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A critical discussion regarding the effectiveness of Virtual Reality interventions (VR-I)and Animal Assistant Therapy (AAT) in youth with Autism Spectrum Conditions: scoping Randomized Clinical Trials

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Abstract

Disorders, or more properly, Conditions of Autism Spectrum (ASC), are a pervasive, neurodevelopmental, lifelong condition that develops through complications in socio-emotional reciprocity, communication difficulties, and restrictive and repetitive behaviors. The establishment of ASC in the cognitive dimension of young people can cause comorbidity and therefore, the assessment and treatment of ASC should be applied immediately when symptoms are emerged. However, the difficulties in dealing with, but also in the detection of ASC in combination with the high rates of misdiagnosis, poses the imperative need for effective interventions. Satisfactory therapeutic tools have been developed to help young people with an ASC. The present literature review targeted two of them: Animal Assistant Therapy (AAT) and Virtual Reality Interventions (VR-I). These were investigated by evaluating their effectiveness by scoping Randomized Clinical Trials, derived from the PubMed.gov and Clinicaltrials.gov databases. AAT will be evaluated on its effectiveness in improving the Aspects of Interpersonal and Functional Problems, Theory of Mind and hyperactivity behaviors, while the VR-I will be evaluated on its effectiveness in enhancing the expression and regulation of emotions, socio-emotional reciprocity and the adaptation of motor and cognitive skills. The results of the study highlight deficiencies in the structure of the research methods evaluated, the effect of interventions on the second level symptoms, while a pioneering use of VR-I will be discussed, which can utilize motor learning as a bridge, providing potential for improvements to individuals with an ASC.

Keywords

Autism Spectrum Conditions; Animal Assistant Therapy; Virtual Reality-Interventions; Motor Behavioral Learning

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Introduction

Autism Spectrum Conditions (ASC) is an umbrella term that captures difficulties or differences defined as non-typical behavioural manifestations resulting from a non-typical neurodevelopmental pathway or different phenotypical expression of DNA [1]. 'Neurodevelopmental Disorders' is a reclassified term of the DSM-V (Diagnostic Statistic Manual) [1] that attributes to the condition its immovable permanence that onsets in childhood (3-5 years old). However, the difficulties arising from this complex genetic-mental state make it difficult for the scientific community to define, leading experts to reconsiderations in capturing and explaining it. The DSM-IV [2] framed the ASC in the Pervasive Developmental Disorders (PDD) diagnostic category along with Asperger's Disorder, Rett's Disorder, Childhood Disintegrative Disorder and PDD-NOS (Not Otherwise Specified) to apprehend the holistic way in which the condition affects individuals. However, in order to conceptualize the aforementioned conditions existing in the PDD as entities that are founded within the spectrum of autism and also to capture and explain the comorbidity phenomenon within and between other 'Disorders Usually First Diagnosed in Infancy, Childhood, or Adolescence', DSM-V [1] categorized ASC alongside e.g., Attention-Deficit/Hyperactivity Disorders (ADHD), Intellectual Disabilities, Social (Pragmatic) and/or Communication Disorders, Specific Learning Disorders, Motor Disorders and Other Neurodevelopmental Disorders. It has been repeatedly demonstrated that individuals within the spectrum experience difficulties in understanding emotional manifestation of others [3]. Therefore, deficits in socio-emotional reciprocity may underlie an emotional mis-conceptualization [4]. This difficulty grounds on a diverse cognitive style, specialized to process perceptual details on a systemizing account, turning individuals within the spectrum to introversion [5]. Beyond the markers highlighting impairment in social interaction, communication deficits, and stereotypic behaviour [2], hypo- or hyper- reactivity to sensory stimuli added [1], forcing behaviour to manifest in a restricted pattern, constituting sensory processing deficits [6]. Other factors that lead individuals with an ASC to introversion are poor nonverbal communication skills, such as difficulty to keep eye contact, gesture and perceptual fixation to an object with a predisposition that is both obsessive and self-healing [7].

Blumberg et al. [8] suggested high percentages of misdiagnosed and missed diagnosis in young individuals with ASC, whereby this argument reveals five crucial explanatory factors for such failure to support these individuals. First factor refers to the fact that there is no single biological marker to rely on and explain the presence of an ASC [9]. The second factor is about the challenging difficulties expressed by autism, which in combination with non-targeted education decrease the awareness of the condition [10]. The third factor captures gender differences masking the condition in females than males, where the latter appear to have more visibility between the sexes [11]. The fourth one, refers to another masker which is called comorbidity psychopathology [12]. Fifth and last factor refers to the misuse of experimental designs grounded on the preference of utilizing more quantitative approaches [13], a fact that will be discussed further in the discussion section. Failure to diagnose youth with ASC, results to the non-setting of assessments and interventions. However, it is very important to facilitate early interventions to achieve a good prognosis even if either early or later set of interventions, small effect sizes are mainly produced in clinical trials, revealing the ineffectiveness of most of the strategies to fulfil existed needs [14]. Yet again, when finally assessing young individuals within the spectrum of autism, the five aforementioned factors remain, and may lead to the predominance of residues of its condition leaving young individuals to be exposed also to the comorbidity phenomenon [15] and unable to adjust with social mechanisms, regardless of their willingness and potentiality [16]. Anxiety – particularly Social Anxiety - and Mood Disorders, Disruptive Behavior Disorder and Psychosis are the most prominent comorbid disorders reported in pediatric [17; 18; 19; 20]. Impairments in Working Memory are included in the distortion of cognitive abilities within autism, leading individuals vulnerable against other Neurodevelopmental Disorders, Learning Disorders or difficulties affecting academic attainment [21] whereby all the above-discussed difficulties, comorbidities and impairments to cognitive and emotional dimensions tend to weaken the effectiveness of most interventions [22]. Applied Behavioral Analysis, Social Skills Training, Occupational Therapy, Physical Therapy, Sensory Integration Therapy, Animal Assistant Therapy (AAT) and the use of assistive technology such as Virtual Reality Interventions (VRI) are the most prominent interventions utilized for tackling the challenging condition in youth.

This literature review amends to explore within a critical scope the effectiveness of AAT and VR-I. The study adopted a methodological approach including the most relevant RCT studies published. All studies yielded remarkable markers grounded on vital differences in outcomes, emerged by the utilization of the selected interventions to assist young individuals found themselves within the spectrum of autism. Due to the five aforementioned factors, controlling the condition becomes perplexing. Thus, the Randomized Clinical Trials (RCT) studies selected for this report to frame this complex phenomenon unfolded in the spectrum of autism, either have utilized one of the two approaches or another one e.g., med-

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ication, yet, not in combination, to explore their interactions with targeted difficulties manifested by youth with ASC and its phenomenon. Therefore, and precisely because there is lack of evidence regarding the effectiveness of the selected approaches in youth, six central RCT's studies (see Appendix 1) have been settled on the scope. A synthetical discussion will follow considering factors which pose to the interventions both effective and ineffective roles in tackling difficulties in youth with ASC and aspects of psychological theory and qualitative approaches which may exploit some autistic patterns, characterized as retrograded, in a positive manner.

Methods

As it is mentioned, difficulties around ASC lurk both on assessment and definition of it. Therefore, this study used parts of DSM-IV and V [2; 1] in a synthetical core for a satisfactory definition to be attributed. The six analyzed RCT studies have been chosen from the PubMed.gov and Clinicaltrials.gov databases. To evaluate the efficacy of AAT and VRI on ACS young patients, studies published between the period of 2010-2020 were chosen and analyzed so as to ensure the recency of the findings and data. For the two approaches to be unfolded, the analysis investigated studies using the Social Skills Training incorporating Dogs (SSK-D), Therapeutic Horseback Riding (THR), Free Play with Peers and Guinea Pigs (FRPGP), academic activities, VR-Based training programs, VR-Social Cognition Training intervention, Brief VR-treatment alongside CBT and typical training. More than satisfying was the CASP check of the selected studies, acknowledging the fact that the sample recruited in the studies was young children, clinically diagnosed with an ASC and, therefore ethical considerations and rigorous data analysis was accomplished (Appendix 2).

Factors such as the lack of research considering the above-mentioned concerns, sample sizes issues and the fact that autism as a multidimensional entity cannot be captured holistically by a single intervention, made the selection of the studies extremely strict regarding the measurements that used to explain the presence of ASC. Keywords used in the search was "Autism", "Youth", "AAT", "VR" and "Randomised Clinical Trials", including studies published only in English to avoid time and translation issues. The selected studies will be analysed for their effectiveness in accordance with their selective action to manipulate difficulties expressed by the ASC. Therefore, according to the way in which interventions have been applied in the selected studies, ATT will be analyzed in terms of its efficacy on improving aspects of Children's Depression Inventory (CDI-2), Interpersonal Problems and Functional Problems subscales, theory of mind (ToM), Social Language Development Test (SLDT), skin conductance responses, irritability and hyperactivity behaviors, whereas VRI will be analyzed on its efficacy to expand emotion expression and regulation and social-emotional reciprocity, motor and cognitive skills. Both interventions are experiential and behavioral tools.

AAT and VRI cores

As a complementary type of therapy, AAT includes the use of animals in the core of the therapeutic strategy to bound a therapeutic context such as emotional support animals, service animals trained to assist with daily activities, and animal assisted activity [23; 24; 25; 6]. AAT can be categorized by the type of animal and the targeted population of the scope. Canine-assistants and horse-assistants are the most used types of AAT, whereas cats, rabbits and guinea pigs are also used for assisting individuals with ASC [27]. The individual's social, emotional, and cognitive ability to operate in the environment is amended in order to be improved with the use of AAT [28]. Literature reviews declare that animals for the interaction with animals enhances academic attainment and motivational efficiency for participants, measured by subjective self-rating scales and on objective physiological measures such as blood pressure and hormone levels [28]. The psychotherapeutic mechanisms that are employed by AAT for autism due to the internalizing nature of the condition since animals are intuitive, nonjudgmental, and non-verbal communicators, providing from animals a psychotherapeutic effect [29]. However, a major ethical concern emerges regarding the emotional bond that is created between the participants and animals. The fact that the animal does not belong to the child may give rise to negative side effects creating a discontinuity in therapy [27].

VR devices has been utilized in health settings as a novel procedure within initial interventions or for supporting treatment side effects including, physical pain and symptoms of psychiatric disorders such as mood and anxiety disorders [30]. Virtual environments seem to be very useful for educational and training purposes precisely because it promotes elaborative and experiential participation exploiting deep semantical and cognitive mechanisms [31]. A study showed that introvert participants are more likely to use and benefit by such training [32]. Exposing individuals to such controlled and calm environments, assist and guide them to act by positively, depending on their spatial intelligence's abilities. This factor may be crucial for managing difficulties in ASC's, acknowledging the existent introversion to which autistic people resort with e.g., stereotype motor manifestation and behaviors, which mani-

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folds motor deficits [33]. However, if the Attenuation Theory of selective attention unfolds, it would reveal the need for understanding the reasons that force individuals to proceed on such attentional filter [34]. The use of VR has increased in studies on ASC in recent years and aims to respond to spectrum difficulties involving cognitive impairment, motor skills, learning disabilities, social communication, information processing, multisensory integration, and hypo- or hyperresponsivity [35; 36; 37]. Three metanalytic studies yielded significant improvements in ASC symptomatology, grounded on significant treatment effects and effect sizes yet, and pointed to the need for further research in order to validate and state that VR can effectively supplement the traditional strategies for tackling ASC's difficulties [38; 39; 40].

Scoping the efficacy of AAT

The three studies that are used in the present paper for evaluating the effectiveness of AAT in ASC compare, either the performance of two ASC groups between them [41;42], or the performance of an ASC group to one of Typically Developing Children (TDC) [43]. Becker and colleagues [41] compare the effectiveness of traditional social skills intervention with and without dog assistance, by assessing social and linguistic skills, Theory of Mind (ToM) and overall depressive symptoms. The results yield statically significant differences regarding social skills, engagement in social interactions (e.g. eye contact, initiation of interactions), self-esteem, isolation, Restricted and Repetitive Behaviors (RRB) and most depressive symptoms, with AAT group demonstrating heightened performance. The detected difference may be attributed to the experience of AAT as more enjoyable and as reinforced learning. Simultaneously, the animal stimuli could contribute to decreased sensory overloading effect and anxiety, assisting learning processes, subsequent acquisition of skills and ultimately generalization of skills acquired across contexts, as enhanced social skills were reported by teachers outside the intervention setting. The significant reduction of RRB in the AAT-group might imply the indirect association between RRB, depressive symptoms and the social domain. Given that RRB may be understood as safety behaviors and elements of an internalizing condition, the enhancement of social skills and the decrease of negative affect may contribute to decreased RRB. However, no differences are detected regarding linguistic skills for both groups, whereas performance in ToM task appear significantly increased for both groups. Considering ToM performance, the supportive nature of both tasks may be accountable for not detecting between-group differences. The duration of the study (12 hours in total) may be accountable for not detecting enhancement of the linguistic skills in general and between groups in specific, which constitutes a type 2 error due to limitations of the design. Also, the small sample size employed (31 participants) may contribute to statistical errors., as the study does not refer to effect sizes that would clarify the above. Even if it was mentioned, it would probably be non-representative of the real effect since effect size can appear larger in small samples. The simultaneous interventions, in which the children participate are overlooked and not included in the methodology so as to control the input of confounding variables in the results. Moreover, teachers were asked to assess ASC symptoms in children, who may have been aware of group allocation, hindering the RCT design. The recruitment of mild and moderate cases of ASC and the exclusion of individuals within the ASC that have severe linguistic and intellectual difficulties, do not allow understanding regarding the general implications of AAT in ASC, rather than the implications for the high functioning dimension. O'Haire and colleagues [43] compare, among others, arousal of TD children and ASC children in four conditions: reading aloud, reading silently, playing with given toys and peers and playing with guinea pigs and peers. Parent and teacher reports are employed to address skills in the social domain and the arousal is assessed via devices that measure skin Conductance responses. The results of the study yield that children in the ASC demonstrate significant decrease in physiological arousal in the presence of guinea pigs compared to other conditions but also compared to TD children. The differences in conductance levels demonstrate a medium effect size (d=0.46) and the differences in conductance responses demonstrate a small effect size (d=0.19). These findings indicate that animals can be employed to decrease anxiety in social contexts, which has implications for AAT, but do not provide findings regarding facilitated research on AAT whatsoever. Moreover, the small to medium effect size of the anxiety reduced due to animal presence, indicate the mild to moderate contribution of animal presence to decrease social anxiety in ASC. Social anxiety constitutes a comorbid condition to ASC, which implies the non-ASC-specific implications of the abovementioned research [43]. Moreover, the study is based on the assumption that physiological arousal is attributed only to social anxiety. Yet, this assumption may be mistaken, since the facilitation of two conditions involve reading, in which children with ASC may face difficulties compared to TD children. Hence, this may act as a confounding variable to the results and the observed arousal may be attributed to the difficulty experienced in reading. Gabriels and colleagues [42] divided 116 participants in the autism spectrum into two groups for which, activities in

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the barn or horse-riding activities were facilitated for 10 weeks and 45-minute sessions. This intervention considered training regarding horse-riding. All participants included were in the ASC. The results of the study yield that participant in the horse-riding intervention demonstrate decreased irritability and hyperactivity pre- and post- intervention. Social skills (e.g. motivation, cognition) appear significantly enhanced in the horse-riding group alongside linguistic skills involving manipulation of more words during speech and manipulation of a greater vocabulary range compared to the barn group. However, inclusion of variables such as IQ, age etc. in the processing of data yields non-significant effect of group allocation considering social cognition. The changes in hyperactive behavior and irritability can be attributed to the calming context that the presence of animals offers. The calming context and the non-overloading stimuli context related to animals combined may assist learning processes e.g. terms regarding horse-riding, which may explain the progress in linguistic and social skills. Although the design of this research appears to be superior to the designs of the other two e.g. acknowledging the input of other interventions on results and having larger sample size etc., this study also has methodological issues. Caregivers were responsible for conducting assessments, who were not blinded to the allocation. The short duration of the intervention and the inexistence of a group such as waiting list may have contributed to the study yielding no statistically significant effects for measured variables such as social cognition. Collectively, there is inconsistency regarding ToM performance in the above-mentioned studies [41;42], with one yielding effectiveness of AAT in ToM performance, whereas the other yielding no effect. This can be attributed to the characteristic of the participants recruited, with the first study recruiting only high functioning ASC cases, whereas the latter recruiting participants regardless level of functionality. All studies have many methodological limitations and confounding variables may impact their results and hence cautious interpretation is needed. However, it appears that AAT may assist individuals with ASC in the social domain, secondary symptoms e.g. low self-esteem and might lead to indirect decrease of RRB. Yet, this effect seems to be at best described as small to moderate.

Scoping the efficacy of VR-I

The three analyzed studies utilized VR-I. Two of them were specified on exposing young individuals in VR social scenarios [44;45] and one on training individuals on a same task of a cross-trial design [46], with the latter study producing promising evidence. All three studies have failed to explain or to manipulate secondary symptoms or comorbidities yet, acknowledging the fact that all background designs are very strict-targeted, this fact may be considered as non-retrograded. However, on a same methodological error-axis, Ip et al [44] and Zhao et al. [45] included gender as a demographic and not as an independent variable, despite their use of a MANOVA. Similarly, De Moreas et al. [46], they indeed included sex yet, gender's inclusion was considered only in the part of the statistical analysis with t-tests, instead of using gender as a group including criterion, precisely because a group of females with an ASC may provide the ground to understand better the masking factors. Ip et al. [44] executed a protocol of 28 training sessions (14 weeks) consisted of three stages, i.e. briefing, VR-enabled 40-minutes (10 minutes of direct exposure, 30 minutes observing) debriefing, whereas behavioral techniques of the design included also family and school treatments. Using virtual reality enabled program to amplify emotional and social adaptation, targeting deficits in social-emotional reciprocity, they utilized six virtual learning scenarios: one focused on emotion control and relaxation, four stimuli-leakers of various social situations, and that attributes to consolidation and generalization. Zhao et al.'s [45] cognitive training protocol was practiced for 30 min every time, twice a day for four weeks. Zhao et al. [45] created environments to stimulate social situation in accordance with the participants' age, with represented avatars, one for the child and one for the therapist, both navigated by each with the use of a keyboard. Both studies used VR-I to gain the ability to expose young children with ASC in social situations which activate embarrassment and the sense of danger in a real-life context, also out of risk. In contrast, De Moraes et al. [46] took acquisition and retention of information and skills on the scope. They settled up a sample of 100 young children (50 with an ASC and 50 TD) on a cross-over design to contrast the effect of two sequences: a coincident timing task, reflecting the ability to "perform a movement where the arrival of the hand (gesture or touching) at a target coincides with the arrival time of a moving object" (p.3) in firstly, using Kinect's virtual environment and same task on a digital environment using a keyboard (sequence A) and vice versa (sequence B) on 20 attempts at acquisition (divided into four blocks) and five attempts at retention (test was then performed after 5 min without contact with task). Ip et al's [44] clinical group, having received the training on VR environment, scored higher on emotion expression and regulation, similarly with social interaction and adaptation, in contrast to the control group which had no training. Results compared to the pre- and post- assessments revealed a significant improvement on expression and regulation, on communication, and most importantly, on social-emotional

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reciprocity but, communication in control group was improved. Secondary analysis brought to the fore insignificancy on enhancing emotion recognition and interaction on time Eye's test. This insignificancy emerges internal bias based on unacknowledging the fact that young children with ASC had difficulties on keeping eye-contact. Zhao et al [45] scoped attraction, produced by their program, as a significant effective variable. Compared with the Control group (watching the animation of island tourism), which attracted 38.33% patients in 4 weeks to complete the training, the Experimental group (VR-cognitive training) attracted 81.67% patients in 4 weeks to complete the training. Symptoms of social communication disorder, speech retardation, narrow interest and rigid behavior was improved, whereby a significant perfection was noted on the clinical rating scales. Attraction to the specific training had a significant effect. This efficacy may answer to the need for adapting behavioral tools that will enhance desire for keeping their attention to social information, whereby an explanation of the impairments in social communication may hinder in the absence of motivation for that, according to the theory of Social Motivation. However, insignificancy on the above-mentioned improvements, turns the focus of the scope on transfer effect issues. Individuals in both studies showed good standards of social interaction, reduction of stereotype and repetitive behaviors but, only when interacting with virtual stimuli. Therefore, there was not a significant transference of the virtual training of social situation in real life. Another factor that may acted as a limiter for emotion recognition to be established, is the fact that VR program trained individuals to recognize emotions related to specific stimulus, either virtual or real. This could be explained that semantic networks, crucial architectures which hold a schematic transference of emotions, cognitions, and behaviors through Working Memory [47], are not activated as a part of the cognitive process of individuals with an ASC. However, De Moraes et al. [46] produced partial evidence regarding the effect of the transferability of VR. By the analysis for each group, subgroup and sequence revealed the existence of a general tendency for delay in movements. However, subgroups of both neurodevelopmental groups that first participate in the real-digital task, showed higher levels of movement delay. Therefore, this motor-behavioral delay when real task was first performed, magnified the fact of a motor-behavioral transfer effect from virtual to digital and real manipulation when VR-task was first performed, with TD group consolidating the cognitive and behavioral patterns of the tasks faster. However, in the accuracy of movement, ASC groups perform was grounded on a significant main effect on the contrary to the TD group. Significantly, the ASD group succeeded to create cognitive, motor, and behavioral transference from the virtual to the real environment which indicates that VR-I may enhance learning of movement in this group. This transference contained the acquisition and retention of behaviors than are difficult to be manifested by individuals within the spectrum of autism e.g., gesture. This may support the aspect of Attenuation Theory, and the fact that VR may answer to a most challenging cognitive loop underlying behavioral stereotyping in ASC, by utilizing new learned motor behaviors in the same transference mechanism.

Discussion

This systematic literature review focuses on exploringthe effectiveness that emerges by the utilization of AAT and VR-I considering symptoms of ASC. Following such psychological conceptualization of how the interventions were facilitated, and through synthetical analysis, introductory evidence re-emerged by the discussion and should be pointed out.

AAT interventions appear to have a small to moderate effect in aiding individuals within an ASC considering the two main domains, in which difficulties are faced: the social and the behavioral that includes RRB [1]. Simultaneously, a positive effect of such interventions may be observed in secondary symptoms e.g. vocabulary acquired and comorbid conditions e.g. social anxiety and depressive symptoms. More specifically considering the social domain Becker et al. [41] yield enhanced engagement in social interactions, with participants facilitating more eye contact and initiating more interactions, whereas Gabriels et al. [42] demonstrate a positive effect in motivation for social interaction as well as in social cognition. In terms of RRB, the study of Becker et al. [41] was the only one of the chosen studies investigating the mentioned domain and demonstrates a statistically significant reduction in RRB.

Regarding secondary symptomatology, focusing on linguistic skills and ToM-related abilities, studies appear inconsistent, with Becker et al. [41] yielding non-statistical difference and Gabriels et al. [42] yielding positive effects for ASC. The differences in the findings may be attributed to the differences in the nature of the interventions, design issues or participant characteristics. Regarding the nature of the intervention the later may be accounted as more educational in nature considering the animal employed as it aims to educate regarding horse-riding skillset, rather than just being facilitated with the mere presence of animals. Moreover, there might be a difference in the effect due to the animal employed. The horse as a stimulus may be more attention-capturing than a dog, due to the often exposure to the latter. Thus, since both studies [41;42] focus on educative processes, variables included such

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as interaction and the attention-capturing effect of the stimuli can play a role in the consolidation of information in working memory and subsequentlylong-term memory [48]. As far as design issues are considered, the inconsistency detected in the above-mentioned findings may derive from short time-framed intervention, confounding variables e.g. teachers, parents assessing progress being aware of allocation, small sample sizes leading to questionable reliability etc. Lastly, participants' characteristics e.g. degree of difficulties faced, sex and age may be accountable for the differences detected. The study of Becker et al. [41] considered age groups between 8 and 14, whereas Gabriels et al. [42] considered age groups between 6 and 16. In ASC, ToM is suggested to be linked with late development. However, neither of the studies mention the number of participants employed from each age group. The imbalance considering the age variable across the two studies may contribute to their different findings, which is what could be argued for sex and degree of functionality as well.

The utilization of VR-I gives the advantage on manipulating, or at least on interacting with core traits of autism, on the contrary to the most widespread interventions which are secondary-symptoms-focused. Discussing the efficacy of Ip et al. and Zhao et al. [44;45] protocols, it emerges that children with an ASC scored higher on emotion expression and regulation, on social interaction and adaptation, whereby the application of such intervention, magnified the attraction of the participants, accompanied by the reduction of stereotyped and repetitive behavior. Therefore, narrow interest and rigid behavior was improved, supporting the holding aspect of the theory of Social Motivation for social information. Furthermore, a significant improvement was noticed on clinical rating scales regarding symptoms of social communication disorder and speech-related issues, with pre- and post-assessments to signify the above discussed evidence. However, two critical methodological errors producing insignificant results were captured. Firstly, internal bias emerged regarding the utilization of Eye's test task, unacknowledging the difficulty of children with an ASC to manipulate eye movement [44] and issues on the transference of social scenarios within virtual training to real life, in both studies. Hence, a phenomenon whereby the cognitive mobility and emotional response that was noted through the VR tasks, imposed on Working Memory to function selectively and compulsively within the virtual environment. However, De Moraes et al. [46] evident opposite potentiality for VR's transference effect. Despite the approve of the general tendency for delay in movementssubgroups of both neurodevelopmental groups that participate in the motor-behavioralreal-virtual task, showed reduction on the levels of movement delay, whereby they gain the ability to manifest their motor-behaviors on the real-digital task. Therefore, the adjustment of motor learning may enhance the ability of Working Memory to hold more holistically chunks of the given information, serving the transfer of skills from the virtual to the real environment.

Limitations

Given the fact that for both intervenor tools, more research is needed for establishing that they may act as a primary, or at least as a secondary yet, effective strategies, some discussed factors on the introduction of the study, emerged as limiters for the six chosen studies, and should be highlighted. Firstly, all studies produced small effect sizes and thus, the non-efficacy of the interventions may lurk when generalization comes to the fore. And secondly, gender did not have a central role to the studies' design, in order to serve the need of deconstruction of gender-masking factors. Yet, the present study has also limitations. Firstly, only three studies were employed to be analyzed per intervention. The employment of more studies could contribute to a more informed view regarding the effects of each intervention. Secondly, some of the studies analyzed employ a small number of participants, which may lead to non-reliable results. Moreover, statistical tests for investigating reliability and validity factors could be employed rather than qualitative analysis in order to produce more reliable suggestions regarding the effectiveness of interventions. Lastly, the small number of authors contributed to this analysis may led personal bias to emerge.

Implications and Future Studies

In AAT, the positive effects detected may be attributed to the experience of AAT as enjoyable and hence this may reinforce learning. Simultaneously, the animal stimuli may contribute to decreased sensory overloading effect, assisting learning processes and subsequent acquisition of skills. Reflecting on the consistent findings it appears that AAT produces a positive effect on difficulties of ASC in the social domain, by enhancing initiation and motivation for social interactions. However, it is important to note that the presence of animals may as well reduce stress levels. Hence, synthesizing the findings animal presence may reduce social-related stress which in combination with social skill training may produce a state of being motivated for initiating social interaction. The context of calmness and reduced overloading effect produced by animal presence when interacting with peers in the intervention context may lead to unconsciously combining the two in a

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cognitive schema so the interaction is associated with a state of calmness and enjoyability, thus promoting motivation and initiation of interactions. RRB behaviors on the other hand may be conceptualized as behavioral manifestation of an internalized condition. Thus, it may be argued that the enhancement of motivation for social interaction might reduce internalizing conditions e.g., RRB and depressive symptoms. Considering that language is a communication tool, being more interested and engaging in social interaction may be associated with development of linguistic skills. Furthermore, considering ToM is also related to the social domain, enhancement in the social domain might be followed with enhancement in Tom. Hence, future studies could investigate the role of the AAT context in the enhancement of social skills, motivation and willingness of initiating interaction in ASC considering the way it is associated (causally or merely sharing an association) with RRB, depressive symptoms, linguistic skills and self-esteem.

Based on the effectiveness that emerged from the application of VR-I on enhancing crucial cognitive abilities and reinforcing socio-emotional reciprocity but, more specifically in its transference effect to real life, which was established with the utilization of motor learning, the findings of Barzouka [49] should be brought to the scope. In order to train complex kinetic skills in young athletes, Barzouka [49] utilized visual feedback by showing to her participants a video record with the overlapping projection of an expert athlete manifesting the complex kinetic skill and the participants. Hence, this simultaneously projection acted as an enhancer of both intrinsic and extrinsic motivation, magnifying also the confidence of the participants on adapting a new motor behavior. This method may have an implication on teaching desired or typical behaviors. Therefore, grounding on the high transferability of motor-behavior from a virtual environment to a real one and on the adaptation of new motor skills in amateur individuals with the simultaneously projection of their self's and expert individuals when executing the motor skill [49], this study suggests a novel virtual task to expand the above two findings. Using a VR-device, children with an ASC may be exposed to a virtual environment on a motor-behavior task designed on specific social scenarios, whereby desired and/or typical behaviors will be projected by an advanced peer, simultaneously with their self's. Acknowledging the fact that attraction, cognitive mobility, and motor behavior adaptation have been succeeded, this suggestion may open space for the utilization of VR-I on children with ASC. In addition, taking advantage of the disadvantage of small impact sizes, i.e., the small sample of participants, there is an urgent need to both adopt qualitative methods, as Ladas, Iliopoulou and Louka [50] suggested when neurodevelopmental difficulties are explored.

Conclusions

AAT appears to be promising regarding social elements of ASC. Even though existent studies yield small to moderate efficacy for AAT, the need for more well-designed research is apparent as well as the study of how different symptoms and dimensions of autism interact with each other, in order to facilitate more effective interventions referring to AAT or/ and others. Simultaneously, there is a potentially between motor behavior, motor learning and visual feedback which may enhance the acquisition of new behaviors in children with an ASC. This fact may be enhanced by utilizing VR-I, acknowledging the high levels of transference of motor-behavior skills trained from VR environments to real once. Hence, typical behavior may be established by such intervention.

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Appendices

Appendix 1

Author	Year	CASP	Design	Intervention	Sample (age)	N	Main Findings
Ip et al.	2018	/10	Randomized Controlled Trial	VR-scenarios	10-11.5	94	By comparing pre- and post-assessments, results reported in this paper show significant improvements in the project's primary measures on children's emotion expression and regulation and social-emotional reciprocity but not on other secondary measures.
Morag et al.	2019	/10	Randomised Controlled Trial	Brief VR-treatment alongside CBT vs Usual Care	8-14	32	Brief VRE exposure with CBT is feasible and acceptable to deliver through child clinical services and is effective for some participants.
Moraes et al.	2019	0/10	Randomized cross over controlled trial	VR-Motor Learning	7-15	50	Results showed that practice in the virtual task was more difficult (producing more errors), but led to a better performance in the subsequent practice in the real task, with more pronounced improvement in the ASD as compared to the TD group. It can be concluded that the ASD group managed to transfer the practice from a virtual to a real environment, indicating that virtual methods may enhance learning of motor and cognitive skills.

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Becker et al.	2017	10/10	Randomised Controlled Trial	Animal Assisted Therapy	8-14	32	Based on self-report ratings using the Children's Depression Inventory (CDI-2), participants in the groups with dogs experienced significantly greater reductions in symptoms measured by the Interpersonal Problems and Functional Problems subscales, and not on the other subscales of the CDI-2. Both groups showed improvement in theory of mind and decreased feelings of isolation and overall depressive symptoms; however, the effect of group on change over time was not significant. On the Social Language Development Test (SLDT), no significant differences were observed. The current findings indicate animal-assisted social skills training may be more beneficial for improving social skills and reducing related affective symptoms than traditional training models.
O' Haire et al.	2015	/10	Randomised Controlled Trial	Animal (guinea pigs) Assisted Therapy	5-13	114 (38 children with ASC)	Results confirmed heightened arousal among children with ASD compared to TD children in all conditions, except when the animals were present. Children with ASD showed a 43% decrease in skin conductance responses during free play with peers in the presence of animals, compared to toys. Thus, animals may act as social buffers for children with ASD, conferring unique anxiolytic effects.
Gabriels et al.	2018	9/10	Randomized Controlled Trial	Therapeutic Horseback Riding	6-16		THR group maintained reductions in irritability behavior. Hyperactivity behaviors did not sustain this same trend. Comparisons from baseline and 6-months after the intervention revealed that the THR group sustained significant initial improvements made in social and communication behaviors, along with number of words and different words spoken during a standard language sample. This is the first known study to examine and demonstrate the longer-term effects of THR for individuals with ASD and warrants a more thorough evaluation of whether the effects of THR are maintained for at least 6-months after the intervention compared to a control.

Appendix 2

CASP

1. Did the study address a clearly focused question or hypothesis?
3. Is the chosen methodology appropriate?
4. Was the research design appropriate?
5. Was the recruitment strategy appropriate?
6. Did data collection strategy fit with the research question?
7. a) If the research is qualitative, has the relationship between researcher & participants been considered?
   b) If the research is qualitative, have relevant methodological issues been outlined?
8. Have ethical issues been considered?
9. Was data analysis sufficiently rigorous?
10. Is there a clear statement of findings?

CASP	Becker	Gabriels	O'Haire	Chacko	Van Doon	Steeger
1	v	v	v	v	v	v
2	v	v	v	v	v	v
3	v	v	v	v	v	v
4	v	v	v	v	v	v
5	v	v	v	v	v	v
6	v	v	v	v	v	v
7	v	x	x	x	v	x
8	v	v	v	x	x	v
9	v	x	x	x	x	v
10	v	v	v	V	v	v