Research Paper   Open Access

Enhancing Emotional Intelligence among children with ASD with mobile applications, virtual games, and virtual reality

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ABSTRACT: This literature review sought to determine if mobile applications, virtual reality, and games can enhance emotional intelligence among the pediatric population diagnosed with ASD. A total of five studies were analyzed—each using a specific technological modality that included mobile applications, virtual games, or virtual reality. Based on the current literature, the author could not determine a definitive conclusion. Therefore, the results are inconclusive. However, this demonstrates the need for more research to be generated in standardizing better and incorporating technology in treating children with ASD.

I.   INTRODUCTION

Enhancing Emotional Intelligence among children with ASD with mobile applications, virtual games, and virtual reality

Literature Review

The existing literature concerning technology and Autism Spectrum Disorder (ASD) has focused on interactive video games, applications, and tools created as a means to improve the social and emotional cognitive abilities of disabled individuals (Dawe, 2006). The literature focuses on the effectiveness of implementing early intervention programs to understand and assess for emotional skills of individuals with Down Syndrome via assistive technology (Jameel, 2017). Interactive video games have been created with the intent of improving the cognitive, language, and intellectual skills of children with Down Syndrome. These interactive video games involve real-world scenarios that focus on comprehension and visual skills (Corrales-Astorgano, Escuedero-Mancebo, Gonzalez-Ferreras, Guiterrez-Gonzalez, Flores-Lucas, Cardenoso-Payo, & Aguilar-Cuevas, 2016).

Research indicates that children with ASD learn to interpret better different social situations and emotions with multimedia-based social stories (Saad, 2016). Improvement in behavior among children with ASD is noted with the implementation of social stories. Furthermore, social interactions increase when social stories are frequently implemented (Karal & Wolfe, 2018). Children with ASD can learn appropriate social behaviors more efficiently when using interactive multimedia-based social stories (Sani-Bozkurt, Vuran, & Akbulut, 2017). Studies find that social stories combined with augmented 3-D animation improve social skills (Syahputra, Arisandi, Lumbanbatu, Kemit, Nababan, & Sheta, 2017).

Researchers have developed real-time gesture tracking systems to improve the sensory skill development of children with low-functioning ASD by focusing on sound stimuli. The enhancement of sound and motion tracking interaction assists children with low-functioning ASD to accustom themselves to theirenvironments (Magrini & Curzio, 2016). Investigators have examined the enhancement of behavior therapy for ASD by combining it with technological devices. The study included learning social skills via I.T. devices, the results were significant (Artoni, Bastiani, Buzzi, Curzio, Pelagatti, & Senette, 2017)

Theoretical Model/ Foundations/ Conceptual Framework

ASD

ASD is a neurodevelopmental disorder marked by social difficulties, communication difficulties, and restricted interests and behaviors (American Psychiatric Association, 2013). According to The Diagnostic and Statistical Manual for Mental Disorders (DSM-5; American Psychiatric Association, 2013), impaired social interactions are characterized by 1) having abnormal social approaches as well as difficulty in having dialogue and conversation 2) reduction in sharing interests, emotions, and affect in developing appropriate peer relationships according to developmental level, 3) absence of spontaneously seeking to share their enjoyment and interests (e.g., sharing a toy with a caregiver or fellow peer), and 4) absence of emotional and social reciprocity (DSM-5; American Psychiatric Association, 2013).

Emotional Intelligence

In 1990, Peter Salovey and John D. Mayer developed the concept of Emotional Intelligence (E.I.). E.I. enables an individual to appraise their emotions, the emotions of others, emotionally regulate and use emotions for problem-solving (Mayer, Salovey, & Caruso, 2004).E.I. is built from four branches (Mayer et al., 2004). The first branch, self-awareness, relates to interpreting and perceiving different emotions. The second branch, self-management, is when a person uses their own emotion(s) to "match" the circumstances they're in. Social awareness, the third branch, relates to a person's capability in expressing both concern and empathy. Lastly, relationship management relates to managing one's emotions within current situations (Mayer et al., 2004).

E.I. and ASD

Literature concerning ASD and E.I. has noted that individuals with ASD have marked deficits in E.I. These deficits suggest impairment in intrapersonal and interpersonal skills. Regarding intrapersonal skills, children with ASD have deficits in discriminating among emotions, labeling emotions, using emotions to guide their behaviors, and effectively controlling affective range and intensity (Begeer, Rieffe, Terwogt, Meerum & Stockmann, 2006). In regards to interpersonal skills, children with ASD have difficulty decoding feelings, intentions, and motivations. They have difficulty correctly recognizing the personal characteristics of others (e.g., age, gender, and ethnicity). They struggle with influencing others to behave in desirable ways (Dalrymple, 1992).

Additionally, individuals with ASD struggle with social interaction and communication and possess difficulty with integrating social-emotional behaviors (El Kaliouby, Teeters, & Picard, 2006; Klin, Saulnier, Sparrow, Cicchetti, Volkmar, & Lord, 2007; Hudepohl, Robins, King, & Henrich, 2015). Studies show that individuals with ASD have difficulty using facial stimuli to encode emotional and social information (Baron-Cohen, Whelwright, Hill, Raste, & Phumb, 2001). Although most studies focus on face stimuli, other studies suggest that abnormalities of emotion processing could be present in different types of visual stimuli (e.g., body movement) (Hubert, Wicker, Moore, Monfardini, Duverger, Da Fonseca, & Deruelle, 2007; Philip, Whalley, Stanfield, Sperengelmayer, Santos, Young, & Hall, 2010).

Purpose of the Study

Technology advances and is becoming available via different modalities (e.g., smartphones, tablets, etc.). It is no surprise that mental health treatment incorporates technology. The previously mentioned studies show that children with neurodevelopmental disorders can improve their social and emotional skills with technology, such as interactive games. Therefore, the purpose of this study is to review the literature and determine the effectiveness of mobile applications, virtual games, and virtual reality in enhancing E.I. among children with ASD.

Research Questions and Hypothesis

It is hypothesized that mobile applications, virtual games, and virtual reality will effectively enhanceE.I. among children with ASD.

II.   METHODOLOGY

Search Strategy

A systematic literature review was conducted. Journal articles that were searched investigate the effectiveness of mobile applications, virtual games, and virtual reality in enhancingthe emotional or social skillsof the pediatric population diagnosed with ASD. In searching for the right fit of articles, the search engine searches were limited to peer-review journals. The researcher electronically retrieved journal articles with the following databases: Google Scholar, Psych INFO (EBSCO), and ResearchGate. The researcher used the following keywords: "ASD and Emotional Intelligence," "E.I.," "ASD, mobile applications, and Emotional Intelligence," "ASD, virtual reality, and Emotional Intelligence," "E.I. and games," "Emotional intelligence, games, and ASD," and "Enhancing Emotional Intelligence in ASD."

Inclusion Criteria

For the systematic review, the following inclusion criteria were identified: (a) published between 2011 and 2021; (b) scholarly or peer-reviewed; (c) studies that investigated mobile applications, virtual games, and virtual reality within the ASD pediatric population; (d) studies that were submitted for publication within the last ten years (e); and, if the studies' abstract and content were relevant with the keyword descriptors.

Exclusion Criteria

The following classifications of publications were excluded from the systematic review: (a) books; (b) case studies; (c) newspaper articles; (d) magazine articles; (e); studies published before 2010 (f); studies submitted for publication before 2010, and (g) studies that did not include ASD.

Article Selection Process

Several articles were reviewed based on the inclusion and exclusion criteria previously noted. The researcher read the titles and abstracts of the remaining papers. Additional articles were removed because they were not relevant to the purposes of the systematic review. Expressly, articles were excluded if they: (a) did not include ASD, mobile applications, virtual games, or virtual reality; and (b) did not utilize validated measures or

research designs. A total of five articles were selected. The articles were literature reviews that examinedan array of serious games, mobile applications, or virtual realities. Two of the literature reviews were purely conceptual, while the remaining ran statistical analyses. The articles selected were all published between 2011-2021.

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III. RESULTS
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Mobile Application

　　Papoutsi, Drigas, and Skaianis (2018) conducted a comprehensive literature review of mobile applications created to enhance the E.I. of children and adolescents with ASD. The authors reviewed a total of 29 mobile applications, including "HANDS," "Wrong Planet," "My Drama," and "LOOK AT ME." All mobile applications were developed to give the pediatric population with ASD the opportunity to practice in a way that was both accessible and creative (Papoutsi et al., 2018). In general, the mobile applications all aim to increase the following:1) learning about emotions;2) enhance emotion recognition; 3) assist in developing empathy; 4) promote facial recognition via mimicking facial expressions with live video;5) increase social integration; 6) increase the expression of emotions, and7) increase eye contact.

　　Papoutsi et al. (2018) find that mobile applications have several advantages. First, mobile applications are user-friendly to navigate. Because some mobile applications include touch screens, they are accessible to children diagnosed with intellectual disabilities and sensory-motor difficulties. Because mobile applications are visually engaging, it provides a consistent and predictable learning environment (Shane & Albert, 2008 cited in Papoustsi et al., 2018). Lastly, mobile devices can be easily transferred anywhere at any time (Papoustsi et al., 2018).

　　The authors suggest that emotion-aware apps can improve the EI of individuals with ASD and enable them to better integrate into social contexts. Mobile applications that focus on emotions assist in better understanding the minds of others, reduce experiencing negative situations and interactions, and decrease psychiatric comorbidity (Papoustsi et al., 2018). Furthermore, mobile applications can assist caregivers, educators, and parents in understandingand determining better-informed decisions (Gay& Leijdekkers, 2014 as cited in Papoustsi et al., 2018).

Critical Analysis

　　Papoustsi et al. (2018) reviewed 29 mobile applications developed to enhance the E.I. of children and adolescents with ASD. It gives a comprehensive review of mobile applications that are currently used by the population of interest. Each mobile application is thoroughly explained as to its purpose. However, this study is purely conceptual. No statistical testing was run or reviewed; therefore, there is no objective data. The findings can potentially be under the influence of the authors' subjectivity and biases.

Virtual Reality

　　In 2018, Mesa-Gresa, Gil-Gomez, Lozano-Quilis, and Gil-Gomez conducted an evidenced-based systematic literature review. Both clinical and technical databases are examined. A total of 31 articles were evaluated using the PICO criteria. The PICO criteria include the following: P-population: Children with ASD; 18 and younger; I-intervention: VR-based treatment; C-comparison: non-VR-based treatment, participants' conditions before VR-based treatment, and no treatment; and, O-outcome: the primary outcomes obtained (Mesa-Gresa et al., 2018). Because of the nature of research and the limits of technology, many of the studies are short-term exposure pilots. The authors did not expect to find significant outcomes; therefore, little emphasis is given to the outcome's aspect of the PICO criteria.

　　The study yields a total of 602 participants. 451 participants are in the experimental groups (E.G.s). Ten studies compare E.G.s to C.G.s. 21 studies focus solely on the effectiveness of the intervention. The E.G.s consists of 85.15% male and 14.85% female. The age range for all the articles is between 3-20(Mesa-Gresaet al., 2018).

　　Four articles include children diagnosed with Asperger's. Six studies included participants with high-functioning autism, whereas one study focused on low-functioning autism. One study includes children diagnosed with ASD and ADHD. One study focuses on children suspected of having ASD in theE.G.,55.26% of the articles focus on emotional and social skills, including emotion recognition, collaboration, and social interactions tasks (Mesa-Gresa et al., 2018). 30 reports demonstrate that VR-based treatment improves at least one of the seven addressed objectives (e.g., attention, social skills, emotions, emotion recognition, etc.). Ten articles demonstrate significant improvement. Overall, the systematic literature review indicates moderate effectiveness. However, due to the absence of definitive findings, it cannot be said that VR-based interventions can improve the results of traditional treatments (Mesa-Gresa et al., 2018).

　　In 2011, authors Bellani, Fornasari, and Brambillaconducted a literature review examining the effectiveness of virtual reality with the population of interest. The study uses a total of eight studies. The participants' information and testing processesare both analyzed. V.R. environments enable the opportunity to learn, repeat, and perform specific tasks (Chittaro & Ramon, 2007 as cited in Bellani et al., 2011). V.R. environments enable such opportunities by 1) removing confounding variables, 2) allowing for short breaks

wherevariables involved within the interaction processes are discussed, and 3) allowing participants to learn while playing (Vera et al., 2007 as cited in Bellani et al., 2011).

Because V.R.'s environments are similar to reality. Itallows the child to learn essential skills and increases the likelihood of transferring those skills to real-life(Strickland et al., 1997; McComas et al., 1998; Wang & Reid, 2010 as cited in Bellani et al., 2011). Head-mounted displays (HMDs) are used in V.R. interventions because it enhances the feeling ofbeing immersed. However, HMDs are costly and uncomfortable (Parsons et al., 2004; Wang & Reid, 2010 cited in Bellani et al., 2011). HMDs cause "cyber-sickness," which includes symptoms of nausea, vomiting, migraines, fatigue,loss of balance, and alterations in hand-eye coordination (Holden, 2005 as cited in Bellani et al., 2011). However, V.R.environments can be used with computer monitors. It allows the user to move around using input devices (e.g., mouse, keyboard, touchscreen, etc.). Using V.R. environments with this type of technological modality makes itcost-effective, accessibleand decreases cyber-sickness.

Bellani et al. (2011) found that seven studies demonstrate that children with ASD acquire new information usingV.R. environments. More so, individuals with ASDquickly learn how to use the equipment and showsignificantly improved performance (Strickland et al., 1996; Strickland, 1997; Parsons et al., 2004 as cited in Bellani et al., 2011). The studies by Mitchell et al. (2007) and Herrera et al.(2008) (as cited by Bellani et al., 2011) suggestthat using V.R. environments as a habilitation tool teaches children how to behave in social domains as well as understand social conventions. The first study noted that using a "virtual café" to teachsocial skills,the speed of execution of the given social task improves after repetition, as did understanding social skills.

The second study uses a "virtual supermarket" that consists of several functions. The participants' performance increased after the intervention, and one child could transfer the acquired skills to real life. Other studies focus on Collaborative Virtual Environments (CVEs),allowingmultiple usersto communicate via avatars. CVEs are used to assess the ability to recognize emotions (Moore et al., 2005 as cited in Bellani et al., 2011). CVEs are used to enhance social interactions, teach the manifestations of emotions, and understand the emotions of others (Cheng & Ye, 2009 as cited in Bellani et al., 2011).

The studies indicate improved performance in identifying emotions as well as social performance.Overall, the literature review by Bellani et al. (2011) finds that V.R. interventions can potentially assist caregivers and educators in enhancing the daily social behaviors of individuals with ASD. The authors suggest that more research should be conducted concerning the transferenceof acquired skills

Critical Analysis

Thea-Gresa et al. (2018) study an evidence-based systematic review that includes clinical and technical databases. This study, in particular, focuses solely on ASD and VR-based intervention. In contrast, studies previouslyconcentrated on various logical modalities and psychopathologies, including ASD and V.R. Mesa-Gresa et al. (2018), selected articles with the PICO criteria, making the selection process more rigorous than most literature reviews.

A limitation is that most articles are based on short-term exposure pilots; therefore, statistically significant results were not expected or obtained, considering that ten studies demonstrate statistical significance. Another limitation is that the authors evaluated the entire autism spectrum (e.g., low functioning autism, Asperger's). Perhaps if they focus on a specific part of the spectrum, they would obtain more statistically significant results. Considering that the study is a literature review, the authors' biases and subjectivities may have influenced the interpretation of the results.

Bellani et al. (2011) examined eight articles to determine the effectiveness of V.R. The authors thoroughly explain how the V.R. environment enables the opportunity to learn and practice specific skills. Further, this study argues how V.R. environments canallow transference of skills from technology to reality. The authors discuss the disadvantages of V.R., such as how it can be costly and cause "cyber-sickness." Overall, seven studies demonstrate improved performance. However, there are limitations. The authors conducted a literature review which makes it purely conceptual. No statistical testing was run or reviewed; therefore, there is no objective data to support the study's conclusions. The results may be under the influence of subjectivity and biases on behalf of the authors.

Games

Hassan, Pinkwart, and Shafi (2021) conducted a literature review that examines 40 serious games. The serious games are all in English and developed between 2000-2019. All the games are intendedto improve social behaviors. The design of each gamewas examined based on the literature's conceptual framework. The quality of each serious game was based on the data, target population, if the game itself is based on a specific model or treatment framework, different variables such as population, sample size, design, and clinical validation (Hassan, Pinkwart, & Shafi, 2021).

Three different scales were used for evaluation. The scale by Connolly et al. (2012 as cited in Hassan, Pinkwart, & Shafi, 2021) is based on the following criteria: the type of study, methods, analysis, generalizability, pertinence, and results. The scales byYusoff (2010 as cited Hassan, Pinkwart, & Shafi, 2021) and Khowaja et al. (2017 as cited in Hassan, Pinkwart, & Shafi, 2021)have overlapping frameworks. The

frameworks consist of incremental learning, attention span, learner control, intermittent feedback, ASD symptoms and behaviors, game mechanics, dynamics, storytelling, user achievement, debriefing, etc.

Each game is scored based on the scale'scriteria (Connolly et al., 2012, as cited in Hassan, Pinkwart, & Shafi, 2021). With three being the highest score (having the most attributes) and one the lowest (having the least attributes). The authors developed a scale based on the works of Yusoff and Khowaja. With two being the highest score and zero being the lowest score. All of the games are rated by totaling their attributes. The maximum score obtained on the Yusoff scale is 24, whereas 40 is the maximum score for the Khowaja scale. The higher the score,the more attributes are present. The correlation between all three scales came out weak, indicating that the three scales measure different characteristics (Hassan, Pinkwart, & Shafi, 2021)

Overall, the literature review demonstrates that computer-based interventions are effective. Furthermore, the literature indicates that serious games can improve attention and visual perceptual skills. This study indicates that computer-based interventions can potentially enhance the social and emotional skills of individuals with ASD.

Grossard, Grynspan, Serret, Jouen, Baily, and Cohen (2017) conducted a literature review concerning serious games developed to teach social interactions to the population of interest. The study focuses on the games' principles and theories, clinical validations, and design/playability. All 31 selected articles are in English and published between 2001-2014.

The article selection process is based on the following criteria: 1) reports on serious games,2) reports on serious games that focus on social interactions training, and 3) targets the population of interest. Grossard et al. (2017) evaluated each article using the Connolly scale (Connolly et al., 2012 cited by Grossard et al., 2017). The Connolly scale (2012 as cited by Grossard et al., 2017) adheres to the following criteria: type of study, methods, analysis, generalizability, pertinence, and results. Each game is scored on a scale of one to three, with the lowest score as one and three being the highest. The maximum total score is 15 for the Connolly scale.

The attributes of each game are summarized using Yusoff's scale (2010 as cited by Grossward et al., 2017). The conceptual framework by Yussoff proposes a list of attributes such as incremental learning, intermittent feedback, attention span, scaffolding, etc. These same attributes were used to create a scale by the authors. The scale ranges from zero to two, with zero being the lowest score and two the highest. The maximum score obtainable is 24. High scores indicate that the game has conceptual complexity and a well-written description.

The interclass correlation coefficients (ICC) for the Connolly scale yields .95 and .90 for the Yusoff scale. The correlation between the Yusoff and Connolly scale yields a weak correlation of 0.3. Therefore, indicating that both scales assess for different characteristics.16 studies focus on emotion recognition or production, while the remaining focuson social skills. Six serious games are designed for Asperger's or high functioning autism. Good reading skills are a requirement for two selected games. Ten gameswere assessed with the population of interest. Seven studies include a control group, including some with a sample of 30 plus. Because only four studies were randomized,only one study was found that consisted of a control group and an ASD group matched on developmental age and diagnosis. In regards to efficacy, six games demonstrate improvement after training. However, these results cannot be generalized to the whole autism spectrum, given how limited the samples are. Furthermore, the studies could not demonstrate clinical relevance meaning that scores on a social interactions measure (e.g., ADOS or Vineland) did not improve even after playing a game that focuses on social interaction skills.

Grossward et al. (2017) found that many games were created for Asperger's or high functioning autism, making it inaccessible to the rest of the spectrum. Because some games require good reading skills, it makes them inaccessible to many children on the spectrum. Although some games compensate with oral explanations, it may be difficult and limited for children with severe ASD. Few games focus on nonverbal communications such as face-to-face contact and eye contact, making it relevant for high functioning and low functioning autism. This study finds that many serious games have limited clinical validation. 16.1% of games arenot tested on participants with ASD. 12.5% have a small sample of participants with ASD. Some studies only report on the enjoyability of the games butnot the effectiveness. Based on evidence-based guidelines, the authors find that the overall quality of the selected articlesispoor. Many studies have a small sample which limits the authors to draw a definite conclusion.

Because many studies are short-term, long-term efficacy is limited. Many studies did not have matching control and experimental groups. Further, not many studies address the concern of transferring acquired skills. The authors highlight the concern of defining a standard framework for serious games. Most of the games emphasizetherapeutic objectives but do not emphasize on accessibility or enjoyability of the game. This suggests that future studies need to focus more on game design in creating a standard framework.

Critical Analysis

The literature review by Hassan, Pinkwart, and Shafi (2021) evaluated 40 serious games using three different scales. Therefore, analyzing each selected literature is more rigorous than most literature reviews. The

authors demonstrate that computer-based interventions are effective. This study indicates that the attention and visual perception skills of children with ASD can be enhanced with serious games.

However, the study by Hassan, Pinkwart, and Shafi (2021) has a few limitations. All of the games evaluated are in English therefore, limiting the generalizability of the results. Most selected studies focus on children who are 10-years-old or younger or concentrate on games developed for high functioning autism or Asperger's syndrome, limiting the generalizability of the results. A majority of the serious games lack clinical validation. Many have small sample sizes with short training periods. Therefore, the results of these games cannot be generalized to the entire population of interest, considering that ASD varies on the spectrum (Hassan, Pinkwart, & Shafi, 2021)

The results obtained do not indicate any certainty that learning or mimicking emotions can be transferred from a game to real-life conversations or situations. Therefore, it is suggested that future development of games include progress levels that are similar to routine social interactions (Hassan, Pinkwart, & Shafi, 2021). Doing so will better enable the transfer of learned emotions to everyday routines. Furthermore, better results can be obtained if games include a storyline and reward system to motivate users.

Grossard et al. (2017) conducted a literature review of 31 serious games. The articles' selection was basedon the following criteria: principles and theories, clinical validations, and designs/playability. They were makingthe selection process more rigorous than most literature reviews. All selected articles are evaluated by using three different scales. Therefore, making the analysis of each article more rigorous.

The authors believe that serious games can be promising. Serious games can support many skills training and enhance interactions in diverse contexts and situations, including those similar to real life. However, the selected articles have limitations in regards to clinical benefits. Because all of the games are in English, it limits the generalizability of the results. Most serious games are created for high-functioning ASD. This limits the generalizability of the results and potential benefits to those in the lower half of the spectrum. The clinical validation of the games rarely meets evidence-based medicine standards.16% of the games did not examine the ASD population. One serious game was not clinically tested. Therefore, compromising the integrity of the results. Most studies rarely disclose their game designs which limit the interpretation of the results. Finally, the clinical validation of the games and the playability/game design are incompatible in most cases.

It is suggested that future studies become more robust. More studies need to emphasize game design and create a specific and standardized framework. Future studies should consider nonverbal communications as an objective. Furthermore, clinical experts and game design experts need to collaborate more to maximize the potential benefits of serious games.

IV.   DISCUSSION

Summary of the Findings

In 2018, Papoutsi, Drigas, and Skaianis conducted a comprehensive literature review of 29 mobile applications. These mobile applications were developed to enhance the E.I. of the population of interest. The authors conclude that mobile applications have the following advantages: 1) Mobile applications are user-friendly to navigate; 2) Mobile applications with touch screen features make the application accessible to children with comorbid diagnoses such as intellectual disabilities and sensory-motor difficulties; 3) Mobile applications provide a consistent and predictable learning environment due to being visually engaging (Shane & Albert, 2008 cited in Papoustsi et al., 2018); and 4) Mobile devices are easily transferrable (Papoustsi et al., 2018).

The authorssuggest that E.I. can be enhanced with emotion-aware apps by enabling better integration of social contexts. Mobile applications that focus on emotions assist in better understanding the minds of others, reduce experiencing negative situations and interactions, and decrease psychiatric comorbidity (Papoustsi et al., 2018). Furthermore, mobile applications enable caregivers, educators, and parents to understand betterand determine better-informed decisions (Gay & Leijdekkers, 2014 as cited in Papoustsi et al., 2018).

Mesa-Gresa et al. (2018) conducted an evidenced-based systematic literature review examining clinical and technical databases. Because of the nature of research and the limits of technology, many studies were short-term exposure pilots. Therefore, the authors did not expect to find,nor did they obtain,significant outcomes.

The study consists of 602 participants. The E.G.s consists of 85.15% male and 14.85% female. The age range is 3-20 (Mesa-Gresa et al., 2018). 55.26% of the articles focuson emotional and social skills (Mesa-Gresa et al., 2018). 30 articles indicate that VR-based treatment improves at least one of the seven addressed objectives (e.g., attention, social skills, emotions, emotion recognition, etc.). Ten articles demonstrate significant improvement. Overall, this study finds that VR-based interventions are moderately effective. However, due to the absence of definitive findings, it cannot be said that VR-based interventions can improve or complement the results of traditional treatments (Mesa-Gresa et al., 2018).

Bellani et al. (2011) conducted a literature review that evaluates the effectiveness of virtual reality. Eight studies are examined using the participants' information and testing processes. This study finds that V.R.

environments provide the opportunity to learn, repeat, and perform specific tasks (Chittaro & Ramon, 2007 as cited in Bellani et al., 2011).

Because V.R. environments are stimulated realities, it enablesan individual with ASD to learn essential skills and increases the likelihood of transference (Strickland et al., 1997; McComas et al., 1998; Wang & Reid, 2010 as cited in Bellani et al., 2011). Seven studies suggest that children with ASD acquire new information usingV.R. environments, such as learning how to use the equipment. Performance improvementis noted. (Strickland et al., 1996; Strickland, 1997; Parsons et al., 2004 as cited in Bellani et al., 2011). In conclusion, Bellani et al. (2011) find thatV.R. interventions can potentially assist caregivers and educators to enhance the daily social behaviors of loved ones diagnosed with ASD.

Hassan, Pinkwart, and Shafi (2021) conducted a literature review that examines 40 serious games. The games were developed with the intent to improve social behaviors. The games' designsare evaluated based on the literature's conceptual framework. The quality of each serious game is based on the following: 1) data;2) target population;3) if the game itself is based on a specific model or treatment framework;4) different variables (e.g., population, sample size, etc.); and 5) the clinical validation of each game (Hassan, Pinkwart, & Shafi, 2021).

Three different scales were used for evaluation. These scales include the Connolly scale (Connolly et al., 2012 as cited in Hassan, Pinkwart, & Shafi, 2021), Yusoff's scale (2010 as cited Hassan, Pinkwart, & Shafi, 2021), and Khawaja's scale (Khowaja et al., 2017 as cited in Hassan, Pinkwart, & Shafi, 2021). Each game is evaluated using the Connoly scale's criteria (Connoly et al., 2012,as cited in Hassan, Pinkwart, & Shafi, 2021). The authors developed a scale based on the works of Yusoff and Khowaja. All of the games were rated by totaling their attributes. The maximum score obtained on the Yusoff scale is 24, whereas 40 is the maximum score for the Khowaja scale. The higher the score, the more attributes are present. The correlation between all three scales came out weak, indicating that the three scales measure different characteristics (Hassan, Pinkwart, & Shafi, 2021). Overall, the study demonstratesthat computer-based interventions are effective. Serious games can improve attention and visual perceptual skills,enhancing the social and emotional skills of individuals with ASD.

Grossard et al. (2017) conducted a literature review concerning serious games developed to teach social interactions. 31 articles were evaluated based on the games' principles and theories, clinical validations, and design/playability. Grossard et al. (2017) assessed each article using the Connolly scale with a maximum score of 15 (Connolly et al., 2012 as cited by Grossard et al., 2017). The attributes of each game are outlined using Yusoff's scale with a maximum score of 24 (2010 as cited by Grossward et al., 2017). The higher the score on each scale, the more conceptually complex and better description each game has. The interclass correlation coefficients (ICC) for the Connolly scale yields .95 and .90 for the Yusoff scale. The correlation between the Yusoff and Connolly scale yields a weak correlation. Therefore, indicating that both scales assess for different characteristics.

This study finds that many serious games have limited clinical validation. 16.1% of the games are not tested with the population of interest. 12.5% have a small sample of participants with ASD. Some studies report the enjoyability of the games instead of the effectiveness. Based on evidence-based guidelines, the authors find that the overall quality of the selected articlesispoor. Many of the studies have a small sample which limits the authors to conclude

Because many of the studies are short-term pilots, long-term efficacy is limited. Many studies do not have matching control groups and experimental groups. Further, not many studies address the concern of transference. Thestudy highlights the concern of defining a standard framework for serious games. Most of the games emphasizethe therapeutic objectives but not on the games' accessibility or enjoyability. This suggests that future studies need to focus more on game design to create a standard framework.

Interpretation of Findings

The purpose of this literature review was to determineif mobile applications, virtual reality, and games would be deemed effective in enhancing E.I. among children with ASD.Papoutsi, Drigas, and Skaianis (2018) thoroughly reviewed 29 mobile applications currently used by the population of interest. Because this study was purely conceptual, mobile applications may be a promising approach in enhancing E.I. among children with ASD. However, no definitive conclusion can be made since no statistical testing was run. There is no objective data that can be used to deem mobile applications as effective.

Mesa-Gresa et al. (2018) suggest that virtual reality may be moderately effective. Ten studies demonstrate significant results, and 30 articles find that one of theseven addressed attributes improves with V.R. However, the results obtained cannot determine if V.R. can surpass or complement traditional therapy. Seven of the studies evaluated by Bellani et al. (2011)suggest that individuals with ASD can acquire new information with V.R. This study, in particular, found that because V.R. is similar to reality,it can potentiallyenable the transference of acquired skills. Overall, the results suggest that V.R. is effective to some extent; however, it may be more effective than the current literature is,meaning, therefore, more research needs to be conducted.

Hassan, Pinkwart, and Shafi (2021) evaluated a total of 40 serious games. The games were developed with the intent to improve social behaviors. This study found that computer-based interventions are effective.

Attention and visual perceptual skills can be enhanced with the use of computer intervention games. The improvement of attention and visual perceptual skills can, in turn,improve social and emotional skills. Grossard et al. (2017) reviewed a total of 31 serious games. The games were developed with the intent to teach social interactions to children with ASD. Overall, this study found that the quality of most serious games is poor. Most of the games did not have clinical validation. The authors could not draw a definitive conclusion. Because the previously mentioned studies contradict each other serious games cannot be deemed as effective.

Limitations of the Study

Limitations of this study include the limited research concerning technology in enhancingE.I. among children with ASD. In particular,little research strictly concerns itself with mobile applications, virtual reality, and games. Many of the research that has been conducted are literature reviews. There are few empirical studies. Therefore, the author had to use literature reviews that may influence the interpretation of the results because the interpreted results were under the influence of other authors' personal biases and subjectivity.

Further, the present literature review is a qualitative study and depends heavily on the author's skills. As such, the results may be influenced by the author's personal biases and idiosyncrasies. Many of the studies focused on the whole autism spectrum instead of one aspect of the spectrum. This could have affected the results considering that the autism spectrum varies.

Recommendations

It is recommended that more empirical studies be conducted in the future. More research needs to be done concerning mobile applications to determine theireffect in enhancing E.I. and the transference of acquired skills from a mobile application to reality. Future studies should examine itsimpact on E.I. while investigating virtual reality and consider its effectiveness in transferring acquired skills to reality. More research needs to be generated evaluating if virtual reality surpasses or compliments traditional therapy for ASD. In particular, a study should consider comparing role-playing to virtual reality and determine if both interventions can complement each other. More research needs to be generated concerning serious gamesto establish a standard framework and attributes. In selecting a standard framework and attributes, then the effectiveness of serious games can be determined. Further, more scales that assess for the same characteristics should also be standardized.

Conclusions

This literature review sought to determine if mobile applications, virtual reality, and games can enhance emotional intelligence among the pediatric population with ASD. Based on the current literature,the author could not determine a definitive conclusion. Therefore, the results are inconclusive. The existing literature is conceptual, has little to no objective data, or contradicts one another.

The results are inconclusive; it illustrates the need for more research to determine the effectiveness of certain technological modalities in treating ASD. It is vital to evaluate the effectiveness of certain technological modalities because 1) technology is advancing, and 2) technology is slowly but surely being integrated into mental health treatment. It would be in the best interest of mental health practitioners and researchers in learning how to maximize the benefits of technology by first determining which technological modalities are most effective. Furthermore, mobile applications, virtual reality, and serious games may be a great addition to traditional therapy for ASD.

Research must determine how technology can be used in enhancing the E.I. of children with ASD. Research concerning ASD and E.I. has determined that children with ASD have marked deficits in E.I.E.I.is an essential human component., It enables people to manage their emotions, understand others, and play a part in peoples' success. The interpersonal and intrapersonal skills that compose E.I. play a significantrolein the day-to-day lives of people. Therefore, if E.I. can be enhanced,then the interpersonal and intrapersonal skills of children with ASD can also be improved, enhancing their overall quality of life.

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