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Immersive Virtual Reality to Improve Police Interaction Skills in Adolescents and Adults with Autism Spectrum Disorder: Preliminary Results of a Phase I Feasibility and Safety Trial

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Abstract. Individuals with social and cognitive challenges, including autism spectrum disorder (ASD), are at elevated risk of poor outcomes when interacting with police. This paper describes safety and feasibility testing for an immersive virtual reality (VR) application designed to teach essential skills for interacting with law enforcement (Floreo Police Safety Module; PSM). First, we present evidence that using immersive VR in verbally able adolescents and adults with ASD is feasible. Of 28 participants, 100% were able to complete one session of Floreo PSM. Second, we show that Floreo PSM is safe; no severe adverse events occurred during or after study participation. Third, we report that Floreo PSM is highly usable. An industry-standard measure of usability – the System Usability Scale (SUS) – was carefully modified to meet the particular needs of our clinical sample, resulting in an improved SUS-ASD. The SUS-ASD demonstrates good internal reliability and broad range, with scores that are statistically independent of age, IQ, and autism symptomology. In Phase II of this government-funded research project, we will test the efficacy of Floreo PSM to improve targeted behaviors during a live police interaction, and will conduct a community-based randomized controlled trial that lays the groundwork for deploying Floreo PSM to schools, homes, clinics, prisons, and halfway houses. The long-term goals of this project are to improve safety outcomes for vulnerable civilians while reducing stress on law enforcement personnel.

Keywords. Autism spectrum disorder, ASD, immersive virtual reality, police, law enforcement, intervention, feasibility, safety, system usability

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1. Introduction

Autism spectrum disorder (ASD) is characterized by social communication deficits and repetitive behaviors/restricted interests that significantly impair everyday functioning [1]. Despite many overarching commonalities in ASD, heterogeneity is the rule. While ASD is clearly recognizable in some individuals, particularly those who are minimally verbal (approximately 30% of children with ASD never acquire fluent speech [2]) or produce visible motor stereotypies such as hand flapping, others have less recognizable symptoms, and may initially appear unaffected to the naïve observer. This apparent “normalcy” could be problematic when individuals with ASD are required to interact with strangers during low-likelihood, high-impact and/or high-risk events like crimes, fires, or natural disasters.

Most autism research focuses on children, but ASD is a lifelong condition that persists into adulthood. As children with ASD mature into their late teens and 20s, and begin to engage with the public sphere, it is increasingly likely that they will interact with public servants, including police officers. Given adequate preparation, many individuals with ASD are capable of handling a wide variety of situations (e.g., maintain a job, go to the store, take public transportation, etc). Much of this preparation is accomplished through supported practice, wherein role-playing and repetition help solidify adaptive behavior patterns [3]. However, supported role-playing and repetition are more difficult for certain scenarios that have a very low likelihood of occurring, but carry high risk when they go poorly. Novel approaches are necessary for teaching appropriate skill sets for these types of interactions. In this paper, we focus on police encounters.

Civilian fatalities at the hands of police are more common in the United States than any other developed country [4]. Furthermore, these fatalities disproportionately affect people with disabilities [5]. In recent years, police departments have aimed to heighten their own autism awareness and safety protocols via training videos, in-person seminars, and informational pamphlets. However, given that 1 in 5 young adults with ASD will be stopped and questioned by police before age 21 [6], it is critical to prepare individuals with ASD themselves for police interactions. Existing text-based curricula and educational videos available for individuals with ASD rarely involve active participation, reducing potential generalizability to actual encounters with police. Training that involves direct practice (role-playing) in a simulated real-world environment has significant potential to improve police interaction skills more effectively than traditional approaches.

The Floreo Police Safety Module (PSM) uses next-generation mobile immersive virtual reality (VR) to help adolescents and adults with ASD acquire critical safety skills when interacting with law enforcement (e.g., keeping hands in sight, looking at officers when they speak). The Floreo system is unique; its paired design includes an iPhone in an inexpensive VR headset, and an iPad that is wirelessly linked to the iPhone in real time. Thus, while participants wear the headset and participate in an immersive virtual environment, the monitor (e.g., teacher, parent, therapist) is able to see what the participant sees, and can provide live feedback. Furthermore, monitors are able to control certain aspects of the virtual environment from the Floreo iPad platform, further personalizing the Floreo PSM experience.

Here, we report results from Cycle A of a Phase I safety, feasibility, and usability trial designed to determine whether Floreo PSM is appropriate for use with verbally

able adolescents and adults with ASD. This project lays the groundwork for future efficacy testing to assess whether Floreo PSM improves real-world police interaction skills (Phase IIa). Finally, a community-based randomized controlled clinical trial will test the community-based efficacy of Floreo PSM for improving police interaction skills, as compared with video-based instruction (Phase IIb).

2. Methods

This on-going safety and feasibility trial is being conducted at the Center for Autism Research (CAR) at the Children’s Hospital of Philadelphia (CHOP). All aspects of the research protocol were approved by the CHOP Institutional Review Board. Adult participants provided written informed consent to participate in the present study, while the parents of adolescent participants and some legal guardians of adult participants provided written informed consent on the participants’ behalf. All participants, regardless of age, were informed that they could cease participation at any time, for any reason, without consequence, and that participation was entirely voluntary.

Participants. Twenty-eight individuals with ASD have participated in Cycle A to date. Demographic information, family/medical history, and clinical characterization questionnaires were completed online in advance, with IQ estimates derived at the study visit (Wechsler Abbreviated Scales of Intelligence (WASI-II); [7]; Table 1). Participants were included if they were 12 years of age or older, had a documented diagnosis of ASD, and had full-scale IQ estimates in the average range (>75; 2 missing). Participants were excluded if they had a known genetic syndrome, blindness or deafness, strabismus or eye muscle problems, had previously undergone eye surgery, had been hospitalized for a concussion or other brain-related problem, had medical conditions like Fetal Alcohol Syndrome, brain injury, stroke, or brain tumor that could affect cognitive, sensory, or motor functioning, or reported a personal or family history of seizures, migraines, or vertigo. A technology experience questionnaire revealed that 29% of participants had never used VR before, 54% had used VR ‘rarely’ or ‘occasionally’, and 23% of participants had used VR ‘frequently’ or ‘very frequently’.

Table 1. Participant characteristics. AQ = Autism quotient, self-report (1 missing) [8]; SCQ = Social Communication Questionnaire, parent/guardian report (2 missing) [9]; higher scores = greater impairment; SD = Standard deviation.

	Age (years)	Full-scale IQ	AQ score	SCQ score
Mean (SD)	16.36 (5.99)	100 (11.31)	25.37 (8.82)	18.27 (6.84)
Min-Max	12-37	76-120	12-40	7-30

Materials. Equipment for this study included an iPhone, iPad, lightweight head mounted display (HMD), and the Floreo PSM software application. Floreo PSM is a mobile immersive virtual environment that includes interactive police officers (1 or 2, male/female, diverse appearances) and background distractors (e.g., cars driving by, dogs barking in the background). The PSM includes multiple scenarios, including an officer walking by without interacting, officers approaching the participant and asking about current or recent activity, and officers asking for personal information (i.e., “What’s your name?”). There are also daytime and nighttime scenes. Officer speech is pre-recorded, but can be controlled to some extent by the monitor. For example, if the

participant does not reply to a question, the monitor can press a button that prompts the officer to say, “Did you hear me?”



Figure 1. Example screen shot of the Floreo PSM virtual environment and police officers.

Procedure. Participants engaged in one session of Floreo PSM in a quiet room at the Center for Autism Research, with trained study staff. This session included approximately 8 total minutes of VR, with breaks approximately every 2 minutes. After the session, participants completed a questionnaire about system usability and reported any side effects in a qualitative interview. *Statistical approach.* Three primary outcome variables were assessed: Feasibility, safety, and system usability. Feasibility was gauged by measuring the percentage of participants who successfully completed an entire session of Floreo PSM. Safety was assessed via a self-report questionnaire item about side effects, a post-VR qualitative interview, and through clinical observation of behaviors that might indicate side effects (e.g., eye rubbing). Safety included recording whether Serious Adverse Events (adverse events requiring a visit to a hospital Emergency Department) or mild Adverse Effects (e.g., persistent headache, nausea, dizziness) occurred during or immediately after Floreo PSM. System usability was measured using the industry-standard System Usability Scale [10], modified for participants with ASD. In this study, we set satisfactory usability criteria as group mean SUS scores > 70, and measured internal reliability via Cronbach’s alpha. Spearman’s Rho assessed relationships between system usability scores and age, IQ, and autism symptoms.

3. Results

Feasibility. All 28 participants who began Floreo PSM completed the entire session (100%), suggesting that immersive VR utilizing a lightweight HMD is highly feasible in verbal adolescents and adults with ASD. Evidence of feasibility was found for individuals with milder autism symptoms as well as for participants with greater symptomology and worked equally well for participants with lower IQ estimates and higher IQ estimates within our participant IQ range.

Safety. No serious adverse events occurred, defined as events requiring hospitalization. Two brief headaches were reported, which resolved upon follow-up the next day. Twenty-seven out of 28 participants (96%) responded “no” when asked whether negative side effects (like serious nausea or disorientation, or fear and anxiety) were bad enough that they wouldn’t use the app again.

System Usability. The System Usability Scale (SUS) is a widely used measure of usability that is designed to be modified to fit the parameters of individual systems [10]. It consists of 10 questions that alternate wording in opposite directions, to control for positive response biases and to reduce the likelihood of automatic responding without reading (e.g., circling all 5s without reading each question). The SUS is coded on a 1-5 Likert scale. In the course of running the first 12 participants through Floreo PSM, it became clear that a significant percentage of participants were not picking up on reverse-worded questions, and were responding in ways that contradicted their earlier answers. For example, two items asked exactly the same question with reversed wording: (3) “The app was easy to use”; and (8) “The app was too hard to use”. Of 12 participants, 4 (33%) gave these two questions contradictory or inconclusive ratings. Importantly, we found that this pattern covaried with participant clinical phenotype. SCQ scores were nearly twice as high in participants that rated these two questions inconsistently or inconclusively (Mean=23.00) vs. participants who rated them consistently (Mean=12.66), suggesting that autism symptom severity was related to difficulty switching back and forth from positively to negatively worded questions. Given significant prior research showing attention switching challenges in children, adolescents, and adults with ASD [11] our study team assembled a panel of expert autism researchers and clinicians to determine whether the original format of the SUS was appropriate for this clinical population, and to advise on possible changes. The result of this effort was the SUS-ASD, which has been administered to 16 participants.

The SUS-ASD is collected on paper and presents statements about “this VR” rather than “the app”. Standardized instructions are read to participants beforehand to ensure that they understand the purpose of the SUS and understand the way the questions are rated (1 = lowest, 5 = highest). A visual aid was added at the top of the page; a sad face emoticon was placed on the left side of the scale (indicating disagreement with each statement) and a happy face emoticon on the right side (indicating agreement with each statement). Due to the elimination of negatively worded questions, the SUS-ASD has a simplified scoring system (item scores are reduced by 1 to render the scale 0-4, summed, and multiplied by 2.5 for interpretability; final range is 0-100). Potential concerns with the new format include the “audience effect,” wherein typically developing participants change their behavior to please or impress observers, resulting in artificially high ratings. However, research suggests that individuals with ASD are less susceptible to performance changes in the presence of an audience [12], thus reducing this concern in our sample. Second, it is possible that participants will generate homogeneous positive responses (e.g., straight 4s or 5s)

because they do not read each question individually. To check this possibility, we examined intra-question range. We found that participants were still willing to give low ratings on the SUS-ASD (40% of questions received at least one score of 1 or 2, 80% of questions received at least one 3, and only 20% of questions received only 4s and 5s). Finally, there is the possibility that changing the wording of questions in the SUS-ASD could reduce internal reliability relative to the original SUS. However, we found that Cronbach's alpha is in the "good" range for the SUS-ASD (Mean = .81; 95% CI: .68-.95).

Results from 16 participants tested thus far reveal that average participant score on the recoded SUS-ASD is 85.00 (N=16), with a standard deviation of 12.42 and a median score of 88.75. Scores range from 52.5 to 100, demonstrating good range. Seventy-five percent of participants rated average usability at 80% or higher, which corresponds to a rating of 4 on a 1-5 scale. Chronological age, full-scale IQ, AQ scores, and SCQ scores did not significantly correlate with SUS-ASD scores (all $ps > .05$). These preliminary results indicate that Floreo PSM has good system usability, and that usability ratings are independent of clinical phenotype in our sample of verbal adolescents and adults with ASD.

4. Discussion and Conclusion

The preliminary results of this on-going Phase I trial suggest that Floreo PSM is safe and feasible for use with verbal adolescents and adults with ASD, laying the initial groundwork for deploying Floreo PSM to homes, outpatient clinics, schools, prisons, and halfway houses. The newly developed SUS-ASD demonstrates good internal reliability, and participant ratings thus far strongly suggest that Floreo PSM is a usable system. Of note, the new SUS-ASD was developed and administered with advice from a panel of expert clinical psychologists and researchers and will be valuable for other groups interested in collecting technology usability ratings from verbally able adolescents and adults with ASD. Future iterations of this innovative mobile VR technology will include adaptations for individuals with neurodevelopmental and psychiatric conditions other than ASD. Floreo, Inc.'s unique approach holds promise as an inexpensive, flexible, scalable platform for future social and community skills interventions targeting a variety of social and behavioral needs across multiple populations, and serves the critical long-term goal of improving safety outcomes for vulnerable civilians while reducing stress on law enforcement personnel.

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