Effective Game-Based Training for Police Officer Decision-Making: Linking Missions, Skills, and Virtual Content

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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. This paper presents a pilot study that 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. This approach maps standard policing missions to content within a virtual training environment. It includes: (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 and measures of trainee performance; (4) developing vignettes in a gaming environment; (5) developing a research protocol to test the system, and implementing the protocol with a sample of police officers; and (6) developing a plan to implement the proposed gaming technology in police department training curricula. Using this approach, we were able to target a large range of training tasks and skills in existing law enforcement curricula with just a few vignettes. Furthermore, this approach is scalable; it may improve access to simulation-based training content across law enforcement departments, and it can be applied to other job domains.

ABOUT THE PRIMARY AUTHORS

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INTRODUCTION

Policing can involve complex interactions between officers and individuals in the community. Many of these circumstances present dangerous and stressful situations that require police officers to make rapid decisions in order to mitigate escalation and prevent harm. Learning to operate in such circumstances is critical with law enforcement, given that such skills as shooting accuracy, self-defense, memory, and communication can be impaired in stressful situations (Alpert et al., 2012; Artwohl 2002; Klinger 2006; Nieuwenhuys and Oudejans, 2010; Renden et al., 2014; Renden et al., 2015). More generally, when performing under stress, judgment processes shift from controlled to automatic thinking (e.g., Kahneman, 2011). Thus, while repetitive exposure to such situations and opportunities for practice can foster appropriate responses, help improve decision making under stress, and even reduce underlying stress (Niewenhuys and Oudejans, 2011), formal police training often may not address stress as effectively as needed (Nuwer, 2016). Consequently, some police forces use extensive physical mock-ups to simulate various settings for training (Dunlap, 2016), or complex projection-based force option simulators (FOS), which are training platforms that allow for the use of simulated firearms and less-lethal devices for force response. However, training for high-intensity interactions can be time-consuming and expensive because of the costs of human actors, trainers, simulator equipment, and facilities, and this reduces opportunities for practice.

Technological advancements can meet some of these training needs. For example, use of simulators and projection virtual reality (VR) systems that essentially immerse a user in a 3D environment is increasing in police departments, especially for training when to use one's weapon or for exposing implicit biases (Francescani and Margolin, 2019; Fussell, 2016; Lapowsky, 2015). In fact, Davies (2015) found that simulation-based training could be effective in training decision making in shoot/don't shoot scenarios. Applications of VR for training also extend to the Border Patrol (Santos, 2016), again helping to train officers to avoid escalation and possible violence. Compared to pre-recorded movies that are currently used in the FOS, scenarios in VR training allow for branching logic and can be easily modified to address multiple or changing training goals. Moreover, basic gaming technology, along with low-cost VR equipment and capabilities—to include the use of constructive elements and the ability to program numerous scenarios and vary parameters within a scenario—can be used for training without the need for large facilities, human actors, or instructor intervention. This increases opportunities for repetition and practice. In contrast to other types of training approaches, VR can also capture objective measures of trainee performance such as reaction time, and VR allows users to revisit past scenarios to assess how they might have performed more effectively (Kofman, 2016).

Extensive research has been conducted to evaluate and substantiate the use of VR and gaming technology for training, referred to as game-based training (GBT) or "serious games," in a variety of contexts (e.g., Bhagat et al., 2016; Cain and Piascik, 2015; Laamarti et al., 2014; Verdaasdonk et al., 2009). In many cases, relatively inexpensive VR goggles provide a viable alternative to large and expensive VR facilities (de Lima et al., 2016; Freina and Ott, 2015; He et al., 2016). While the use of VR is increasing for training law enforcement officers and other first-responders (e.g., Babak, 2019), this technology has not been fully leveraged in this context. Furthermore, the development of virtual content must derive from targeted real-world skills and training goals. Thus, the purpose of this research is to develop and test a framework for implementing low-cost, game-based, VR training to enhance police officers' decision-making skills in stressful situations. This work presents a feasibility study to determine how to leverage GBT most effectively for law enforcement training.

Overview of the Approach

Our approach starts with determining appropriate training goals in terms of common, stressful policing scenarios, and then derives appropriate training content, as illustrated in Figure 1. 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 rather than first-person shooter, given that there are already many simulation systems for use-of-force training, and effective communication and de-escalation is increasingly important in policing. The specific steps for our approach provide an outline for the paper and are summarized as follows:

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.
5) System deployment: Integrate the system with police training by developing 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.

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

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.

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 Refinement

To identify critical topics in the context of training decision-making under stress, we examined the research literature and conducted interviews with law enforcement subject matter experts (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).

Interviews of law enforcement SMEs included eleven first responders and police officers. We also consulted our contacts at LAPD, LASD, BPD, and POST. Figure 2 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.

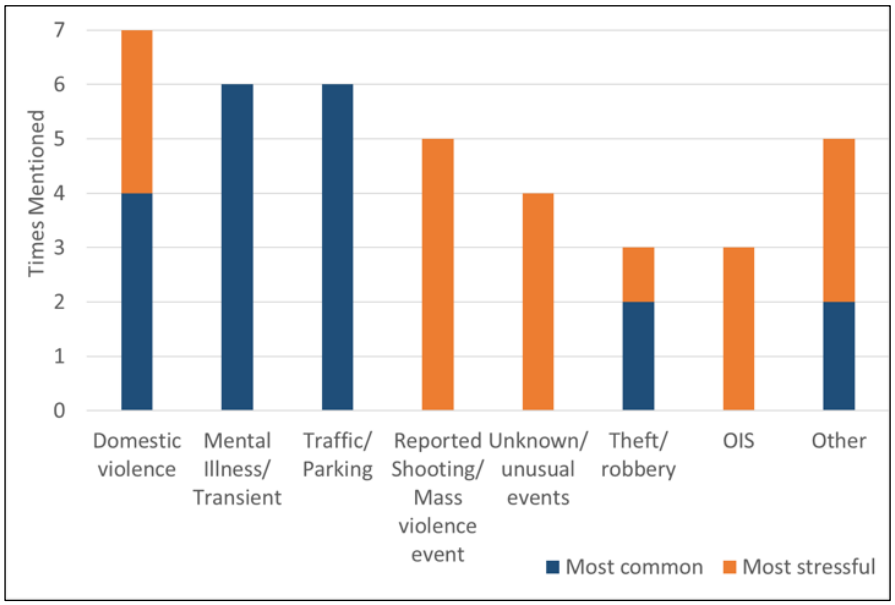

Figure 2. Most Stressful Situations

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 3 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 4 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 4. 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.

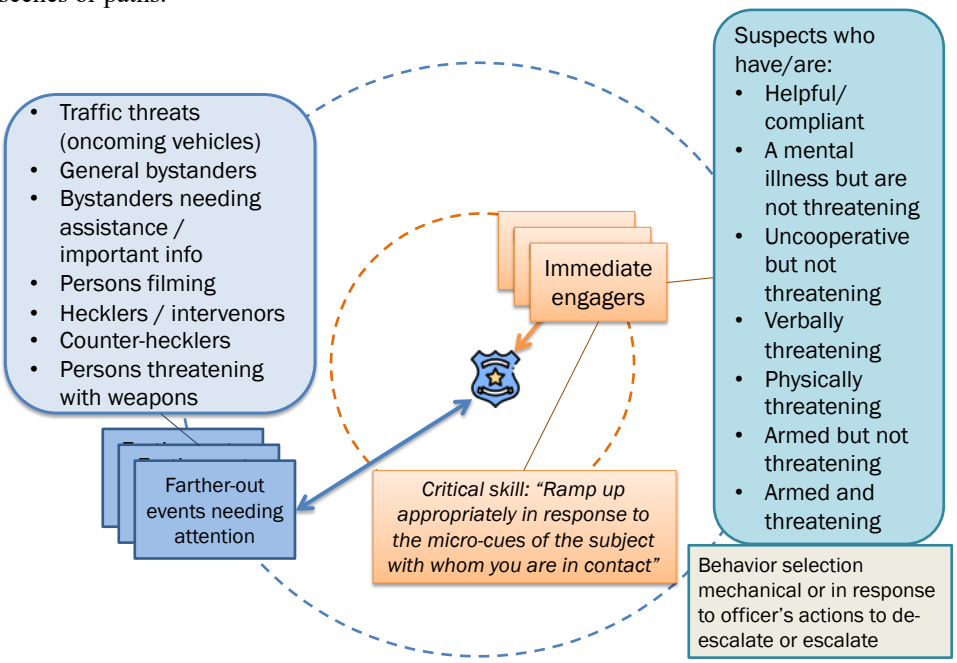

Figure 3. Framework for Vignette Development

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.

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.

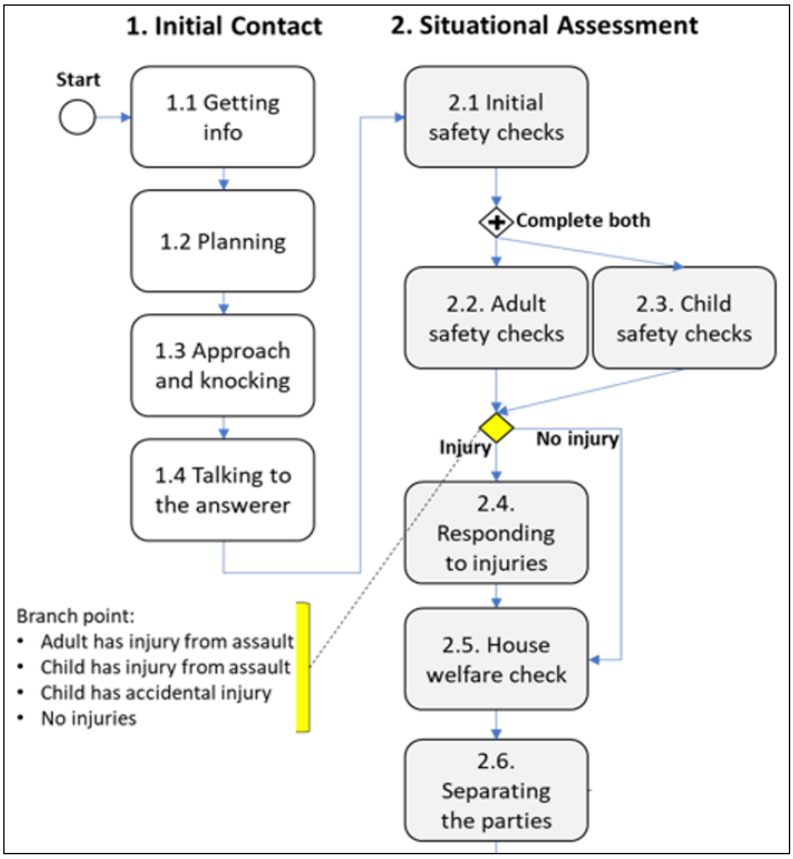

Figure 4. Example Script for Domestic Violence Vignette

Next, we mapped each vignette's training goals onto its checkpoints. The results for the domestic violence vignette are shown in Figure 5. 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 4 and 5), 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.

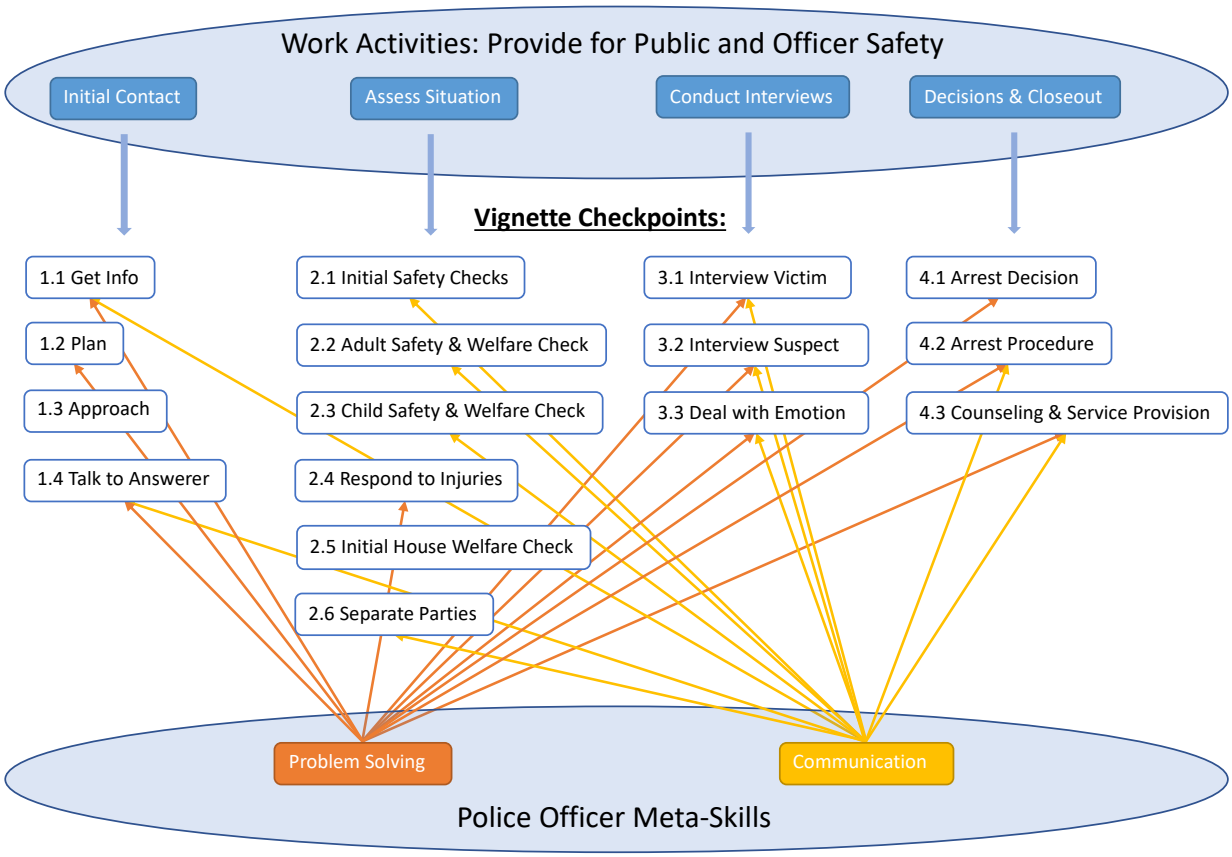

Figure 5. Framework for Aligning skills and Virtual Content shown with the Domestic Violence Vignette

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 5, the user's decisions at checkpoints is 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 because of social distancing practices). The intent is 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 is 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 affect physiological responses (both self-report and objective performance measures)?
- 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

Approximately 30 LAPD officers will participate in the test. Participants will represent a broad cross section of potential users, including new graduates form the police academy who are required to work with a trainer in the field, officers who no longer require a trainer, and officers who serve as trainers.

Methods, Measures, and Procedures

Police officers will go through the VR training scenario using HTC Vive VR goggles (technically other VR hardware could be used). We will collect measures of trainees' experiences and characteristics or individual differences; attitudes toward the training; and physiological responses using the following methods and measures. In addition, we will record each officer's performance within the virtual environment, which will include 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 wish to participate will sign a consent form that explains the purpose of the research, how their responses will be used, procedures to ensure confidentiality of their responses, the voluntary nature of participation, risks and benefits, and contact information for RAND's Institutional Review Board.
2) Prior to beginning the VR training, officers will complete an online survey. Measures include 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, perceived value of the training, and physiological responses. 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) In addition to obtaining self-report measures of physiological responses, we will collect objective measures using a non-invasive, wearable biometric sensor, the Empatica E4 wristband, to determine whether the training scenario triggers anticipated stress responses (see also Clifford et al., 2019). Responses such as heart rate (HR), heart rate variability (HRV), electrodermal activity (EA) or galvanic skin response (GSR) are well-established markers of the Autonomic Nervous System (ANS). These markers (1) signal stress, which in turn prepares individual for flight or fight in response to dangerous situations (e.g., Russell, 2019); and (2) provide markers of an individual's ability to respond to those situations effectively (e.g., Kallen, 2010; Kim, 2018; Villarejo, 2012). The Empatica E4 wristband is designed for research and consumer use; it captures HR, HRV, EA/GSR, along with other measures. Study participants will wear the wristband before, during, and after the training, so that we can monitor whether stress responses change during the training trial in response to events designed to trigger stress.
4) Participants will then participate in the VR training. The training will involve two steps. First, the participants will complete a tutorial, allowing them to practice moving, selecting objects, and selecting decision. Then, the participants will work through all of the scenes and checkpoints in the domestic violence vignette.

5) Following the training, participants will complete another online questionnaire. This questionnaire includes the same simulator sickness scale (to examine whether participants experience such symptoms from the VR training), feeling of presence in the training (adapted from igroup 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 will conduct an interview with participants 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.

CONCLUSIONS

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 5. 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 5 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 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.

Going forward, a potential significant advantage of using virtual training is the deployment of GBT 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 discussed above, 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.

ACKNOWLEDGEMENTS

Portions of this work were supported by funding from the National Institute of Justice, under the FY17 Research to Improve Officer Decision-making, grant # 2017-R2-CX-0025. The authors would to thank our law enforcement partners from LAPD, BPD, LASD, and POST for their valuable insight and contributions. We are especially grateful to Sargent Richard Stark and Dr. Luann Pannell of LAPD for their input and oversight.

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