Chapter 6
The Potential of Virtual Reality for Police Training Under Stress:
A SWOT Analysis

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ABSTRACT

To prepare for critical incidents on duty, police officers need to acquire the skills and tactics in realistic environments so that they transfer to high-stress circumstances. To bridge the gap between empirical research and applied practice, the present chapter informs about training concepts within the ecological dynamics framework that effectively promotes performance under stress. Specifically, scenario-based police training is critically discussed by identifying research gaps and challenges in the current practice. Virtual reality (VR) is introduced as a promising tool to overcome these challenges in police training and research. The aim of the present chapter is to inform, update, and improve researchers', police trainers', and curriculum developers' knowledge of VR as a tool to address the need for representative stress training while acknowledging its strengths, weaknesses, opportunities, and threats.

INTRODUCTION

On duty, police officers are entrusted with the task to ensure the personal safety of citizens, in some cases necessitating the use of (potentially lethal) force. As a result, the most far-reaching decisions and actions by police officers usually occur in highly stressful, unpredictable, ambiguous, and rapidly unfolding situations. Although the majority of calls for services involve non-threatening duties, in those rare situations of high threat, officers need to perform in complex and unforgiving environments, which require optimal task performance. Performance failure in these situations may have tremendous – potentially lethal – consequences for the officers themselves, colleagues, suspects, or innocent bystanders. Therefore, the essential challenge for police academies is to teach officers skills and tactics in such a way that they transfer even to the high-stress circumstances on police duty.

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Critically, there is little evidence that officers are immune to the body's automatic responses to threat and stress (Anderson et al., 2002; Baldwin et al., 2019; Giessing et al., 2020). When individual coping resources are judged as insufficient to meet the environmental demands (Lazarus and Folkman, 1984), stress arises. Stress leads to a variety of consequences for the individual, including emotional responses (e.g., anxiety) and physiological changes (e.g., increased heart rate, cortisol secretion; McEwen and Stellar, 1993). These stress responses influence cognition and behavior by shifting attention from goal-directed control to stimulus-driven control (Eysenck et al.,2007; Hermans et al., 2014) – sometimes resulting in impaired police performance (Arble et al., 2019; Giessing et al., 2019; Hope, 2016; Nieuwenhuys and Oudejans, 2010; Nieuwenhuys et al., 2012, 2017; Renden et al., 2013, 2017; Taverniers and De Boeck, 2014, for an overview see Nieuwenhuys and Oudejans, 2017). However, while performance might be challenging, most officers manage to solve even stressful situations professionally and adequately. Apparently, individuals are able and also highly motivated to counteract the debilitative effects of stress: they are predicted to spend extra mental effort in an attempt to reduce stress responses, enforce goal-directed processing of information, and inhibit stimulus-driven impulses (Eysenck et al., 2007; Nieuwenhuys and Oudejans, 2017). Therefore, police training should provide police officers with the opportunity to experience psychophysiological stress responses and their impact on behavior in order to develop and try out effective coping strategies.

Given the inherent complexity and stress of police work, it has been recently highlighted that police training should develop officers to be independent, creative problem solvers despite elevated stress levels (Blumberg et al., 2019; Staller and Zaiser, 2015). To achieve this, police academies should primarily follow the training principle of "train as you fight", which aims to replicate the performance context as closely as possible to maximize learning outcomes (e.g., Low et al., 2020). The decisive difference between real police operations and training situations is the extent of threat and stress. Therefore, police training should create representative environments that incorporate situational constraints from real-life contexts with the aim to put trainees under stress (Anderson et al., 2019; Di Nota and Huhta, 2019).

Although training under stress might not be able to perfectly replicate real-life stress situations, it has been shown to enhance performance delivery in various high-stress domains (Gröpel and Mesagno, 2017; Kent et al., 2018; Low et al., 2020), including law enforcement (Oudejans, 2008; Nieuwenhuys and Oudejans, 2010, 2011). However, various open questions and challenges remain in the implementation of the principles of training under stress into police training. New technologies such as Virtual Reality (VR) offer the potential to address these challenges. Therefore, the present chapter conducts an analysis of the strengths, weaknesses, opportunities, and threats (SWOT) associated with the use of VR in scenario-based stress training in police settings. SWOT analyses are widely utilized as a strategic planning methodology to meet goals and improve operations in developmental processes (Pickton and Wright, 1998; Tao and Shi, 2016). As such, the aim of the present chapter is to inform, update, and improve researchers', police trainers', and curriculum developers' knowledge of VR as a tool to address the need for representative stress training while acknowledging its strengths, weaknesses, opportunities and threats.

"TRAIN AS YOU FIGHT": SCENARIO-BASED TRAINING UNDER STRESS

In police training, scenario-based training is considered the gold-standard for complex motor learning (Di Nota and Huhta, 2019). By nature, it is fully immersive: In real or artificially constructed environments, props, sounds, and lighting are used to expose police officers to realistic and occupationally relevant stressors (i.e., emotional or situational constraints). Professional actors or experienced police instructors role-play various types of critical incidents ranging from vehicle controls to domestic disputes to shooting incidents. In the ideal case, the role plays follow a very detailed script that specifies the context and course of the role play, the logistical requirements, and the learning objectives and evaluation standards. In post-scenario debriefings, trainees articulate their decision-making processes and police trainers provide constructive and immediate feedback on the trainee's performance. Through discussions and mental simulations, trainees can identify their weaknesses and learn how to adapt their behavior and improve future performance (Anderson et al., 2019; Di Nota and Huhta, 2019; Jenkins et al., in press). As such, a practical integration of verbal, physical, cognitive, and psychological skills under realistic circumstances is requested from trainees. Therefore, scenario-based training offers a great opportunity (although not the only one, see Staller and Körner, 2019) to apply the ecological dynamics framework in police training.

According to the ecological dynamics framework (Araújo and Davids, 2011; Körner and Staller, 2018), skill learning refers to the process of adapting and attuning to the environment and its constraints. The situational constraints and the action capabilities of the acting person will determine the way of solving the task. In training, the police trainer acts as a designer of the learning environment, who matches the situational constraints of the environment with the trainee's individual capabilities to create the best possible learning experience. Following the principle of representativeness (Araújo et al., 2007), scenario content should be based on situations and events trainees will typically face in their day-to-day duties. While scenario-based training may include preparation for worst-case events, in terms of representativeness, simulated scenarios and their situational characteristics should be sampled from real-life critical incidents, achieving similar occurrence probabilities in the learning and performance environment (Brunswik, 1956; Araújo et al., 2007; Pinder et al., 2011). Thus, rare conditions in police service (e.g., optimal light and enough time for stable two-handed static stance shooting situations) should seldomly occur in police training. At the same time, an overrepresentation of worst-case events should be avoided as the probability of such rare events might be overweighted – at the expense of learning how to deal with the most common police duties (Anderson et al., 2019).

So far, physical, technical, and tactical performance have been emphasized in police training, while effects of stress have typically been neglected (Blumberg et al., 2019; Hope, 2016). In terms of representativeness in the ecological dynamics framework model, it is important to simulate the physical, perceptual-cognitive, and affective representation of critical police incidents (Headrick et al., 2015; Körner and Staller, 2018). Physical representations in the training environments consider physical features found in real encounters, e.g., weapons, the intensity of attacks. Perceptual-cognitive elements influence individual decision-making and the execution of actions. Affective elements affect the psychological or emotional state of the trainee (Körner and Staller, 2018; for similar dimensions of training representativeness see Wollert and Quail, 2018). Psychophysiological changes in response to stress (McEwen and Stellar, 1993) can be considered as affective representations, as they directly influence the psychological experience and in turn mental processes (Nieuwenhuys and Oudejans, 2012, 2017). Experiencing the debilitative effects of stress on their attention and behavior allows police officers to attune and adapt to the environment by discovering and trying out functional problem solutions, including effective coping strategies (Headrick et al., 2015; Körner and Staller, 2018).

Principles of Training Under Stress

Trainings that focus on the manipulation of affective or emotional constraints (Headrick et al., 2015) are known as training under stress or pressure training and their application is widely spread in domains such as sports, military, and police (Low et al., 2020). It involves physically practicing domain-specific skills (e.g., self-defense and arrest skills, communication skills) under simulated stress with the aim to maintain or even improve performance under stress. As such, training under stress does not necessarily introduce a completely new or unfamiliar exercise. Rather, it enhances the existing training by introducing psychological pressure that will alter the trainee's emotional state (Low et al., 2020). Psychological pressure is defined as "any factors or combination of factors that increase the importance of performing well on a particular occasion" (Baumeister, 1984, p. 610) and is very likely to induce stress responses (Lazarus and Folkman, 1984). It is manipulated by increasing either demands of the task or consequences of the trainee's performance. In police service or training, many tasks contain consequences that have an immediate impact, e.g., an antagonist firing back at the officer upon performance errors (Nieuwenhuys and Oudejans, 2011).

The ultimate goal of training under stress is to train the ability to cope with stress while simultaneously executing skills or making decisions (Low et al., 2020). Therefore, it is distinct from stress inoculation training which also exposes trainees to situational cues to induce stress. Stress inoculation training aims to prepare individuals for stressful situations by diminishing the potential for a maladaptive stress response through the gradual, controlled, and repeated exposure to a stressor (Wiederhold and Wiederhold, 2008). In training under stress, stress responses are not necessarily reduced, but rather the utilization of mental effort despite the presence of stress is improved (Nieuwenhuys and Oudejans, 2011; Oudejans and Pijpers, 2009, 2010). In dealing with the affective elements in learning designs, the trainee is able to experience psychophysiological stress responses associated with the specific task and their effect on cognitive and motor performance (functionality). The trainee is encouraged to use these experiences to explore individualized strategies and functional problem solutions to cope with stress (action fidelity; Körner and Staller, 2018). Variability in behavior is explicitly allowed, since trainees might differ in their prerequisites (e.g., physical capabilities, past experiences, individual stress reactivity) and even the slightest changes in environment (e.g., darkness, limited space) and/or the trainee (e.g., position, balance) require functional adjustments ("no repetition in repetition", Schöllhorn et al., 2012). Through practice and experience, the trainee learns to enhance the stability of coping strategies and performance behaviors and thus increase his or her resistance to variable psychological perturbations. Therefore, as many practice trials as possible under variable circumstances should be conducted in training to allow generalization (Headrick et al., 2015).

Naturally, individual verbal, physical, cognitive, and psychological skills may change and optimize with increasing training and work experience (Landman et al., 2016; Nieuwenhuys, and Oudejans, 2011; Oudejans, 2008; Vickers and Lewinski, 2012). Therefore, scenario-based training under stress should expose officers to increasingly complex and demanding situational and emotional constraints (Di Nota, and Huhta, 2019). Training under stress has been shown to be equally effective for both novices and experts (Low et al., 2020), suggesting that appropriate amounts of constraints can already be introduced at an early stage in a trainee's development and should then be adapted as the trainee gains experience.

Importantly, when imposing emotional constraints in the learning environment, police trainers should take caution that emotional constraints do not overwhelm the officers to a point where they experience maladaptive stress that impedes their ability to retrieve and encode information effectively (see stress-memory continuum; Di Nota and Huhta, 2019). Based on Yerkes and Dodson's (1908) seminal work, stress is assumed to influence learning and memory processes on an inverted U-shaped continuum. At moderate levels, stress even facilitates learning by promoting attentional arousal and encoding of novel information. Research has established a memory advantage for emotionally arousing events compared to neutral events (e.g., Payne et al., 2006) and inducing physiological stress responses immediately prior to or during learning improved learning outcomes (Cahill and Alkire, 2003; Cahill and McGaugh, 1998). However, extreme stress interferes with both encoding and retrieval processes (Shackman et al., 2006; also see Davis and Loftus, 2009; Hope, 2016), thereby impairing learning outcomes. In this sense, emotional constraints in training under stress should be aimed to be located at an optimal position in the middle of the stress-memory continuum (Di Nota and Huhta, 2019).

The principles of scenario-based police training following the recommendations for training under stress are summarized in Table 1.

Table 1. Principles of scenario-based police training following the recommendations for training under stress

Principle 1	Scenarios should be **representative of critical incidents** the trainee will typically face in their day-to-day duties.
Principle 2	Scenarios should **induce psychophysiological stress responses** allowing officers to discover and try out coping strategies to mitigate stress responses and effectively utilize mental effort.
Principle 3	**Optimal stress levels** should promote encoding of the learning experience.
Principle 4	Scenario-based training needs to be **individualized depending on the trainee's skill level** and experience, so that it requires effortful cognitive engagement.
Principle 5	**Many practice trials** are necessary to stabilize resistance to variable (psychological) perturbations.
Principle 6	Trainees should be exposed to **increasingly complex and demanding scenarios.**
Principle 7	**Constructive and concrete feedback** from qualified instructors allows learners to explore multiple behavioral options (including coping strategies) to successfully achieve the desired outcome in a controlled, safe environment.

(Araújo and Davids, 2011; Körner and Staller, 2018; Low et al., 2020)

Challenges in the Application of Scenario-Based Training Under Stress

Although scenario-based training is commonly practiced in police academies (Di Nota and Huhta, 2019), various open questions and challenges remain concerning its application. Some of these challenges result from a lack of (scientific) knowledge about the efficacy mechanisms, others from organizational constraints in the current training practice.

Challenge 1: Resource Intensity

Scenario-based training is highly resource-intensive (Di Nota and Huhta, 2019). Therefore, budget is a severe threat to adequate training. Many unique and relevant scenarios need to be developed to comply with the principles of representative, increasingly emotionally demanding, and challenging scenarios. This requires numerous, highly qualified personnel and space-consuming training facilities (e.g., different premises, accessible facades of urban houses and vehicles), including the costs of maintenance and adaptation for different circumstances. Nevertheless, solid training or shooting facilities offer limited variability in scenario creation, leading to trainees' familiarity and habituation with a certain environment, although split-second decisions in novel situations are intended to be trained. Additionally, set-up and reconstruction of solid facilities is time-consuming, taking away valuable training hours (Cushion, 2018; Staller et al., 2020). Since training is limited, the principle of many practice trials is challenged. As a consequence, police officers demand more frequent and realistic training opportunities (Renden et al., 2015). To meet these demands, innovative training practices are warranted that allow diverse and flexible learning environments which can provide more on-task time during training.

Challenge 2: Optimal Stress Induction

To establish the principle of optimal stress level during training, police trainers would require knowledge about both optimal and elicited psychophysiological stress responses. The unawareness of stress levels during training puts trainers at risk to incorporate too extreme scenarios too early in the training process, which might negatively condition officers, resulting in decreased ability to perform well in similar scenarios in the future. Thus, the scenario content and/or situational constraints should not be randomly selected by the trainer. However, two major scientific knowledge gaps about (police) stressors, elicited stress levels, and their role in the efficacy of training under stress complicate the development of evidence-based guidelines: 1) how much stress should be elicited during scenario-based training to maximize learning outcomes, and 2) how can police trainers manipulate scenarios to achieve these optimal stress levels.

The scientific identification of these optimal stress levels is complicated because stress reactivity is highly situational and individual. People differ in their response to the same threat because of personal attributes, appraisals, coping strategies, social support, and past experiences. For instance, recent evidence shows that police officers have significantly higher baseline levels of cortisol relative to the general population (Planche et al., 2019), which might result in less pronounced cortisol reactivity to acute stress situations (Giessing et al., 2019, 2020; Strahler and Ziegert, 2015). Further, self-reported stress levels do not necessarily match physiologically measured stress levels (Campbell and Ehlert, 2012; Giessing et al., 2020). Thus, an individual's current position on the stress-memory continuum might be confounded by the individual and occupationally mediated differences in stress reactivity (Di Nota and Huhta, 2019).

But even if the optimal stress level of the trainee in a given scenario was known, police trainers would then face the challenge of how to manipulate the scenario content and its situational constraints so that it accurately elicits the desired stress level. So far, it remains unclear which situational constraints simulated in scenarios elicit which amount of psychophysiological stress responses. To meet the principle of representativeness, systematic and representative data about stress-inducing situational constraints, their occurrence probabilities in police service, and evaluations of their stress potential are necessary. This knowledge could result in a stress cue repository from which police trainers can draw valid stress cues to systematically manipulate the scenarios in accordance with desired stress levels.

Challenge 3: Feedback Options

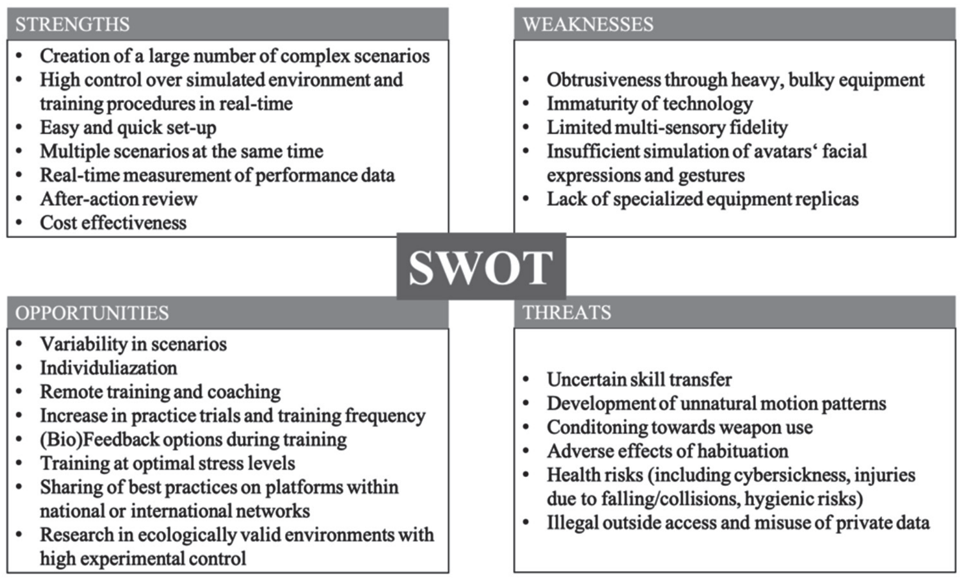
The principle of constructive and concrete feedback in scenario-based training is repeatedly emphasized (Bennell et al., 2020; Jenkins et al., 2020; Rajakaruma et al., 2017) and observational case studies confirm police trainers spend a large part of the training time on explanations, demonstrations, and corrections (Cushion, 2018; Staller et al., 2020). Nevertheless, police trainers are criticized for providing lengthy, corrective feedback that focuses too much on the precise imitation of a technical or tactical solution (Blumberg, et al., 2019; Staller et al., 2020). Following the idea of the ecological dynamics framework (Araújo and Davids, 2011; Körner and Staller, 2018), feedback should rather target the feasibility and effectiveness of individualized solutions to cope with the given context constraints. Instead of discussing the correct execution of technical skills in isolation, the perception, interpretation, and execution of the skills should be considered as a united process (cf. Nieuwenhuys and Oudejans, 2012, 2017) against the background of the situational constraints. In the current practice, lengthy, verbal feedbacks take away much time of the valuable training hours that could otherwise be spent for qualitative time-on-task (Staller et al., 2020). Additionally, feedback sessions are often conducted immediately after scenario completion, when trainees are still likely to be aroused (Andersen et al., 2018) and therefore, unable to focus on and internalize the feedback (Bennell et al., 2020; Jenkins et al., 2020). To provide trainees with adequate feedback on their utilization of coping strategies, non-intrusive feedback options during the tasks in the scenarios or guided feedback sessions after the scenarios are needed in police training. Augmenting feedback sessions with video material of the scenarios can reduce cognitive load in still aroused trainees or might allow the delay of feedback sessions to give trainees to time to recover from the stress levels during the scenario (Bennell et al., 2020; Jenkins et al., 2020).

VIRTUAL REALITY: NEW DIRECTIONS IN SCENARIO-BASED POLICE TRAINING

Virtual Reality (VR) has the potential to address the current challenges of scenario-based police training while fulfilling the proposed principles of training under stress (see Table 1). VR provides a computer-generated simulation, in which the trainee can move through an artificial three-dimensional environment, interact with objects in this space or communicate with avatars. Through headsets consisting of a head-mounted display or specially designed rooms with multiple large screens, VR generates realistic images, sounds, and other sensations that simulate the trainee's mental and physical presence in a virtual environment. As the trainee interacts with and/or reacts to the environment, movement is captured by sensors, allowing the system to provide feedback.

Because of the promising properties of VR, law enforcement agencies, research groups, and technology companies are already discussing its implementation in police training curricula (e.g., Europeans Union's Horizon 2020 project SHOTPROS, grant No. 833672, https://shotpros.eu). VR promises to enable a safe, immersive, and cost-effective way of experiential learning in varied and complex environments. However, the main challenge of VR training lies in its questionable efficacy and transferability to real-life incidents. Although there are first attempts to investigate the efficacy of VR (stress) training in first responders (Bertram et al., 2015; Moskaliuk, Bertram, and Cress, 2013; Caserman, Cornel, Dieter, and Göbel, 2018; Muñoz et al., 2020), it cannot be considered empirically validated yet (Anderson et al., 2019; Di Nota and Huhta, 2019). Nevertheless, police-specific VR solutions are already on the market (for an overview see SHOTPROS, 2020). To direct an evidence-based integration of VR in police training and related research, a SWOT analysis was conducted to identify the strengths, weaknesses, opportunities, and threats when applying VR in police training. While the SWOT framework was originally used as a tool to analyse market forces impacting the standing of companies, it has been utilized successfully in academia to analyse the application of emerging technologies in a specific field (e.g., Düking et al., 2018; Engelbrecht et al., 2019). A summary of the strengths, weaknesses, opportunities, and threats can be found in Figure 1. The following sections will discuss the results of the SWOT analysis in relation to the current challenges in police training: (1) the potential cost-effectiveness of VR due to its flexibility, (2) the potential for (optimal) stress induction in training, and (3) the potential for concrete, interactive feedback sessions after the scenarios.

Figure 1. Strengths, weaknesses, opportunities, and threats of the use of VR in police training.



Unlimited Possibilities?

By virtue of its nature, an almost infinite number of complex scenarios can be designed and manipulated in VR (Düking et al., 2018), which are difficult or immensely resource intensive to simulate in the real world. Police trainers have higher control over the training procedures (e.g., order of events, level of complexity, reduction of risks) and can configure scenarios according to their needs and training aims. As such, VR training offers a great variability of training scenarios, so that a range of examples and permutations of conditions can be provided as learning opportunities within a single training session. Instead of repeatedly training the same procedure under the same conditions, trainees learn to flexibly adapt their skills to varying conditions (for a good example of implementation see Caserman et al., 2018).

To fully utilize this potential, it is important to allow for enough variability in the action options ranging from personal communication, physical self-defence skills, pepper spray, to firearms. Traditionally, skills for weapon use and defence tactics are overrepresented in police training (Blumberg et al., 2019). Certain training methods (e.g., colour ammunition training with full body protection equipment) imply the expectation of firearm use even before the training scenario begins, limiting the number of decisions trainees (think they have to) make. To ensure that VR training does not become part of the tradition of yet another shooting training, it should promote the use of a variety of skills including decision-making for these options. The most prominent police intervention is communication. Certainly, integrating multiple real and simulated characters in the scenarios and the use of voice commands (e.g., “Hands behind your head!") facilitate the interaction with avatars. However, in the applied practice, the insufficient simulation of facial expressions and gestures are often mentioned as a severe limitation, as they are important information sources for emotion and social recognition in high-stress situations (Damjanovic et al., 2014). In clinical research, there are first findings that VR training can enhance emotion and social recognition in populations with psychological disorders (Didehbani et al., 2016; Kandalaft et al., 2013; Nijman et al., 2019; Peyroux and Franck, 2016; Rus-Calafell et al., 2014; Yang et al., 2017). While these training programs usually focus on the simulation of avatars without providing context, future efforts in the development of VR police training should aim to integrate high-fidelity avatar simulations in complex environments.

VR can handle the variety of training scenarios in the same location, only requiring relatively modest open space. With user-friendly interfaces and well-educated trainers, VR scenarios are easily set up and several officers can train simultaneously in the same scenarios, which saves training time for on-task experiences and can result in larger numbers of repetitions per training session (Düking et al., 2018). While the initial costs for the purchase of the equipment and the development of training scenarios may be high, the relatively cheap adaptation of different scenario contents, the lower costs for maintenance, and the portability of the equipment to different training sites might be cost-effective. Additionally, VR might even allow remote training: either individually at any time fitting the trainee's everyday schedule or with multiple trainees that may be geographically apart. Consequently, remote training might reduce the logistic obstacles (e.g., long travel distances to appropriate training centers including travel expenses and time) and therefore, increase training frequency. Equipping every police department or individual police officer with the potential to train in a wide range of scenarios at a fraction of the cost could greatly increase the police officers' preparedness for critical incidents on police duty.

Despite the supposedly unlimited possibilities, VR training should rather supplement the existing training practices than replace them (Haskin et al., 2020). One major concern in the application of VR in police training is the potential development of unnatural patterns of motion (e.g., in the shooting technique), partly due to the obtrusiveness of bulky, heavy equipment (Düking et al., 2018) or imprecise replicas of police equipment. Therefore, the training aims of VR need to be clearly outlined before the implementation in police training. Clearly, traditional training is much better suited to teach motor movement sequences such as shooting or intervention techniques. However, traditional scenario-based training does not typically provide (or is too expensive to support) the full context that officers need to adequately assess the situation. Therefore, it is often necessary that the trainer verbally describes the context of the simulated incident based on the role play script. By this, the trainer might draw attention to details of the incident – potentially giving away the critical learning experiences – that might not have been noticed by the trainees themselves (Haskin et al., 2020). VR offers the ability to simulate very detailed visual and audio contexts containing both explicit and subtle cues. Therefore, VR can serve the training objectives of searching for hazards (perception), assessing the situation (interpretation), and taking appropriate actions (action; cf. Nieuwenhuys and Oudenjans, 2012, 2017). As such, VR should serve as a bridge between existing, empirically validated training practices and novel learning opportunities in representative environments.

Artificial Environments – Real Emotions?

VR has been receiving a lot of attention due to the high level of immersion which allows ecological validity in the training scenarios. In police training, the immersive VR might be an especially valuable tool since it can simulate potentially dangerous scenarios which are difficult or impossible to simulate in the real world for financial, personnel, or ethical reasons. As highlighted in the ecological dynamics framework (Araújo and Davids, 2011; Körner and Staller, 2018; Headrick et al., 2015), a realistic training environment that accurately portrays real-life threats and stimulates the corresponding psychological responses is an essential part of preparing officers for their working conditions in real life. Therefore, authentic VR simulation is needed to produce a close proxy to the real world and tasks. Research has already shown that virtual environments and cues can successfully induce stress and the corresponding psychophysiological responses in established stress protocols (e.g., Trier Social Stress Test; Zimmer et al., 2019) and in high-stress domains, such as sports (Sanz et al., 2015; Stinson and Bowman, 2014), and police (Groer et al., 2010, Muñoz et al., 2020). Changes in the audio-visual environment in a virtual performance setting (e.g., display of score boards, virtual opponents or spectators or acoustic feedback) elicited self-reported stress levels (Sanz et al., 2015) and anxiety (Stinson and Bowman, 2014) as well as galvanic skin responses (Stinson and Bowman, 2014). In a sample of police officers, two types of shooting scenarios elicited various psychophysiological stress responses, including increases in salivary cortisol, alpha-amylase, secretory immunoglobulin A (sIgA), and interleukin-6 (Groer et al., 2010). All in all, this research suggests that specific cues in virtual reality scenarios produce psychophysiological stress responses, mimicking occupational stress.

In the body of VR literature, there is an ongoing debate about which factors influence the effectiveness of VR to elicit stress responses. The concepts of immersion and presence are defining elements. As defined by Slater and Wilbur (1997), immersion refers to the objective level of sensory fidelity, and presence refers to the user's subjective psychological response to a VR system. It is assumed that higher levels of immersion lead to higher levels of perceived sense of presence and, therefore, lead to stronger psychophysiological (stress) responses. As such, it might be concluded that the most advanced, technologically immersive system possible should be designed to maximize user presence. Therefore, the immaturity of the technology and the resulting cybersickness are considered as weaknesses of VR training (Engelbrecht et al., 2019). Therefore, great developmental efforts have been put into improving frame-rate, tracking, field of view, refresh rate, latency, and resolution over the past years (Cummings and Bailenson, 2016). However, high immersion hardware comes with certain costs, e.g., financial expenses, greater cumbersomeness, and calibration requirements. Therefore, the benefit of newer or additional technology must be balanced by practical restrictions and their actual addition to the trainee's sense of presence. A recent meta-analysis found that tracking level, stereoscopy, and field of view have a stronger impact on user presence compared to other features, particularly image quality, resolution, and sound (Cummings and Bailenson, 2016). Importantly, however, immersion is not limited to visual and audio fidelity. Multi-sensory VR simulations including haptics (e.g., vibration for collision feedback, pain stimuli when being hit or shot) or olfactory stimulation (e.g., smell leaking gas, smell of alcohol, strong body odour) can increase immersion and serve as important cues for appropriate risk assessment in high-stress situations. Since policing is a team effort, multi-user fidelity in the VR is warranted that enables cooperation in the training scenarios. A current challenge in the multi-user fidelity is the spatial localisation of colleagues through auditory stimuli. For instance, footsteps of the colleagues are not audible and communication via headsets does not convey any information about the location of the speaker. Besides these technical aspects, personal factors also determine the extent of stress experience (Campbell and Ehlert, 2012). By allowing a great diversity in scenarios, VR can account for this individuality.

In order to gather information about the individual stress experience, there are already first (successful) attempts to measure and track psychophysiological stress responses and training progress of police officers in the recent literature, including the measurement of pupil diameter (Bertilsson et al., 2019a, 2019b), brain waves (Muñoz et al., 2020), and heart rate variability (HRV; Brisinda et al., 2015; Muñoz et al., 2020; Thompson et al., 2015). Among those, HRV is a very promising method, as it is easy to administer (e.g., through chest belts) and has been shown to provide reliable biofeedback in relatively high temporal resolution (i.e., 30 sec intervals; Brisinda et al., 2015). A potential disadvantage of HRV is susceptibility to artifacts and biases through physical activity or movements (e..g, walking or sweeping arm movements). However, it is possible to perform ambulatory measurements of HRV while controlling for respiration and physical activity (Laborde et al., 2017; e.g., Baldwin et al., 2019). During various high- and medium-stress realistic police scenarios, HRV parameters even differentiated between rest and stress conditions and between mental (i.e., shoot/no shoot challenge at a simulator) and physical stress (i.e., effort with bicycle ergometer; Brisinda et al., 2015). According to the neurovisceral integration model (Thayer et al., 2009), HRV reflects an individual's capacity to effectively organize physiological and behavioral resources in response to environmental demands. Higher resting HRV allows quicker adaptability and greater behavioral flexibility in demanding environments, while individuals with low HRV might have reduced capacity to respond efficiently (Thayer et al., 2009). Such evaluation is of particular importance in the context of police work, which is characterized by diverse work stressors requiring a large repertoire of fast behavioral responses. Thus, the study of real-time psychophysiological stress markers during realistic VR scenarios might be an objective method to assess the extent of mental effort the trainee is currently investing. As a tool to monitor the trainee's training performance, it provides the trainers insight into the momentary stress level of the trainees and allows them to adapt the difficulty of the task to the trainees' abilities in real time (Düking et al., 2018; Haskins et al., 2020). As a consequence, motivation to keep practicing and stay cognitively engaged is maintained by increasing the task difficulty based on real-time psychophysiological data. However, further (field) research is needed to support the validity and reliability of psychophysiological stress measurements in VR scenarios to guide appropriate interpretation of the outcomes.

Nevertheless, the remaining difficulty is that it is still unclear which stress levels should be elicited during training for optimal learning outcomes and which cues are effective in doing so. While this difficulty concerns both traditional scenario-based and VR training, VR offers novel, promising possibilities for research to answer these questions (Düking et al., 2018; Haskin et al., 2020). Providing high experimental control, potentially stress-inducing situational constraints can be systematically manipulated and tested in ecologically valid environments. In VR, most factors can be held constant (e.g., suspect's behavior which is not possible with live actors), while only altering the factors of interest (e.g., appearance of the suspect, acoustic environment). Especially in the context of police, in which it is impossible to predict and unethical to manipulate real-life critical incidents (Giessing et al., 2019), VR and its immersive contexts can advance research by assessing psychophysiological and behavioral data in representative environments (Düking et al., 2018). By doing so, VR-based research can help to identify optimal stress levels during scenario-based training by manipulating trainees' stress levels through the systematic manipulation of situational cues. Additionally, a high frequency of exposure to stressful training scenarios might habituate trainees to threatening situations over time, thereby aiding the extinction of potentially adaptive stress responses for optimal performance. Therefore, research into the intensity and frequency of VR training is needed to ensure that VR training does accomplish the development of effective coping strategies, but not the extinction of adaptive psychophysiological stress responses (Engelbrecht et al., 2019).

Optimal Feedback Opportunities?

In accordance with the ecological dynamics framework (Headrick et al., 2015), the key learning objectives in VR police training should be understanding stress responses, identifying their impact, learning and applying coping strategies to mitigate the impact of stress, and recognizing when and where to seek support (Bouchard et al., 2012). However, the education of coping skills to officers has been considered a central challenge in police training as some officers show resistance to the practice and use of tools developed for the purpose of stress regulation (Papazoglou and Tuttle, 2018). Thus, it is recommended to introduce tangible coping strategies that can be easily applied within their daily work routines instead of teaching coping strategies outside the work context (Papazoglou and Andersen, 2014; Papazoglou et al., 2020). With various feedback options during and after training scenarios, VR might offer an ideal training ground with novel possibilities to directly integrate coping strategies in police training (Bouchard et al., 2012). Real-time tracking during training can help trainees to become aware of changes in their stress levels, attention, interpretation. The awareness for these processes gives them the opportunity to discover effective coping strategies to mitigate these changes, and the potential of repetitive actions (often not feasible in real-life scenarios) enables their immediate application. Additionally, real-time data collection can direct police trainers' feedback to the individual weaknesses, not only in a post-hoc analysis, but also immediately by displaying relevant metrics for improvement and engagement during the scenario (Engelbrecht et al., 2019).

During training scenarios, psychophysiological biofeedback might facilitate police trainers' efforts to individualize the scenarios. Likewise, trainees might benefit from being continuously informed about their stress level. HRV biofeedback has been shown to be effective in reducing stress and anxiety both in real-life settings (for a recent meta-analysis see Goessl et al., 2017) and in VR (Rockstroh et al., 2019). So far, environments with restorative qualities (e.g., nature settings) have been simulated in VR for biofeedback training (Annerstedt et al., 2013; Gaggioli et al., 2014; Rockstroh et al., 2019), as these environments are assumed to replenish voluntary attention capacity (Attention Restoration Theory; Kaplan and Kaplan, 1989). Following the recommendation of integrative psychological skills training (Papazoglou and Andersen, 2014; Papazoglou et al., 2020), embedding biofeedback in experiential, high-stress scenarios might help police officers to better detect signs of stress themselves while engaging in their occupational tasks. These signs can then serve as cues to use appropriate coping strategies. During the imagery of stressful police scenarios, HRV-focused trainings with police officers have successfully reduced stress responses (Andersen and Gustafsberg, 2016; Andersen et al., 2015; Arnetz et al., 2009, 2013). The advantage of biofeedback in VR might be the increased immersion, which might result in more realistic experiences, higher training engagement, and better transferability of the skills. The fundamental mechanism of biofeedback training is the operant conditioning through positive reinforcement (cf. Gaume et al., 2016, Sherlin et al., 2011). The integration of feedback parameters into the virtual environment might result in greater awareness for the feedback on the corresponding stress levels (e.g., annoying music in a domestic violence case becoming quieter with decreasing stress levels; Bouchard et al., 2012). Thus, biofeedback during scenarios might reinforce the use of appropriate coping strategies and increase perceived self-efficacy when mastering occupationally relevant, stressful tasks. By negative conditioning, biofeedback can even be used to force trainees to use coping strategies by reducing the trainee's possibilities for efficient interaction in case of high stress levels. For instance, the trainee's field of view can progressively be reduced, as stress levels increase (Bouchard et al., 2012). While (HRV) biofeedback has been shown to be effective in reducing stress in police officers, more research is needed on how it relates to performance and how it can be implemented in scenario-based VR training.

Another potential applied use of VR lies in the ability to improve goal-directed attention to specific information sources during the scenarios (Craig, 2014). In the ecological dynamics framework (Araújo and Davids, 2011; Körner and Staller, 2018), the ability to perceive opportunities for goal-directed behavior is predicated on an individual's ability to detect information in a performance environment relative to his/her existing action capabilities. The importance of an efficient visual search rate, enhanced selective attention allocation, an extended visual span, and scan pattern systematicity for expert performance was recently demonstrated in a meta-analysis (Brams et al., 2019; for a review on gaze behavior training in police samples see Heusler and Sutter, 2019). Information processing can be optimized by selectively allocating available attentional resources to task-relevant stimuli and ignoring irrelevant stimuli (Nieuwenhuys and Oudejans, 2012, 2017). Hence, (visual) cues and sight lines can make action opportunities in the environment more explicit and guide visual attention processes. As the trainer is in full control over the presented virtual environment, salient cues could appear in areas of interest helping trainees to focus on the right spots for gathering relevant information at the right time (Craig, 2014).

After training scenarios, the after-action review (i.e., replay of the scenario) offers various feedback options, as it can be enriched with objective and automated performance measures collected during training, e.g., sighting lines, snake lines (i.e., paths walked by the characters), visual fields or perspective taking of various avatars. Given the concrete material to draw on, VR can make the feedback less abstract, while potentially reducing cognitive load during, which might be particularly relevant in feedback sessions immediately after scenario completion when trainees might still be aroused (Bennell et al., 2020; Jenkins et al., 2020). Therefore, the after action-review incentivizes trainees to reflect on their performance based on instructor feedback and self-assessment. In the current debriefings, police trainers often experience that arguments arise if specific cues or actions were visible for the trainee and/or suspect from their point of view. Through the display of visual fields or perspective taking of various avatars, these arguments can be enriched with a greater variety of experiences. VR can recreate different viewpoints of the same event (e.g., allocentric – the trainer's perspective; egocentric – the trainee's perspective or perspective of all other involved avatars), so that trainers and trainees can see an event (replayed) from other perspectives. Seeing an event unfold from different viewpoints and augmented with sighting lines and snake lines might help to spot weaknesses in the tactical movements and positions and in turn, develop and improve tactical strategies (Craig, 2014). As experiences can be visually shared, it might encourage reflection, active participation, and interaction, thereby fostering the learning experience (Bennell et al., 2020; Rajakaruma et al., 2017).

Training data could be stored in specific databases to monitor the training progress of each trainee and/or to share best practices within national or international networks. These best practices can include scenario set-ups serving specific training objectives and after-action reviews of particularly successful solutions to specific scenarios. This kind of knowledge exchange might help to standardize training and intervention procedures which in turn facilitates teamwork across police departments, agencies, and countries. However, intensive data collection must be balanced against data privacy (Spiegel, 2018). Given the nature of data that may be gathered via VR, more delicate personal information will be available to law enforcement agencies including physical features, motor responses, eye-movement patterns, and physiological (health) information of their employees. Law enforcement agencies might misuse the information for health and performance analyses in the selection of personnel. Additionally, digital data is always vulnerable to hacking, which might reveal both sensitive personal information or organizational information about tactics and procedures to the public. Therefore, ethical implementation of VR in police training also requires secure data storage and the development of data protection regulations (e.g., regarding the intended use, access rights, and storage period) to protect data from outside access and misuse (Spiegel, 2018).

CONCLUSION

To summarize, VR systems seem to be a promising tool for improving certain aspects of police training and related research, including coping strategies, situational awareness, decision-making, and creative behavior. Police training requires realistic scenarios in which police officers can learn to attune and adapt to the situational constraints of critical incidents on police duty. So far, scenario-based training is limited by its resource intensity, restricted variability in the scenario set-up and few feedback options. VR has the potential to overcome these challenges by offering high control over flexible learning environments in which scenario content and feedback options can be systematically varied in real-time. Although VR is still a growing technology, police-specific VR solutions are already on the market and law enforcement agencies have started to implement VR in their training curricula. Nevertheless, VR comes with several weaknesses and threats that jeopardize the efficacy of VR training. Therefore, it is crucial to design systems that meet the specific training principles and supports the desired didactical approach. Defining requirements and practical guidelines will help law enforcement agencies to successfully integrate VR in their current training curricula (see Murtinger et al., 2021). These guidelines need to build upon knowledge about the necessary degree of simulation fidelity, optimal stress levels, valuable feedback features, and optimal frequency and duration of VR training. Clearly, more research is warranted to elucidate the learning mechanisms of training under stress and the role of stress levels. VR can advance the current state of research by enabling innovative studies and field trials for examining, validating, and evaluating relevant human and situational factors of police performance and training under stress. Since evaluations of the VR efficacy in police training and its transferability to real-life behaviour are still outstanding, close collaboration among law enforcement, technology companies, and research institutions can help to identify and meet needs for further technological and scientific developments of VR training. This chapter offers a starting point for policy makers, police trainers, as well as researchers to build upon when implementing VR in police training.

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KEY TERMS AND DEFINITIONS

Coping Strategies: Allow to maintain performance under stress by investing mental effort to master, minimize or tolerate stress responses and their impact on cognition and action.

Ecological Dynamics Framework: A theoretical framework to explain the acquisition and transfer of adaptive human behaviors to a specific performance context. In representative learning environments, the trainee can adapt and attune to the constraints of the performance context.

Representativeness: The quality feature of a simulation that indicates how well the essential properties are reflected. Properties should be sampled from the criterion environment, achieving similar occurrence probabilities in the learning and criterion environment.

Scenario-Based Training: An immersive learning environment in which trainees are exposed to realistic and occupationally relevant stressors, which allows the integrated practice of verbal, physical, and cognitive skills under realistic circumstances.

Situational Constraints: Factors in the environment which limits action possibilities of an individual.

Stress: An unpleasant state that arises when an individual perceives his/her coping resources as insufficient to meet the environmental demands. It results in the activation of the sympathetic adreno-medullary system and the hypothalamo-pituitary-adrenal axis.

Training Under Stress: The practice of domain-specific skills under simulated stress (by introducing affective elements in the learning environment that elicit stress) with the aim to maintain or improve the performance in a stressful performance context.

Virtual Reality (VR): A computer-generated simulation of a three-dimensional, immersive environment in which the user can interact with objects and communicate with avatars using electronic equipment, such as head-mounted displays, multiple large screens and motion capture sensors.