Insights into Building VR Solutions in the Police Domain

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Abstract: Advanced technologies such as Virtual Reality (VR) hold immense significance for society, particularly in the law enforcement domain. VR offers a unique platform for immersive, experiential learning, allowing Police Officers (POs) to engage with dynamic scenarios that mirror real-world situations, incidents, and challenges. In the Police domain, the integration of VR solutions provides valuable insights into enhancing POs' training, situational awareness, and community relations. Learning objectives in VR-based Police training encompass a spectrum of skills, including decision-making under pressure, effective communication and collaboration, and de-escalation techniques. Furthermore, evaluation perspectives span both quantitative and qualitative measures, assessing training efficacy, officer performance, and societal impact. This research adopts a systematic literature review approach where it becomes evident that the future of VR-enabled policing lies in interdisciplinary collaboration, technological innovation, and ethical considerations. Future directions entail refining VR solutions to reflect evolving societal dynamics, integrating Artificial Intelligence (AI) for adaptive scenario generation and analytics, and addressing concerns related to algorithmic transparency, fairness, security, and privacy. By leveraging VR technologies, law enforcement agencies can enhance operational effectiveness and foster trust, accountability, and responsibility within the communities they serve.

Keywords: Police, Law enforcement, Police conflict, Police bystander, Virtual Reality

1. Introduction

"Why shouldn't' people be able to teleport wherever they want?" (Palmer Luckey)

In recent years, law enforcement agencies witnessed a significant surge in the number of conflicts and crises that POs need to address. This trend can be attributed to a multitude of factors, including socio-economic disparities and the erosion of trust between communities and law enforcement. Furthermore, the rise of social media and the widespread availability of video-recording devices brought increased scrutiny to police actions, amplifying tensions, and fueling public distrust. This erosion of trust made it more difficult for POs to effectively communicate and establish rapport with the communities they serve, potentially exacerbating conflicts. Additionally, socio-economic factors like poverty, unemployment, and lack of access to education and healthcare contributed to an environment ripe for civil unrest and criminal activity. POs are frequently called upon to address such issues and deal with their implications and consequences. This requires training programs that emphasize communication skills, emotional intelligence, and scenario-based simulations. By equipping POs with the tools to deal with or defuse tense situations, law enforcement agencies can reduce injuries, legal liabilities, and negative publicity, while fostering stronger relationships with the relevant communities. Hence, the development and deployment of VR solutions for training and support of POs in a responsible and trustworthy manner is imperative as this approach offers a unique opportunity to create immersive, scenario-based simulations that closely mimic real-world situations, allowing officers to practice and refine their skills in a safe and controlled environment (Giessing, 2021). In this digital environment, POs are exposed to various situations, from de-escalation to crisis intervention, thus their decision-making abilities, communication skills, and emotional intelligence can improve allowing them to deal with high-stress events effectively (Zechner et al., 2023). Moreover, using VR in police training can foster a culture of responsibility and trustworthiness by supporting accountability and transparency in a human-centered approach that integrates individual needs, include input from diverse community stakeholders, and prioritize ethical considerations while ensuring their adherence to established law enforcement protocols and practices (Xie et al., 2021; Maathuis, 2023). This calls for a systematic development of VR solutions in the Police domain and directly implies a comprehensive analysis of the underlying dimensions, methods, and techniques considered. To the best of our knowledge, such an approach is lacking in the existing body of knowledge. To address this gap, this research reflects on existing learning objectives and evaluation mechanisms considered, and further gathers lessons learned and prospective avenues for building responsible VR solutions within the Police domain. The overarching aim is to both garner valuable insights into prevailing research methodologies and solutions, and further also to foster a deeper understanding of how responsible and trustworthy VR solutions can be developed in the Police domain to bolster security and safety endeavors. To this end, the following research questions are formulated:

- **RQ 1:** What are the learning objectives of existing VR solutions in the Police domain?
- **RQ2:** What are the evaluation mechanisms considered to assess the effectiveness of the VR solutions proposed?

- **RQ 2:** What are the lessons learned and future perspectives for building responsible VR solutions?

To this end, this research conducts a systematic literature review following the principles of the PRISMA methodology as outlined by Page et al. (2021). This approach enables the extraction of valuable insights and future perspectives essential for informing the development of VR solutions finely tuned to meet the unique needs of law enforcement agencies while assuring their development and deployment in a responsible and trustworthy manner.

The outline of the article is structure as follows. In Section 2, the research approach considered is addressed. In Section 3, the learning objectives of existing VR gaming solutions in the Police domain are presented. In Section 4, a comprehensive analysis is adopted to discuss existing evaluation mechanisms used when developing and deploying such solutions. In Section 5 are captured lessons learned that could be of use when building future VR solutions in the Police domain in a responsible manner. Concluding remarks and future perspectives are outlined in Section 6.

2. Research Methodology

The aim of this research is to capture learning objectives, lessons learned, and future perspectives in relation to building responsible VR solutions in the Police domain. It does that to provide insights into existing research approaches and solutions, and to further contribute to efforts that aim at building responsible and trustworthy digital technologies and solutions for security and safety purposes. Accordingly, the following research questions are formulated:

- **RQ 1:** What are the learning objectives of existing VR solutions in the Police domain?
- **RQ2:** What are the evaluation mechanisms considered to assess the effectiveness of the VR solutions proposed?
- **RQ 2:** What are the lessons learned and future perspectives for building responsible VR solutions?

To capture valuable insights and future perspectives when developing VR solutions in the Police domain, a systematic literature review approach is undertaken, following the structured methodology outlined by Denyer and Tranfield (2009). This approach starts with the delineation of objectives, followed by the identification of research studies, in-depth analysis of relevant literature, and ultimately, the presentation of the results gathered. By adhering to the guidelines outlined in the PRISMA methodology, robust data collection is ensured, utilizing the PRISMA 2020's stage flow diagram for meticulous data collection, screening, and analysis (Page et al., 2021). Then valuable insights and future perspectives are extracted to guide the development of VR solutions tailored to the specific requirements of law enforcement agencies. Hence, the following research steps are considered and are depicted in Figure 1 below:

Step 1: Identification: In this step, studies were chosen using various combinations of keywords such as *VR, virtual reality, law enforcement, police, policing, criminal justice, police conflict,* and *police bystander*. Only articles in English were included in the search, conducted across the ACM, IEEE Digital Library, Web of Science, Wiley, and the first ten pages of Google Scholar scientific databases. The search timeframe was restricted to the period between January 1, 2015, and December 31, 2023. As a result, the initial findings yielded 1887 articles, of which 76 duplicates were identified and promptly eliminated.

Step 2: Screening: In this step, the studies were screened based on their abstract, title, and keywords, applying criteria such as relevance to the topic and direct relevance to VR and Police domains for exclusion. Consequently, a final set of 20 studies was selected for further in-depth review.

Step 3: Inclusion: During this step, the final selected 20 research studies are in-depth examined and summarized in Table 1 below:

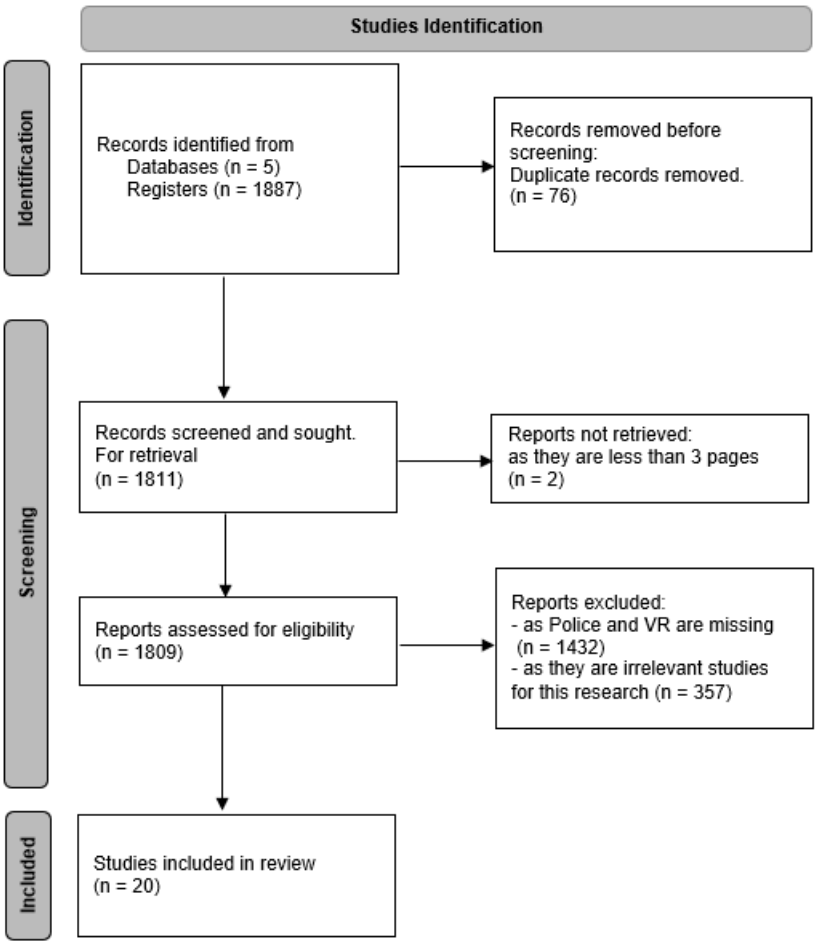

Figure 1: Research approach

Table 1: Information about the studies selected

No	Title Study	Year	Research Aim	Research Type	Reference
1	Virtual Reality Training of Law Enforcement Officers in Predicting Terroristic Attacks Indicators	2022	To design a VR-based serious game for Police training for the identification of suspicious terrorist activities.	Application	Soldatos et al., (2022)
2	Validating Virtual Reality as an Effective Training Medium in the Security Domain	2019	To assess the effectivity of a VR training for LEAs (Law Enforcement Agencies) and first responders, and compare the results in relation to conducting the same exercises without VR in live settings.	Application	Saunders et al., (2019)
3	Trusted Virtual Reality Environment for Training Security Officers	2023	To build a VR-game for training LEAs and security professionals in the analysis and prediction of potentially terroristic activities.	Application	Pantazidis et al., (2023)
4	Exploring VR Training for First Responders	2020	To explore VR training challenges and review four public safety VR scenarios.	Position/Review	Haskins et al., (2020)

No	Title Study	Year	Research Aim	Research Type	Reference
5	The Impact of Virtual Reality in the Social Presence of a Virtual Agent	2020	To assess the impact that a social interaction with an Intelligent Virtual Agent has on subjects across different mediums with different immersion levels.	Application	Guimarães et al., (2020)
6	Virtual reality for law enforcement training: a demonstration and implication for dispatch priming	2022	To assess the impact of a VR-intervention in a case of dispatch priming.	Application	Potts et al., (2022)
7	Virtual reality training for police officers: a comparison of training responses in VR and real-life training	2024	To assess VR SBT in VRT training of POs.	Application	Kleygrewe et al., (2024)
8	Can a Virtual Reality Training Scenario Elicit Similar Stress Response as a Realistic Scenario-Based Training Scenario?	2024	To assess if a VR training scenarios would elicit a similar stress response as a realistic scenario-based training scenario.	Application	Martaindale et al., (2024)
9	Deep-Breathing Biofeedback Trainability in a Virtual-Reality Action Game: A Single-Case Design Study with Police Trainers	2022	To assess response inhibition in police-decision making contexts.	Position/Review	Michela et al., (2022)
10	A Virtual Reality Embodiment Technique to Enhance Helping Behaviour of Police Toward a Victim of Police Racial Aggression	2019	To explore the effectiveness of VR embodiment techniques in reducing implicit racial bias among POs.	Application	Kishore et al., (2019)
11	The Cycle of Violence: Understanding Individual Participation in Collective Violence	2015	To explore the role of group identity in individual participation in collective violence and the impact of such behaviour on group identification.	Position/Review	Litman & Paluck (2015)
12	Measuring presence and performance in a virtual reality police use of force training simulation prototype.	2019	To develop a VR training simulation designed to help police officers learn and apply use of force policies effectively.	Application	Garcia, Ware & Baker (2019)
13	Stress out: translating real-world stressors into audio-visual stress cues in VR for police training	2021	To develop and validate a VR training simulation for police officers, focusing on improving decision-making in use of force scenarios.	Application	Nguyen et al., (2021)
14	A concept of a training environment for police using VR game technology.	2018	To design a police training VR-tool for traffic control.	Application	Caserman et al., (2018)
15	The potential of virtual reality for police training under stress: a SWOT analysis. In Interventions, training, and technologies for improved police well-being and performance	2021	To explore the potential of VR in enhancing police training, particularly in stress management, decision-making, and situational awareness under stress.	Position/Review	Voigt (2021)
16	Virtual training: Making reality work?	2015	To develop a Virtual Training Environment (VTE) for training police personnel in complex collaborative tasks, with a focus on interactions between police ground forces and helicopter crews.	Position/Review	Bertram, Moskaliuk & Cress (2015)

No	Title Study	Year	Research Aim	Research Type	Reference
17	The desert of the unreal: Inequality in virtual and augmented reality.	2017	To investigate the potential of VR and AR technologies to enhance equality and reduce bias in various societal contexts, including job interviews, law enforcement training, and public privacy concerns.	Position/Review	Franks (2017)
18	An Integrated emotional and psychological assessment for VR-based active shooter incident experiments	2021	To test the effectiveness of an active shooter VR experiment on emotional and physiological responses to evaluate the realism of the active shooter scenario for research or training purposes.	Application	Awada et al., (2021)
19	A meta-analysis of virtual reality training programs	2021	To explore the effectiveness of VR training programs compared to traditional training methods across various professions, including police and military personnel.	Position/Review	Howard, Gutworth & Jacobs (2021)
20	A review on virtual reality skill training applications	2021	To evaluate the effectiveness of VR training platforms in enhancing high-level motor skills and ensuring accurate task performance in complex environments.	Position/Review	Xie et al., (2021)

3. Learning Objectives

Based on the analysis conducted in this research, a comprehensive set of learning objectives emerged. These objectives are rooted in the synthesis of both position studies and practical applications developed, aimed at addressing multifaceted challenges encountered in the Police domain. From understanding the intricate psychological and social dynamics driving collective violence to delving into the intricacies of terroristic attack cycles, VR gaming solutions have provided a unique platform for immersive learning experiences. Moreover, by creating realistic social training environments and simulating stressful scenarios, VR facilitates a more in-depth understanding of decision-making processes and stress responses among law enforcement personnel. Importantly, the potential of VR extends to mitigating biases, enhancing equality, and preparing officers for real-life critical incidents. These learning objectives represent an important step forward in building responsible VR solutions to optimize training methodologies and foster a safer, more informed law enforcement community:

- Understand the psychological and social mechanisms driving individuals to participate in collective violence, including the role of group identity, intergroup conflict, and how violent groups reduce psychological obstacles to violence among their members. Nevertheless, this is directly related to the context of the situation and the agents involved.
- Explore the structure and interrelationships of activities leading to the preparation and execution of terroristic attacks, as described by the Terroristic Attack Cycle (TAC), including understanding the categories of activities within the TAC and utilizing the TAC to develop game scenarios involving combinations of actions.
- Create a realistic Social Training Environment (STE) focusing on dyadic interaction with virtual agents.
- Investigate the effect of priming messages and VR technology on responses of POs and civilians in simulated scenarios and determine whether police officers perform differently from untrained civilians in response to VR-simulated scenarios.
- Conduct training scenarios in both VR and real life settings for POs, focusing on protection tasks.
- Assess the stress response of participants exposed to VR scenarios compared to those exposed to traditional scenario-based training.
- Understand the impact of VR on reducing implicit racial bias among POs, evaluate the effectiveness of VR embodiment experiences in fostering empathy and reducing racial biases in policing, assess the potential of VR training simulations in improving police responses and behaviors towards African Americans, explore innovative technological solutions for addressing systemic racial bias within law

enforcement agencies, and contribute to the development of effective training programs that incorporate VR technology to enhance police understanding and empathy towards the experiences of racial aggression victims. At the same time, the need for understanding the underlying goals and perspectives that conduct to incidents is necessary and a way that contributes to this understanding is considering engagement with all roles involved.

- Assess the potential of VR and AR technologies to mitigate biases and enhance equality in various societal sectors, investigate the role of VR and AR in addressing or reinforcing biases in law enforcement training and practices, and examine the implications of VR and AR technologies on privacy, consent, and the exacerbation of social inequalities. Using the informed consent mechanism, the participants are made aware of how their data will be used and which defensive strategies and methods are used in order to assure that the VR solutions are designed with a focus on minimizing or avoiding any inherent biases so that fairness, diversity, and inclusivity are respected.
- Assess the impact of repeated simulation sessions on participants' performance and understanding of use of force policies and investigate how different control types (VR vs. screen and keyboard) affect participants' ability to learn and apply use of force decisions.
- Enhance POs' decision-making skills in use of force scenarios through VR training simulations and validate the effectiveness and realism of the training simulations with expert feedback, ensuring they are a reliable training tool.
- Evaluate the potential of VR training in inducing realistic emotional and physiological responses in active shooter scenarios and assess the role of VR training in preparing both civilians and law enforcement personnel for real-life active shooter incidents.

4. Evaluation Mechanisms

The development of VR solutions for training and skill enhancement in the Police domain necessitates a nuanced understanding of evaluation methodologies to ensure their effectiveness and make sure that they are built and used in a responsible way. Hence, a multi-layered trans/multidisciplinary evaluation approach is adopted by capturing technical, educational, and ethical evaluation methods (Fard & Maathuis, 2021). Technical evaluation methods play a crucial role in assessing the seamless integration of VR technologies into existing training frameworks, including considerations such as hardware reliability, software performance, and system compatibility. Moreover, educational evaluation methods are indispensable for gauging the efficacy of VR solutions in achieving learning objectives, measuring knowledge retention, and assessing skill acquisition among law enforcement personnel. Equally vital are ethically oriented evaluation methods, which scrutinize the ethical implications, legal considerations, and societal impacts of VR training interventions. This approach assures the holistic effectiveness of VR solutions, thereby maximizing their utility in enhancing operational readiness, promoting professional development, and fostering ethical conduct within the law enforcement community.

In the technical category, the following performance and quantitative evaluation methods are defined (Pantazidis et al., 2023; Garcia, Ware & Baker, 2019; Voigt, 2021; Kishore et al., 2019); Xie et al., 2021):

- Scoring Mechanisms: Evaluate the effectiveness of scoring mechanisms in incentivizing user engagement and understanding of police protocols.
- Physiological Monitoring: Monitor physiological responses such as heart rate, skin conductivity, and temperature to gauge presence and stress levels during VR scenarios.
- Behavioral Data Analysis: Analyze participant actions during scenarios to assess performance and decision-making skills.
- After-Action Reviews: Utilize enriched feedback through scenario replays to enhance reflection and learning.
- Physiological Measures: Use physiological responses for quantitative analysis of stress levels and engagement, while when possible considering the relationships between the agents involved in an incident.
- Questionnaire-Based Assessments: Utilize questionnaires for quantitative data collection on user experience and presence.

In the education category, the following user experience and engagement, as well as qualitative evaluation methods are defined (Michela et al., 2022; Nguyen et al., 2021; Awada et al., 2021; Howard, Gutworth & Jacobs, 2021; Garcia, Ware & Baker, 2019; Awada et al., 2021):

- Knowledge Assessment: Conduct pre- and post-tests to evaluate knowledge retention and transfer.

- Subjective Assessments: Measure user presence, immersion, and emotional responses using PANAS (Positive and Negative Affect Scale) emotion scale and subjective evaluations.
- Meta-Analysis: Perform meta-analysis to assess the overall efficacy of VR training programs using Kirkpatrick's Model.
- Comparative Analysis: Compare locomotion techniques and control methods to understand their impact on user experience.
- Expert Evaluation: Gather input from experts to evaluate the training content and its alignment with police protocols.
- Biometric Evaluation: Utilize biometric data (GSR, HRV, eye-tracking) to predict affective states and assess real-time engagement.
- Self-Reported Reflection: Gather qualitative insights from participants on their training experiences and effects.
- Expert Interviews: Conduct interviews with experts for qualitative feedback on training content and effectiveness.

In the ethical category, the following learning, social interaction, equality, and bias assessment methods are considered (Guimarães et al., 2020; Potts et al., 2022; Nguyen et al., 2021; Franks, 2017):

- Hypothesis Testing: Test hypotheses regarding the impact of social interaction and believability levels in VR settings compared to traditional computer settings.
- User Feedback: Collect user feedback on social presence and believability of virtual characters.
- Equality Product Testing: Assess VR technologies for their impact on gender, race, and class equality.
- Bias Activation and Mitigation: Study the effects of VR on user biases and attitudes towards others.
- Iterative Improvement: Continuously iterate and improve VR solutions based on evaluation results and feedback from users, experts, and quantitative analysis.
- Adherence to Protocols: Ensure VR scenarios align with police protocols and training objectives to maximize effectiveness and real-world applicability.

5. Lessons Learned

This study aims to draw insights from these scientific studies to contribute to the responsible evolution of VR solutions and to the further development and deployment of responsible VR solutions. In this way, researchers and developers can grasp the technical intricacies, ethical nuances, and societal implications of deploying VR in policing contexts. By assimilating insights like the significance of human-centered design, strategies to mitigate biases, and the imperative of ethical adherence, future VR solutions can be crafted with heightened responsibility.

Continual iteration based on co-creation and feedback (Haskins et al., 2020)) serves as a foundational principle for ensuring that VR solutions evolve iteratively to address user needs and optimize training outcomes. Expanding content and scenarios, Garcia, Ware & Baker (2019) widens the scope of training, enabling POs to confront diverse and evolving challenges in simulated environments. Furthermore, by integrating advanced technologies such as high-fidelity avatar simulations, remote VR training possibilities, and real-time psychophysiological data integration, enhances the immersive experience and efficacy of VR training. Moreover, Awada et al. (2021) uses emotional and physiological measurement techniques, elevating user engagement and replicating real-world scenarios with greater fidelity. Concurrently, robust evaluation and validation mechanisms are imperative. To this end, evaluation with POs ensures that VR solutions align with operational needs and standards (Soldatos et al., 2022), while longitudinal studies on VR's impact provide valuable insights into the long-term efficacy and transferability of VR training to real-life policing scenarios (Kishore et al., 2019). Through the strategic integration of these approaches, VR solutions developed in the Police domain can evolve responsively, delivering impactful and sustainable simulation and training solutions for the modern faced challenges.

Furthermore, for ethical, safety, security, and privacy considerations, Franks (2017) stresses the importance of safeguarding individual rights and ethical principles amidst technological advancements. At the same time, data collected and analysed from VR sessions should be managed with strict privacy protocols to prevent unauthorized access and priority should be given to defensive mechanisms that address potential risks associated with data breaches. Investigating organizational outcomes, Bertram, Moskaliuk & Cress (2015) delve into the broader impact of VR training on organizational performance and operational costs, emphasizing its efficacy in optimizing resources and enhancing outcomes. Moreover, Xie et al., (2021) addresses the importance

of physical characteristics like headset resolution, field of view, and haptic technologies to deepen immersion and realism. The authors explore collaborative and social VR experiences, offering specialized skills and communication training opportunities in interactive virtual environments. In the realm of research methodology and empirical studies, empirical research, and methodological development, Litman & Paluck (2015) calls for enhanced lab and field-based evidence to elucidate the cycle of violence and group dynamics, informing the development of targeted interventions. At the same time, Howard, Gutworth & Jacobs (2021) consider that the effectivity and ethical assessment of VR solutions needs to be done aligned with the organizational goals, ethical standards, and societal expectations. These lessons learned provide a valuable outlook on how VR solutions in the Police domain can be developed in a responsible manner and further support and/or enhance various decision-making and action skills of POs in diverse contexts and settings.

6. Conclusions

In recent years, the landscape of conflict and crime has expanded significantly, encompassing both physical and cyberspace domains. This proliferation of incidents calls for law enforcement agencies and POs to be adequately prepared, trained, and skilled to address a diverse array of challenges across various contexts and potential incidents. Whether responding to traditional crimes or navigating the complexities of cyber threats, officers must possess the requisite expertise and readiness to safeguard communities and uphold the rule of law. In this evolving environment, advanced technologies like VR present invaluable opportunities for enhancing training effectiveness and readiness (Marler et al., 2020). By immersing officers in realistic and dynamic scenarios, VR enables them to build and/or enhance their decision-making abilities, practice de-escalation techniques, and cultivate situational awareness in a safe and controlled environment. Moreover, VR facilitates training across a wide spectrum of scenarios, ranging from routine patrols to high-stakes crisis interventions, thereby equipping POs with the versatility and adaptability required to effectively navigate the complexities of modern law enforcement. As incidents continue to evolve and diversify, the integration of VR solutions plays an important role in empowering law enforcement personnel with the skills, knowledge, and resilience needed to uphold public safety and security in an ever-changing landscape.

It is then the aim of this research to delve into existing VR solutions built within the Police domain aiming to capture key insights regarding learning objectives, lessons learned, and future perspectives. In this way, this research seeks to contribute to the ongoing efforts directed to building responsible and trustworthy VR solutions for security and safety purposes in the Police domain. Integrating lessons learned from previous scientific studies serves as a cornerstone for developing responsible VR solutions that not only bolster Police capabilities, but also uphold ethical standards and societal welfare (All, Castellar & Van Looy, 2021). This research continues by developing VR and AI conflict simulations in the presence of various agents in order to understand the dynamics, influence, and the role of de-escalation mechanisms, and from there to be able to propose effective conflict resolution and community policing strategies and solutions. Other future perspectives could consider a joint multidisciplinary effort that relies on both field expertise of POs and available incident data in order to build cross-domain solutions that tackle existing legal and socio-ethical challenges (e.g., fairness and safety) existing in this domain considering a co-design and co-participation approach. Conclusively, this research aims to contribute to building/g digital responsible solutions that enhance responsibility and trust (Moreno et al., 2024; Maathuis, 2022), and further prioritize safety, justice, and accountability of all stakeholders involved.

References

All, A., Castellar, E. N. P., & Van Looy, J. (2021). Digital Game-Based Learning effectiveness assessment: Reflections on study design. *Computers & Education*, *167*, 104160.

Awada, M., Zhu, R., Becerik-Gerber, B., Lucas, G., & Southers, E. (2021). An integrated emotional and physiological assessment for VR-based active shooter incident experiments. *Advanced Engineering Informatics*, *47*, 101227.

Bertram, J., Moskaliuk, J., & Cress, U. (2015). Virtual training: Making reality work?. *Computers in Human Behavior*, *43*, 284-292.

Caserman, P., Cornel, M., Dieter, M., & Göbel, S. (2018). A concept of a training environment for police using VR game technology. In *Serious Games: 4th Joint International Conference, JCSG 2018, Darmstadt, Germany, November 7-8, 2018, Proceedings 4* (pp. 175-181). Springer International Publishing.

Denyer, D., & Tranfield, D. (2009). Producing a systematic review. In The SAGE Handbook of Organizational Research Methods.

Fard, A. E., & Maathuis, C. (2021). Toward Capturing the Underlying Offensive Mechanisms of Social Manipulation: A Data Model Approach.

Franks, M. A. (2017). The desert of the unreal: inequality in virtual and augmented reality, 51 UC Davis L. *Rev*, *499*, 502.

Garcia, E. T., Ware, S. G., & Baker, L. J. (2019). Measuring presence and performance in a virtual reality police use of force training simulation prototype. In *Proceedings of the 32nd AAAI international conference of the Florida Artificial Intelligence Research Society*.

Giessing, L. (2021). The potential of virtual reality for police training under stress: a SWOT analysis. In *Interventions, training, and technologies for improved police well-being and performance* (pp. 102-124). IGI Global.

Guimarães, M., Prada, R., Santos, P. A., Dias, J., Jhala, A., & Mascarenhas, S. (2020). The impact of virtual reality in the social presence of a virtual agent. In *Proceedings of the 20th ACM International Conference on Intelligent Virtual Agents* (pp. 1-8).

Haskins, J., Zhu, B., Gainer, S., Huse, W., Eadara, S., Boyd, B., ... & Jerald, J. (2020). Exploring VR training for first responders. In *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)* (pp. 57-62). IEEE.

Howard, M. C., Gutworth, M. B., & Jacobs, R. R. (2021). A meta-analysis of virtual reality training programs. *Computers in Human Behavior*, *121*, 106808.

Kishore, S., Spanlang, B., Iruretagoyena, G., Halan, S., Szostak, D., & Slater, M. (2019). A virtual reality embodiment technique to enhance helping behavior of police toward a victim of police racial aggression. *PRESENCE: Virtual and Augmented Reality*, *28*, 5-27.

Kleygrewe, L., Hutter, R. V., Koedijk, M., & Oudejans, R. R. (2024). Virtual reality training for police officers: A comparison of training responses in VR and real-life training. *Police Practice and Research*, *25*(1), 18-37.

Littman, R., & Paluck, E. L. (2015). The cycle of violence: Understanding individual participation in collective violence. *Political Psychology*, *36*, 79-99.

Maathuis, C. (2022). An Outlook of Digital Twins in Offensive Military Cyber Operations. In *European Conference on the Impact of Artificial Intelligence and Robotics* (Vol. 4, No. 1, pp. 45-53).

Maathuis, C. (2023). Human Centered Explainable AI Framework for Military Cyber Operations. In *MILCOM 2023-2023 IEEE Military Communications Conference (MILCOM)* (pp. 260-267). IEEE.

Marler, T., Straus, S. G., Mizel, M. L., Hollywood, J. S., Harrison, B., Yeung, D., ... & Swain, C. (2020). Effective game-based training for police officer decision-making: Linking missions, skills, and virtual content. *I/ITSEC 2020*.

Martaindale, M. H., Sandel, W. L., Duron, A., & McAllister, M. J. (2024). Can a virtual reality training scenario elicit similar stress response as a realistic scenario-based training scenario?. *Police Quarterly*, *27*(1), 109-129.

Michela, A., van Peer, J. M., Brammer, J. C., Nies, A., van Rooij, M. M., Oostenveld, R., ... & Granic, I. (2022). Deep-breathing biofeedback trainability in a virtual-reality action game: A single-case design study with police trainers. *Frontiers in Psychology*, *13*, 806163.

Moreno, A. F., Karanika-Murray, M., Batista, P., Hill, R., Vilalta, S. R., & Oliveira-Silva, P. (2024). Resilience training programs with police forces: a systematic review. *Journal of Police and Criminal Psychology*, 1-26. Nguyen, Q., Jaspaert, E., Murtinger, M., Schrom-Feiertag, H., Egger-Lampl, S., & Tscheligi, M. (2021). Stress out: translating real-world stressors into audio-visual stress cues in VR for police training. In *IFIP Conference on Human-Computer Interaction* (pp. 551-561). Cham: Springer International Publishing.

Pantazidis, A., Gazis, A., Soldatos, J., Touloupou, M., Kapassa, E., & Karagiorgou, S. (2023). Trusted virtual reality environment for training security officers. In *2023 19th International Conference on Distributed Computing in Smart Systems and the Internet of Things (DCOSS-IoT)* (pp. 518-524). IEEE.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Alonso-Fernández, S. (2021). Declaración PRISMA 2020: una guía actualizada para la publicación de revisiones sistemáticas. *Revista española de cardiología*, *74*(9), 790-799.

Potts, J., Hawken, A., Hillhouse, M., & Farabee, D. (2022). Virtual reality for law enforcement training: a demonstration and implication for dispatch priming. *Police Practice and Research*, *23*(5), 623-632.

Saunders, J., Davey, S., Bayerl, P. S., & Lohrmann, P. (2019). Validating virtual reality as an effective training medium in the security domain. 26th IEEE Conf. *Virtual Real. 3D User Interfaces, VR*.

Soldatos, J., Pantazidis, A., Margariti, K., Velanas, P., & Gornea, B. (2022). Virtual Reality Training of Law Enforcement Officers in Predicting Terroristic Attacks Indicators. In *2022 International Conference on Interactive Media, Smart Systems and Emerging Technologies (IMET)* (pp. 1-4). IEEE.

Voigt, L. (2021). The Potential of Virtual Reality for Police Training Under Stress: A SWOT Analysis.

Xie, B., Liu, H., Alghofaili, R., Zhang, Y., Jiang, Y., Lobo, F. D., ... & Yu, L. F. (2021). A review on virtual reality skill training applications. *Frontiers in Virtual Reality*, *2*, 645153.

Zechner, O., Kleygrewe, L., Jaspaert, E., Schrom-Feiertag, H., Hutter, R. V., & Tscheligi, M. (2023). Enhancing operational police training in high stress situations with virtual reality: experiences, tools, and guidelines. *Multimodal Technologies and Interaction*, *7*(2), 14.