USING SEMIOTICS TO DESIGN A VR VIDEOGAME FOR FACE PROCESSING REHABILITATION IN CHILDREN

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Abstract

In this paper we propose to use the semiotic knowledge on the face acquired by the ERC project «FACETS» for the creation of a serious games in VR capable of helping populations with difficulties in face processing. Differently from what is usually done, we propose to design a game rewarding cognitive operations of face processing by interacting with non-realistic atypical faces that corresponds to the face processing strategies developed by these populations. This proposal is made on the basis of a semiotic take on both face-processing and meaning-making in digital games, both of which are dynamic and strategic experiences that allow to acquire real-life knowledge in multiple ways. After briefly discussing these theoretical points, we take the concrete case of autism to examine existing literature on the face processing impairment in these subjects. We highlight how such impairment is due to the existence of a different pattern/strategy of face interpretation rather than just some incapacity, hence the possibility to improve face-processing by acting on the cognitive level of such strategies through a careful process of game design rewarding both the cognitive operations and social interactions made by healthy individuals. Finally, we examine part of the existing literature on the usage of both videogames and VR by and for the ASD population. From this review, we highlight how 1) there are no relevant risks in designing digital games and VR for these users 2) there are strong evidences of the potential benefits of using both videogames and VR 3) there are good reasons to think that the cognitive operations of face-processing can be improved in virtual environment 4) there is a regrettably general lack of VR gamified experiences for healthcare for this population and 5) our proposal is something unprecedented both from the point of view of a VR experience targeting face-processing and from the one of designing positive interactions with atypical faces.

Keywords: Semiotics, Cognitive Sciences, Seriousgames, Face, Autism.

What is a face? This apparently self-evident question was at the heart of the five years of research of the ERC project FACETS directed by

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Massimo Leone. Since the beginning it was clear that faces are things that we shape as much as they shape us. More than objects that «are», faces *appear to be* and they do so very differently in different historical and cognitive contexts. Almost anything can be endorsed with a face and, vice-versa, faces can also be denied. While on the one hand faces appear as finite items with features and capacities stable through time, let's think of facial expressions, their meaningfulness is ever-changing and ultimately resides in the infinity of the individual being wearing his/her face among others. From these observations, each member of the FACETS research team has focused on some aspects and some consequences of the face as a construction involving every aspect of the human mind both in individual and collective terms. Although this paper is the result of all these years of work inside the group, it is impossible to resume here even a small part of the results acquired. Instead, it may be interesting to highlight how the work presented was strongly influenced by the collaboration and confrontation with one member in particular: Gabriele Marino. In the past years we (the authors) worked on the pragmatic effects of realism of digital faces in virtual contexts, explaining these effects by looking at how the production of these faces is based on some strong cognitive and semiotic fundaments of functional face interactions and meaning-making in real-life (Giuliana 2022a). Almost at the opposite of our work, this Italian semiotician worked instead continuously on the theme of the deconstruction of the real-life face interpreted as a weak object which, from a certain standpoint, is almost *arbitrarily typical and functional* (Marino 2022). When we started to think of an application for health of our research on virtually digital faces, Marino's idea struck us as the right lead to follow. Indeed, users of digital games and virtual realities have long been and are still often confronted with faces which can sometimes be uncanny or very hard to interpret. Very often these phenomena are the results of mistakes and players like to joke about them because they *naturally* approach them with a typical model of face-processing consolidated during their lifetime. Yet, such model is inefficient on these face-items and will consequently lead them to produce *aberrant* interpretations of a certain «wrong visage». The serious part behind these jokes is, therefore, that they suggest how face-processing is a question of adaptable strategies from which some meanings can emerge even in absence of elements or configuration that would normally appear crucial. Hence the question from which our reflection

started: what if a typical face was a wrong one for certain subjects that developed different strategies of face processing for cognitive reasons? And, if yes, what if we could use atypical faces to help them in learning skills and modifying/adapting their strategies to process faces in real-life even when in front of objects that are appearing to them as difficult to interpret (exactly as we often do in virtual contexts)?

In this paper we explore such question by looking first at the semiotic basis of such hypothesis (section 1), then we look at how videogames work in general as experiences from which we learn in terms of adaptive strategies (section 2) and by focusing on the specific case of face processing in the autism spectrum disorder (ASD from now on) we highlight the fundaments of a possible intervention through a VR videogame (section 3) and we finally conclude by confirming the realistic potentiality of such game on the basis of the existing literature (section 4).

1. HUMAN AND MACHINES STRUGGLING «TOGETHER» WITH FACIAL RECOGNITION

The cognitive ability to recognize, read and remember human faces (face processing from now on) has a fundamental role in the social life of everyday. In fact, the neural machinery dedicated to face-recognition is something that we have in common with macaques (Tsao 2008) and which is often thought as a key skill for evolutionary purposes (Jakobsen *et al.* 2021). This skill is something we tend to take for granted and that we do not thinks as something that we actively do as persons (in the beforementioned joke we usually blame our memory and not our face processing). On the contrary, the last twenty years of research on automated face-recognition through AI has proven us how much of a challenge this «simple» act is (Lee-Morrison 2019). On the one hand, strategies which have a determining role in the emergence of the face as perceived object are clearly the result of exposure to the general and genetic traits of the human face: this explains well known phenomena such as the lesser accuracy of inverted face recognition (Sekuler *et al.* 2004) and the hyper correction of reverted eyes in the Thatcher's illusion (Thompson 1980). On the other hand, the contemporary dynamic theories of face processing have also proved how faces are surfaces on which information is not only read but also projected in relation to the

viewer's identity and emotions via factors such as attractiveness and familiarity (Li 2019). Additionally, such projection can even endorse non-biological objects with faces as in the case of resembling plastic configurations (*pareidolia*) or in the case of gaze interactions assuming the presence of a subjectivity (Giuliana 2023). Therefore, a critical approach to face-processing should think of its «performances» as the result of a network-based interpretation of the face as a situated whole emerging from its graspable (i.e. perception) features rather than being just a sum of detected features. In other words, a face is not something we simply «see» in a completely objective way unrelated to both a context and a mind: it is the result of a multidimensional semiotic process consolidating itself into a habit. Any of the three philosophical dimension of the mind, as spirit (culture) and psyche and brain, has a fundamental role in determining both the strategies and the result of face processing. Such acknowledgement brings three consequences. The first one is that even a single alteration to a face-object may change the identity of the whole compromising our ability to recognize a person from its visage. The second one is that any variance in either the psyche, brain or cultural belonging of the perceiving subject (Sato *et al.* 2019) may alter both the interpretation of face-information and the process through which information is gathered. Thirdly, because of the dynamic and network-based nature of face processing, in new contexts undermining either the appearance of some of the object's features or the compromising the interpreter's capacity to grasp these features, a new habit can be established, arising from the initial struggle, to efficiently use this same cognitive capability of face-recognition. This struggle and reinvention are something that we have all experienced in first-person recently due to the outbreak of Covid-19 and the resulting mass usage of masks that covered the lower part of the face (Marini *et al.* 2021). Even more interestingly, they are also part of the recent challenge of the automated-systems of facial recognition in contexts such as the one of VR where the upper part of the human face is covered (Chen, Chen 2023). Indeed, without having access to both the lower and the upper part of a human face it is formally impossible, for example, to distinguish between a fake and a sincere smile. This is the famous case of the Duchenne's smile in which the key marker giving meaning to a smile are not around the mouth but around the eye with wrinkles and bagging. So, putting it simply, grasping a face is as much a question of neurobiology of perception as it is a question of

cognitive pragmatics. A same type of face processing can lead to different strategies of interpretations of the face's information depending on the context and different types of face processing may eventually lead to the same interpretation of any given face because of the adaptive characteristic of the human mind. Even on the cognitive level, face-processing is a problem solved through a strategy of interpretation as in the most classical textbook of semiotics (Eco 1979). As such, from a semiotic take, any processed face is the sign-event of an immediate object that appears to us through a given/certain process of semiosis which must be related to the face as a dynamic *object transcending any given cognition though not beyond cognition* that can arise through different processes of semiosis (Borges 2010). This is, however, not really a special feature of the face as a unique kind of object but rather the consequence of the general semiotic working of the human mind from a cognitive point of view (Paolucci 2021). The point of these semiotic claims about the processed-face being a variable construction depending on cognitive strategies consolidated in pragmatic terms is to highlight the possibility for the human mind to produce a habit of the face through unconventional processes/methods and from a variety of face-items. This is the theoretical basis for the proposal that we wish to discuss in this paper: the design of a videogame presenting pragmatic interactions with unconventional faces to improve face processing in children with cognitive impairment that cannot efficiently process typical faces in typical contexts.

2. DIGITAL GAMES AND COGNITION: SHAPING THE POSSIBLE THROUGH THE IMPOSSIBLE

The academic proposal of a game used for therapeutic purposes related to the cognitive improvement in face processing must rely on different type of scientific evidence that can sustain its premises. Among these, the first one should be related to the proof that human can actually learn through the activity of playing games. Yet, there is something feeling almost superfluous in having to prove this point. Indeed, since their first months of life both human and non-human animals use play as their first form of interaction with the world to understand reality and develop some behaviors and skills which will be fundamental for their adult life. It is no coincidence that important philosophers

(Gadamer 1960; Fink 1968; Wittgenstein 1953) used the notion of «playing» and of «games» to explain the very way in which the human mind can structure its experiences of the world and create systems of meaning which are at the heart of behaviors and interpretations of reality. In front of such commonsense, we will not discuss here the extensive existing pedagogic literature on how playing games can have a crucial role in learning since early childhood (Wood, Attfield 2005; Bruce 2011; Macintyre 2017; Robinson 2018). Rather we will start by highlighting that it is precisely because of their being games that we can find an existing and established literature about the positive effect of videogames on human cognition from a performative point of view. One of the most well-known scholar that continuously worked on this topic in the last decades is Daphne Bavelier (Bediou *et al.* 2018). Similarly, already ten years ago many studies proved the therapeutic effects of active videogames (Staiano, Flynn 2014). This is due even more generally to the effectiveness of games and gamification which in the last ten years has become quite common in different rehabilitation and remediation strategies and especially in the case of children with cognitive difficulties (Prins *et al*. 2013). What we are mostly interested here, however, is the higher semiotic functioning of videogames as imperfect simulations of reality leading to efficient agency in the real world. As scholars we have extensively studied the possibility of understanding the real and acquiring skills to act in it through the «incorrect» experiences of the virtual (Giuliana 2022b). Specifically, in the last four years of the ERC project FACETS we have highlighted such phenomenon by inquiring on the pragmatics behind the interactions of digital faces in virtual contexts. We have seen, described and discussed the key role of virtual and goal-oriented interactions in both the replication and re-shaping of the user's subjectivity. Very recently, we have precisely discussed how such semiotic mechanism can explain the reasons behind some positive therapeutical effects of VR experiences. Thus, the hypothesis of this paper:

– *If:* faces, as objects of perception from which interpretations arise, are the result of semio-cognitive processes enacted by agent-oriented & ambient-sensitive interactions.

– *And, if:* face-interpretation is susceptible of *pragmatic* adjustments due to changes in contexts and habits requiring different strategies.

– *Then, what if*: digitally mediated interactions with atypical faces, experienced in virtual contexts related to gamified goals, could inform us about alternative cognitive models and semiotic paths through which we can *see* and *read* visages?

– *Therefore, what if*: we could use these alternative face-models and processes of semiosis to help populations with impairment in face processing by encouraging and valorizing certain forms of interactions and operations through the techniques of game design?

This hypothesis contains a reversal of perspective both in ethical terms and in methodological ones. In fact, the common assumption is usually that population with troubles in face processing have troubles with *all faces* with this «all» implicitly standing for typical. As we will discuss in the next section, the applicative consequences of such view are products for rehabilitation targeting at exposing such populations to interactions with typical faces so to «normalize» their everyday social relation with the visages and faces of other. With the implication that visually realistic experiences in virtual environments are needed for the users to then apply the knowledge acquired to the «real world». As remarked in the literature, the pursuit of realism is the main reason behind the use of technologies such as VR (Bradley, Newbutt 2018). But, as we have explained, this belief is rather simplistic from the perspective of how both the human mind and virtual realities works. Without denying the validity of previous approaches aiming to realism, we wish here to explore the possibility to improve real face processing through meaningful interactions with atypical faces (ex: non-Y shaped) in virtually gamified contexts which valorize face processing through the cognitive operations implied their rules and interactions (ex: gaze). In this perspective, subjects with typical faces are the ones with the wrong visage for the efficient semiotic processing of a face of a certain population. Neurotypical persons are no more the only one endorsed with the ability to process faces in general terms (dynamic objects) but only to process a specific type of faces through a certain semiotic relation with a certain type of face-object among many. The interest for such a change of perspective is twofolded. From the applicative point of view of rehabilitation, most of these subjects are *already* exposed every day to typical faces and yet do not have acquired an efficient habit of face processing/interpretation. So, it would be unlikely that simple exposure to typical faces in a real-

istic VR-context could significantly improve, by itself, face processing strategies. Although experiencing things like gaze interactions in the safety of a gamified virtual environment could eventually «encourage» them to partially change their face interactions behavior (for example a minor avoidance of eyes in the case of autism, as we will soon discuss), there is no guarantee that in the less safe and less rewarding environment of reality such change would actually occur in the long run due to the complexity (Dandil 2020: 8) of social relations and face interactions. To face this problem, we first need to have our impaired population feeling confident by (re)acquiring the cognitive skills of face processing through face interactions feeling natural and easy for them (their consolidated habit). This is when the design of atypical faces come into play. Then, in a second moment, it will be possible to gradually modify these atypic faces toward more typical configuration during either the game progression or different game sessions. In this way, we would create a learning curve of typical face interactions aiming, ideally, to reproduce real-life situations. In this way, we would trigger through the gamified virtual experience a semiotic process through which a new habit is acquired from the cognitive roots of face processing rather than just positively reinforce a different behavioral habit by exposure. From the theoretical point of view, we could gain new insights from observing interactions with atypical faces both at a neurological and cognitive level. Hence, the results obtained would be important even without observable improvement on rehabilitation (which is not what we imagine but nonetheless a possibility that must be considered). Finally, the medium of digital games is especially suitable for the design of functional faces for non-neurotypical subjects. On the one hand, interactions with atypical faces are quite common among gamers not only in terms of mistakes but also in first-person sci-fi themed games with aliens where atypical faces are created on purpose. This would be a perfect theme/genre for our purposes. On the other hand, the contemporary digital technology of avatars (such as Metahumans) can allow us create extremely rich and specific «atypical» faces for our purposes, with this «atypicity» ranging from a minor analytical feature (such as a minor increase of distance between eyes) to complete holistic reconfigurations. Hence, we can now overcome the oversimplification implied in the previous research from Dandil. Finally, by using a narrative-oriented game played with a VR headset it would be possible to offer both

a complex/multidimensional bodily (with factors such as peripersonal space), physiological (Bekele 2013) and overall psychological experience of social interactions and to accurately track key factors of face processing such as gaze direction and patterns.

Summing up, the advantage[1] of a VR game is to offer I) a safe and controllable environment for repeatable experience. II) based on multimedia information and therefore on semiotic multimodality (more flexible adaptation to the different individuals and possible overcoming of linguistic barriers) III) interacted by the users replicating agentivity, learning patterns/processes and increasing engagement IV) with the possibility of early adoption and easy use from the side of the population while being highly customizable (ex: avatars) from the side of the researchers and therapists V) Enhanced with a possibly fun and social experience due to the gamified nature which is positive for both the engagement and motivation of the users (i.e.: different than a mere task on a computer) VI) With the added value of an increased embodiment and more «natural» interactions (ex: looking by moving the head instead of moving a mouse or analog stick) replicating both the multidimensionality of face perception and the complexity of face-to-face communications.

3. COGNITION AND SEMIOTIC STRATEGIES BEHIND FACE PROCESSING: THE CASE OF AUTISM

Before the actual design of a specific game for rehabilitation, the first step should be to make a systematic review of the scientific literature on the specific impairment in face processing that the game will aim to improve. This paper, however, is not a complete proposal for a game and hence does not contain such a review. Nonetheless, we will still briefly discuss the cognitive dimension of face processing itself to explain what the clinical fundaments behind the idea of such a game are.

When we speak about anomalies in face processing, we usually refer to three main types of impairment: gaze processing, memory of facial identities and recognition of emotions through facial expressions. From a neurological point of view, we know from the literature that the areas of the brain that have the task to process the complex information of face interactions are distributed (Golarai *et al*. 2006: 145). We also know that «Some components of the face processing sys-

tem may exist at birth, while others continue to develop during childhood and adolescence before reaching the adult level» (*ibidem*). Since many causes can be behind these forms of impairment, for the purpose of this paper we will focus on the specific case study of autism which 1) is typically defined through deficits in face processing 2) has been thoroughly studied and 3) is scientifically recognized (Dandil 2020) as a condition on which it is desirable to act through cognitive remediation training (which would be the case of a game like the one we are proposing). As we know, «autism is a pervasive developmental disorder whose causes or underlying biological mechanisms are not well understood. This behaviorally and developmentally defined syndrome is characterized by impairments in non-verbal communication, social relationships and stereotyped patterns» (Golarai *et al*. 2006: 146). Both the developmental nature of this disorder and the role of experience in human face processing (*ibidem*: 156) make digital games a credible and desirable medium for rehabilitation. Moreover, the atypical face processing of autism is related to difficulties which are extremely pertinent and familiar to semiotics: difficulties in the attribution of meaning and significance to human interaction (*ibidem*: 146). So, to design such a game for the ASD population we first of all need to highlight the main components of typical face processing in healthy individuals. When looking at them (*ibidem*: 147-155) we can see that, despite many neurological unknown, all these are generally associated (*ibidem*) with the continuous exposure to face patterns and face-items during growth, hence with an experiential dimension of face processing «tuning» (*ibidem*). Individuals born with a tendency to avoid faces and gazes are therefore likely to compromise their own development of higher social skills due to a lack of experience (ex: fewer face exemplars memorized) and, more generally, the lack of a typical habit toward other's faces. This has consequences on multiple levels, such as making ASD population less capable of both recognizing and memorizing faces with changes in the pose or expressions. Consistently with our idea, however, rather than not having a face pattern at all subjects with ASD have shown to have apply atypical (semiotically relevant as they are called «aberrant viewing strategies») pattern seemingly erratic and most importantly not focused on the internal features of the face (*ibidem*). Similarly, the deficits in interpreting facial expressions and in face recognition seem to be the result of complex cognitive processes rather than simple impairment in generic skills (*ibidem*: 150). Once

again, it seems like the main problem is about the adopted strategies of viewing the face (Bekele *et al.* 2013: 454; Tanaka, Sung 2016).

So, to conclude this section, what a game aimed at helping face processing in population with ASD should do is to aim at valorizing the skills and behaviors observed in healthy individuals through gamification (ex: rewards of non-avoidance of eyes) but by initially adapting the faces to the atypical patterns and strategies of the targeted impaired population. For example, we can imagine a narrative oriented first-person detective game in which you are *systematically* (experience + habit) rewarded with information for sustaining gaze or recognizing a face with some speaking creatures living in an alien world in which the creatures you interact with have key facial features in the external part of the face or in the lower one rather than in the internal one. Then, if positive feedback is obtained, it would be possible to also gradually alter the configurations of faces in the long run (multiple levels of the game and/or multiple game sessions) so that they match more and more the typical configuration of human faces for everyday interactions. Due to the long-term development of face-processing, finally, we can hypothesize that such a game could be useful for children within a wide range of years (such as 6-16).

4. VR GAMES FOR REHABILITATION AND AUTISM: SOME NOTES ON THE EXISTING LITERATURE

The last step to validate the scientific validity of our project is to partially examine the existing literature on previous therapeutic usages of VR games for both face processing and ASD population. As in the previous chapter, we will not do here a systematic review but rather focus on the points which are more relevant for our proposal.

The first step of this criterium of pertinence is to avoid any generic reference of VR experiences about remediation/rehabilitation. The reason for this exclusion is actually quite encouraging since it is related the overwhelming amount of paper and books that discuss the positive effects of VR for both physical, cognitive and psychological remediation/rehabilitation. Scholars such as Giuseppe Riva (2014; 2019) have dedicated a great amount of their work and of their career to prove this point in the last ten years. Recently, we have even seen the positive outcomes of VR experiences in which face-interac-

tions (especially gaze and representation) have a key role such as «I am Freud» (Slater *et al.* 2019). We have therefore no reason to doubt that, in general, VR *may* be effective for our purpose. The second step is to exclude the literature about generic «computer-based» experiences. The reason for this exclusion is that the training tasks involved in these kinds of therapies are quite different from what we are proposing here and may include things like tests which «ask participants to identify and match emotional labels to grayscale pictures of human faces» (Eack 2018: 3). Similarly, computer-based gamified approach to learning, cannot qualify as they include a great variety of activities which may be different than a proper game as the one that we are proposing. Generally speaking, it would seem reasonable to correlate the efficiency of computer-based interventions to the main usage of visual support that has since long been proved as particularly idoneous to children with ASD (Dettmer *et al.* 2000). Such visual dimension would certainly be a central part of the videogame experience, but not the main determining factor in acquiring the desired skill of face processing. We must therefore narrow our focus on papers which are at least mentioning experiences made in some kind of virtual reality targeted for ASD population. While looking both at papers of single experiments and systematic review, however, we immediately notice an issue related the ambiguous use of the term «VR» since it can refer to both the specific technology (with a headset) and generic use of computers processing virtual environments and characters. An example is Bekele 2013 that used the term «VR-based» to describe an experiment in which participants were in front of a computer display. Nonetheless, virtual environments and VR experiences do exist and have proven to be effective for rehabilitative and educational purposes (Bradley, Newbutt 2018). Our project, however, requires answering to more specific questions. Firstly, it is important to ask whether children with ASD are likely to be engaged in videogames and to find it an enjoyable experience. As we could have predicted, the answer is yes. Facts such as the success of the *Minecraft* server created as a safe place for all the Minecraft players with ASD[2] speaks for themselves. Indeed, the success of videogames among autist population is precisely the reason behind much research related to our second question: are there risks related to the usage of videogames for children with ASD? On this point the answer is controversial. One of first the famous paper about these risks was published in 2013 but did not actually make any conclusions prov-

ing that videogaming represented a risk by itself (Mazurek 2013). Additionally, videogames requiring particularly intense physical activity may also prove to be mostly inefficient in the acquisition of certain skills such as the social ones (Chung *et al.* 2015). Generally speaking, it would seem that some genres may be safer than others in relation to their mechanics (game rules/goals and rules of interactions). Something confirmed very recently by the Director of the community interest company «Aspiedent»[3]. Hence, we do not have any reason to avoid the creation of a videogame that would be specifically designed for the ASD population to avoid any possible known risk. Yet do we have actually *good* reasons to design a videogame for such target? As mentioned in the previous quote, there are certainly potential benefits even by playing games nonspecifically designed for autist children[4]. Some of the first research reviewing the usage of complex videogames for mental health date back to the first decade of 2000 (Wilkinson 2008) and were already encouraging on this point. In continuation with these findings, in 2015 doctor Kulman, President of *Learning-Works for Kids*, an educational technology company that specializes in using video games to teach executive-functioning and academic skills, would report[5] several studies in the field of psychology proving the positive effects of computer games for ASD population in terms of better performances (Ozonoff 1995) and overall opportunities for engagement and learning. Soon after, a 2016 review on current research would confirm the potential benefits of different forms of digital gaming (Whalen 2016). These conclusions are broadly still valid in the light of contemporary systematic reviews on this topic (Jimenez-Munoz *et al.* 2022). This seem to also be confirmed by social actors working with ASD population and producing products for them. As an example, the association Toca Boca claims that videogames can improve social skills, flexibility, problem solving and handling frustration[6]. On the basis of evidence about the positive effects of playing and of digital games some scholars in the field of serious games have already started designing experiences for autist player with the purpose of improving real-life skills (Cadieux, Keenan 2020; Kim *et al*. 2023). Lastly, it is however important to highlight how most of the mentioned studies (here and after) that these benefits are usually seen in high-functioning autism which, consequently, should be the target of this game in its first version.

So far everything seems to encourage the idea behind our videogame, but what about the specificity of this game being 1) a VR game and 2) about faces? The first important question in this regard is the following: do face-reading work in VR *almost* as in real life and is therefore reliable for the assessment of features such as emotion recognition? The recent literature is positive on this point (Geraets *et al.* 2021). Secondly, since the recognition of face reading patterns is central in our approach (to design the atypical faces of the avatar, adjust them and track the progresses of the ASD individual), are there precedent experiments of patterns recognition in virtual environment that were targeted at ASD population? The answer is once again yes (Bekele *et al.* 2013). Thirdly, since we ideally aim to rehabilitate the subject through a process of learning inside the game, we have to know if computer based (such as VR) learning and cognitive remediation is generally suitable and effective for population such as ASD. Previous studies (Adjorlu *et al.* 2017; Bradley, Newbutt 2018; Dandil 2020) confirms that it is. Fourthly and finally, are there risks associated with the usage of VR by ASD population? What we learn from the literature is that there are no risks which are specifically related to the usage of VR by individuals with autism. Well known phenomena such as motion sickness or excessive sensory stimulation only have minor and non-compromising mentions in all of the examined literature. It must also be noted that these phenomena have been reduced in general with the newest technologies of headset available and with knowledge acquired on how to design experience for VR. Similarly, a careful process of game design will be able to avoid the reinforcement of stereotypical behavior that may be present in some classical video games intended for non-ASD audience but which are in no-way a necessary trait of any videogame.

Given the positive answers to these fundamental questions (cognitively believable face-interaction with computer generated faces, attainable recognition and tracking of face processing patterns, effectiveness of learning and remediation, risks) about the ASD population and VR, we think that all the premises are there to produce this game. The only true limitation is also the reason to make this game: the lack of literature which was highlighted since the first studies (Parsons, Cobb 2011) and is still remarked in all of the more recent scientific literature (Bradley, Newbutt 2018), and also by companies producing such experiences[7]. This lack becomes even more important when we

look at the type of virtual experiences reported in the literature, which are almost all single task oriented true-to-life scenarios (Adjorlu 2017). In some cases, some narrative elements are present, such as Bekele (2013) facial expression recognition task, but these still do not qualify as games since they lack a proper game design process. It is reasonable to hypothesize that this is the result of both of disciplinary boundaries and of several bias about videogames. Yet, overcoming these boundaries by connecting different metalanguages and knowledges is a defining trait of semiotics. Lastly, it is also true that there are generally speaking very few proper VR games created for population with ASD, the most notorious one being «Blink and the Vacuum of Space[8]» published in 2023. The same also applies to serious games, with the almost only case of *Meeva* also published in 2023[9]. For these reasons, the closest experience to what we are proposing seems[10] to be *SoundsField* which is an interactive virtual reality game designed to address difficulties in processing auditory sensory information by integrating exposure-based therapy techniques into game mechanics (Johnston 2020). Yet, despite the fact that the first proposal of a VR application for the rehabilitation of face processing can already be found in 1999 (Trepagnier 1999), there are currently no VR experiences of a serious game designed for population with ASD that 1) target face processing and/or which 2) do not «simply» rely on exposure.

5. CONCLUSIONS

In this paper we proposed the creation of a single player, first-person view, sci-fi themed, detective-like, VR, videogame for the rehabilitation of face processing in children (from childhood to adolescence) with high-functioning ASD. The general argument behind this paper was that face-processing is a dynamic and constant semiotic construction related to both cognitive and cultural habit. On this assumption, we proposed to design a game of valorized efficient interactions with atypical faces to trigger the alteration of existing habits in subjects with face processing difficulties. We took the specific case of autism as a concrete case of application and, by examining the literature from different point of views, have seen almost only good reasons to hypothesize that such a VR game may help these population. Rather than summing up all the good reasons behind our proposal, we therefore

wish to conclude by inviting scholars, social actors and clinicians to help us in discussing more thoroughly this idea and, hopefully, to finally make it real.

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ENDNOTES

[1] There are also potential risks or at least disadvantages that will be discussed further on.

[2] https://www.ted.com/talks/stuart_duncan_how_i_use_minecraft_to_help_kids_with_autism.

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[6] https://tocaboca.com/magazine/autism-video-games/#:~:text=Video%20games%20provide%20kids%20affected,shared%20focus%20on%20an%20activity.

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[8] https://store.steampowered.com/app/1815540/BLINNK_and_the_Vacuum_of_Space/.

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[10] A systematic review could show otherwise.

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