RAND SOCIAL AND ECONOMIC WELL-BEING

Improved Officer Decision-Making and Stress Management with Virtual Environments

Final Research Report
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Abstract

Police officers encounter a variety of stressful conditions on the job. Learning to operate in such circumstances is critical, as skills can be impaired under stress. While repetitive exposure to these kinds of situations can foster appropriate responses, in-service police training may not address stress as effectively as needed. Virtual reality (VR) and game-based training (GBT) can meet some of these needs by enabling officers to develop skills in an immersive environment without expensive equipment, facilities, or human actors, thereby increasing opportunities for repetition and practice. However, to be effective, training content must be linked to underlying training goals and assessment of trainee performance on those goals. Thus, this pilot study developed a framework for implementing low-cost, game-based, VR technology for training police officers to improve decision-making under stress. Working with partners in the police training community, the study team developed a method to ensure virtual training environments reflect intended training goals, applied this method to the development of a prototype VR system, and conducted a pilot study to elicit feedback from police officers. Specifically, this approach included: (1) identifying the most stressful scenarios for police officers; (2) developing detailed scenario scripts, (3) identifying key tasks and skills required in the scenarios and mapping them to virtual content; (4) programming the scenarios in a VR system; (5) developing a research protocol to test the system, and collecting pilot data in which 26 police officers participated in VR training and provided feedback via surveys and post-training interviews; and (6) developing a plan to implement the proposed technology in police department training curricula. This approach is scalable; ultimately, it may improve access to simulation-based training content across law enforcement departments, and it can be applied to other job domains.

Summary of the Project

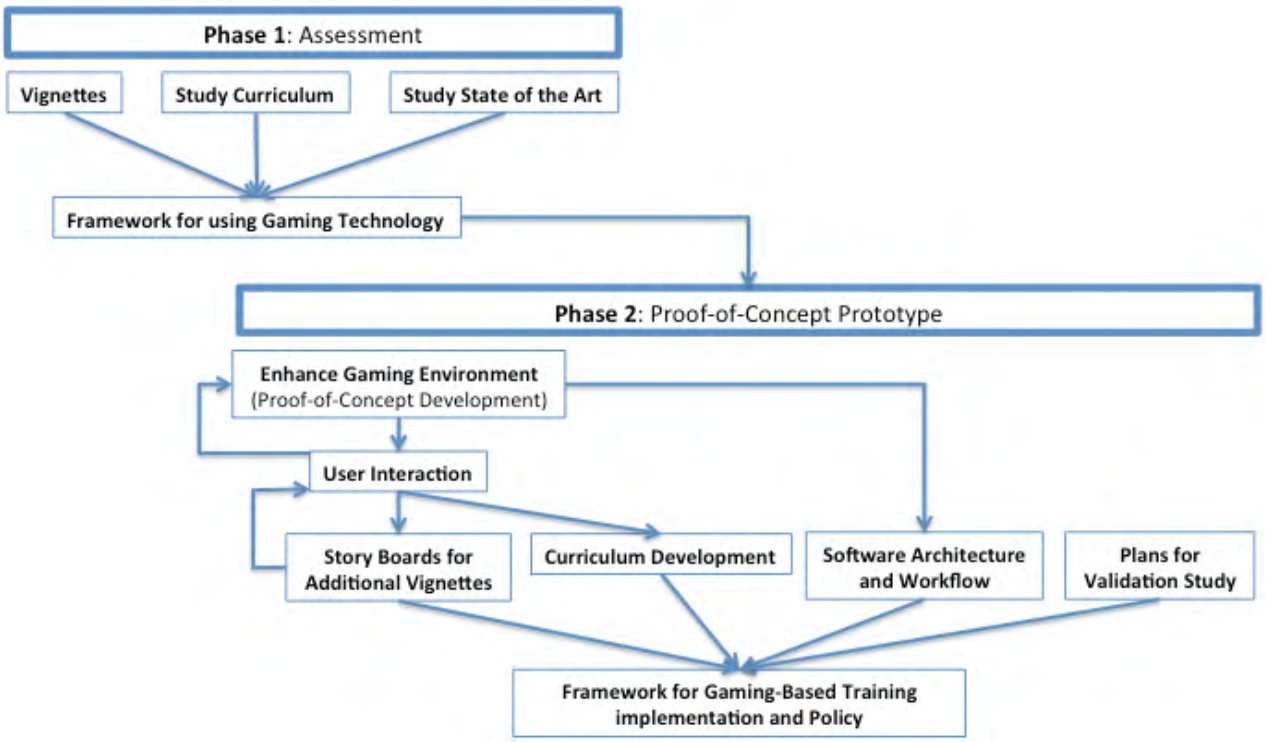
Major Goals and Objectives

The primary goal of this work is to plan, design, and prototype a game-based training (GBT) approach to enhance police officers' decision-making skills in stressful situations. Supporting objectives are as follows:

1. Develop a series of vignettes that represent typical stressful scenarios and that require rapid decision making for police officers
2. Conduct a gap analysis mapping the state of the art for VR and game-based training technology onto the training needs of new police officers
3. Develop a prototype interactive scenario for using low-cost VR and a gaming environment to help train officers
4. Test the prototype with police officers and aggregate feedback
5. Develop a comprehensive open software architecture (design plan) for housing and presenting various interactive scenarios and allowing system expansion
6. Develop a plan to implement the proposed gaming technology in the LAPD training curriculum and potentially in curricula for other police departments across the country

The complete approach is itemized in the original proposal and is summarized as follows. The work was conducted in two phases (shown in Figure 1). Phase 1 entailed studying the current state of the art with respect to procedures for police training and with respect to GBT technology. This first phase included the following components: (a) develop representative vignettes, reflecting typical stressful scenarios that necessitate critical decision-making, (b) evaluate current training curricula and use of gaming and/or VR technology for training at the LAPD, (c) evaluate the state of the art with respect to gaming and VR technology, and (d) conduct a comparative analysis of components a through c in order to develop a plan for using gaming technology for training police officers in decision making under stress.

Figure 1: Multi-Phased Approach to Framework Development



Phase 2 of the proposed effort involves developing and evaluating a basic prototype. This phase included the following components: (a) develop a proof-of-concept/prototype interactive virtual scenario (based on the vignettes mentioned above) to gather feedback from police officers, (b) work with LAPD officers to test the use of the capabilities from component (a), (c) develop a software architecture for an overarching software system and user interface that will ultimately house various simulations and provide a scenario-based immersive virtual training environment, (d) make recommendations for a curriculum that revolves around the capabilities from component (c), and (e) design and conduct a pilot study to test the new software.

Research Questions

Although this work focused primarily on prototype development and testing, there were a series of research questions we implicitly addressed:

- What is the state of the art of training technology for law enforcements?
- How can virtual training-content be aligned with specific training objectives?
- How should VR-based training capabilities be integrated with current police training curricula?
- What are the key technical considerations when developing VR-based content for training police officers?

Research Design, Methods, Analytical and Data Analysis Techniques

Our approach started with determining appropriate training goals in terms of common, stressful policing scenarios, and then deriving appropriate training content, as illustrated in Figure 1.

Figure 1. Development Must Map Training Needs to Virtual Content and Incorporate User Feedback

In general, any virtual training content should be derived from training needs and validated with input from end users, and our work provides a systematic approach for both of these processes. We conducted this work in the context of in-service law enforcement training for non-use-of-force scenarios. That is, we focus on what we call a *first-person talker* scenario given the increasing importance of effective communication and de-escalation in policing (rather than first-person shooter, given that there are already many simulation systems for use-of-force training). The specific steps for our approach are summarized as follows. Details for these steps are provided in subsequent sections of this report.

1) Vignette development and design: Identify real-world training needs in the form of situations or scenarios that pose the greatest stress for police officers and call for them to make rapid decisions and develop a series of vignettes that represent these scenarios as a basis for training.
2) Task and skill assessment: Identify relevant tasks and skills required to respond to each scenario and map those tasks and skill to VR content.
3) System design: Use an agile, iterative process to develop a prototype training scenario and virtual content using low-cost VR and a gaming environment, including performance assessment and feedback that derives from training goals.
4) System testing: Develop a research protocol to test the usability of the technology and implement the protocol with a sample of police officers to elicit feedback from end users.

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5) System deployment: Develop a plan to implement the proposed gaming technology in the one or more police department's training curriculum and potentially in curricula for other police departments across the country.

Expected Applicability of the Research

Potential implications of this project for civil justice practice are significant. As just a few examples of the types of benefits VR gaming may provide in the civil justice environment, emerging technologies on autonomous virtual humans/instructors and complex virtual environments may help improve risk-based decision making. Officers could practice interactions with avatars and reactions to high-risk scenarios in a virtual environment before actually engaging in a dangerous situation or trying to de-escalate a potentially dangerous situation in the real world. Such training will help provide knowledge that can improve officers' decision making and enhance outcomes in police–citizen interactions.

More broadly, VR-based training can offer additional options for performance assessment. Observing how officers act in controlled simulator experiments can provide new insights into how officers' attributes, environment, and training can impact their decision making and performance. Virtual scenario training can help provide consistency in performance evaluations and assessments. It can also help inform policy on officer performance and effective approaches to deal with dangerous scenarios.

While simulators are increasingly used in police training, the focus to date has been on projection systems for shooting simulators within dedicated facilities. These systems are costly, require personnel to serve as instructors or observer/controllers, and offer limited opportunities for practice, with officers typically having access to the system for training only one time per year. In contrast, the new generation of immersive VR equipment allows for officers to be immersed in a wide array of stressful situations (beyond traditional shooting simulators), is relatively low cost (several hundred dollars per pair of VR goggles), and can eliminate the need for instructors or observer/controllers or dedicated training facilities, thereby enhancing opportunities for much more frequent training.

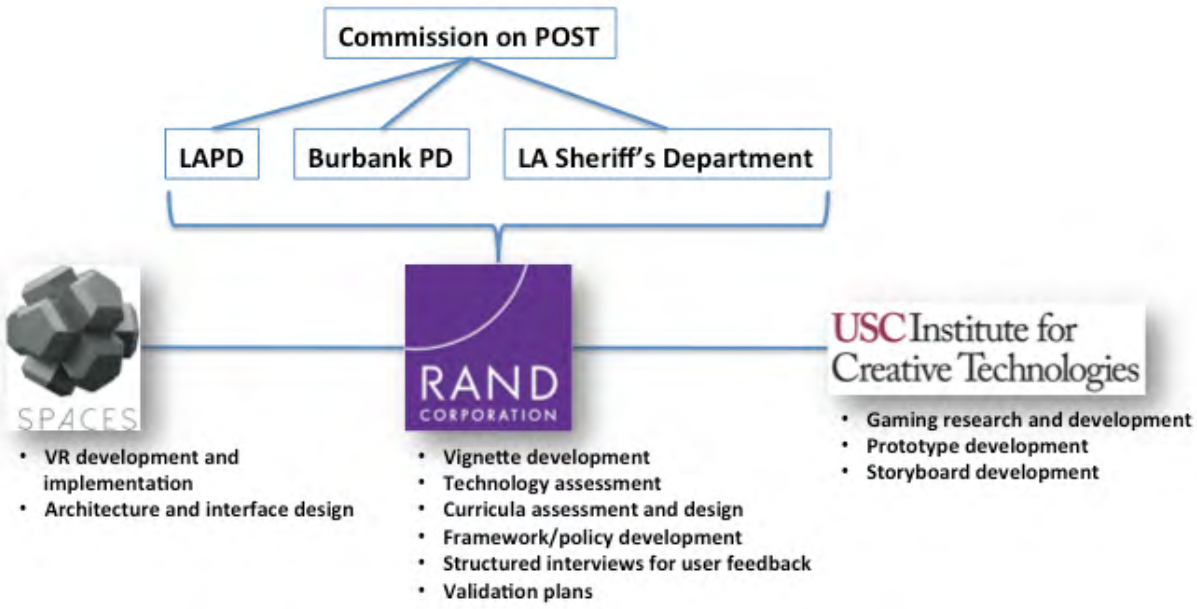
Furthermore, VR-based systems and virtual environments in general can allow for scalability and coordination. Virtual content is relatively easy to edit, augment, and distribute to various users. As we discuss later in the report, creating a central repository of VR-based training scenarios and content could help coordinate law enforcement training. In addition, it could facilitate exchange of best practices across the country.

Participants and Other Collaborating Organizations

RAND Corporation conducted this work in collaboration with the University of Southern California Institute for Creative Technologies and Spaces® Inc. Subject-matter experts from the LAPD, LA Sheriff's Department (LASD), Burbank Police Department (BPD), and Commission on Police Officer Standards and Training (POST) provided project oversight and input to ensure operational relevance and consistency with standards.

Figure 3 illustrates the management and oversight structure of this work. As the prime, RAND oversaw overall program efforts and coordinated all technical developments. RAND led the review of the state-of-the-art and the technology assessments. RAND also oversaw the testing of the prototype and conducted all reviews and the development of curricula. USC ICT was responsible for all technical research and development for the gaming environment. SPACES lead the design of the software architecture, interface, and workflow; and helped ensure software development aligned with plans for future dissemination and ease of use.

Figure 3. Management and Oversight Structure



Collectively, the LAPD, the LA Sheriff's Department, the Burbank PD, and the Commission on POST will form the oversight committee. The committee ensured operational relevance of all new capabilities and plans and ensured the proposed work will synchronize with training curricula.

LAPD as an Important Partner

LAPD played a particularly important role in this work and developed a strong partnership with RAND. In many respects, LAPD is a leader with respect to police training. As one of the largest police forces in the country with three police academies, leveraging technology to improve training is particularly important to them. In fact, they are beginning to use extensive VR facilities, including a large motion-capture facility (approximately the size of a basketball court) that allows multiple officers to training collectively in immersive virtual scenarios (e.g., an active shooter in a high school). In addition, California POST has provided LAPD (and most other police departments across California) software and hardware to replace traditional force option simulators (FOSs) with VR-based FOSs that allow trainers to adapt a virtual simulation on the fly as a trainee works through different situations. Use of these facilities spurred especially strong interest from LAPD in the RAND study.

In addition, many of the initial subject matter experts (SMEs) who informed development of the prototype, as well as all of the participants for testing the prototype were from LPAD; and the final prototype tests were run at an LAPD police academy.

As with other police departments across the country, effective training is increasingly critical for LAPD. A fundamental problem for officers is that they face a barrage of stressors that can negatively impact their health and well-being and their decision-making capabilities. Even less-stressful events can have negative consequences for officers if repeated over a long period of time (Beshears, 2016). In addition, techniques for de-escalation have drawn interests from law enforcement departments and policy makers alike. Thus, lessons learned from this study can play important role in addressing needs for LAPD.

Changes in Approach from Original Design and Reasons for Change

For the most part, the methods and approach of this work adhered to the originally proposed plan. We did, however, ***deviate from the proposal in some minor respects***, notes as follows:

- We did not use the critical incidents technique (CIT) (Flanagan, 1954) as a methodological framework. Given the expertise within RAND and a decision to script the vignettes (use cases) with more detail than originally planned, CIT was not necessary.
- Because of significant time delays, noted below, we did not refine the prototype after the final system tests and feedback from participant officers. This feedback nonetheless yielded important lessons learned concerning 1) desired capabilities for user interaction (i.e., how the trainee interacts with virtual avatars and articulates decisions), 2) details of virtual content (e.g., appropriate wording for decision options for the trainee), and 3) accuracy of the scenario. In addition, the prototype provided a catalyst for feedback concerning the challenges and rewards of working as a police officer in general.
- We did not incorporate predominant models of personality characterization. We eliminated this aspect of the data collection to reduce burden on officers/study participants.

The most significant deviation from the proposed work was the timeline (see Figure 4). ***Completion of this study was delayed substantially because of the COVID 19 pandemic*** throughout Southern California, which falls under the topic of natural disasters. As a result, running the final in-person tests was delayed by approximately two years. The participating research organizations were under restriction to work from home and minimize any social interaction. In addition, the police officers from LAPD were dedicated to other duties, and all in-service training had been temporarily canceled. For some time, much of LAPD exercised "modified mobilization," whereby many officers, including desk officers, were assigned to other duties to support public safety during COVID-19. Thus, they were unable to support the study as test participants or coordinators. Subsequently, the initial COVID 19 outbreak and subsequent surges due to variants disrupted initial and contingency plans.

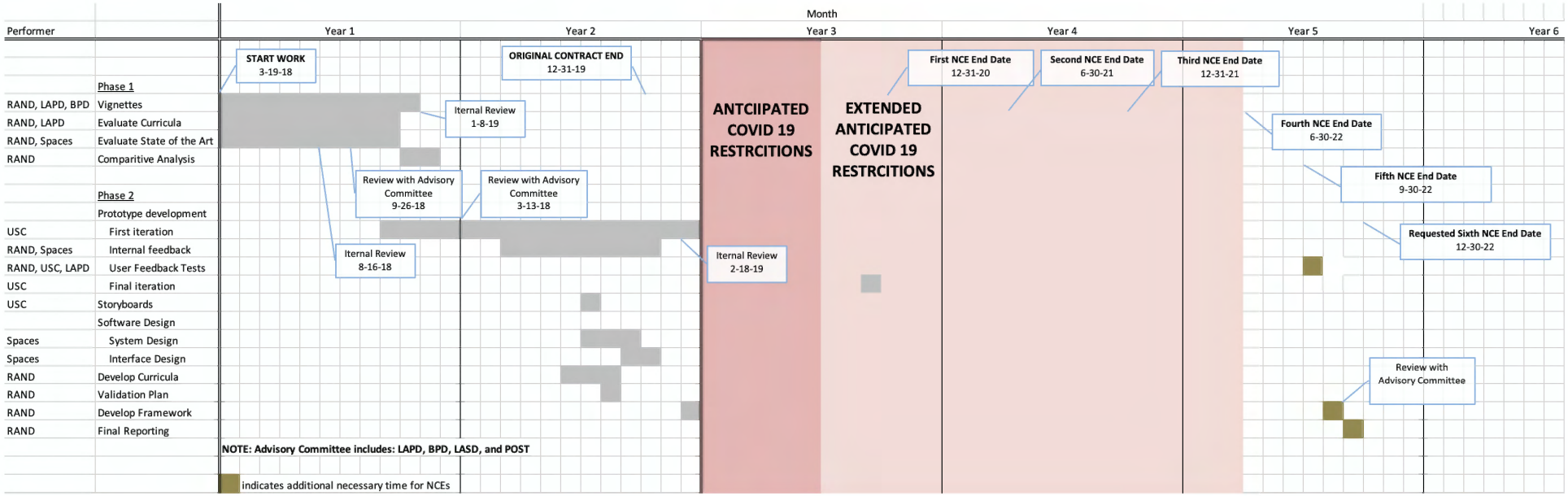
Delays were exacerbated by promotions and attrition within LAPD that resulted in multiple changes in project contacts. First, our primary partner and advocate from LAPD since the beginning of the grant left the organization. The new contact was unresponsive as the result of a promotion; subsequently, we were provided with an alternate contact. The new contact informed us that scheduling officers likely requires one-month advanced notice, a policy that had not been mentioned in the past. This presented significant difficulties scheduling and coordinating times for a cadre of officers of appropriate levels. Finally, just prior to our final efforts to schedule tests, LAPD training staff had been focused on testing other new facilities and supporting major

local events, all of which postponed data collection efforts. Despite these delays, we were able to run the pilot test with LAPD officers near the end of the grant's period of performance.

Despite some setbacks, we ***extended some aspects of the proposed work*** as follows:

- When developing the vignettes, we scripted the scenarios with much more detail than originally anticipated. The consequent scripts stepped through each decision-making point in a scenario (e.g., domestic violence call, road-side stop, active shooter) and included details of potential correct and incorrect responses and decisions. This resulted in an approach for thoroughly representing different scenarios in a form that was relatively easy to translate into virtual content.
- In addition to reviewing the overall curricula for training, we looked at the details of relevant LAPD course syllabi and identified how VR could be leveraged in specific courses.
- The development process for the prototype was much more extensive than originally proposed, including nine agile development iterations, exploration of methods for user interaction, inclusion of various entities in the different scenes, and use of subtle changes in lighting and sound to help induce stress.

Figure 4. Project Timeline and No-Cost Extensions



Outcomes

The section details the work we completed and the methods we used to develop the proposed prototype. Note that both the RAND and NIJ IRBs approved all data collection activities involving human subjects.

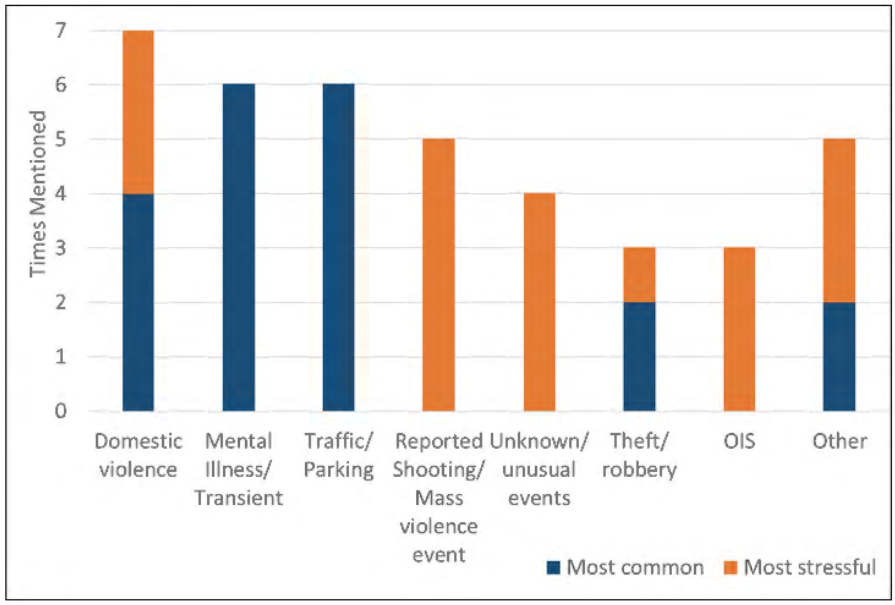
Vignette Development and Design

An initial step in training development involves conducting a needs analysis to determine what should be trained (e.g., Moore and Dutton, 1978). In the case of serious games for training police officers, this entails, (1) determining the kinds of job situations or scenarios that are most stressful and are conducive to training with VR, and (2) developing detailed vignettes or scripts representing how law enforcement officers might proceed through those scenarios. These processes are arguably the most critical steps of serious-game development, and it is only after such work is completed that one can begin programming the virtual content.

Topic Identification and Refinements

To identify critical topics in the context of training decision-making under stress, we examined the research literature and conducted interviews with law enforcement SMEs. For police officers, overall stress exposure rates are highest for violent situations, including exposure to harmed children, killing someone in the line of duty, having a fellow officer killed in the line of duty, facing situations requiring the use of force, family disputes, and being attacked physically (Spielberger et al., 1981; Violanti et al., 2016; Violanti et al., 2017). Additional sources of stress include organizational and management stressors (Brown et al., 1990), culture and workload (Collins et al., 2003), court appearances, working second jobs, and lack of support from supervisors (Violanti et al., 2016).

Figure 5. Most Stressful Situations



Interviews of law enforcement SMEs included eleven first responders and police officers. We also consulted our contacts at LAPD, LASD, BPD, and POST. Figure 5 shows the results of these discussions. SMEs identified domestic violence as both common and stressful. In addition, SMEs suggested multiple situational characteristics contributing to stress that can be manipulated in a VR vignette: 1) situations that divide an officer's focus of attention; 2) dynamic situations and actors (avatars), 3) densely-populated areas; 4) poor weather; 5) poor lighting; and 6) noisy areas. Ultimately, these characteristics should be integrated in the virtual content.

After cross-walking the literature review and discussions with SMEs, we distilled the results into the following list of candidate training vignettes: 1) routine roadside stop; 2) potential crime in progress; 3) disturbance, possibly involving a person who has a mental illness or is incapacitated; 4) domestic violence; and 5) active shooter response.

Framework for Scenario Development

Given the primary vignette topics, we then developed a framework to guide the development of step-by-step scripts for the vignettes as implemented in VR. The framework is illustrated in Figure 6 and includes a variety of key components. First, the user (trainee) should experience engagements and events from a 360-degree perspective, i.e., in front, to the side, and behind the user. This applies to issues requiring an immediate response as well as those with less pressing needs for attention. Second, the vignettes should allow users to vary basic situational factors (e.g., threats; weather, lighting, avatars, etc.) and should allow developers to make more complex changes (e.g. avatar behaviors). Third, the vignettes should incorporate various decision points

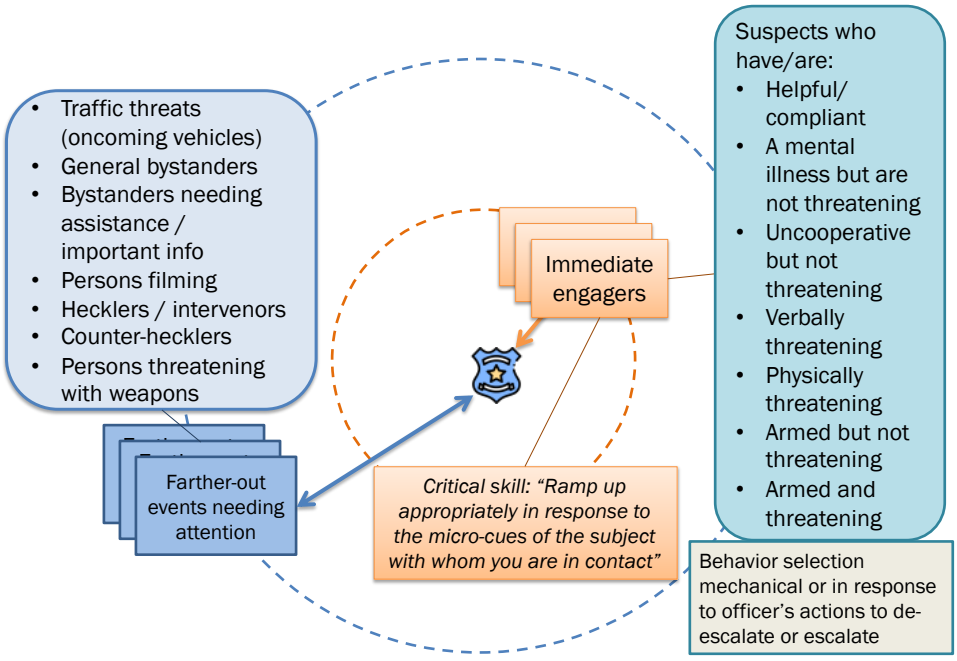
to reflect appropriate law-enforcement procedures, and breakpoints allowing trainers to stop and ask questions or provide instruction.

Script Development

After developing the general layout for a vignette, the next step was to produce a detailed script that describes what exactly happens in the scene, per the framework. The script lays out the key aspects of vignettes, including what steps an officer would typically be required to take. Figure 7 shows a portion of the script for the domestic violence vignette, which the study team developed based on extensive discussions with SMEs.

The scripts are subdivided into *scenes* and *checkpoints*. Each scene represents a small portion of a vignette and includes multiple checkpoints as shown in the examples in Figure 7. At each checkpoint, the system prompts the user to make a decision and provides options for responses or actions. If the user selects the correct action or response, he or she proceeds to the next scene. If not, the user must continue to explore the scene and select another course of action. Each vignette may also involve *branch points*, which are points in the script where the users' decisions lead to alternative scenes or paths.

Figure 6. Framework for Vignette Development



Task and Skill Assessment

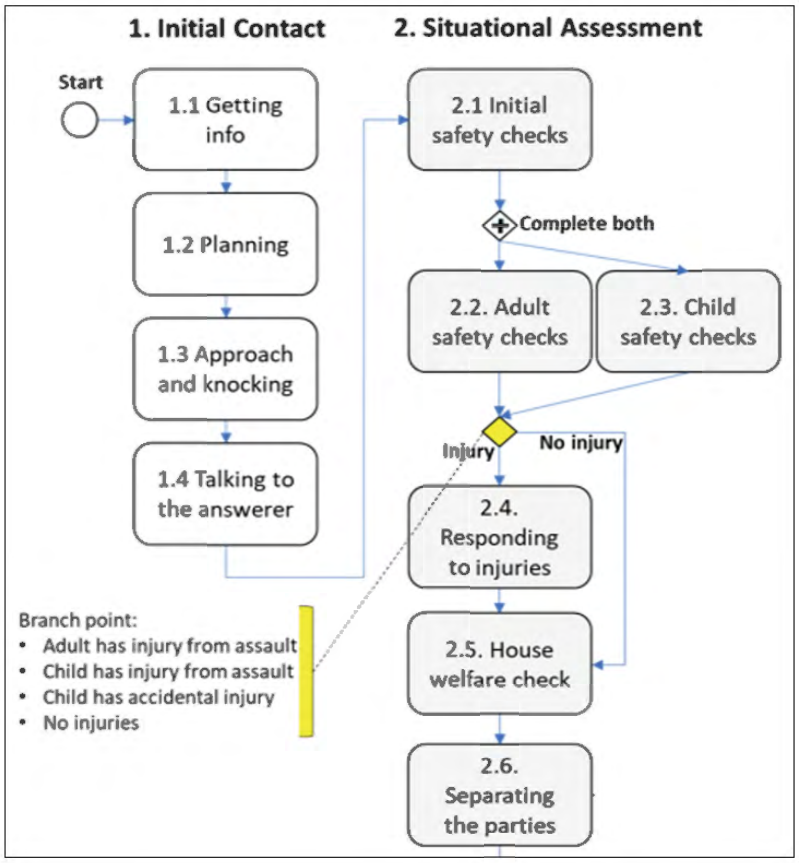
To ensure that the vignettes met real world needs, we performed a task and skill assessment for law enforcement officers. To do so, we interviewed additional SMEs, conducted a review of

relevant literature, and capitalized on information available through the Occupational Information Network (O*Net). Sponsored by the U.S. Department of Labor/Employment and Training Administration, O*Net contains hundreds of standardized and occupation-specific descriptors for nearly one thousand occupations throughout the American economy and is continually updated through surveys of workers in each occupation (site: https://www.onetcenter.org/overview.html). The following tasks were the most common for police officers per O*NET while also being consistent with law enforcement SME input about what constitutes stressful decision making on the job:

- Identify, pursue, and arrest suspects and perpetrators of criminal acts.
- Provide for public safety (maintain order, respond to emergencies, protect people and property, enforce motor vehicle and criminal laws, and promote good community relations).
- Render aid to accident victims and other persons requiring first aid for physical injuries.
- Monitor, note, report, and investigate suspicious persons and situations, safety hazards, and unusual or illegal activity in patrol areas.
- Relay complaint and emergency-request information to appropriate agency dispatchers.
- Evaluate complaint and emergency-request information to determine response requirements.

Comparing these tasks with the literature on GBT and VR, we found research evidence indicating that VR can be effective for teaching each of these tasks (BinSubaih, Maddock, and Romano, 2009; Nullmeyer et al., 2006; Planchon et al., 2018). As validation, we then cross-walked these law enforcement tasks with our completed vignettes to check whether they would address the needed tasks of the job. Collectively, our vignettes included decision making points that addressed each of these key tasks.

Figure 7. Example Script for Domestic Violence Vignette



We performed a similar research and crosswalk with the skills for law enforcement for each vignette. We identified several key skills that we grouped into two meta-skills: problem solving and communication. Problem solving included critical thinking, complex problem solving, coordination, judgement and decision making, and active learning. Communication encompassed active listening, speaking, social perceptiveness, negotiation, persuasion, reading comprehension, and writing. Cross-walking those skills with the completed vignettes revealed that as a group, the vignettes trained on these skills with each scenario using unique checkpoints to test the needed skills.

Next, we mapped each vignette's training goals onto its checkpoints. The results for the domestic violence vignette are shown in Figure 8. When reviewing each vignette, we grouped the training goals into three main categories: 1) work activities that provide for public and officer safety, 2) the meta-skill of problem solving, and 3) the meta-skill of communication. Training on work activities occurs when participants navigate the vignette checkpoints, thereby learning to execute the mechanics of providing public and officer safety. In so doing, the trainees are developing the skills needed to work in law enforcement. Thus, not only are participants

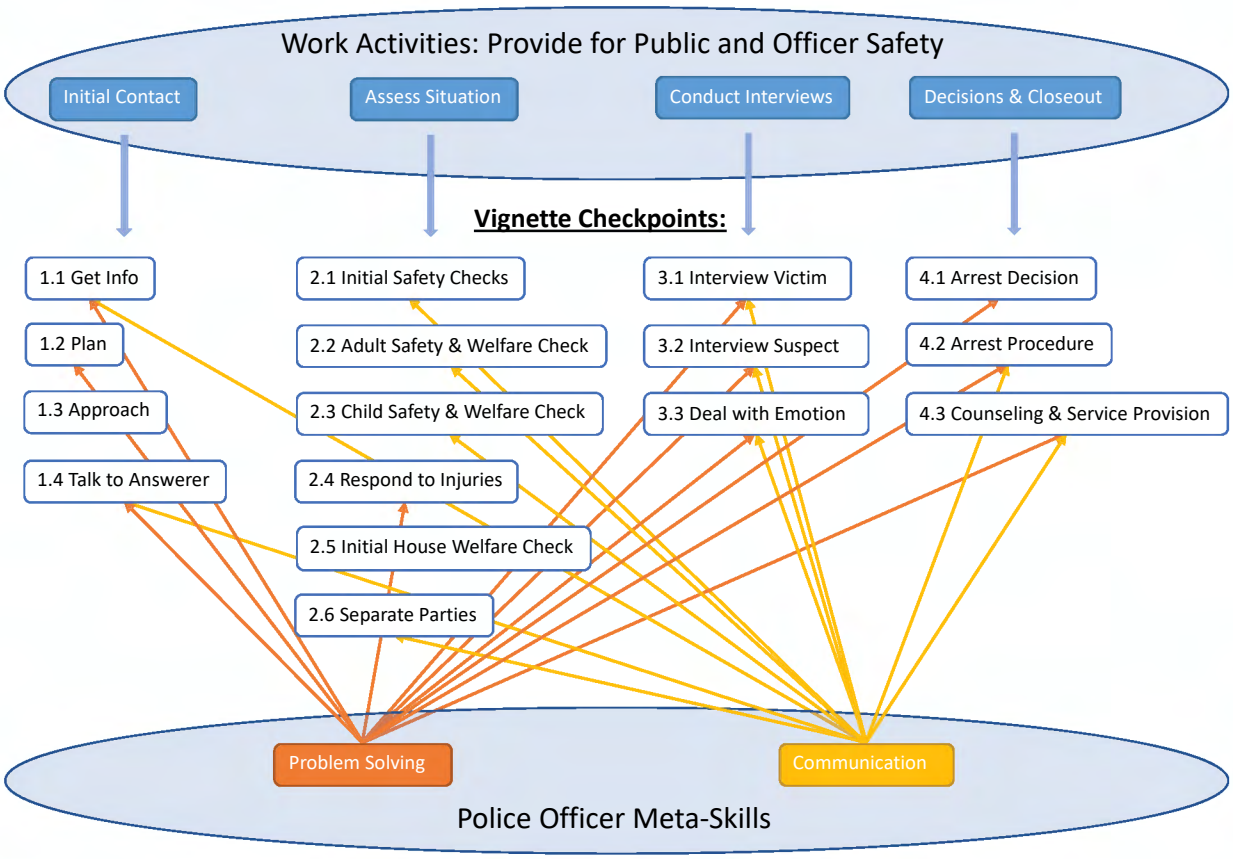
mastering the steps to handle specific stressful situations, but they are honing skills that may transfer to other situations on the job.

We then built a scoring function to measure whether the participant executed the correct behaviors as determined by SMEs and demonstrated the appropriate skills within each meta-skill (communication and problem solving) and work activities. For example, trainees in the domestic violence scenario must assess the safety and welfare of adults and children (Steps 2.2 and 2.3, respectively, in Figures 7 and 8), which enlists their communication skills. Trainees must engage in the appropriate work activities, such as asking for necessary information about adult and child safety and appropriately phrasing the questions, to complete Steps 2.2 and 2.3. This enlists the communication skills of active listening and social perceptiveness and differs from problem solving, which encompasses such skills as critical thinking and active learning. The system automatically records the user's decision or response at each checkpoint and awards or penalizes a point for the associated meta-skill, depending on the appropriateness of the response.

System Design

Having studied the training needs and used them to derive a structure for virtual content, we then developed the prototype training system. This prototype was intended for eliciting feedback from end users rather than for commercial development. The development approach followed an agile and iterative ADDIE (analysis, design, development, implementation, evaluation) curriculum design process. We incrementally developed and tested multiple iterations of the prototype. The system was designed for prescriptive learning, whereby the user is essentially guided through a series of scenes. The user is naturally directed through the appropriate steps for a given situation, which allows the user to learn while progressing through the scenes, regardless of his or her responses at checkpoints. The alternative, which is typically used with entertainment games, is discovery learning, whereby the user is free to explore a complete virtual world.

Figure 8. Framework for Aligning skills and Virtual Content shown with the Domestic Violence Vignette



Although we developed detailed written scripts for each of the five vignettes, for the purposes of creating a prototype, we focused on the domestic violence vignette. It can incorporate a rich variety of threats and is consistent with our focus on "first-person talker" training, involving the need for empathy, investigation, critical decision making, and de-escalation. In addition, we leveraged VR capabilities to further induce stress, as reported in the literature (e.g., Compton et al., 2009; Nieuwenhuys & Oudejans 2010, 2012; Renden et al., 2014, 2015, 2017) and our SME interviews. This involved including a timer with each checkpoint (that decreased the user's score if they ran out of time); distracting ambient noise; and sounds of arguments and commotion when approaching the residence; dim lighting; random avatar motion; and avatars with an imposing figure, stance, and/or expression. In addition, during the design process, we observed that proper positioning of threatening objects and/or avatars could help induce stress, which can be manipulated directly in VR. For example, if an imposing avatar were just outside the user's field as they turned to interview another subject, the situation became more stressful for the user.

Game Play and Workflow

The virtual environment game play essentially follows the scenes and checkpoints in the script for the domestic-violence vignette. The user can move throughout the virtual environment but only for a given scene. As the trainee approaches critical checkpoints, a marker appears indicating a checkpoint and the need to take an action or make a decision. The system presents decision options as a list of text-based statements or actions from which the user must choose. The user can make a selection either by using an integrated laser pointer or by speaking and having a trainer make the selection at a console. Once the user accesses all checkpoints in a scene, he or she is transported to the next scene (the current scene fades out and the new scene fades in).

As noted, per Figure 8, the user's decisions at checkpoints are the basis for evaluating performance, with scores tied directly to training goals in the form of the meta-skills and work activities. During after action reviews, the user or trainer can replay the virtual game and see exactly what the user did at each point. In addition, the user can see what score they received at each checkpoint, thus learning which tasks or skills may need attention.

System Testing

Following development of the prototype system, we developed a protocol to test the usability and efficacy of the domestic violence scenario (intended for Spring, 2020 but postponed until November, 2022, because of demands of COVID-19 on the law enforcement community along with social distancing practices, as described earlier in this report). The intent was to elicit feedback from the potential user base and refine the system for subsequent research on training effectiveness (e.g., effects of training on skills development and subsequent performance on the job). The protocol was designed to address such questions as:

- To what extent do officers feel immersed and have a sense of presence in the training system and scenario?
- How does the training elicit simulator sickness??
- How valuable do officers find the system, scenario, and performance feedback for training? What improvements do they suggest?
- What factors—such as gaming experience, immersive tendencies, job experience, and demographic characteristics—are associated with feelings of immersion and presence, physiological responses, and perceived value for training?

Study Participants

Twenty-six LAPD officers participated in the test. Approximately half of the participants were mid-level officers, and approximately half were senior officers.

Methods, Measures, and Procedures

Police went through the VR training scenario using, and during the training, we recorded each officer's performance within the virtual environment, which included their actions within the environment, their decisions or choices at the checkpoints, and their score with respect to problem solving and communication as calculated from their choices at decision points.

The test procedure is itemized as follows:

1. Police officers who wished to participate signed a consent form that explained the purpose of the research, how their responses would be used, procedures to ensure confidentiality of their responses, the voluntary nature of participation, risks and benefits, and contact information for the principal investigators and RAND's Institutional Review Board.
2. Prior to beginning the VR training, officers completed an online survey. Measures included gaming experience (Straus et al., 2019), symptoms of simulator sickness (as adapted by Kennedy et al., 1993), immersive tendencies (adapted from Witmer and Singer, 1998 and Witmer et al., 2005), job experience, and demographic characteristics. We will analyze the association of gaming experience, immersive tendencies, job experience, and demographic characteristics to assess whether responses are associated with performance in the training, feedback about experiences during the tests, perceived value of the training, and simulator sickness. In addition, we will compare pre-training and post-training responses to determine whether participating in VR triggers symptoms of simulator sickness, and if so, whether officer characteristics (e.g., gaming experience) moderate this effect.
3. Participants put on a set of HTC Vive VR goggles.
4. Participants then participated in the VR training. The training involved two steps. First, the participants completed a tutorial, allowing them to practice moving, selecting objects, and selecting decision. Then, the participants worked through all of the scenes and checkpoints in the domestic violence vignette.
5. Following the training, participants completed another online questionnaire. This questionnaire included the same simulator sickness scale (to examine whether participants experienced a change in symptoms following the VR training), feeling of presence in the training (adapted from group presence questionnaire, e.g., Regenbrecht and Schubert, 2002, see http://www.igroup.org/pq/ipq/download.php; and from Witmer and Singer 1998), and original items assessing perceived usefulness of the system for training police officers.
6. In the last step, we conducted an interview with each participant to gather qualitative descriptions of their experience during the training, perceptions of value for training, and recommendations for improvement.

System Deployment and Integration with Police Training Curricula

When developing new technology, deployment can be just as challenging as technical development. It is critical to understand existing training processes and how new capabilities

integrate with those processes. Thus, to prepare the GBT system for deployment, we studied industry training standards and existing law enforcement curricula from our partner agencies.

Curricula Assessment

To understand the overall process for in-service officer training, we assessed relevant external training standards. The primary organization for determining curricula is the California POST, and most states have their own POST or similar entity that fulfills that function. These organizations identify the key perishable skills and set the minimum requirements for in-service training, including providing some online training material. In California, POST stipulates at least 24 hours of qualifying continuing professional training in each two-year period. That includes a minimum of four hours each in driver training/awareness or driving simulator, tactical firearms, and arrest and control. In addition, they advise departments to offer a minimum of two hours of communications training, either tactical or interpersonal, to be completed in each two-year period. Finally, law enforcement officers are required to take one hour per month of tactical firearms training. VR can potentially be helpful for meeting the continuing professional training requirements as well as the specific training requirements for driver training awareness (with sufficient driving simulation), tactical firearms (with shooting accuracy measurement), and communication. Additional training guidelines come from California Occupational Safety and Health Administration (Cal/OSHA), the California Penal Code, and the Commission on Accreditation for Law Enforcement Agencies, Inc. (CALEA).

In comparing the training offered by our partner agencies with the external standards, we identified opportunities for VR to enhance their existing training. For example, VR can augment courses through experiential learning that provides first-person experiences for students that improve learning (Gosen & Washbush, 2004). In addition, police trainers view role-playing as effective for interviewing and hostage negotiation, and VR can enhance this training through immersion into scenarios that would be otherwise be impossible to create (Sharp, 2000; Van Hasselt, Romano, & Vecchi, 2008). In short, VR provides opportunities to practice through immersive experiences that would otherwise be difficult or unsafe to create.

Syllabi Assessment

To further assess the potential to integrate VR training with existing training, we collected a variety of course outlines from partner agencies. We focused on the syllabi from the two largest agencies for their domestic violence courses in order to support our pilot vignette. We examined whether and how VR could be used in conjunction with their in-class training to pinpoint instances when VR could enhance training. We then created a user guide that included the law enforcement course outline with the recommended VR insertion points as well as a documented course plan with suggested VR use instructions. We grounded the guide in educational research, providing reasoning and citations to support the VR curriculum. For example, in mastering the

arrest decision and process, VR allows for repeated opportunities to engage in deliberate practice of complex decisions in which the participant can learn from mistakes, boosting learning potential (Crochet, et al, 2011). VR also appears to be an effective tool for increasing empathy, which is a growing public demand (Herrera et al., 2018). This user guide can serve as the foundation for building a library of vignettes for VR vignettes in law enforcement training.

Conclusion

This research has provided a new framework for developing low-cost, game-based training systems for training police officers to improve decision-making under stress. A key aspect of this framework is the ability to derive virtual content from real-world training goals and ensure the metrics for performance assessment tie back to these goals, as shown in Figure 8. Furthermore, this work stresses the importance of not only developing a prototype that responds to training needs but also ensuring that end user feedback is captured in a structured and systematic fashion throughout the process for scenario identification, vignette development, and prototype testing. Finally, we outline a process for deploying the proposed system, ensuring it integrates with and adds value to current curricula and syllabi. Thus, we provide a roadmap for serious-game development that spans identification of initial training needs to system deployment. The framework in Figure 8 also provides a system for summarizing and archiving vignettes, which can be useful with the continuous development of virtual training content. Furthermore, metadata describing the training goals for each vignette allows for cataloguing the content to make it findable by other users. In the future, users could search a library of vignettes to identify ones that train on specific work activities or skills.

VR and GBT can provide multiple advantages, including adaptability, accessibility, and affordability. Consequently, it offers a flexible platform for both training operations and research, i.e., (1) to allow officers to practice skills in high-risk scenarios under varying conditions before engaging in such situations on the job, and (2) for research to investigate how best to train critical skills in law enforcement, particularly for scenarios requiring de-escalation.

With regards to adaptability, developers and even users can easily modify virtual environments to meet training goals. Such alterations can include variations in the appearance and behaviors of avatars, modifications to physical environments (e.g. lighting, sound, weather, etc.), or modifications in the interface with respect to data input and output (e.g. text in menus presented to the user or virtual feedback for after action reviews). Alternatively, FOS systems require hiring actors and re-recording a movie for similar modifications. Systems like the one we propose can also be modified to facilitate collective training where multiple users train together as a team, comparable to traditional entertainment games. Moreover, this framework for training development and implementation is not limited to police officer or first responder training; it can be adapted to support training for a variety of jobs in such domains as

manufacturing, medicine, and national defense. In addition, GBT is more accessible than large, physical systems like a FOS. Typically, only relatively large police departments can afford more complex simulation systems. GBT offers a more accessible alterative for both large and small departments, allowing users potentially to practice almost any time or place, thus increased training cycles, which in turn could result in improved performance.

In addition to proposing a process and system to support operational training, this study is an initial step in a potentially broad program of research on the use of VR for police officer training. The research platform we have designed lays the foundation for a wide range of controlled experiments examining effects of different system configurations and patterns of use on training outcomes. For example, parameters in the scenario can be changed to enable officers to practice under such varying conditions as time of day, weather, noise, and the presence of weapons. The system can vary the constructive elements or avatars with respect to the number of purported victims, suspects, and/or bystanders in the scenario; characteristics of those individuals such as race, gender, age, and sustainment of injuries; and behaviors of those avatars. Other questions to address include the number and timing (massed or distributive practice) of trials required to achieve proficiency. Moreover, this platform and approach set the stage for studying key, longer-term outcomes of training, such as knowledge retention, generalization of skills learned to other stressful situations, transfer of training (how performance in training affects job performance), and return on investment of alternative training strategies.

A significant challenge in improving the effectiveness of GBT is enhancing how users interact with the system, and this reflects a significant area for future research. This challenge is especially apparent within an immersive VR environment (as opposed to a basic desktop system). To date, this has involved selecting items with a cursor, a virtual laser pointer, or with eye tracking and continued gaze. However, voice recognition and natural language processing could make interfacing with virtual avatars much more efficient and realistic, as could implementation of (artificial intelligence) AI to govern avatar responses. A natural language process interface would allow for greater realism, enabling trainees using VR to proceed through the vignette as they would in the actual situation.

Limitations

This project had several limitations that point towards valuable future work. These limitations concern the extent of experimental analysis, given that this was a pilot study. First, because of the COVID-19 pandemic, we were not able to analyze the data collected from the VR trials within the grant's period of performance. Second, because the trials consisted of a pilot study (by design), results are largely descriptive rather than, for example, showing impacts of VR training on outcomes and training transfer. Also, because the sample size was relatively

small (also by design), the study likely lacked the statistical power needed to show significant associations among variables (e.g., pre-trial and post-trial survey measures).

With respect to the development of the prototype, as planned, we developed and tested just one scenario. Going forward, using a collection of scenarios would enable testing under various(virtual) conditions. In addition, as with many commercial VR-based training systems, interaction with the virtual environments was limited to discrete choices, with the user making selections from drop-down menus. Given that much of what police officers do depends on communication skills, eventual advances with natural-language-processing and AL could provide significant benefits.

However, as described above, the approach we used sets the stage for a program of research using quasi-experimental designs or randomized controlled trials to examine impacts of variation in such elements as training conditions, elements of the scenarios, and number of trials on participant learning, knowledge, retention, behavior, and job performance.

Future Work

Although this work was essentially a feasibility study that produced a prototype system, it lays the foundation for new software capabilities and a new approach to training police officers. The following next steps would leverage the results of this study and target ***additional development, dissemination, and validation***. It would entail extending this pilot study to evaluate the degree to which training in virtual environments can improve decision making under stressful situations. The architecture designed under this effort would be developed and populated with additional interactive scenarios. This new software system would then be validated with extensive and formal testing. This would involve additional larger, controlled experiments and field studies to test efficacy and training transfer. Ultimately, this kind of testing could be extended to long-term tracking, possibly over a ten-year period, to evaluate the effects of virtual training technology. We would then conduct a thorough cost-benefit analysis to quantify the potential saving of low-cost training aids.

A potential significant advantage of using virtual training is the ***deployment of systems and content for use at a large scale***. Many police departments have similar training needs, such as learning de-escalation techniques; however, law enforcement departments tend to operate independently rather than sharing lessons and approaches. A long-term goal of our work is not simply to develop a finite set of scenarios. Rather, by creating a repository of exemplar scenarios in the form of a large, scalable digital library, police departments across the nation can access vetted scenarios for training that they can adapt to meet local needs and policies. This, in turn, can balance centralized coordination with decentralized training needs. When coupled with the customizable vignettes, this benefit applies to many different sectors and provides not just a new training tool for law enforcement but a new approach to scalable simulation-based training.

One of the most significant technical challenges with VR-based training is implementing ***effective methods for users to interact with the virtual environment*** (avatars, furniture, etc.) and articulate decisions. In particular, much of a police officer's job involves communication, and new methods are needed for interacting with virtual avatars verbally. Natural language processing and machine learning (ML) (with this particular type of application) are not yet advanced enough to facilitate seamless and realistic interaction. However, there are alternatives to advanced ML that could still improve the fluidity with systems users interact with virtual avatars. In addition to providing new capabilities for trainees, there is a need for trainer capabilities, such that they could use menus to allow for repetitions under varying conditions and characteristics and actions of individuals in the scenario to support equity in policing.

Given a well-validated and cost-effective game-based training system, methods and policy would be explored to foster off-duty use, as well as collective training of groups of officers. In addition, the benefits of this system would be explored in terms of mitigating implicit bias

Artifacts

Intermediate Materials

1. Games-for-training literature review
2. Detailed police training vignettes
3. Protype testing procedures
4. Prototype and software design documentation
    a. Presentation of objectives and constraints for prototype and software-system development
    b. Software system architecture overview
    c. Software system product requirements document
5. State-of-the-Art Review
    a. Review of game engines
    b. Review of VR hardware
    c. Review of police training simulators

Dissemination Activities

1. Project-review presentations
    a. Interim Project Review, 9-26-18
    b. Interim Project Review, 3-13-19
    c. Internal Interim Project Review, 2-18-20
        i. The sponsor had to cancel the formal project review
2. Presentation at International Association of Chiefs of Police (IACP) Conference
   Marler, T., Harrison, B., Stark, R. (2019), "Virtual Games: Training Officers in Decision-Making in Stressful Situations," *International Association of Chiefs of Police 2019 Technology Conference*, May, Jacksonville, FL.
3. Publication and presentation at large training-simulation conference
   Marler, T., Straus, S. G., Mizel, M. L., Hollywood, J. S., Harrison, B., Yeung, D., Klima, K., Lewis, W. L., Rizzo, S., Hartholt, A., Swain, C. (2020), "Effective Game-Based Training for Police Officer Decision-Making: Linking Missions, Skills, and Virtual Content," *Interservice/Industry Training, Simulation and Education Conference (I/ITSEC)*, November, Orlando, FL.

Data

1. Unity game-engine executable for the virtual environment prototype
2. Interview minutes with police officers
3. Per- and post-experiment digital-survey data

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