASD 8-12 years old	• A typical Hong Kong apartment, elevator scene, apartment lobby scene • VRT- HMD (oculus rift, Oculus Touch controllers) Alienware 15-inch laptop with NVIDIA GTX 1080 graphics card.	• No graphic aspects are reported in order to understand relation between results and VE representation. • The children understood verbal instructions and navigated through the scenario by following the visual cues. • Good spatial presence, engagement and ecological validity. • Some children might have reported a lower score due to some anxiety or reluctance to fully engage in the scenario.
Realpe A. et al. 2019. University of Warwick, Coventry, UK, Manchester Academic Health Sciences, Manchester, UK, Imperial College London, UK	AIM: • Designing a VE to deliver a space for social cognition intervention. • Creating an intervention that young people feel motivated to use STAGES: • Develop initial ideas • Creating a prototype of the VE • Screening the prototype • Testing the VE • Piloting the intervention with target population	People with cognitive impairme nts 16-25 years old	• Avatar -Second Life	• Preference for realism and lesser similarity to video game • Preference for simple design, less distracting. • The users suggest spaces should be functional and look familiar. • The focus group objected to the use of some of the possible features in Second Life, such as avatars changing identity or the ability to fall and fly. • Avoiding open spaces and adding walls to distinguish therapy rooms.
Maskey M. et al., 2019. Newcastle University	AIMS: • Examining the feasibility and acceptability of using an immersive virtual reality environment • randomising the BLUE ROOM results- Randomized Controlled Trial (RCT) • evaluating answers • monitoring benefits over time STAGES: total time 12 months (6months post treatment) • introducing CBT Cognitive Behavior techniques • preliminary relaxing session 45 minuts before therapy in VR • four VRE individual sessions with therapist. 20min. • observing reactions • debates	n.32 ASD, 8-14 years old Anxiety Diagnosti c Interview Schedule (ADIS)	• Environments connected to specific phobias • Third eye technologies, CAVE (screened room) $4m^3$	• Strong detailed scene • Chromatic saturation and extreme fidelity to the real model. • Lack of light effects that could favor the ecological validity. • From the descriptions, it is not possible to establish relationships between the results achieved and the spatial characteristics. • All participants concluded the experience without discomforts. • Improvement in behavior also found in the two weeks following the experiment. In part, it also maintained the results 6 months later. • 5 children in the control group showed worsening in the following six months and one child in the treatment group showed immediate worsening.
Newbutt N. et al. 2020. Department of Education and Childhood, The University of the West of England, Bristol, United Kingdom	AIMS: • Evaluating what type of VR HMD device (and experiences therein) are preferred by children on the autism spectrum using HMDs • How do children on the autism spectrum report the physical experience, enjoyment, and potential of VR HMDs in their classrooms? STAGES: • Event with pupils and parents to test the willingness of participants to wear the HMD. Demo of VR in school • Introduction to the kit and space. Run applications. Check for any negative effects. Figurative Questionnaire • Full VR experience, with different devices	n.43 31 ASD 6 - 16 years old	• No description about VE. Some Photos show: moon walk, inside the tomb of Ramesses VI, Fun House • HTC Vive; ClassVR; Google Cardboard. VR, virtual reality.	• The reported data don't allow to understand relations between the results and the representation elements of the space • High levels of confidence, willingness, and enjoyment using HMDs • Researchers suggest that effects related to motion sickness are in many ways software and hardware dependent

Fig. 7. Tab. A: Researches about Usability Test.

B.

PUBLICATIONS ABOUT RESEARCHES ON VR AND AUTISM
Field of study: **LIFE SKILLS**

Autors	Project	Users	VE/ Technologies	Conclusions
Strickland D. 1996. Chapel Hill School of Medicine. University of North Carolina USA	AIMS: Crossing the street without help STAGES: • Preliminary Helmet Acceptance • Recognizing and tracking common object in a VE • Locating objects and moving towards them	n.2 with ASD 7-9 years-old	• A simplified street scene: a sidewalk and building shape. All motion objects removed. • Low contrast with gray scale except for target objects • ProVision 100 VR (by Division Inc.). Tracker Polhemus FASTRAK. HMD Risolution 345x259 pixels. Wheight 8 pounds	• Good adaptation to technology. • The simplified scene helps focusing on visual targets. • The lack of geometrical patterns and spatial references creates problems in understanding distances in VE.
VIRART PROJECTS. 1997 - 2005 **Quoted in:** • Parsons et al.(1996)	• Meakin et al. (1998) • Brown et al. (1998) • Cobb et al. (1998) • Brown et al. (1999)	SLD Students With teachers	• Simplified and geometrical scene and objects • Virtual house • Bus • Cafè • Supermarket • Joystick, mouse, keyboard	• Good understanding of visual targets when virtual environment is simplified with few stimuli • Benefit to performance and good usability occur when graphic design focuses on targets and the environment provides few visual stimuli
Josman N. et al . 2008. University of Haifa, Department of Occupational Therapy, Faculty of Social Welfare and Health Sciences, Mount.	AIM: Crossing street STEPS: • Setting a range scale to evaluate safe behavior • Testing the baseline performance of users • Individual training	n.12 6 ASD 6 ND	• Urban street: sidewalk, traffic light, car road. Low definition • The VE programmed by means of Superscape's 3D Webmaster running on a Pentium 3 desktop computer	• Technological limits provide the low resolution. • Surfaces and objects aren't distinct because of pixels texture • Trough description is not possible to understand relations between space representation and results. • Improving in functioning while operating the VE • One participant has difficulty in understanding the functionality of the VE. • More accidents occur at the traffic light crosswalk: it represents a visual attraction for ASD people.
Herrera. G. et al., 2006. *University of Valencia, University of Birmingham, UK*	AIMS: • Undertanding symbols • Developing Imagination	n.2 ASD 8-15 years old	• Virtual school and Supermarket • Real Time Graphics Touchscreen	• Graphic aspects not reported. • Improvement of imagination and in understanding of symbols. • One boy reports progress also in day life.
Strickland et al. 2013. University of Atlanta, North Carolina State University, USA	• Job interview simulation	n.22 Asperger 16-19 years old	• Virtual office • VR, Videos on VenuGen 4 platform	• The illumination and the environment design provide a good sense of immersion. • The few visual stimuli allow to focus on target. • Authors report an improvement of language during the interviews.
Wade W. J. 2015. Graduate School of Vanderbilt University. Nashville, Tennessee. USA	AIM: • Acquiring driving skills STAGES: • designing a model • watching a tutorial and calibrating eye tracking • familiarization: three minutes free training, no objects in the scene • exercise phase, reaching the goal in different levels of difficulty • observation, keeping the results • reaction time, observation, ability in driving, errors	n.7 ASD t 16 Years old 7 TD	• Urban environment (roads, traffic lights, buildings) • CityEngine. Autodesk Maya, Unity3D with Logitech G27 driving controller. Monitor, steering wheel with controls for driving control	• Richness of details in surface textures and strong realism. • The research focuses on technological aspects without giving details about graphic aspects of the environment. • Relations between results and VE representation are not reported. • People with ASD report more errors: the eye tracking puts in evidence their natural inclination to long lasting gaze on details as for example the traffic lights.
Saiano M., et al. 2015. Department Informatics, Bioengineering, Robotics and Systems Engineering, University of Genova	AIM: Understanding if realism helps learning in DSA people STAGES: • Familiarization phase • Subsequent training phase, participants had to follow road signs and to cross streets with and without traffic lights	n.7adults with ASD	• City (buildings, sidewalks, streets, squares) • VE based on the open-source virtual reality platform NeuroVR 2.0 Microsoft Kinect to record the subjects' Full-body movements in 3D space.	• The strong realism of representation depends by the research purpose. • One case with impairment in deep perception is excluded by the experiment. • Some improvements in learning occur when action are highlighted by simple colors as in the traffic light.
J. Cox D. et al. 2017. University of Virginia USA , University of Iowa USA, Hasselt University Belgium	AIMS: • Understanding if VE can be a space for driving training • Observing visual and physical reaction during training	n.51 ASD	• Urban environment (roads, traffic lights, buildings) • Driver Guidance System (DGS-78) VRDS is a realistic driver's cockpit with side and rear-view mirrors	• Richness of details in surface textures and strong realism. • The study puts in evidence that many problems for ASD people are related to their perceptual impairments. • Adolescents with ASD have difficulties with shifting their attention, sequential task performance, and the integration and coordination of visuomotor responses. • During simulated driving, they performed worse than healthy controls on lane maintenance, visual scanning, speed regulation, signaling, and adjusting to stimuli

Fig. 8.Tab. B.: Researches about Life Skills.

C.

PUBLICATIONS ABOUT RESEARCHES ON VR AND AUTISM
Field of study: **SOCIALSKILLS**

Autors	Project	Users	VE/ Technologies	Conclusions
Cobb S. et al, 2002. VIRART / School of Computer Science and Information Technology / School of Psychology, University of Nottingham, UK National Autistic Society, UK	AIMS: • Appropriate use of personal space • Choosing appropriate responses for behavior and communication • Dealing with unexpected situations STAGES: • Prototype creation • test and feedback • training with ASD and non ASD (entering into the café, select the sitting place, interaction with others • final discussion	n.36 ASDs, and non-ASD 16-18 years old	• Generic Cafè: empty room with geometrical counter, tables chairs. General illumination, without shades. Flat colors without textures. • Double interface 2d - 3d. Different points of view • Desktop, monitor mouse	• Problems in understanding object position in the environment and in the sense of immersion. • The description doesn't allow to understand relations between some navigation problems (moving to and from the table, sitting) and extreme simplification of graphical space characters. • Problems with the true sense of avatar's body, maybe because of the incorrect point of view. • Some problems were experienced with object interactions, mostly relating to the unusual behavior of virtual objects
VIRART PROJECTS 1997 - 2005 **Quoted in:** Parsons et al.(1996)	• Pearsons et al. (2000) • Cobb et al. (2002) • Neale et al. (2002) • Kerr, Neale, Cobb (2002) • Rutten et al.(2003) • Parsons, Mitchell (2002) • Parsons,Mitchell, Leonard (2004) • Parsons,Mitchell, Leonard (2007) (segue)	Teenager and adults ASD	• Social caffè • Interview room • joystick, mouse, keyboard	• Simplified and geometrical scene and objects • Good understanding of basic difference between VE and videos • Appropriate rensponses • Transfer of learning between media but not between contexts
Parsons S. Et al. 2004. University of Nottingham, University of Birmingham	AIM: answering social rules STAGES: • Training environment • Recognizing objects in VE • Communication, navigation, interaction in VE	n.36 12 with ASD 13-18 years old	For Training environment: • Simple building in an open space. For exercises: • Virtual café Desktop monitor • Joystick, mouse virtual environments built in Superscape VRT and run on a laptop computer	• Clear definition of visual stimuli, located into a neutral environment helps the good results in the training step. • Some problems occur when stimuli raise. • Correct understanding the differences between virtual and real context.
Moore D. et al. 2005-2007. UK **Quoted in:** • M. Bellaniet al., (2011) Parsons et al., (2011)	• Understanding of emotions trough avatars' facial expressions	n.34, 18 Asperger, 16 DSA low function 7-16 years old	• Avatar • Desktop monitor with mouse	• Graphic aspects not reported. • Many users understand avatar facial expressions. • Results not verified
John Lester Dallas Center of Brain Healt **Quoted in:** • Gorini et al. (2008) • Aresti Bartolome et al., (2014)	AIMS: • Providing an ideal place in Second Life platform for people with a form of high-functioning autism • Developing social skills by interacting with other people dealing with the same problems	People with Asperger	• On line Second Life Platform • Virtual Island	• No description about Virtual Environment • Improving in social relations and communication
Mitchell et al., 2006. University of Nottingham, University of Birmingham	Training behaviors in social contexts: entering into a cafè, sitting, interaction with others	n.7 14 -16 years old	• Virtual cafè, bus • Desktop monitor. Mouse, Superscape Virtual Reality ToolkitTM,VisualiserTM software	• Simplified and geometrical scene and objects. • The simplified scene helps focusing on visual targets. • Description doesn't help to understand if the lack of spatial references and difficulties in tasks are related. • Improvement in interpersonal interaction.
Ehrlich et al. 2008. University of Kansas, USA **Quoted in:** • Bartolome A. et al., (2014)	AIM: • Understanding social conventions	Asperger teenagers	• Virtual school • VR	• No graphic data are reported about VE. • Negative responses to the avatars.
Cheng et al. 2010. **Quoted in:** • Bellani M. et al., (2011)	AIMS: • Understanding emotions • Immagination developement	n.3 7-8 years old	• Virtual classroom and outdoor environment • Desktop monitor with mouse	• No graphic data are reported about VE. • Benefit to performance during experiment.
Kandalaft M.R. et al . 2012. Department of Psychiatry, University of Texas, USA	AIM: • Understanding emotions trough avatars' facial expressions	n.8 Asperger 18-26 years old	• Office building, a pool hall, a fast food restaurant, a technology store, an apartment, a coffee house, an outlet store, a school, a campground, and a central park. • Secon Life 2.1 Avatars are driven by a standard QWERTY keyboard and mouse audio voice manipulation software: MorphVoxTM	• Scenarios constructed in order to emphasize realism and learning objective of the session in varying contexts. • No graphic aspects are reported in order to understand relation between results and VE representation. • Improvement in social behavior.
Ke et al. 2013. **Quoted in:** • Bartolome A. et al., (2014)	AIM: • Understanding body and facial expressions • Improving Comunication trough avatars	n.4 ASD High function 4-5 years old	• School, cafè, birthday party • VR	• No graphic aspects are reported in order to understand relation between results and VE representation. • Improvement in communication during the program
Wallace S.et al. 2017. University of Southampton	AIMS: Evaluating the sense of presence and understanding facial expressions in avatars	n.20 ASD 12-16 years old	• Customised houses and galleries on a network of roads • Active-Worlds Educational Universe (AWEDU©)	• The strong realism of avatars, their dominance respect to the environment and the presence of human control, help in reaching good results in task performance. • Empty environment, focused on the avatars face that are oversized.
Ponsaran R.N. et al. 2017. Illinois Institute of Technology, Chicago	AIMS: Usability and feasibility study to determine whether the computer-automated and animated format was usable and likeable by school-aged children with ASD STAGES: • usability and feasibility test • training in ten scenes	n.24 Asperger, 8-12 years old, 30 TD	• School spaces. 5 of the 10 scenarios, are customizable with preferred Items or topic. • VESIP, 3d game technology	• No graphic aspects are reported in order to understand relation between results and VE representation. • Children with and without ASD appreciated the ability to design their self-character. • Ease in understanding social situations. • The results demonstrate that the program is useful to understand the reasons of some ASD behaviors.

Fig. 9. Tab. C.: Researches about Social Skills.

D

PUBLICATIONS ABOUT RESEARCHES ON VR AND AUTISM Field of study: **SPECIAL EDUCATION**				
Autors	Project	Users	VE /Technologies	Conclusions
VIRART PROJECTS. 1997 2005. Virtual Reality Application Research Team University of Nottingham, UK	(LEANGUAGE) • Brown et al. (1997) • Brown et al. (1997) • Brown,Cobb, Eastgate (1995)	SLD Students With teachers	• Urban environment, Sky slope, virtual house, supermarket • Graphical symbols • joystick, mouse, keyboard	• Simplified and geometrical scene and objects • The changing viewpoint can influence the Way finding. • Some children recognize and copy virtual objects, whereas others have difficulties. Usability issues raises
Gorini et al. 2008 Istituto Auxologico Italiano, Milan, Research Institute Brain and Behaviour, Maastricht University,Psychology Department, Catholic University of Milan	AIMS: • Using motivation provided by virtual worlds to teach users about how to improve their living habits • using the strength of virtual communities to provide real-life insights using the feeling of presence provided by the virtual experience to practice both emotional and relational management and general decision	People with psychological disorders	• Virtual island. • On line Second Life Platform	• The graphic and visual aspects are not customized since they are set by the platform Second Life. • There are not descriptions concerning composition of the spaces related to specific goals. • Results are not reported.
Fornasari et al. Italia. 2013. **Quoted in:** • Aresti Bartolome et al., (2014)	STAGES: • Free exploration in VR • Exploration with a defined target	n.16 ASD	• Urban environment	• No graphic aspects are reported in order to understand relation. between results and VE representation. • Children with ASD explore the VE faster than the TD children.
Kok N. et al. 2014. National Institute of Education Nanyang Technological University	AIM: learning basic language concepts and skills	Children with ASD	• Dolphanarium • VDAI,stereoscopic lightweight 3-D glasses Kinect to track positions • and movements	• No graphic aspects are reported neither results.
Naranjo C. A. et al. 2018. Universidad de las Fuerzas Armadas ESPE, Sangolquí-Ecuador Universidad Técnica de Ambato, Ambato-Ecuador	AIM: Helping children with ASD to socialize and contributing to interpersonal interaction STAGES: • Avatar selection • Control of robot movements in order to complete tasks defined by the teacher • Observing the changes made in VE	children DSA	• Virtual castle, open spaces • HMD oculus rift, robot BIOLOID, webcam, motion sensors Unity 3D platform	• No graphic aspects are reported in order to understand relation between results and VE representation. • The results demonstrate the efficiency of the system under the supervision of a teacher/therapist, allowing the children to increase their stimulation.

Fig. 10. Tab. D: Researches about Special Education.

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